Report on: # A Hazard Identification and Risk Assessment for the proposed Rietkol Silica Mine

Date: 26 May 2017

Project No: 160337-PM

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STATEMENT

I, P.J. Marais, herewith confirm that the HIRA reflected in this report was conducted in accordance with the stated protocol(s) and provides an unbiased reflection of the health risks anticipated for the proposed project.

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Registered Occupational Hygienist (SAIOH)

I, L.T. Roux, accept technical responsibility for the content of this report and hereby approve the report for release.

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EXECUTIVE SUMMARY

AirCHECK was requested to conduct a Hazard Identification and Risk Assessment (HIRA) on the potential hazards that may be presented to employees and the public during the construction and operation of the proposed Rietkol Silica Mine in the Victor Khanye Municipal area of the Nkangala District, Mpumalanga Province.

The health and safety hazards that are relevant to the proposed silica mine were assessed as part of this project. The following conclusions may be drawn from the assessment:

Occupational Exposure Risks during Construction Phase of Silica Mine

- Construction workers may be presented with a High Risk of contracting noise induced hearing loss as a result of exposure to noise from equipment such as, *inter alia*, chain saws, earthmoving equipment, compactors, jack hammers and grinders. Construction workers, who often work outdoors, may also have a High Risk of skin cancer due to exposure to UV radiation from the sun. Furthermore, construction work presents workers with a particularly High Risk of struck-by, as well as slip, trip and fall accidents.

- Exposure to air pollutants, such as agricultural and construction dusts, vehicle exhaust emissions and welding fumes may present construction workers with a Moderate Risk. Hand-arm and whole body vibration resulting from the use of hand tools and earthmoving equipment, respectively, may present employees with a Moderate Risk of suffering ill health. Roll-over accidents and collapsing trenches also presented workers with Moderate Risks. The congregation of many workers on a work site without proper infrastructure may present a Moderate Risk of contracting vector borne diseases, infections, sexually transmitted diseases and even attacks by wild animals.

- Some of the environmental agents assessed were assigned Risk Scores that fell within the Low Risk categories with Risk Scores less than 120. Examples included poor lighting and thermal discomfort.

Occupational Exposure Risks during Operational Phase of Silica Mine

- Employees at the proposed Rietkol Silica Mine may be presented with a High Risk of contracting silicosis as a result of the dusty nature of the operations and the high crystalline silica content of the dust. Exposure to noise from various noisy operations, including mobile equipment, crushers and the beneficiation plant, may present a High Risk of contracting noise induced hearing loss. Safety risks such as slips, trips and falls remain ever present in the mining environment with its many levels, trenches and different plant infrastructure. The 24 / 7 operations require shift work, which may be the cause of serious health problems, if not managed well.

- Several hazards were identified that may present employees with a Moderate Risk of suffering ill health. These included an increased risk of contracting respiratory diseases such as COPD due to exposure to diesel exhaust fumes, exposure to vibration during the operation of mobile equipment and bacteriological agents, including *E. coli,* faecal coliforms and cholera due to a lack of potable drinking water, refrigeration, preservation and sanitation facilities. Poor night time illumination may present a Moderate Risk of poor visual acuity, eye strain, and an increased risk of accidents and injury.

- Thermal discomfort when working outdoors may present employees with a Low Risk.

Public Exposure Risks

- During construction and operation of the proposed Rietkol Silica Mine, dust and diesel exhaust emissions may be generated, which may present members of the public with a Moderate Risk of contracting respiratory diseases such as COPD, wheezing, cough and lung cancer.

- Members of the public are also presented with a Moderate Risk of annoyance caused by noisy activities during both the construction and operational phases of the mine, especially those in close proximity and along the transport routes.

Implementation of certain engineering, administrative and PPE control measures may reduce the above risks to acceptable levels.

1. PURPOSE

The purpose of this Hazard Identification and Risk Assessment (HIRA) was to identify and assess the potential hazards that may be presented to Contractors, Mine Employees, as well as to Members of the Community, during the construction and operation of the proposed Rietkol Silica Mine, and to recommend appropriate measures to mitigate any adverse impacts.

2. LOCATION

The proposed Rietkol Silica Mine will be located on Modder East Agriculture Holdings, near Delmas in the Victor Khanye Local Municipal area, Nkangala District.

3. INTRODUCTION

AirCHECK CC was requested by Ms M. Eksteen of Jacana Environmentals CC to conduct an assessment on the potential health and safety hazards that may be presented to Contractors, Mine Employees and Members of the Public during the construction and operation of the proposed Rietkol Silica Mine near Delmas. The HIRA is conducted as part of the Environmental Impact Assessment (EIA) process that is required by the applicant for environmental authorization.

The proposed Rietkol Silica Mine will find a home in a green field, which will require the clearing of land and the subsequent provision of infrastructure such as roads, storm water drainage, as well as water and sanitation for workers. The process would require the elimination of trees, shrubs, surface vegetation, rocks and stones using hand tools, explosives and earth moving equipment.

Sandstone will be extracted from an open pit by means of excavation equipment, loaded onto haulers and tipped into the crusher receiving bin. The sandstone chunks are crushed into sand grains and transported with conveyors to the beneficiation plant from where the sand will be washed and screened. The final product is dewatered, dried and packed before marketing.

The main occupational health and safety concerns during the construction of the proposed Rietkol Silica Mine include exposures to dusts, exhaust gases and noise, whilst serious injuries may be incurred from the use of machinery and hand tools. During the operational phase of the mine, employees may be exposed to respirable crystalline silica dust, noise, vibration and the elements, whilst occupational health risks such as ergonomics and shift work must also be considered.

Members of the public, such as neighbouring communities, their institutional activities and farming that are located within the impact zone of the proposed Rietkol Silica Mine may be exposed to health hazards that are similar to those experienced by employees of the mine. However, public exposure to health risks is often controversial, as it may involve infants, young children and the elderly. In contrast to employees directly involved in operations, members of the public are less likely to receive education regarding the risks to their health, personal protective equipment, engineering controls, or medical surveillance.

This report presents the findings of a HIRA that was conducted for the proposed Rietkol Silica Mine. The findings and conclusions of the assessment were used to provide preliminary recommendations on the mitigation and control of any anticipated negative health and safety impacts.

4. ASSESSMENT PROTOCOL

The method that was used to conduct the HIRA is described in AirCHECK Method Statement MS 002/15: Method for conducting a Hazard Identification and Risk Assessment. The process involved the structured identification and assessment of potential health and safety hazards that may be presented to Contractors, Employees and Members of the Public within the impact zone of the proposed Rietkol Silica Mine.

Information regarding the anticipated health and safety risks were obtained from the following sources:

- Desk top study of relevant literature to list / extract health and safety risks that were documented during similar projects, locally and internationally.
- Analysis of specialist and environmental modelling reports on the various environmental studies, such as, *inter alia*, air quality, water quality and noise impacts that are conducted as part of the Environmental Impact Assessment to establish the extent to which the proposed Rietkol Silica Mine may impact on the health of employees and members of the community.
- Evaluation of employee exposure to respirable dust and crystalline silica at a similar / existing silica mine near Delmas. Samples were collected and analyzed in accordance with MDHS 14/4 and NIOSH Method 7602.
- Experience of the author(s) drawn from actual surveys / data regarding the health hazards that may be presented by similar silica mines.

During the baseline HIRA, three variables of the potential health or safety hazard were quantified, namely *consequence*, *frequency* and *probability*. Collectively, these variables reflect the degree of employee or public exposure and were used to calculate the Risk Score.

- *Consequence* is the severity of the health effect posed by the health or safety hazard in question. The selected consequence index describes a typical example of a potential negative effect presented by a hazard (eg. cancer) and is adopted irrespective of existing control measures or conditions.
- *Frequency* relates to both the duration and number of exposures to the specific hazard, for example five 10-minute exposures per day, continuous 8-hour exposure throughout a shift, or once a month for 2 hours.
- *Probability* is the likelihood that the negative effect presented by the hazard will follow through or materialise. The probability relies on a number of factors, the most important being the existing measures that control employee / public exposure.

A Risk Score for each hazard was mathematically calculated to establish the extent of the risk, using the formula: *Risk Score (RS) = Consequence (C) x Frequency (F) x Probability (P).*

Table 4.1 on Page 8 provides the algorithms for the Consequence and the Frequency that were used to calculate the Risk Score. The recommended actions for the calculated Risk Score are provided in Table 4.2 on Page 9.

TABLE 4.1: INDICES FOR CONSEQUENCE (C), FREQUENCY (F) AND PROBABILITY (P).

Index	Consequence (C) Description	Frequency (C) Description	Probability (P) Description
10	Death – highly serious, extremely toxic and life threatening; non-reversible effects from exposure characterized by acute lethal toxicity (H_2S, HF, simple and chemical asphyxiants) and Group 4 Hazardous Biological Agents.	Hazard present during 7 – 8 hrs of an 8 hr shift, 10 – 12 hrs of a 12 hr shift	Inevitable (100 % chance)
9	Permanent partial incapacity & unemployable – non-reversible chronic cumulative systemic effects; known human carcinogens (OSHA, IARC and NTP listed); reproductive hazards; characterized by incapacitating and poisonous nature (Asbestos, Benzene, Vinyl Chloride).	Hazard present during 4 – 7 hrs of an 8 hr shift, 6 – 10 hrs of a 12 hr shift	Almost certain (90 % chance)
8	Serious but not immediately / acutely life threatening – non-reversible consequences from exposure characterized by acute systemic effects (ie respiratory, CNS, kidneys, liver, heart); chronic systemic effects; suspect carcinogen, mutagen / teratogen. Group 3 HBAs.	Hazard present ± 4 hrs of an 8 hr shift, ± 6 hrs of a 12 hr shift	Very likely (80 % chance)
7	Permanent partial incapacity with / without work absence – may cause temporary reversible and irreversible health effects; can cause considerable discomfort ie noise induced hearing loss.	Hazard present 2 – 4 hrs of an 8 hr shift, 3 – 6 hours of a 12 hr shift	Probable (70 % chance)
6	Serious but not life threatening effects from exposure characterized by marked irritation, occupational asthma. Group 2 Hazardous Biological Agents, acids and bases.	Hazard present 1 – 2 hrs of an 8 hr shift, 1.5 – 3 hrs of a 12 hr shift	More than even chance (60 % chance)
5	Temporary incapacity with / without work absence – reversible health condition with subsequent complete recovery after extended period of absence. Cumulative trauma disorders / injury reoccurrence (ie carpal tunnel syndrome).	Hazard present < 1 hr of an 8 hr shift, < 1.5 hrs of a 12 hr shift	Even chance (50 % chance)
4	Reversible health condition with subsequent complete recovery after short leave of absence – can cause readily reversible tissue damage that disappears when exposure stops (ie dermatitis, etc).	Hazard arises a few times per week (± 4 hrs of an 8 hr shift, ± 6 hrs of a 12 hr shift)	Less than even chance (30 % - 40 % chance)
3	Minor temporary or reversible effects from excess exposure characterized by mild to moderate irritants, volatile organic compounds, or odorous materials – can cause discomfort (ie nuisance noise, nuisance dust). Group 1 Hazardous Biological Agents.	Hazard arises once a week (± 2 – 4 hrs of an 8 hr shift, 3 – 6 hrs of a 12 hr shift)	Unusual sequence/coincidence (10 % - 20 % chance)
2	Minor health effects with no lost time and complete recovery.	Hazard arises every 2nd week, once a month or infrequently	Improbable (1 % - 10 % chance)
1	No incapacity expected under normal working conditions.	Hazard arises quarterly, once a year or very rarely	Practically impossible (<1% chance)

End of Table 4.1.

TABLE 4.2: RISK SCORE (RS) AND RECOMMENDED ACTIONS.

Risk Score	Action
Very low (≥1 - < 30)	No action is required and no documentary records need to be kept.
Low (≥30 - < 120)	No additional controls required. Consideration may be given to a more cost-effective solution or improvement that imposes no additional cost burden.
Moderate (≥120 - < 340)	Efforts should be made to reduce risk, but costs or prevention should be carefully limited. Risk reduction measures should be implemented within a defined period. Where the moderate risk is associated with extremely harmful consequences, further assessment may be necessary to establish more precisely the likelihood of harm as a basis for determining the need to improved control measures. Occupational Hygiene Monitoring and Medical Surveillance are required and regular revision of controls should be done.
High (≥340 - < 730)	Work should not be started until the risk has been reduced. Considerable resources may have to be allocated to reduce the risk. Where the risk involves work in progress, urgent action should be taken. Occupational Hygiene Monitoring and Medical Surveillance are required and regular revision of controls should be done.
Very high (≥730 - ≤1000)	Work should not be started or continued until the risk has been reduced. If it is not possible to reduce the risk even with unlimited resources, work has to remain suspended.

End of Table 4.2.

5. STANDARDS AND CRITERIA

The standards and criteria that served as a point of reference for the purposes of this HIRA a provided below.

5.1 OCCUPATIONAL EXPOSURE IMPACTS

The Mine Health and Safety Act (29 of 1996), requires that every mine manager shall assess and respond to risk. Furthermore, every employer must:

- Ensure that the occupational exposure to health hazards of employees is maintained below the limits set out in Schedule 22.9(2) (a) and (b).
- Establish and maintain a system of occupational hygiene measurements, as contemplated in section 12, of all working places where the following hazard limits prevail: Airborne pollutants, thermal stress and noise.
- The competent person engaged by the employer in terms of section 12(1) must, as part of the compliance with section 12(2)(b), report to the employer on:
  - The occupational hygiene risk assessment, with specific reference to planning, design, implementation and management of occupational hygiene at the mine;
  - The occupational hygiene hazards that may cause illness or adverse health effects to persons, assess the results in terms of the implementation of control systems and the management thereof, and recommend remedial actions to the employer.

In addition to the above, applicable SANS Codes and International Standards of good Occupational Hygiene practise were used.

5.2 PUBLIC EXPOSURE IMPACTS

Various acts, regulations and local authority by-laws govern environmental pollution in South Africa. However, where local standards were not available, international guidelines were used as a terms of reference.

The most important environmental standards relating to this assessment are provided below.

- Minerals and Petroleum Resources Development Act (49 of 2008).
- National Environmental Management Amendment Act (62 of 2008).
- National Environmental Management: Air Quality Amendment Act (20 of 2014).
- National Water Amended Act (45 of 1999).
- Provincial and local authority regulations, by-laws and standards.

In addition to the above, applicable SANS Codes and International Standards of good Environmental practice were used.

6. POPULATIONS AT RISK

For the purposes of this HIRA, three populations were identified that may be at risk from exposure to health and safety hazards potentially presented by the proposed Rietkol Silica Mine.

The populations that were identified may be classified as follows:

- Construction Workers, also referred to as Contractors.
- Silica Mine Workers, also referred to as Mine Employees.
- Members of the Public.

A description of the nature and composition of each population is provided below.

6.1 CONSTRUCTION WORKERS

During the preparation and construction of the mine, land is cleared, buildings are erected, plant items are installed and services provided. The workers of many different contractors with various skills, such as earth moving, concrete work, steel structures and beneficiation plant construction may be found on the same site. Construction workers may be composed of a small core of permanent workers, but labour is generally recruited in the site area, or includes a large proportion of migrant workers.

It follows that construction workers may constitute numerous occupational categories. Examples of the occupational categories that may be relevant during construction are provided in Table 6.1 below.

TABLE 6.1: OCCUPATIONAL CATEGORIES FOR CONSTRUCTION WORKERS.

Site Clearance and Civil Work	Building, Installation and Commissioning
✓ Chain Saw Operators.	✓ Mobile Equipment Operators.
✓ Drill Operators.	✓ Concrete and Rebar Operators.
✓ Blasters.	✓ Boilermakers and Welders.
✓ Earth Moving Equipment Operators.	✓ Fitters.
✓ Surveyors.	✓ Electricians.
	✓ Steel Workers.
	✓ Beneficiation Plant Specialists.

6.2 SILICA MINE WORKERS

Activities at the proposed Rietkol Silica Mine include open pit mining, operation of the beneficiation plant and maintenance of plant and equipment. Operations and Maintenance may be further sub-divided to include the following occupational categories in Table 6.2 below.

TABLE 6.2: OCCUPATIONAL CATEGORIES FOR SILICA MINE WORKERS.

Operations	Maintenance
✓ Mobile Equipment Operators.	✓ Boilermakers and Welders.
✓ Crusher Plant Operators.	✓ Fitters.
✓ Screening and Washing Plant Operators.	✓ Electricians.
✓ Packing Plant Operators.	✓ Diesel Mechanics.
✓ Cleaners / Labourers / Packers.	

6.3 MEMBERS OF THE PUBLIC

The proposed Rietkol Silica Mine may be situated on farm land, close to the town of Delmas and close lying farms and smallholdings. The members of the public that may be affected by the proposed Rietkol Silica Mine are provided in Table 6.3 below.

TABLE 6.3: MEMBERS OF THE PUBLIC.

Members of the Public
✓ Residents in the town of Delmas.
✓ Farming Communities.
✓ Informal Settlements.
✓ Schools.
✓ Tourists / Travelers.

7. HAZARD IDENTIFICATION

An overview of the most important potential health and safety risks associated with the construction and operation of a silica sand mine are provided below. This section is discussed under two headings, firstly Occupational Hazards and secondly, Public Hazards.

7.1 OCCUPATIONAL HAZARDS

The occupational health and safety risks associated with silica sand mining have been the subject of many studies. Although the health risks are varied, the respiratory impacts due to the inhalation of respirable silica dust are the key health risk related to the industry.

7.1.1 Crystalline Silica Dust

Dust may be released into the air by various operations during the construction and operational phases of the proposed Rietkol Silica Mine, such as dust liberated by earth moving equipment, from the crushing and screening plants, as well as from run of mine (ROM) sand stockpiles.

Dust particles vary in size from visible to invisible. The smaller the particle, the longer it stays in the air and the further it can travel into the human respiratory system. The effects of inhaled dust particles depend on where it settles in the respiratory system when inhaled by workers.

Large dust particles tend to be trapped in the nose and mouth when breathed in and can be readily breathed out or swallowed harmlessly. In some instances, dust that settles in the nose and mouth may be referred to as nuisance / irritant dust, which causes rhinitis and inflammation of the mucous membranes among workers. Further complications may occur if the particles that settle in the above-mentioned regions reach larger air passages, where they may cause inflammation of the trachea (tracheitis) or the bronchi (bronchitis).

Smaller or fine dust particles are more likely to penetrate deeply into the lungs while ultrafine particles can be absorbed directly into the blood stream. Dust that reaches the sacs and the lower part of the airways where there are no cilia is attacked by cells called macrophages, which swallow the particles. However, if workers are exposed to high dust concentrations, the macrophage system may fail. As a result, dust particles and dust-containing macrophages will collect in the lung tissues, causing injury to the lungs.

It is said by the World Health Organisation (WHO) that breathing in high concentrations of dust over several years may reduce lung function in the long term and contribute to disorders like chronic bronchitis and heart and lung disorders.

The dust emanating from silica sand mining processes may contain crystalline silica in variable amounts. Numerous studies in the USA and elsewhere report an average crystalline silica content of 15%, with levels varying between 6 % to 26 %. During a survey conducted by AirCHECK at an existing silica mine in the Delmas area, it was established that the crystalline silica content of the dust was 26 %. (Refer AirCHECK Test Report, Project No: 160337.01-GF, issued with this HIRA Report).

Silicosis is a form of occupational lung disease caused by inhalation of crystalline silica dust, especially where the dust contains more than 5 % crystalline silica. Silicosis is a type of pneumoconiosis that is marked by inflammation and scarring in the form of nodular lesions in the upper lobes of the lungs. The disease is characterized by a shortness of breath, cough, fever and cyanosis (bluish skin).

Employees with silicosis run a high risk of contracting tuberculosis (TB) as a complication. The risks of silicosis and human immunodeficiency virus (HIV) infection combine in a multiplicative manner, and positive silicosis have considerably higher TB incidence rates than those reported from other HIV-positive populations. Special attention should be paid to workers with respiratory conditions like asthma, chronic obstructive airways disease (COAD) or emphysema, as even small increases in dust concentration can make their symptoms worse.

Exact statistics regarding deaths caused by silicosis are unknown, but it has been estimated that there are at least 480 000 cases of silicosis and 226 000 cases of tuberculosis in former mineworkers attributable to work in South African mines.

7.1.2 Diesel Exhaust Emissions

Diesel powered earth moving equipment, such as graders, bulldozers, front end loaders, excavators and trucks will be required from the first steps to clear the virgin land, as well as throughout the life-cycle of the proposed Rietkol Silica Mine. Where diesel-powered mobile equipment is deployed in close proximity to each other, the potential to superimpose exhaust emissions is high.

The exhaust gases of the gasoline-fuelled combustion engine (spark ignition) are the most important source of ambient carbon monoxide (CO) and contain 1 to 10 % of CO depending on the mode of operation of the engine. The diesel engine (compression ignition) exhaust gas contains about 0,1 % of CO when the engine is operating properly, but maladjusted, overloaded or badly maintained diesel engines may emit considerable amounts of CO.

Diesel exhaust typically contains both the components of perfect air carbon combustion (nitrogen, water, carbon dioxide), as well as imperfect combustion (carbon monoxide, the oxides of nitrogen, various hydrocarbons and partially oxidised hydrocarbons such as aldehydes, ketones, phenols and sulphur compounds). Compared with the gasoline engine, the diesel engine produces less carbon monoxide, but more oxides of nitrogen and more aldehydes and these are the components of exhaust likely to be associated with increased morbidity, particularly irritation.

Diesel engines produce submicron particulates (DPM) that have long been regarded with disfavour because of soiling and causing reduced visibility, but were considered to pose a minimal health risk. In addition, health effects such as eye and nose irritation, headaches, nausea, and asthma may be observed from workers as they have been linked elevated to exposure to diesel exhaust concentrations. Several studies of workers exposed to diesel exhaust have shown small but significant increases in the risk of lung cancer. Men with the heaviest and most prolonged exposures, such as miners and truck drivers, have been found to have higher lung cancer death rates than unexposed workers. Based on the number of people that will be exposed at site of the proposed Rietkol Silica Mine, diesel exhaust may pose a substantial health risk.

The presence of mutagens and carcinogens (diesel particulate matter is classified as a Group 2A probable human carcinogen according to the International Agency for Research of Cancer) absorbed on the particulates has changed the perspective of health effects of diesel emissions.

7.1.3 Blasting Fumes

Studies have shown that when explosives detonate, they generate nitrogen, carbon dioxide and water vapour. These gases are non-poisonous and therefore do not have an impact. There are trace amounts of ammonia and nitrous fumes that produce the characteristic smell to blasting fumes just after a blast. These quickly dissipate and do not extend more than a few hundred metres from a blast. However, when explosives are not stoichiometrically balanced or poor blasting practices are applied, the number of nitrous fumes can increase. These are visible as orange to deep red fumes.

7.1.4 Noise

Noise may be the result of numerous activities at the proposed Rietkol Silica Mine. Examples include excavation operations of the mining site, blasting activities, operation of mobile equipment, operation of crushers and operation of the beneficiation plant.

Continuous exposure to noise levels equal to or above 85 dBA for 8 hours may result in permanent hearing damage. Noise induced hearing loss (NIHL) is the most prevalent occupational disease in mining. NIHL caused by acoustic trauma refers to permanent cochlear damage from a one-time exposure to excessive sound pressure. This form of NIHL commonly results from exposure to high-intensity sounds such as blasting explosions.

The negative effects of noise include the induction of permanent hearing damage, masking of wanted sounds such as verbal communication and interference with the nervous and cardiovascular systems. Protection of the hearing sense is regarded as the most important aim, mainly because NIHL is an irreversible condition and the result thereof is experienced by the worker long after exposure has ceased.

The relationship between exposure to noise and hearing damage is well known. However, the magnitude of the risk will depend on the noise intensity, its frequency, duration of exposure and individual susceptibility.

7.1.5 Vibration

Vibration induced health conditions progress slowly in the beginning and usually starts as a localized pain. As the vibration exposure continues, the pain may develop into an injury or disease. Vibration induced disease can be divided into two principal areas, ie whole body vibration (WBV) and Hand-Arm Vibration Syndrome (HAVS), also referred to as Raynaud's phenomenon. The development of HAVS is gradual and increases in severity over time. It may take a few months to several years for the symptoms of HAVS to become clinically noticeable.

During operation of the mine, workers will be exposed to WBV through operation of mobile equipment such as front end loaders, graders, hauler trucks and blasting. Exposure to high levels of WBV may aggravate lower back injuries. Symptoms such as sciatic pain, gastrointestinal tract disturbances and dizziness shortly after or during exposure are less well documented. The risks are greatest when the vibration magnitudes are high, the exposure durations long, frequent, regular and the vibration includes severe shocks or jolts.

In the case of HAV, workers that work for prolonged periods with hand held tools, such as chain saws and pneumatic tools are at the greatest risk. The handle of the tool vibrates rapidly and this motion is transmitted into the hand and arm. Vibration-induced white finger (VWF) is the most common condition among the operators of hand-held vibrating tools. The symptoms of VWF are aggravated when the hands are exposed to cold.

7.1.6 Thermal Comfort

The location of the proposed Rietkol Silica Mine may place employees at risk of heat stress in summer months due to the hot climatic conditions and cold stress in winter months due to outside operations.

Opencast mining operations may present employees with a risk of heat stress, especially during summer. When the temperature deviates from the optimum for comfort, employees may first experience discomfort that are of a subjective nature, but eventually physical problems that impair health and productivity are incurred. Exposure to heat in the workplace has at least three negative consequences. Firstly, as the environmental heat load increases above the comfort level, so productivity drops. Secondly, employees in a heat stress situation may lose concentration and become more accident prone, thus causing a risk not only to themselves, but also to their fellow workers. Finally, employees may suffer heat diseases when the upper tolerance limits of the body are reached and employees may experience conditions such as heat fatigue, or even heat stroke with potential fatal consequences.

During exposure to cold, the sensation of discomfort gives rise to increased irritability, loss of concentration and a reduced efficiency in mental tasks. Physical problems that occur when the lower level of tolerance is approached include vasoconstriction in the peripheral circulation, especially the skin and limbs. Fatigue caused by exposure to cold may increase the risk of myocardial ischemia and pathological coronary artery vasoconstriction. Research has found that incident rates increase as the temperature falls below 19°C. A body temperature that is too low decreases dexterity and sensitivity, as well as affects the brain, which may render the workers unable to think clearly or move well, increasing accident rates.

7.1.7 Non-ionising Radiation

During daytime, exposure to the ultra-violet radiation of the sun presents employees with a risk of skin cancer. Ultra-violet radiation from the sun also increases the skin effects of some industrial irritants and photosensitizing chemicals.

Infra-red radiation from the sun increases the risk of skin burns and heat exposure.

7.1.8 Shift Work

The proposed mining operation shifts are to be confirmed but would typically include a day and night shift.

Shift work is of increasing importance in employee health and well-being. The negative effects that shift work has on employee health may include weariness, mental irritability, depression, fatigue and digestive troubles.

7.1.9 Ergonomic Stressors

Activities during mining operations may require that employees use force to lift heavy loads, perform repetitive motions and adopt awkward / static body postures.

Force, repetition, awkward / static body postures and long duration are examples of ergonomic risk factors that may give rise to musculoskeletal injuries (MSIs). MSI is defined as an injury or disorder of the muscles, tendons, ligaments, joints, nerves, blood vessels or related soft tissue including a sprain, strain and inflammation, which may be caused or aggravated by work.

Work-related MSI can make normal work routines uncomfortable and even painful, leading to stress and dissatisfaction at work, reduced productivity, the inability to perform some or all work duties and even difficulty with activities at home.

Finally, a combination of irregular heavy work and sedentary work may aggravate MSI due to the reduced time in which the body is 'trained' to complete a certain activity (also known as a reduced training effect).

7.1.10 Slips, Trips and Falls

In the occupational setting, falling incidents are commonly referred to as slips, trips, and falls (STFs). Falls from elevation hazards are present at almost every jobsite, and many workers are exposed to these hazards daily.

Any walking / working surface could be a potential fall hazard. An unprotected side or edge which is 1.8 m or more above a lower level should be protected from falling by the use of a guard rail system, safety net system, or personal fall arrest system.

These hazardous exposures exist in many forms, and can be as seemingly innocuous as changing a light bulb from a step ladder to something as high-risk as installing bolts on wash plants.

7.2 PUBLIC EXPOSURE RISKS

7.2.1 Particulate Matter

SPM (Suspended Particulate Matter) may be generated by the proposed Rietkol Silica Mine, which may pose a threat to the local environment. Particle pollution includes PM_{10} or inhalable dust particles, with diameters that are generally 10 micrometres and smaller and $PM_{2.5}$ which is fine inhalable particles, with diameters that are generally 2.5 micrometres and smaller.

Particulate matter (PM), also known as particle pollution, includes the tiny particles of silica dust that will be expelled from the processes at proposed Rietkol Silica Mine. Among particles, fine particles are of gravest concern because they are so tiny that they can be inhaled deeply, thus evading the human lungs' natural defences.

Studies have shown that exposure to particulate matter is also related to an increase of respiratory and cardiac mortality. Particulate matter can irritate small airways in the lungs. This may pose a health hazard to community members situated next to the proposed Rietkol Silica Mine with respiratory conditions such as asthma, COPD or emphysema, as even small increases in dust concentration can make their symptoms worse.

Mining activities that break up soil and rock layers by digging or blasting release particles into the air that are invisible to the naked eye. The smallest of these particles that are broken up can become airborne for an extended period of time. Crystalline silica is a specific kind of particulate matter. The concentration of crystalline silica in air is based on a specific particle size range called PM_{10} (particulate matter 10 micrograms in diameter and smaller).

Monitoring particulate matter for silica is important because mining activities will generate this type of particles that can cause adverse human health effects. Studies have shown that communities residing near silica mines suffer from symptoms such as irritation of lungs and are more susceptible to respiratory ailments like COPD, which silica is a contributing risk factor for.

7.2.2 Air Pollutants other than Dust

Earthmoving equipment and haul trucks transporting silica sand may release airborne pollutants, including nitrogen oxides and particulate matter through diesel exhaust, adding to the prevailing air contaminants present within the Delmas district. These pollutants are associated with infant mortality, chronic COPD, ischemic stroke, worsening of asthma and lung cancer.

Increased concentrations may present the public with a risk of attaining health effects of nitrogen oxides and diesel particulate matter which are linked to lung disease, heart disease and congestive heart failure.

In addition, research shows that death rates in cities with high nitrogen oxide concentrations were found to be four times higher than in cities with low nitrogen oxide concentrations.

7.2.3 Noise

An increase in public noise levels may result from numerous activities at the proposed silica mine. An increase of between 5 dBA and 15 dBA in the ambient noise level will elicit a ‘medium public response’ with ‘widespread complaints’ from affected residents.

Relatively low levels of sound may result in annoyance. Experience has shown that offending sounds may propagate over considerable distances and consequently affect a large population. Annoyance may occur at sound levels well below those responsible for hearing damage.

Many characteristics are important in the generation of annoyance. As the intensity of noise increases, the more annoying it becomes. Sound at low frequencies, such as from the diesel engines of earthmoving equipment and hauler trucks, will cause significant annoyance. In addition, if the noise is intermittent, irregular or rhythmic or contains impulses or recognisable pure tones, it may be considerably more annoying than a steady noise of the same intensity or even the same perceived loudness.

The negative health effects that noise may have on the public includes hypertension, ischemic heart disease, annoyance, interference with speech communication and sleep disturbance. Changes in the immune system and birth defects have been attributed to noise exposure.

Young children exposed to speech interference levels of noise on a regular basis may develop speech or reading difficulties, because auditory processing functions are compromised. Children continue to develop their speech perception abilities until they reach their teenage years. Evidence has shown that when children learn in noisier classrooms, they have a more tough time understanding speech than those who learn in quieter settings.

7.2.4 Shock and Vibration

Blasting during operations may result in vibrations that are transmitted through the ground that surrounds the blast as a series of waves that have the ability to travel rapidly over long distances and gradually decreases in amplitude over distances. Both public above-ground and below-ground municipal structures of Delmas are susceptible to vibration impacts.

Structures can include buildings, as well as residences, schools, churches, power transmission lines and buried pipelines. Some of these structures may include historic or cultural features sensitive to even low levels of vibrations. According to a study commissioned by the European Union in 2000: Shocks and vibrations as a result of blasting in connection with mining can lead to collapse of structures in surrounding inhabited areas. The animal life, on which the local population may depend, might also be disturbed.

Ground and air vibrations affect structure shaking in different ways. The public general may react unfavourably to vibrations based on annoyance, fear of damage to property and the fact that a structure shaking may be startling to the residents and may cause heartbeat irregularities or palpitations, difficulties in breathing, nausea and vomiting.

It is extremely rare that safe blasting practices damage structures. Air blast damage is chiefly limited to the cracking of glass window panes and damage from ground vibrations.

7.2.5 Fly Rock

Fly rock is the single factor of surface mining that is most likely to cause a fatality. Blasting operations may result in the fragmentation and possible projection of rocks. In some cases, the rocks may be thrown beyond the anticipated limits, which may result in blasting-related accidents. Fly rock that is produced during blasting activities may also result in severe damage to the community structures and property such as houses and other structures or buildings.

Generally, fly rock is a result of mismatched explosive energy with the geomechanically strength of the rock mass that surrounds the explosive charge. The main factors that are responsible for the formation of fly rock includes an abrupt decrease in rock resistance, high explosive concentrations that may lead to high energy densities, inadequate delay between the holes in the same row, or between the rows (such as during opencast mine blasting), inappropriate blast design, deviation of the blast holes from the intended directions and improper loading and firing practice that also includes the secondary blasting of boulders and holes.

7.2.6 Water

The communities closest to the proposed Rietkol Silica Mine may also experience health problems linked to water pollution and shortage due to large amounts utilised during operations.

Water will be used in large amounts for washing in the refining process of silica sand at the proposed Rietkol Silica Mine. In order to meet this requirement, water will have to be acquired (and removed) from surface or groundwater supplies from nearby agricultural or domestic users. Due to large extraction of ground water, the water table in the area may get lowered rapidly which may reduce the availability of these sources. In addition, water pollution may occur from dissolved explosive salts.

Due to surface run-off, accumulation of mud, silt and sand in the natural channels, the natural drainage system of the area may get disturbed. Furthermore, accidental releases of fuel, oil, or automotive liquids may create a contamination plume that could reach a water supply well. A spill emergency response plan should be in place that identifies how a response to a spill will be implemented, the parties that will be involved and how the public water supplier will be informed.

8. ASSESSMENT OF HEALTH AND SAFETY HAZARDS

An assessment of employee and public exposure to health and safety hazards is reflected in Tables 8.1 and 8.2 on Pages 19 and 55, respectively.

TABLE 8.1: ASSESSMENT OF HEALTH AND SAFETY HAZARDS THAT MAY BE PRESENTED TO CONTRACTORS AND EMPLOYEES OF THE PROPOSED RIETKOL SILICA MINE.

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
CONSTRUCTION WORKERS											
Exposure hazards during clearing of land											
1.	Agricultural (soil) dust, comprising of organic and inorganic (mineral) particulate, liberated by Earth Moving Equipment and other activities during bush clearing.	Irritation of the upper respiratory tract, asthma, hypersensitivity pneumonitis, increased risk of chronic bronchitis and COPD.	6	8	6	**288 Moderate**	✓ Implement personal respiratory protection programme. ✓ Provide mobile equipment with enclosed cabins and air conditioning. ✓ Wetting of roads with water tankers. ✓ Provide information and training to workers.	6	6	3	**108 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
2.	Petrol (2-Stroke) and diesel exhaust fumes containing CO, NO_x, SO_2, DPM and aldehydes from chain saws, brush cutters, generators and Earth Moving Equipment. 	Respiratory irritation, methemo-globinemia, dyspnea, chronic bronchitis, pulmonary oedema, pulmonary function changes. DPM is a potential occupational carcinogen.	8	8	4	**256 Moderate**	✓ Provide diesel exhausts with filtration and catalytic converters. ✓ Provide mobile equipment with enclosed cabins and air conditioning. ✓ Maintain petrol and diesel operated equipment to minimize exhaust emissions. ✓ Provide information and training to workers.	8	6	3	**144 Moderate**
3.	Blasting fumes, containing nitrous oxides (NO_x), ammonia (NH_3), carbon monoxide (CO) and carbon dioxide (CO_2), in gas form.	Respiratory irritation, respiratory oedema, systemic effects.	6	2	4	**48 Low**	✓ Evacuate a radius of at least 500 m from blast zone before blasting. ✓ Provide information and training.	6	2	2	**24 Very low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
4.	Noise from hand tools, such as brush cutters, chain saws, as well as from mobile equipment, generators and blasting operations. 	Noise induced hearing loss, annoyance, interference with speech communication and warning signals.	7	8	7	**392 High**	✓ Implement engineering controls, ie provide mobile equipment with acoustically enclosed cabins. ✓ Purchasing to specify lower noise levels for equipment used on site. ✓ Implement administrative controls, ie rotate employees between quiet and noisy tasks. ✓ Implement personal hearing protection programme. ✓ Implement medical surveillance (audiometric testing) programme. ✓ Provide information and training.	7	6	4	**168 Moderate**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
5.	Hand-arm vibration from operation of brush cutters and chain saws. 	Numbness, disabling of hands, arms and fingers, VWF.	5	8	6	**240 Moderate**	✓ Select tool consumables and accessories designed to reduce vibration exposure. ✓ Service power tools and other work equipment at regular intervals. ✓ Provide 'anti-vibration' gloves to reduce vibration. ✓ Avoid working in the cold or wet due to increased risk of finger blanching.	5	8	2	**80 Low**
6.	Whole body vibration from operation of Earth Moving Equipment. 	Lower back pain, intervertebral disc disorders, gastro-intestinal tract disturbances, fatigue.	5	8	5	**200 Moderate**	✓ Provide ergonomically well designed seating. ✓ Provide vibration isolation between seat and body of equipment. ✓ Maintain seating of equipment.	5	8	2	**80 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
7.	Ultra-violet radiation from the sun. 	Skin burns, basal cell carcinoma (BCC) and squamous cell carcinoma (SCC). Fair-skinned people have a greater risk than black- or brown-skinned people.	9	8	5	**360 High**	✓ Provide shaded refuge areas to limit exposure time. ✓ Avoid exposure to sun between 10h00 and 15h00. ✓ Issue and wear wide rimmed hats and long sleeved garments. ✓ Provide sunscreen lotion with SPF 15 +.	9	5	2	**90 Low**
8.	Glare due to sunlight.	Eye strain, headaches, errors and / or accidents, injury.	3	6	7	**126 Moderate**	✓ Provide tinted safety glasses. ✓ Clean windows of mobile equipment at regular intervals. ✓ Consider solar film on windows to prevent excessive sunlight from entering.	3	5	2	**30 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
9.	Climatic conditions, extremes of temperature. 	Thermal discomfort, heat stroke, heat collapse, hypothermia.	4	3	6	**72 Low**	✓ Issue and wear suitable protective clothing. ✓ Provide areas of refuge from the elements. ✓ Provide adequate drinking water and encourage employees to drink often. ✓ Observe medical selection criteria. ✓ Provide information and training.	4	3	2	**24 Very low**
10.	Slips, trips and falls due to uneven terrain, excavations and loose sand.	Bruises, bone fractures and serious injury.	6	8	8	**384 High**	✓ Provide fall protection plan. ✓ Restrict access to uneven terrain, excavations and other dangerous areas. ✓ Remove obstructions. ✓ Provide training.	6	5	4	**120 Moderate**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
11.	Struck by falling trees, rocks, moving equipment and flying particles.	Eye injury, fractures, severe injury, death.	10	8	8	**640 High**	✓ Provide safety plan. ✓ Establish safe pedestrian routes. ✓ Provide high visibility safety clothing. ✓ Designate person(s) to signal to the operators of mobile equipment when it is safe to reverse. ✓ Mobile equipment fitted with audible reverse alarm. ✓ Provide training. ✓ Provide first aid, evacuation and medical facilities capable to handle trauma patients.	10	5	4	**200 Moderate**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
12.	Thorns, splinters and sharp objects.	Hand injuries, lacerations, skin infections.	4	5	6	**120 Moderate**	✓ Provide safety plan. ✓ Provide appropriate hand protection. ✓ Provide first aid facilities capable to handle injuries. ✓ Provide training.	4	5	3	**60 Low**
13.	Vector borne disease such as tick bite fever. 	Headaches, fever, weakness, muscle aches and rashes.	6	8	7	**336 Moderate**	✓ Apply topical insect repellents. ✓ Provide appropriate personal protective clothing. ✓ Provide training.	6	8	2	**96 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
14.	Bacteriological agents, including *E. coli,* faecal coliforms and cholera due to a lack of potable drinking water, refrigeration, preservation and sanitation facilities.	Diarrhoea, vomiting, abdominal pain, gastrointestinal disturbances, dehydration and shock.	6	5	6	**180 Moderate**	✓ Ensure a safe water supply. ✓ Ensure careful supervision over food and drink supply. ✓ Provide running water, soap and / or hand sanitizer at sanitary facilities. ✓ Promote good personal hygiene practices. ✓ Provide safe facilities for sewage disposal. ✓ Provide education and training.	6	3	3	**54 Low**
15.	Sexually transmitted diseases (STDs) also referred to as social diseases.	Infections with Hepatitis B, Chlamydia, Herpes Simplex Virus, Human Papilloma Virus (HPV), Gonorrhoea and Human Immunodeficiency Virus (HIV).	8	4	7	**224 Moderate**	✓ Vaccinate workers against Hepatitis B. ✓ Provide sexual health clinics. ✓ Provide prophylaxis. ✓ Provide screening tests. ✓ Provide training.	8	4	3	**96 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
16.	Dangerous insects, arachnids and reptiles, such as scorpions, spiders and snakes. 	Anaphylactic shock, serious injury, death.	10	3	5	**150 Moderate**	✓ Inspect area for nests before disturbing trees, grass and rocks. ✓ Be careful when overturning rocks. ✓ Provide anti-venom and first aid facilities. ✓ Provide education and training.	10	3	3	**90 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
Exposure hazards during civil works											
17.	Agricultural (soil) dust, comprising of organic and inorganic (mineral) particulate, liberated by Earth Moving Equipment and other activities, such as building of roads and infrastructure.	Irritation of the upper respiratory tract, asthma, hypersensitivity pneumonitis, increased risk of chronic bronchitis and COPD.	6	7	6	**252 Moderate**	✓ Implement personal respiratory protection programme. ✓ Provide mobile equipment with enclosed cabins and air conditioning. ✓ Wetting of roads with water tankers. ✓ Provide information and training to workers.	6	5	3	**90 Low**
18.	Diesel exhaust fumes containing CO, NO_x, SO_2, diesel particulate matter (DPM) and aldehydes from Earth Moving Equipment, haulers, generators and an increase in vehicular traffic. 	Respiratory irritation, methemo-globinemia, dyspnea, chronic bronchitis, pulmonary oedema, pulmonary function changes. Diesel particulate matter (DPM) is a potential occupational carcinogen.	8	7	4	**224 Moderate**	✓ Provide diesel exhausts with filtration and catalytic converters. ✓ Provide mobile equipment with enclosed cabins and air conditioning. ✓ Maintain diesel operated equipment to minimize exhaust emissions. ✓ Provide information and training to workers.	8	5	3	**120 Moderate**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
19.	Noise from mobile equipment, generators, compactors, jack hammers and other hand tools. 	Noise induced hearing loss, annoyance, interference with speech communication and warning signals.	7	8	8	**448 High**	✓ Implement engineering controls, ie provide mobile equipment with acoustically enclosed cabins. ✓ Purchasing to specify lower noise levels for equipment used on site. ✓ Implement administrative controls, ie rotate employees between quiet and noisy tasks. ✓ Implement personal hearing protection programme. ✓ Implement medical surveillance (audiometric testing) programme. ✓ Provide information and training.	7	6	5	**210 Moderate**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
20.	Hand-arm vibration from operation hand tools such as jack hammers, compactors, grinders, drills, etc. 	Numbness, disabling of hands, arms and fingers, VWF.	5	8	6	**240 Moderate**	✓ Select tool consumables and accessories designed to reduce vibration exposure. ✓ Service power tools and other work equipment at regular intervals. ✓ Provide 'anti-vibration' gloves to reduce vibration. ✓ Avoid working in the cold or wet due to increased risk of finger blanching.	5	8	2	**80 Low**
21.	Whole body vibration from operation of Earth Moving Equipment.	Lower back pain, intervertebral disc disorders, gastro-intestinal tract disturbances, fatigue.	5	8	5	**200 Moderate**	✓ Provide ergonomically well designed seating. ✓ Provide vibration isolation between seat and body of equipment. ✓ Maintain seating of equipment.	5	8	2	**80 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
22.	Ultra-violet radiation from the sun.	Skin burns, basal cell carcinoma (BCC) and squamous cell carcinoma (SCC). Fair-skinned people have a greater risk than black or brown-skinned people.	9	8	5	**360 High**	✓ Provide shaded refuge areas to limit exposure time. ✓ Avoid exposure to sun between 10h00 and 15h00. ✓ Issue and wear wide rimmed hats and long sleeved garments. ✓ Provide sunscreen lotion with SPF 15 +.	9	5	2	**90 Low**
23.	Poor night-time lighting.	Poor visual acuity, eye strain, increased risk of accidents and injury.	3	6	8	**144 Moderate**	✓ Provide mobile equipment with lamps suitable for the task. ✓ Maintain lamps of mobile equipment. ✓ Illuminate access ways and critical work areas. ✓ Provide portable lighting. ✓ Maintain good housekeeping practices. ✓ Evaluate lighting levels on a regular basis.	3	6	4	**72 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
24.	Glare due to sunlight.	Eye strain, headaches, errors and / or accidents, injury.	3	6	7	**126 Moderate**	✓ Provide tinted safety glasses. ✓ Clean windows of mobile equipment at regular intervals. ✓ Consider solar film on windows to prevent excessive sunlight from entering.	3	5	2	**30 Low**
25.	Climatic conditions, extremes of temperature.	Thermal discomfort, heat stroke, heat collapse, hypothermia.	4	3	6	**72 Low**	✓ Issue and wear suitable protective clothing. ✓ Provide areas of refuge from the elements. ✓ Provide adequate drinking water and encourage employees to drink often. ✓ Provide first aid facilities. ✓ Provide information and training.	4	3	2	**24 Very low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
26.	Slips, trips and falls due to uneven terrain, excavations and loose sand.	Bruises, bone fractures and serious injury.	6	8	8	**384 High**	✓ Provide fall protection plan. ✓ Restrict access to uneven terrain, excavations and other dangerous areas. ✓ Remove obstructions. ✓ Provide training.	6	5	4	**120 Moderate**
27.	Struck by or caught between moving construction vehicles or equipment, suspended loads and flying objects. 	Eye injury, fractures, serious injury, death.	10	8	8	**640 High**	✓ Provide safety plan. ✓ Establish safe pedestrian routes. ✓ Provide high visibility safety clothing. ✓ Designate person(s) to signal to the operators of mobile equipment when it is safe to reverse. ✓ Provide training. ✓ Provide first aid, evacuation and medical facilities capable to handle trauma patients.	10	5	4	**200 Moderate**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
28.	Collapsing trenches. 	Engulfment, suffocation and death.	10	4	8	**320 Moderate**	✓ Inspect trenches daily by competent person. ✓ Provide shoring and shielding. ✓ Provide safe access and egress. ✓ Keep heavy equipment away from trench edges.	8	4	3	**96 Low**
29.	Uneven slopes. 	Roll-over accidents, severe injury.	8	6	7	**336 Moderate**	✓ Provide mobile equipment with roll-over protection. ✓ Establish safe access routes, turn around points and parking. ✓ Designate person(s) to signal to the operators of mobile equipment when it is safe to reverse. ✓ Provide operator training.	8	4	3	**96 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
30.	Vector borne disease such as tick bite fever.	Headaches, fever, weakness, muscle aches and rashes.	6	6	5	**180 Moderate**	✓ Apply topical insect repellents. ✓ Provide appropriate personal protective clothing. ✓ Provide training.	6	6	2	**72 Low**
31.	Bacteriological agents, including *E. coli,* faecal coliforms and cholera due to a lack of potable drinking water, refrigeration, preservation and sanitation facilities.	Diarrhoea, vomiting, abdominal pain, gastrointestinal disturbances, dehydration and shock.	6	5	6	**180 Moderate**	✓ Ensure a safe water supply. ✓ Ensure careful supervision over food and drink supply. ✓ Provide running water, soap and / or hand sanitizer at sanitary facilities. ✓ Promote good personal hygiene practices. ✓ Provide safe facilities for sewage disposal. ✓ Provide education and training.	6	3	3	**54 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
32.	Sexually transmitted diseases (STDs) also referred to as social diseases.	Infections with Hepatitis B, Chlamydia, Herpes Simplex Virus, Human Papilloma Virus (HPV), Gonorrhoea and Human Immunodeficiency Virus (HIV).	8	4	7	**224 Moderate**	✓ Vaccinate workers against Hepatitis B. ✓ Provide sexual health clinics. ✓ Provide prophylaxis. ✓ Provide screening tests. ✓ Provide training.	8	4	3	**96 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
Exposure hazards during building, construction and fitting of silica mine and beneficiation plant											
33.	Cement dust containing cobalt, nickel and chromium.	Lung function impairment, COPD, restrictive lung disease, pneumoconiosis and carcinoma of the lungs, stomach and colon.	8	7	5	**280 Moderate**	✓ Implement personal respiratory protection programme. ✓ Mix cement in well ventilated areas. ✓ Avoid dust, especially when emptying bags. ✓ Provide information and training to workers. ✓ Provide medical surveillance.	8	5	2	**80 Low**
34.	Construction dusts, liberated during the cutting of rock, bricks, concrete, plaster, ceramics and during sandblasting, plastering, rhinoliting and insulation activities. 	Irritation of the upper respiratory tract, asthma, hypersensitivity pneumonitis, increased risk of chronic bronchitis, pulmonary fibrosis / silicosis and COPD.	7	7	5	**245 Moderate**	✓ Implement personal respiratory protection programme. ✓ Use wet cutting methods where possible. ✓ Provide information and training to workers. ✓ Provide medical surveillance.	7	5	2	**70 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
35.	Wet ready mix-concrete.	Skin irritation, burns, allergic sensitization.	6	8	6	**288 Moderate**	✓ Provide alkali resistant hand and foot protection. ✓ Avoid skin contact with wet concrete. ✓ Use ready mix concrete instead of mix on site. ✓ Provide information and training to workers.	6	6	3	**108 Low**
36.	Diesel exhaust emissions, containing CO, NO_x, SO_2, DPM and aldehydes from diesel powered mobile equipment, increase in vehicular traffic.	Respiratory irritation, methemo-globinemia, dyspnea, chronic bronchitis, pulmonary oedema, pulmonary function changes. DPM is a potential occupational carcinogen.	8	6	4	**192 Moderate**	✓ Provide diesel exhausts with filtration and catalytic converters. ✓ Provide mobile equipment with enclosed cabins ✓ Maintain diesel operated equipment to minimize exhaust emissions. ✓ Provide information and training to workers.	8	4	3	**96 Low**
37.	Welding fumes and gases, such as iron oxide, zinc, manganese, copper, from base metal and electrodes.	Respiratory irritation, metal fume fever, siderosis and chronic respiratory disorders, including asthma, pneumonia, bronchitis and pneumoconiosis.	6	7	8	**336 Moderate**	✓ Provide mechanical extraction ventilation. ✓ Provide Welders with respiratory protection. ✓ Provide information and training to Welders.	6	5	3	**90 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
38.	Hazardous chemical substances, including fuels, lubricants, organic solvents, asphalt, paints, curing and retarding agents, gases, etc	Respiratory irritation, CNS effects, headaches, nausea. Skin and eye irritation.	3	3	6	**54 Low**	✓ Provide employees with long sleeved overalls, impervious gloves, safety glasses and respiratory protection. ✓ Dilute before use to reduce the exposure risk. ✓ Use hazardous chemicals in a well-ventilated area. ✓ Provide employee training.	3	3	3	**27 Very low**
39.	Noise from hand tools, mobile equipment and sirens.	Noise induced hearing loss, annoyance, interference with speech communication and warning signals.	7	8	8	**448 High**	✓ Implement engineering controls. ✓ Implement administrative controls, ie rotate employees between quiet and noisy tasks. ✓ Implement personal hearing protection programme. ✓ Implement medical surveillance (audiometric testing) programme. ✓ Provide information and training.	7	6	4	**168 Moderate**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
40.	Hand-arm vibration from jack hammers, compactors, grinders, drills, etc. 	Numbness, disabling of hands, arms and fingers, VWF.	5	8	6	**240 Moderate**	✓ Select tool consumables and accessories designed to reduce vibration exposure. ✓ Service power tools and other work equipment at regular intervals. ✓ Provide 'anti-vibration' gloves to reduce vibration. ✓ Avoid working in the cold or wet due to increased risk of finger blanching.	5	8	2	**80 Low**
41.	Whole body vibration from operation of Earth Moving Equipment.	Lower back pain, intervertebral disc disorders, gastro-intestinal tract disturbances, fatigue.	5	8	5	**200 Moderate**	✓ Provide ergonomically well designed seating. ✓ Provide vibration isolation between seat and body of equipment. ✓ Maintain seating of equipment.	5	8	2	**80 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
42.	Ultra-violet radiation from the sun.	Skin burns, basal cell carcinoma (BCC) and squamous cell carcinoma (SCC). Fair-skinned people have a greater risk than black- or brown-skinned people.	9	8	5	**360 High**	✓ Provide shaded refuge areas to limit exposure time. ✓ Avoid exposure to sun between 10h00 and 15h00. ✓ Issue and wear hats and long sleeved garments. ✓ Provide sunscreen lotion with SPF 15 +.	9	5	2	**90 Low**
43.	Poor night-time lighting.	Poor visual acuity, eye strain, increased risk of accidents and injury.	3	6	8	**144 Moderate**	✓ Provide mobile equipment with lamps suitable for the task. ✓ Maintain lamps of mobile equipment. ✓ Illuminate access ways and critical work areas. ✓ Provide portable lighting. ✓ Maintain good housekeeping practices.	3	6	4	**72 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
44.	Glare due to sunlight.	Eye strain, headaches, errors and / or accidents, injury.	3	6	7	**126 Moderate**	✓ Provide tinted safety glasses. ✓ Clean windows of mobile equipment at regular intervals. ✓ Consider solar film on windows to prevent excessive sunlight from entering.	3	5	2	**30 Low**
45.	Climatic conditions, extremes of temperature. 	Thermal discomfort, heat stroke, heat collapse, hypothermia.	4	3	6	**72 Low**	✓ Issue and wear suitable protective clothing. ✓ Provide areas of refuge from the elements. ✓ Provide adequate drinking water and encourage employees to drink often. ✓ Provide first aid facilities. ✓ Provide information and training.	4	3	2	**24 Very low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
46.	Manual materials handling and the adoption of awkward body postures, including overhead work.	Work-related musculoskeletal disorders, back injury.	5	4	6	**120 Moderate**	✓ Provide mechanical lifting equipment. ✓ Provide trolleys and carts for moving of heavy equipment. ✓ Seek assistance. ✓ Provide training in correct lifting techniques.	5	3	2	**30 Low**
47.	Slips, trips and falls, eg during collapse of scaffolding.	Bruises, bone fractures and severe injury.	6	8	8	**384 High**	✓ Provide fall protection plan. ✓ Restrict access to uneven terrain, excavations and other dangerous areas. ✓ Remove obstructions. ✓ Provide training.	6	5	4	**120 Moderate**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
48.	Struck by mobile equipment, flying particles, falling objects and incidents, such as failure of concrete elements.	Eye injury, fractures, severe injury, death.	10	8	8	**640 High**	✓ Provide safety plan. ✓ Establish safe pedestrian routes. ✓ Provide high visibility safety clothing. ✓ Designate person(s) to signal to the operators of mobile equipment when it is safe to reverse. ✓ Provide training. ✓ Provide first aid, evacuation and medical facilities capable to handle trauma patients.	10	5	4	**200 Moderate**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
49.	Bacteriological agents, including *E. coli,* faecal coliforms and cholera due to a lack of potable drinking water, refrigeration, preservation and sanitation facilities.	Diarrhoea, vomiting, abdominal pain, gastrointestinal disturbances, dehydration and shock.	6	5	6	**180 Moderate**	✓ Ensure a safe water supply. ✓ Ensure careful supervision over food and drink supply. ✓ Provide running water, soap and / or hand sanitizer at sanitary facilities. ✓ Promote good personal hygiene practices. ✓ Provide safe facilities for sewage disposal. ✓ Provide education and training.	6	3	3	**54 Low**
50.	Sexually transmitted diseases (STDs) also referred to as social diseases.	Infections with Hepatitis B, Chlamydia, Herpes Simplex Virus, Human Papilloma Virus (HPV), Gonorrhoea and Human Immunodeficiency Virus (HIV).	8	4	7	**224 Moderate**	✓ Vaccinate workers against Hepatitis B. ✓ Provide sexual health clinics. ✓ Provide prophylaxis. ✓ Provide screening tests. ✓ Provide training.	8	4	3	**96 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
SILICA MINE WORKERS											
Exposure hazards at Open Pit Area and Stockpile											
51.	Crystalline silica dust (> 5%).	Silicosis, increased risk of TB and cancer.	8	8	8	**512 High**	✓ Employ wet methods to suppress dust. ✓ Implement respiratory protection programme. ✓ Provide air monitoring to evaluate dust exposure. ✓ Implement medical surveillance programme. ✓ Apply pre-placement medical selection criteria. ✓ Provide information and training.	8	6	2	**96 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
52.	Diesel exhaust fumes containing CO, NO_x, SO_2, DPM and aldehydes from Earth Moving Equipment, haulers, generators and an increase in vehicular traffic.	Respiratory irritation, methemo-globinemia, dyspnea, chronic bronchitis, pulmonary oedema, pulmonary function changes. DPM is a potential occupational carcinogen.	8	6	4	**192 Moderate**	✓ Provide diesel exhausts with filtration and catalytic converters. ✓ Provide mobile equipment with enclosed cabins. ✓ Maintain diesel operated equipment to minimize exhaust emissions. ✓ Provide information and training to workers.	8	4	3	**96 Low**
53.	Noise from mobile equipment and sirens.	Noise induced hearing loss, annoyance, interference with speech communication and warning signals.	7	8	8	**448 High**	✓ Implement engineering controls. ✓ Invest in mobile equipment with low noise emission levels. ✓ Maintain mobile equipment to reduce noise emissions. ✓ Implement personal hearing protection programme. ✓ Implement medical surveillance (audiometric testing) programme. ✓ Provide information and training.	7	6	4	**168 Moderate**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
54.	Whole body vibration from operation of Earth Moving Equipment.	Lower back pain, intervertebral disc disorders, gastro-intestinal tract disturbances, fatigue.	5	8	5	**200 Moderate**	✓ Provide ergonomically well designed seating. ✓ Provide vibration isolation between seat and body of equipment. ✓ Maintain seating of equipment.	5	8	2	**80 Low**
55.	Slips, trips and falls due to uneven terrain, excavations and loose sand.	Bruises, bone fractures and severe injury.	6	8	8	**384 High**	✓ Provide fall protection plan. ✓ Restrict access to uneven terrain, excavations and other dangerous areas. ✓ Remove obstructions. ✓ Provide training.	6	5	4	**120 Moderate**
56.	Poor night-time lighting. 	Poor visual acuity, eye strain, injury.	3	7	7	**147 Moderate**	✓ Provide adequate illumination on the task. ✓ Illuminate access ways. ✓ Maintain good housekeeping practices. ✓ Maintain lighting systems.	3	1	1	**3 Very low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
57.	Glare due to sunlight.	Eye strain, headaches, errors and / or accidents, injury.	3	6	7	**126 Moderate**	✓ Provide tinted safety glasses. ✓ Clean windows of mobile equipment at regular intervals. ✓ Consider solar film on windows to prevent excessive sunlight from entering.	3	5	2	**30 Low**
58.	Uneven slopes. 	Roll-over accidents, severe injury.	8	6	7	**336 Moderate**	✓ Provide mobile equipment with roll-over protection. ✓ Establish safe access routes, turn around points and parking. ✓ Designate person(s) to signal to the operators of mobile equipment when it is safe to reverse. ✓ Provide operator training.	8	4	3	**96 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
59.	Shift work.	Inefficiency, reduced well-being, impaired health, sleep disorders, chronic fatigue, digestive disorders, peptic ulcer, nervous disorders, anxiety.	5	10	8	**400 High**	✓ Allow at least two consecutive rest days. ✓ Allow at least one break during each shift for a proper meal. ✓ Exclude employees with stomach ailments, those that are emotionally unstable or prone to insomnia.	5	10	5	**250 Moderate**
Exposure hazards at Crushing and Beneficiation Plant											
60.	Crystalline silica dust (> 5%). 	Silicosis, increased risk of TB and cancer.	8	8	8	**512 High**	✓ Employ wet methods to suppress dust. ✓ Implement respiratory protection programme. ✓ Provide air monitoring to evaluate dust exposure. ✓ Implement medical surveillance programme. ✓ Apply pre-placement medical selection criteria. ✓ Provide information and training.	8	6	4	**192 Moderate**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
61.	Noise from crusher and processing plant electric motors. 	Noise induced hearing loss.	7	7	8	**392 High**	✓ Implement engineering controls, ie reduce noise at the source, interrupt the noise path, reduce structure-borne vibration, etc. ✓ Implement administrative controls, ie rotate employees between tasks in quiet and noisy environments. ✓ Implement hearing protection programme. ✓ Provide information and training.	7	6	4	**168 Moderate**
62.	Whole body vibration from Crusher, Vibrating Screens and other Equipment.	Lower back pain, intervertebral disc disorders, gastro-intestinal tract disturbances, fatigue.	5	8	5	**200 Moderate**	✓ Provide vibration damping foundations. ✓ Provide vibration isolation between equipment and structures. ✓ Maintain equipment.	5	8	2	**80 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
63.	Poor night-time lighting.	Poor visual acuity, eye strain, injury.	3	7	7	**147 Moderate**	✓ Provide adequate illumination on the task. ✓ Illuminate access ways. ✓ Maintain good housekeeping practices. ✓ Maintain lighting systems. ✓ Evaluate lighting levels.	3	7	3	**63 Low**
Exposure hazards at Product Bagging Plant											
64.	Crystalline silica dust (> 5%). 	Silicosis, increased risk of TB and cancer.	8	8	8	**512 High**	✓ Employ wet methods to suppress dust when cleaning. ✓ Implement respiratory protection programme. ✓ Provide air monitoring to evaluate dust exposure. ✓ Implement medical surveillance programme. ✓ Apply pre-placement medical selection criteria. ✓ Provide information and training.	8	6	4	**192 Moderate**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
65.	Poor night-time lighting.	Poor visual acuity, eye strain, injury.	3	7	7	**147 Moderate**	✓ Provide adequate illumination on the task. ✓ Illuminate access ways. ✓ Maintain good housekeeping practices. ✓ Maintain lighting systems.	3	7	3	***63 Low***
66.	Slips, trips and falls, eg injuries during bag handling, etc.	Fractures, severe injury.	6	5	7	**210 Moderate**	✓ Provide fall protection plan. ✓ Restrict access to elevated risk areas. ✓ Provide training.	6	5	3	**90 Low**
67.	Shift work.	Inefficiency, reduced well-being, impaired health, sleep disorders, chronic fatigue, digestive disorders, peptic ulcer, nervous disorders, anxiety	5	10	8	**400 High**	✓ Allow at least two consecutive rest days. ✓ Allow at least one break during each shift for a proper meal. ✓ Exclude employees with stomach ailments, those that are emotionally unstable or prone to insomnia.	5	10	5	**250 Moderate**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
Exposure hazards at Sewage Treatment Facility											
68.	Bacteriological agents, including *E. coli,* faecal coliforms and cholera due to potential contact with raw sewerage.	Diarrhoea, vomiting, abdominal pain, gastrointestinal disturbances, dehydration and shock.	6	5	6	**180 Moderate**	✓ Provide running water, soap and / or hand sanitizer at sanitary facilities. ✓ Promote good personal hygiene practices. ✓ Provide safe facilities for sewage disposal. ✓ Provide education and training.	6	3	3	**54 Low**
69.	Poor night-time lighting.	Poor visual acuity, eye strain, increased risk of accidents and injury.	3	6	8	**144 Moderate**	✓ Provide adequate illumination on the task. ✓ Illuminate access ways. ✓ Maintain good housekeeping practices. ✓ Maintain lighting systems. ✓ Evaluate lighting levels.	3	7	3	**63 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
70.	Climatic conditions, extremes of temperature.	Thermal discomfort, heat stroke, heat collapse, hypothermia.	4	2	7	**56 Low**	✓ Issue and wear suitable protective clothing. ✓ Provide areas of refuge from the elements. ✓ Provide adequate drinking water and encourage operators to drink often. ✓ Provide first aid facilities. ✓ Provide information and training.	4	2	3	**24 Very low**
71.	Slips, trips and falls.	Fractures, severe injury.	6	5	7	**210 Moderate**	✓ Provide fall protection plan. ✓ Restrict access. ✓ Provide training.	6	5	3	**90 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
72.	Slips, trips and falls.	Fractures, severe injury.	6	5	7	**210 Moderate**	✓ Provide fall protection plan. ✓ Restrict access. ✓ Provide training.	6	5	3	**90 Low**
73.	Shift work.	Inefficiency, reduced well-being, impaired health, sleep disorders, chronic fatigue, digestive disorders, peptic ulcer, nervous system disorders, anxiety.	5	10	8	**400 High**	✓ Allow at least two consecutive rest days. ✓ Allow at least one break during each shift for a proper meal. ✓ Exclude employees with stomach ailments, those that are emotionally unstable or prone to insomnia.	5	10	5	**250 Moderate**

End of Table 8.1

TABLE 8.2: ASSESSMENT OF HEALTH AND SAFETY HAZARDS THAT MAY BE PRESENTED TO MEMBERS OF THE PUBLIC BY PROPOSED RIETKOL SILICA MINE.

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
MEMBERS OF THE PUBLIC											
Public exposures during Construction Phase											
1.	Dust (PM_{10}), liberated during blasting, civil works and construction.	COPD, wheezing and cough, lung cancer.	8	5	4	**160 Moderate**	✓ Implement dust control measures, ie. wetting of roads, vehicle speed limits and reduced tipping heights. ✓ Consider relocation of communities in close proximity to construction areas. ✓ Provide communities with information regarding the risk and how to protect themselves. ✓ Implement an environmental dust monitoring programme. ✓ Conduct medical surveillance.	8	3	3	**72 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
2.	Diesel exhaust fumes, containing DPM, nitrogen oxide gases and aldehydes emanating from the operation of diesel-powered mobile equipment and an increase in vehicular traffic.	Asthma, COPD, respiratory irritation, lung disease, kidney disease, high blood pressure.	8	6	4	**192 Moderate**	✓ Maintain diesel-powered mobile equipment to reduce emissions. ✓ Engine idle reduction control. ✓ Equipment operator training. ✓ Use ultra-low sulphur diesel or biodiesel. ✓ Provide diesel exhausts with filtration and catalytic converters.	8	6	2	**96 Low**
3.	Blasting fumes, containing nitrogen oxides, ammonia, carbon monoxide and carbon dioxide, in gas form.	Respiratory irritation, worsening of asthma, cardio-pulmonary disease, infant mortality and ischemic stroke.	6	2	4	**48 Low**	✓ Wait for reduced wind speeds or calm conditions before blasting. ✓ Consider the wind direction in relation to sensitive receptors before blasting.	6	2	2	**24 Very low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
4.	Noise of annoying nature.	Noise annoyance, increased irritability, interference with speech communication, particularly at educational buildings.	3	9	8	**216 Moderate**	✓ Invest in plant equipment with low noise emission levels. ✓ Maintain noise-producing equipment to reduce noise emissions. ✓ Acoustically enclose noise sources. ✓ Avoid use of reverse alarms near sensitive receptors. ✓ Implement environmental noise monitoring programme. ✓ Limit working hours. ✓ Introduce a community complaints mechanism and act swiftly on complaints.	3	5	5	**75 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
5.	Shock and vibration from blasting activities.	Irregular heartbeats, stress, palpations, anxiety and damage to property.	3	2	9	**54 Low**	✓ Limit blasting activity to daytime hours. ✓ Agree blasting times with community. ✓ Conduct blasting at set / agreed times only.	3	2	4	**24 Very low**
6.	Fly rock. 	Personal injury, possible fatality and damage to property.	10	2	4	**80 Low**	✓ Provide adequate quality stemming in each blast hole as outlined for air blast control. ✓ Remove all people and animals to a minimum distance of 500 m from each blast. ✓ Ensure that there are no under-burdened holes in any blast closer than 1000 m from buildings and people.	10	2	2	**40 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
7.	Sexually transmitted diseases (STDs) also referred to as social diseases.	Infections with Hepatitis B, Chlamydia, Herpes Simplex Virus, Human Papilloma Virus (HPV), Gonorrhoea and Human Immunodeficiency Virus (HIV).	8	4	7	**224 Moderate**	✓ Vaccinate workers against Hepatitis B. ✓ Provide sexual health clinics. ✓ Provide prophylaxis. ✓ Provide screening tests. ✓ Provide training.	8	4	3	**96 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
Public exposures during Operational Phase											
8.	Dust ($PM_{2.5}$ and PM_{10}), liberated from silica handling.	Silicosis with prolonged exposure, COPD, wheezing and cough, lung cancer.	8	7	6	**336 Moderate**	✓ Identify measures for improving operating and management practices. ✓ Employ wet methods to suppress dust. ✓ Implement respiratory protection programme. ✓ Provide air monitoring to evaluate dust exposure. ✓ Provide information and training. ✓ Implement environmental monitoring programme. ✓ Conduct medical surveillance.	8	4	3	**96 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
9.	Inferior quality and availability of potable water because of leaks and spills of fuel, engine oil and run-off from contaminant sources or illegally dumped waste in the mine.	Acute and chronic toxicity, carcinogenic effects, skin irritation, central and peripheral nervous system neuropathy caused by acrylamide, a common flocculant used to clean water.	8	5	5	**200 Moderate**	✓ Erect bund walls around diesel and chemical storage areas. ✓ Provide chemical spill kits in areas where chemicals are stored and handled. ✓ Implement monitoring programme. ✓ Provide alternative sources of potable water to communities. ✓ Provide additional or improved sanitation systems to prevent water contamination.	8	4	2	**64 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
10.	Light pollution / glare.	Glare, annoyance, increased irritability, interference with sleep patterns.	3	4	8	**96 Low**	✓ Plan and install floodlights in such a way to not cause glare or annoyance.	3	4	5	**60 Low**
11.	Noise of annoying nature from silica mine mobile machinery and plants.	Noise annoyance, increased irritability, interference with sleep patterns, interference with speech communication, particularly at educational buildings.	3	6	8	**144 Moderate**	✓ Place noisy equipment away from sensitive receptors. ✓ Invest in plant equipment with low noise emission levels. ✓ Maintain noise-producing equipment to reduce noise emissions. ✓ Implement environmental noise monitoring programme. ✓ Introduce a community complaints mechanism and act swiftly on complaints.	3	6	4	**72 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
Members of the Public residing along Silica Transportation Routes											
12.	Dust (PM_{10}), including silica and other particulate matter. 	Silicosis with prolonged exposure, COPD, wheezing and cough, lung cancer.	8	6	4	**192 Moderate**	✓ Cover trucks to reduce windblown material. ✓ Wet silica sand load to suppress dust.	8	2	3	**48 Low**
13.	Diesel exhaust fumes, containing DPM, nitrogen oxide gases and aldehydes.	Asthma, COPD, Respiratory irritation, lung disease, kidney disease, high blood pressure.	8	6	4	**192 Moderate**	✓ Maintain diesel-powered mobile equipment to reduce emissions. ✓ Engine idle reduction control. ✓ Equipment operator training. ✓ Use ultra-low sulphur diesel or biodiesel. ✓ Provide diesel exhausts with filtration and catalytic converters.	8	6	2	**96 Low**

No	Hazard Description	Consequence Description	Risk without Mitigation / Controls				Recommended Mitigation / Controls	Risk with Mitigation / Controls			
			C	F	P	RS		C	F	P	RS
14.	Noise from increase in road traffic.	Noise annoyance, increased irritability, interference with sleep patterns, interference with speech communication.	3	6	8	**144 Moderate**	✓ Select transport routes to avoid sensitive receptors. ✓ Limit transport activity to daytime hours. ✓ Observe noise emission standards for trucks. ✓ Maintain engine silencers.	3	5	6	**90 Low**

End of Table 8.2

9. CONCLUSION

A Hazard Identification and Risk Assessment (HIRA) was conducted in order to identify and assess the potential health and safety hazards that may be presented to construction workers, employees, as well as to members of the public, by the proposed Rietkol Silica Mine.

The following conclusions may be drawn from the assessment:

9.1 Construction Workers

- Construction workers may be presented with a High Risk of contracting noise induced hearing loss as a result of exposure to noise from equipment such as, *inter alia*, chain saws, earthmoving equipment, compactors, jack hammers and grinders. Construction workers, who often work outdoors, may also have a High Risk of skin cancer due to exposure to UV radiation from the sun. Furthermore, construction work presents workers with a particularly High Risk of struck-by, as well as slip, trip and fall accidents.

- Exposure to air pollutants, such as agricultural and construction dusts, exhaust emissions and welding fumes may present construction workers with a Moderate Risk. Hand-arm and whole body vibration resulting from the use of hand tools and earthmoving equipment, respectively, may present employees with a Moderate Risk of suffering ill health. Roll-over accidents and collapsing trenches also presented workers with Moderate Risks. The congregation of many workers on a work site without proper infrastructure may present a Moderate Risk of contracting vector borne diseases, infections, sexually transmitted diseases and even attacks by wild animals.

- Some of the environmental agents assessed were assigned Risk Scores that fell within the Low Risk categories with Risk Scores less than 120. Examples included exposure to hazardous chemicals (other than dust and thermal discomfort.

9.2 Silica Mine Employees

- Employees at the proposed Rietkol Silica Mine may be presented with a High Risk of contracting silicosis as a result of the dusty nature of the operations and the high crystalline silica content of the dust. Exposure to noise from various noisy operations, including mobile equipment, crushers and the beneficiation plant, may present a High Risk of contracting noise induced hearing loss. Safety risks such as slips, trips and falls remain ever present in the mining environment with its many levels, trenches and different plant infrastructure. The 24 / 7 operations require shift work, which may be the cause of serious health problems, if not managed well.

- Several hazards were identified that may present employees with a Moderate Risk of suffering ill health. These included an increased risk of contracting respiratory diseases due to exposure to diesel exhaust fumes, exposure to vibration during the operation of mobile equipment and bacteriological agents, including *E. coli,* faecal coliforms and cholera due to a lack of potable drinking water, refrigeration, preservation and sanitation facilities. Poor night time illumination may present a Moderate Risk of poor visual acuity, eye strain, and an increased risk of accidents and injury.

- Thermal discomfort when working outdoors may present employees with a Low Risk.

9.3 Members of the Public

- During construction and operation of the proposed Rietkol Silica Mine, dust and diesel exhaust emissions may be generated, which may present members of the public with a Moderate Risk of contracting respiratory diseases such as COPD, wheezing and cough, lung cancer.

- Members of the public are also presented with Moderate Risk of annoyance caused by noisy activities during both the construction and operational phases of the mine, especially those in close proximity and along the transport routes.

Implementation of certain engineering, administrative and PPE control measures may mitigate the assessed risk as indicated in Table 7.1.

10. RECOMMENDATIONS

The following control measures are recommended to mitigate employee and public health risks that may be presented by the proposed Rietkol Silica Mine.

No	Control Measure(s)
Occupational Hygiene, Medical Surveillance and Environmental Monitoring	
1.	Implement an Occupational Hygiene Monitoring and Medical Surveillance Programme at the proposed Rietkol Silica Mine, as required in terms of Sections 12 and 13 of the MHSAct (29 of 1996). Occupational Hygiene Monitoring should be carried out by a person qualified in occupational hygiene techniques, to determine the extent of employee exposure to the relevant agent. Medical Surveillance should be carried out by an Occupational Health or Occupational Medical Practitioner. The Monitoring Programme provided in Item 11, Tables 11.1 and 11.2, may be used to determine where further action is required.
2.	An Environmental Monitoring and Community Medical Surveillance Programme should be implemented as required by various sections of the Environment Management Act (39 of 2004), National Water Act (36 of 1998), as well as provincial and local authority by-laws. The Monitoring Programme provided in Item 11, Table 11.3, may be used to determine where further action is required.
Crystalline Silica Dust	
3.	Mining areas, crushers, conveyors, as well as the beneficiation and bagging plants should be demarcated and identified as respirator zones by posting the SANS MV12 symbolic safety sign (see Figure 1) in a conspicuous place at entrances that lead to these areas, or on the body work of mobile equipment.  **Figure 1: SANS MV12, indicating that respiratory protection shall be worn during dust producing activities.**
4.	The correct respirator / dust mask should be selected for each task. Employees who work in dusty areas should be issued with and wear FFP2 dust masks when they enter respirator zones.
5.	Employees and members of the public who are potentially exposed to dust should receive formal training and information in the risk and how to protect themselves.
6.	Mobile equipment must be provided with enclosed, airtight cabins. The rubber seals of the cabin should be well maintained at all times. Operators should close the windows of the cabin to limit their dust exposure. For this purpose, the installation and maintenance of an air conditioner inside the cabin should be investigated.
7.	Gravel roads and stockpiles should be watered down / sprayed with water in order to control dust liberated by vehicles or mobile equipment. Where possible, dusty roads should paved, or chemically treated with a product such as Dust-a-Side® to prevent dust liberation. Contact Dust-a-Side® at Tel (017) 647-1667 for further information.

No	Control Measure(s)
8.	Dust suppression systems, such as mist or water sprayers, should be provided at conveyor transfer points, crushers and screens. Water should be sprayed as a fine mist in order to provide dust suppression over a wide area. Visit www.spray.co.za/dust-control for more information.
Airborne Pollutants / Chemical Agents, Other than Crystalline Silica Dust	
9.	The wind direction and speed should be considered before blasting activity. Blasting should be avoided when the wind speed is high or in the direction of sensitive receptors.
10.	Where nitrous oxide fumes are observed during a blast, blasting activity should be halted until the cause of the fumes is identified and corrected. Causes may include poor charging practices, incorrect explosives formulation or holes that are too close together in softer formations.
11.	Diesel powered mobile equipment should be well maintained to reduce exhaust emissions.
12.	Catalytic convertors and filtration of exhaust fumes should be considered to reduce harmful emissions.
13.	Employees exposed to chemical agents in the workplace should be issued with the necessary personal protective equipment and clothing.
14.	Chemical agents that are classified as carcinogens or sensitizers should, wherever practical, be replaced (substituted) with products that are less hazardous.
Noise Exposure	
15.	Workplaces and noise-producing equipment must be clearly demarcated as noise zones or identified as noise sources. For this purpose, SANS MV4 symbolic safety signs (see Figure 2) should be posted at all entrances that lead to these areas, or on the body work of mobile equipment, to identify them as noise zones and to indicate that it is compulsory to wear hearing protectors.  **Figure 2: SANS MV4, indicating that hearing protection shall be worn in noise zones.**
16.	Employees who are required to work in noise zones or operate noise-producing equipment should be provided, free of charge, with personal hearing protective equipment. The wearing of personal hearing protective equipment must be enforced.
17.	A comprehensive hearing conservation programme should be established. Once implemented, the programme should be maintained and a responsible person should be appointed to oversee the programme. Such a programme must make provision for the following: ✓ Noise measurement and demarcation of noise zones at intervals not exceeding twenty-four months. ✓ Education, motivation and training of management, supervisors and employees. ✓ Issuing of suitable hearing protective equipment. ✓ Enforcing the wearing of hearing protective equipment. ✓ Implementation of Engineering Control measures to eliminate or reduce noise at its source.

No	Control Measure(s)
18.	Management should invest in plant and equipment with low noise emission levels. The acceptable noise emission levels should be contractually agreed with suppliers. Noise acceptance tests should be conducted by a competent, independent party, during commissioning of the equipment.
19.	Noise sources such as compressors, pumps, fans and electrical motors should be acoustically enclosed.
20.	The use of *"reverse warning alarms*" that are the source of great public annoyance, should be avoided near sensitive receptors
21.	Noise-producing equipment should be serviced and maintained on a regular basis, in order to prevent excessive noise liberation due to, for example, vibrating panels or broken equipment.
22.	Processes or tasks that do not require ongoing 24/7 operation, such as drilling and blasting, should be limited to day time and weekdays.
Whole-Body Vibration	
23.	The seats of mobile equipment should not be mounted directly on the chassis or body. Instead, a vibration dampening mechanism should be provided in-between the seat and chassis.
24.	A good posture is vital for minimising the risks of back injury when driving mobile equipment. Posture can be improved through the implementation of the following measures: ✓ Improving the driver's vision from the cab to minimise twisting of the back and neck. ✓ Relocating machine controls to minimise repeated stretching. ✓ Providing a seat, that fits all the drivers that will use the vehicle, fits the space available within the cab and is suitable for the task being carried out. ✓ Use of seat-belts to maintain the driver in the best position, providing support for the back.
25.	The seats of mobile equipment should be serviced and maintained to help keep vibration magnitudes down to the minimum necessary.
Hand-Arm Vibration	
26.	Consumables (eg. abrasives for grinders and sanders) or tool accessories (such as drill bits) should be carefully selected not to affect the vibration exposure. Some manufacturers supply accessories designed to reduce vibration exposure.
27.	"Anti-vibration" handles may reduce the vibration, but incorrect selection of this type of handle may actually increase the vibration at the hand, so only handles that are endorsed by the tool manufacturer should be used.
28.	Low body temperature increases the risk of finger blanching because of the reduced blood circulation. Working in the outdoor environment on cold winter days should therefore be avoided.
29.	The Procurement Department must have a policy on purchasing suitable tools. The policy should take into account vibration emission, ergonomic factors and operating requirements.
Good Lighting	
30.	Mining areas, plant and equipment should be well illuminated according to accepted standards.
31.	Lamps should be installed parallel to and above walkways, catwalks, stairs and ramps.
32.	The headlamps of mobile equipment should be able to provide a minimum of 10 lux at 20 metres in the direction of travel. Headlamps must be clean and well maintained.

No	Control Measure(s)
33.	A planned maintenance programme should be implemented to ensure that lamps are kept clean and when defective are replaced or repaired immediately.
34.	Lighting systems, and particularly flood lamps, must be planned and installed in such a way that they do not cause glare or annoyance to local communities.
Environmental Elements	
35.	The cabins of surface mobile equipment should be fitted with air conditioning equipment in order to provide a comfortable work environment during summer and winter.
36.	Employees that are required to work outdoors should be provided with appropriate protective clothing, ie. loose fitting long sleeved garments for summer, warm jackets for winter and hats to provide protection against the harmful UV rays of the sun.
37.	Where exposure to the sun cannot be prevented, employees must be provided with a sunscreen lotion with at least a SPF 15 +.
38.	Shaded and enclosed refuge areas should be placed at strategic points where employees converge, or at locations such as security check points, in order to limit exposure to the elements.
Ergonomic Stresses	
39.	Procurement standards should be specified for tools, equipment and furniture such as hand tools, seats of mobile equipment, as well chairs and desks used in offices and control rooms. Requirements regarding the design of tools, equipment or furniture should be communicated to suppliers.
40.	Man / job specifications should be compiled for each job category on site. These specifications include, amongst others, their physical requirements, workload, special skills, working environment and education.
41.	Manual handling of heavy loads should be considered as a last resort in special cases were the application of mechanical means are not feasible.
42.	The control of awkward body postures is done through redesign of the contributory risk factors that influence task demands eg. the work area, tools or equipment, loads and load handling activities. Where it is not possible to redesign the task, work organization factors such as job rotation, job enlargement and work / recovery cycles may need to be considered to decrease the duration of exposure to an awkward posture.
43.	When it is necessary for employees to support their weight on their knees or sit on hard surfaces which may cause reduced blood flow and contact stress, knee guards, cushions, rubber mats or equivalent should be provided.
Shift Work	
44.	Night shift workers should not be engaged if they are over 50 years of age.
45.	Employees, who have a tendency towards ailments of the stomach and intestine, are emotionally unstable, prone to psychosomatic symptoms or to sleeplessness should not be employed on night shift work.
46.	Twelve hour shifts should be avoided since the extended hours increase exposure times to health hazards such as dust, noise and vibration, leaving less time for the body to recuperate. The usual three shift system, changing over at 7h00 – 15h00 – 23h00, or 8h00 – 16h00 – 24h00 is preferred.
47.	Continuous night work without rotation should be avoided. Short term rotations are better than long-term ones. Forward rotation is preferred.

No	Control Measure(s)
48.	Any shift plan should include some weekends with at least two consecutive rest days.
49.	Every shift should include one longer break for a hot meal, to ensure adequate nourishment.
Hazardous Biological Agents	
50.	Employees should be encouraged to practice good personal hygiene, ie. washing of hands prior to and after eating, drinking and smoking.
51.	Impervious gloves should be worn where employees are presented with a potential skin contact risk to hazardous biological agents.
52.	Adequate (hand and body) washing facilities (with soap and if necessary disinfectants) and easy access to such facilities should be provided.
Pollution of Water Resources	
53.	Effective bund walls must be erected around diesel and chemical storage areas to prevent spillage onto the ground.
54.	Chemical spill kits must be provided in areas where chemicals are stored and handled for the prompt cleaning of spills.
Community Exposure to Fly Rock	
55.	Fly rock in opencast mining needs to be controlled by providing adequate quality stemming in each blast hole as outlined for air blast control. Strict control needs to be applied to prevent the occurrence of over-charged holes.
56.	For safety, it will be necessary to remove all people and animals to a minimum distance of 500 m from each blast during blasting operations.
57.	In areas where mining occurs closer than 1000 m from buildings and people, it will be necessary to ensure that there are no under-burdened holes in any blast. This must be done for all blasts with free faces facing buildings and people within 1000 m.

11. PROPOSED OCCUPATIONAL HYGIENE MONITORING AND MEDICAL SURVEILLANCE PROGRAMMES

Occupational Hygiene Monitoring and Medical Surveillance are required of the environmental agents identified during this assessment, in terms of Sections 12 and 13 of the Mine Health and Safety Act (29 of 1996). An Occupational Hygienist should carry out the occupational hygiene surveys. In addition, medical surveillance should be conducted as directed by an Occupation Health Practitioner from time to time. For this purpose, the Monitoring Programmes indicated under Items 11.1 and 11.2 of this Section should be used to determine where further action is required.

11.1 CHEMICAL AGENTS

The following Air Monitoring and Medical Surveillance Programmes are recommended for employees who are exposed to airborne pollutants / chemical agents.

TABLE 11.1: OCCUPATIONAL HYGIENE AND MEDICAL SURVEILLANCE PROGRAMMES FOR CHEMICAL AGENTS.

No	Area / Department	Hazardous Chemical Substance	Air Monitoring Programme	Medical Surveillance Programme
1.	Exposed Occupations in Silica Sand Mining Operations.	Crystalline silica (> 5%) Total inhalable dust (PNOC)	As per the minimum frequencies required per Category Classification, as specified in the SAMOHP Codebook.	Respiratory examination, including ✓ Chest X-rays, once every 12 months. ✓ Lung function testing, once every 12 months.
2.	Exposed Occupations at Crushers, Screens, Stockpiles, as well as beneficiation and Bagging Plants.	Crystalline silica (> 5%).	As per the minimum frequencies required per Category Classification, as specified in the SAMOHP Codebook.	Respiratory examination, including ✓ Chest X-rays, once every 12 months. ✓ Lung function testing, once every 12 months.
3.	Exposed Occupations in Earthmoving Equipment Maintenance Workshops	Metal fumes and gases, such as iron oxide, zinc, manganese, chromium, nickel, lead, vanadium, copper and ozone from the base metal and the electrodes.	As per the minimum frequencies required per Category Classification, as specified in the SAMOHP Codebook.	Respiratory examination, including ✓ Chest X-rays, once every 12 months. ✓ Lung function testing, once every 12 months.

No	Area / Department	Hazardous Chemical Substance	Air Monitoring Programme	Medical Surveillance Programme
		Oils, greases, diesel (containing petroleum hydrocarbons and mineral additives) and anti-freeze (containing ethylene glycol).	—	Clinical examination for skin disorders, once every 12 months.

End of Table 11.1

11.2 PHYSICAL, ERGONOMIC AND PSYCHOLOGICAL AGENTS

The following Occupational Hygiene and Medical Surveillance Programmes are recommended for Physical, Ergonomic and Psychological Agents.

TABLE 11.2: OCCUPATIONAL HYGIENE AND MEDICAL SURVEILLANCE PROGRAMMES FOR PHYSICAL, ERGONOMIC AND PSYCHOLOGICAL AGENTS.

No	Environmental Agent (Excl. Chemical Agents)	Occupational Hygiene Monitoring Programme	Medical Surveillance Programme
1.	Lighting.	Lighting survey of all working environments and mobile equipment, at least every 24 months, in accordance with Regulation 9.2(9) of the Mine Environmental Engineering and Occupational Hygiene Regulations, MHSAct (29 of 1996) and the SANS 10114-1.	Drivers of mobile equipment should undergo eye screening tests, including visual acuity, colour deficiency and night vision tests (where applicable).
2.	Ultra-violet Radiation	—	Skin examinations employees exposed to UV radiation, once every 24 months. Occupational Health Personnel should ascertain signs of photo-sensitization caused by combined exposure to UV radiation and the use of certain medicines.
3.	Noise.	Personal noise exposure monitoring on an annual cycle period, as required by Regulation 9.2(2) of the Mine Environmental Engineering and Occupational Hygiene Regulations, MHSAct (29 of 1996) and the requirements under the *Guideline for the Compilation of a Mandatory Code of Practice for an Occupational Health Programme for Noise*. Area noise assessments for the purpose of rating the work environment in accordance with SANS 10083, once every 24 months.	Audiometric testing in accordance with Section 11 of SANS 10083 for employees working in noise zones.

No	Environmental Agent (Excl. Chemical Agents)	Occupational Hygiene Monitoring Programme	Medical Surveillance Programme
4.	Whole-body Vibration (WBV).	Identify high-risk occupations (ie. Mobile Equipment Operators) and monitor the effectiveness of measures. Assess the exposure of at-risk occupations by means of quantitative measurements where possible, otherwise by means of qualitative risk assessments.	Employees exposed to whole body vibration (especially Mobile Equipment Operators) should undergo the following medical examinations: ✓ Full medical examination, including tests for hypertension and diabetes, ✓ Evaluation of the mobility of the back and neck (evaluation of the degeneration of the intervertebral discs), and ✓ Kidney function tests. Examinations should be conducted at least once every 12 months.

No	Environmental Agent (Excl. Chemical Agents)	Occupational Hygiene Monitoring Programme	Medical Surveillance Programme
5.	Hand-arm Vibration (HAV).	Identify high-risk occupations and monitor the effectiveness of control measures. Assess the exposure of at-risk occupations (Operators of vibrating hand tools) by means of quantitative measurements where possible, otherwise by means of qualitative risk assessments.	Conduct the following clinical tests / examinations on employees exposed to hand arm vibration: √ Examine the hands, fingers and upper body for callosities, scars, trophic changes and any skeletal abnormalities. √ Take blood pressure. √ Conduct Allen's, Tinel Phalen's and Adson's tests, where the requirement for such tests is identified. √ Purdue pegboard test to assess the dexterity of the hands and fingers. √ Grip strength – assess the muscle strength of the hands using a dynamometer. Examinations should be conducted at least once every 24 months.
6.	Ventilation / Indoor Air Quality.	Ventilation surveys at all offices, control rooms and workshops, once every 24 months.	Monitor and record complaints of headaches, fatigue, ill-health, poor productivity and lack of concentration, especially amongst office workers.
7.	Cold.	Evaluation of cold stress in accordance with the requirements under Regulation 9.2(2) of the Mine Environmental Engineering and Occupational Hygiene Regulations, MHSAct (29 of 1996) and the requirements under the *Guideline for the Compilation of a Mandatory Code of Practice for an Occupational Health Programme on Thermal Stress*.	Pre-placement medicals for employees working in cold environments as indicated by cold stress survey.

No	Environmental Agent (Excl. Chemical Agents)	Occupational Hygiene Monitoring Programme	Medical Surveillance Programme
8.	Ergonomics.	Ergonomics survey at least once every 24 months or when existing work procedures or equipment are changed or modified. This survey should include observations while employees carry out their tasks and the identification of tasks that may be regarded as hazardous, such as the handling of heavy equipment. It should also include an assessment of body postures, the design and condition of seats, workstation heights, the use and handling of hand tools and accessibility to equipment.	Employees exposed to poor ergonomical conditions should be monitored for musculoskeletal disorders caused by any physical activity, including lifting that places stress on the body's capabilities or the operation of mobile equipment.
9.	Shift Work.	Make employees who conduct shift work aware of the risks associated with this type of work by sending out regular information leaflets. Employees who conduct tasks that require intense concentration, such as Mobile Equipment Operators, should fill in a questionnaire on a regular basis to determine whether they show symptoms of "shift lag".	Medical surveys / questionnaires filled in by shift / night time workers should include the following: ✓ Any difficulties that the employee may have adjusting to shift or night work, ✓ Any health problems that may be aggravated by shift or night work, including health conditions where it is advisable not to engage in night work (i.e. uncontrolled diabetes), and ✓ Any psychological / mental problems and work or social stress. Medical Practitioners must consider the impact that medication may have on a person's ability to conduct their tasks and cope with night / shift work and should advise the worker accordingly.

End of Table 11.2

TABLE 11.3: PROPOSED ENVIRONMENTAL MONITORING AND COMMUNITY MEDICAL SURVEILLANCE PROGRAMMES.

No	Environmental Agent	Monitoring Programme	Medical Surveillance Programme
1.	Environmental Dust.	Dust fall out sampling (bucket sampling) at strategic locations at, or near sensitive receptors. PM_{10} sampling at strategic locations at, or near sensitive receptors. Baseline levels should be recorded before commencement of operations and on a monthly basis thereafter, or as recommended by specialist.	Conduct lung function testing, once every 12 months on selected members of the public, including children.
2.	Diesel Exhaust Emissions.	Measurement of levels of nitrogen oxides, sulphur dioxide, carbon dioxide, carbon monoxide and DPM at strategic locations at, or near sensitive receptors. Baseline levels should be recorded before commencement of operations and on a monthly basis thereafter, or as recommended by specialist.	Selected members of the public, including children, should undergo the following medical examinations: ✓ Full medical examination, including tests for hypertension. ✓ Lung function testing. Examinations should be conducted at least once every 12 months.

No	Environmental Agent	Monitoring Programme	Medical Surveillance Programme
3.	Noise.	Measurement of noise levels at sensitive receptors. Baseline levels should be recorded before commencement of operations and on an annual basis thereafter, or as recommended by specialist.	Monitor complaints from members of the community regarding annoyance, sleep disturbance and anxiety.
4.	Water.	Measurement of pH, as well as the levels of nitrates and heavy metals in underground and surface water resources within the impact zone of the proposed mine. Baseline levels should be recorded before commencement of operations and on a quarterly basis thereafter, or as recommended by specialist.	Selected members of the public, including children, should undergo the following medical examinations: ✓ Full medical examination. ✓ Kidney function testing. Examinations should be conducted at least once every 12 months.

End of Table 11.3

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OCCUPATIONAL HYGIENE REPORT

Client / Applicant

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Date of Issue 26 May 2017
Project No 160337.01-GF
Enquiries P.J. Marais

SUBJECT: EMPLOYEE EXPOSURE TO RESPIRABLE SILICA DUST AT SILICA QUARTZ, DELMAS.

1. PURPOSE

The purpose of the survey is to reflect the results of employee exposure to respirable silica dust at **SILICA QUARTZ, DELMAS** against the requirements of the Mine Health and Safety Act (29 of 1993) and to provide measurement data for a proposed Silica Mine near Delmas.

2. DATE OF SURVEY

The survey was conducted on 17 February 2017.

3. LOCATION

The survey was carried out at the following premises:

SILICA QUARTZ
Farm Groenfontein
Delmas
2210

4. INSTRUMENTATION AND METHOD(S)

The following instrumentation and methods were used:

Instrumentation	✓ GILAIR constant flow sampling pumps calibrated at 2,2 ℓ/min before and after sampling to ensure that the airflow rate remained constant. ✓ Mixed Cellulose Ester filters (37 mm diameter, 0.8 micron pore size). ✓ Respirable fraction cyclonse. ✓ 5 decimal AND GR-202 Balance (Serial No 14246827), Calibration Certificate No DM 10297-1 (19 May 2016).
Calibration	Gilian Gilibrator (S/N: 1404026), Calibration Certificate No CAL006/15 (21 September 2016).
Method(s)	✓ MDHS 14/4, *General methods for sampling and gravimetric analysis of respirable, thoracic and inhalable aerosols.* ✓ NIOSH Method 7602.

Legend:

ℓ/min	*Litres per minute.*
mm	*Millimetres.*
MDHS	*Method for the determination of Hazardous Substances of the Health and Safety Executive, United Kingdom.*
NIOSH	*National Institute of Occupational Safety and Health methods derived from the NIOSH Manual of Analytical Methods, 4th Edition, United States of America.*
Note	*The measurement programme was in accordance with the requirements of the Occupational Exposure Sampling Strategy Manual (OESSM), published by the NIOSH, Publication No. 77-173 of 1977, United States of America: Department of Health, Education and Welfare.*

5. RESULT(S) AND EVALUATION

The results of employee exposure to respirable crystalline silica at **SILICA QUARTZ, DELMAS** and evaluation thereof are reflected in Table 1 on Page 3.

TABLE 1: EMPLOYEE EXPOSURE TO SILICA DUST AT SILICA QUARTZ, DELMAS. 17 FEBRUARY 2017.

Sample No	Person Exposed / Occupational Category	Location / Department	Substance Measured	Exposure Level (mg/m^3)	8-Hr TWA OEL (mg/m^3)	Total Sampling Time (Min)
MCE 075/16	Vusi Masuko / Excavator Operator	Quarry Pit	Respirable dust - Crystalline silica	0,07 0,02	5,0 0,1	480
MCE 003/17	Themba Sibanyone / Bobcat Operator	Crusher Plant	Respirable dust - Crystalline silica	0,61 **0,16 •**	5,0 0,1	392
MCE 078/16	Mthokozisi Zulu / Screening Plant Operator	Screening Plant	Respirable dust - Crystalline silica	2,21 **0,57 •**	5,0 0,1	402
MCE 002/17	Jabu Gumede / Dryer Plant Operator	Dryer Plant	Respirable dust - Crystalline silica	0,27 **0,07 #**	5,0 0,1	397
MCE 076/16	Petros Mahlangu / Packer	Bagging Plant	Respirable dust - Crystalline silica	0,26 **0,07 #**	5,0 0,1	393
MCE 077/16	Aaron Mahlangu / Laboratory Technician	Laboratory	Respirable dust - Crystalline silica	0,16 0,04	5,0 0,1	420

Legend:

•	*Exceeds the statutory limit.*
#	*Equals and / or exceeds the action level (50 % of the OEL)*
mg/m^3	*Milligrams per cubic metres.*
8-hr TWA OEL	*Eight-hour Time Weighted Average Occupational Exposure Limit.*
Min	*Minutes.*
Note 1	*OELs are reflected in the Amendment to the Regulations in Respect of Occupational Hygiene, Government Notice 989, Mine Health and Safety Act (29 of 1996), 2006 Occupational Exposure Limits for Airborne Pollutants.*
Note 2	*Analysis conducted by SANAS Accredited Testing Laboratory T0361.*
Limit of detection	*The limit of detection for the analytical method was 0,004 mg.*

6. COMMENTS

An evaluation of employee exposure to respirable silica dust was conducted at **SILICA QUARTZ, DELMAS** to provide measurement data for a proposed Silica Mine near Delmas.

The exposure to respirable silica dust of a number of occupational categories were evaluated during the survey, including Mobile Equipment Operators, Screening and Dryer Plant Operators, Packer and Laboratory Technician to provide guidance on anticipated exposures for a similar mining operation at a nearby location.

Employees were exposed to respirable dust levels of between 0,07 mg/m^3 and 2,21 mg/m^3, which complied with the OEL of 5 mg/m^3.

Analysis of the respirable dust samples revealed that the dust comprised of approximately 26 % crystalline silica.

The Bobcat Operator at the Crusher Plant and Screening Plant Operator at the Screening Plant were exposed to crystalline silica at levels of 0,16 mg/m^3 and 0,57 mg/m^3, respectively, which exceeded the OEL of 0,1 mg/m^3. The Bobcat Operator at the Crusher Plant and Screening Plant Operator at the Screening Plant were therefore presented with a health risk pertaining to the inhalation of crystalline silica.

The Dryer Plant Operator at the Dryer Plant and Packer at the Bagging Plant were exposed to crystalline silica at a level of 0,07 mg/m^3, which complied with the OEL, but exceeded the action level. The action level is 50 % of the OEL and represents that point at which it is recommended that management take action to reduce the exposure risk presented to employees.

The Excavator Operator at the Quarry Pit and Laboratory Technician at the Laboratory were exposed to crystalline silica at levels that complied with the OEL of 0,1 mg/m^3 and therefore employees were not presented with a silicosis risk on the day of the survey.

7. STATEMENT

I, G. Farmer, prepared this report and hereby declare that the results are a true reflection of conditions encountered during the survey.

26 May 2017

GEORGE FARMER
REGISTERED OCCUPATIONAL HYGIENE ASSISTANT (SAIOH)

DATE

I, L.T. Roux, accept technical responsibility for the content of this report and hereby approve the report for release.

26 May 2017

LISA ROUX
REGISTERED OCCUPATIONAL HYGIENIST (SAIOH)

DATE

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