DENISON MINES ZAMBIA LIMITED

ENVIRONMENTAL IMPACT ASSESSMENT

MUTANGA PROJECT, SIAVONGA DISTRICT

Prepared for:-

DENISON MINES ZAMBIA LIMITED
Lusaka, Zambia

By

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List of Terms and Abbreviations

°C	Degrees Celsius
AAS	Atomic Absorption Spectrometer
AfDB	African Development Bank
AGIP	AGIP SPA, Italian Oil Company
AIDS	Acquired Immune Deficiency Syndrome
AMC	African Mining Consultants
AMEX	American Stock Exchange
amsl	Above mean sea level
ARD	Acid Rock Drainage
ASX	Australian Stock Exchange
AQI	Air Quality Index
BSI	British Standards Institute
CBD	Convention on Biological Diversity
CCDC	Community Consultation and Development Coordinator
CCC	Community Consulting Committee
CEC	Cation Exchange Capacity
CITES	Convention on international Trade in endangered Species
CIX	Continuous Ion Exchange
CO_2	Carbon Dioxide
CVP	Conservation and Vegetation Program
cps	counts per second
CSA	Geological, Mining and Management Consultancy
DA	DA
dB	Decibels
dB (A)	A-weighted noise
dB (C)	C-weighted noise
DDCC	District Development Coordinating Committee
DC	District Commissioner
DES	Denison Environmental Services
DMZL	Denison Mines Zambia Limited
DRC	Democratic Republic of Congo
DRP	Displacement and Relocation Plan
EBS	Environmental Baseline Study
EC	Electrical Conductivity
ECZ	Environmental Council of Zambia
ECP	Emergency Containment Pond
EGF	Escarpment Grit Formation
EHS	Environmental Health and Safety
EIS	Environmental Impact Study
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
EPB	Environmental Project Brief
EPF	Environmental Protection Fund
EPFI	Equator Principles Financial Institutions
EPPCA	Environmental Protection and Pollution Control Act
ERP	Emergency Response Plan
ESP	Exchangeable Sodium Percent
ERB	Energy Regulation Board
FAO	Food and Agriculture Organisation
FS	Feasibility Study
GIIP	Good International Industry Practice
g/l	Grams per litre
GM	General Manager

GMA	Game Management Areas
GSD	Geological Survey Department
ha	Hectare
H_2SO_4	Sulphuric Acid
HDPE	High-density Polyethylene
HIV	Human Immuno-Deficieny Virus
IAEA	International Atomic Energy Association
IBA	Important Bird Area
IBRD	International Bank for Reconstruction and Development
ICP-MS	inductively coupled plasma-mass spectrometry
IDA	International Development Association
IEC	International Electro-technical Commission
IFC	International Finance Corporation
IRP	Ionising Radiation Protection
JV	Joint Venture
kg	kilogram
kg/m^3	kilograms per cubic metre
km	kilometre
LEAD	Leadership for Environment and Development
m	Metre
m^2	Metres squared
m^3	Metres cubed
m/s^2	Metres per squared second
m/s	Metres per second
m^3/h	Cubic metres per hour
mg/kg	Milligrams per kilogram
mg/l	Milligrams per litre
mm	Millimetres
mSv/yr	MilliSiverts per year
Mt	Million tonnes
Mtpa	Million tonnes per annum
MAC	Mining Advisory Committee (Zambia)
MDM	Mine Design & Project Management Consultancy, S.A
MMMD	Ministry of Mines and Minerals Development
MMDA	Mines and Minerals Development Act (Zambia), 2008
MMF	Madumabisa Mudstone Formation
MOU	Memorandum of Understanding
MSD	Mines Safety Department
MSDS	Material Safety Data Sheet
NGO	Non Government Organisation
NORM	Naturally Occurring Radioactive Material
NEAP	National Environmental Action Plan
NCS	National Conservation Strategy
NCSIR	National Council for Scientific and Industrial
NO_2	Nitrogen Dioxide
OHS	Occupational Health and Safety
OML	OmegaCorp Minerals Limited
OL	OmegaCorp Limited
OP	Operational Procedure
OSHA	Occupational Safety and Health Organisation
PFS	Pre-Feasibility Study
PLS	Pregnant Liquor Solution
PLLS	Exploration Permit (pre-2008)
LPL	Large Prospecting License (2008)
PPAH	Pollution Prevention and Abatement Handbook

PPE	Personal Protective Equipment
PRA	Participatory Rural Appraisal
QEMSCAN	Quantitative Electo-Magnetic Scan
RAP	Relocation Action Plan
RC	Reverse Circulation
RC	Relocation Committee
RHC	Rural Health Centre
RMC	Regional Member Country(ies) – members of the AfDB
RPA	Radiation Protection Authority
RPB	Radiation Protection Board
RPO	Radiation Protection Officer
RM	Radiation Monitor
ROM	Run-of-mine
RWP	Raw Water Pond
RWT	Raw Water Tank
RWMP	Radiation Waste Management Plan
SDU	Sodium Di-Uranate
SAR	Sodium Absorption Ratio
SHEO	Safety, Health and Environment Officer
SHE	Safety, Health and Environment
SHEN	School Health and Nutrition Program
SI	Standards Institute
SIL	Sound Intensity Level
SIT	Sterile Insect Technique
SDP	Sustainable Development Plan
SO_2	Sulphur Dioxide
SPL	Sound Pressure Level
Sv	Sieverts
TDS	Total Dissolved Solids
TORs	Terms of Reference
t/h	Tonnes per hour
tpa	Tonnes per annum
tpm	Tonnes per month
TSF	Tailings Storage Facility
TSS	Total Suspended Solids
TSX	Toronto Stock Exchange
TWA	Time Weighted Average
U	Uranium
U_3O_8	Uranium Oxide
µm	Micron
USDA	United States Department of Agriculture
UXO	Unexploded Ordinance
VHF	Very High Frequency
VSAT	Very Small Aperture Terminal
W	Watt
WB	World Bank
WHO	World Health Organisation
WNTI	World National Transport Institute
WRD	Waste Rock Dump
ZMAC	Zambia Mine Action Centre
XRF	X-Ray Flourescence
ZAWA	Zambia Wildlife Authority
ZESCO	Zambia Electricity Supply Coorperation

EXECUTIVE SUMMARY

Introduction

This report is the Environmental Impact Study (EIS) and Environmental Management Plan (EMP) for Denison Mines Zambia Limited (thereinafter called "DMZL") Mutanga's Project in the Siavonga District in the Southern Province of Zambia. The EIS was conducted by African Mining Consultants (AMC) in Kitwe.

DMZL intends to mine 18.8Mt of Uraniun Ore from the Mutanga and Dibbwe Open Pits and Subsquently process it into Uranium Oxide Concentrates. The Uranium Oxide Concentrates also known as "Yellow Cake" will be shipped to the international Market for use in Nuclear Energy Generation.

The EIS and EMP form part of a Feasibility Study (FS) conducted from January 2008 until March 2009 to provide part of the documentation for project financing purposes and for the regulatory authorities of Zambia for application of a mining license. The EIS was conducted from January 2007 to March 2009.

Project History

Exploration activities were initiated in the area in 2005 for Uranium mineralisation when OmegaCorp Limited (OL) acquired PLLS 237 from Okorusu Fluorspar Pty Limited (Okorusu). OL, an ASX listed company. OmegaCorp Limited was 100% acquired by Denison Mines Corp (DMC), a joint TSX and AMEX listed company, in September 2007. OmegaCorp Minerals Limited (OML) was the Zambian subsidiary of OL, which has since 2009 changed its name to Denison Mines Zambia Limited (DMZL). DMZL is a Zambian company and a wholly owned subsidiary of Denison Mines Corp. The lease is currently held by Denison Mines Zambia Limited (DMZL).

Project Location and Proponent

The Mutanga Project is located in the Matuba area of the Siavonga District in the Southern Province of Zambia. The project is approximately 175km south of Lusaka and approximately 39km northwest of Siavonga Town. The site is accessed from Lusaka via the Lusaka-Chirundu and Chirundu-Siavonga tarmac roads and then the Matuwa-Mutanga dirt track. The exploration license LPL 237 covers an area of 946.3km^2

Denison Mines Zambia Limited (DMZL) is a Zambian company, wholly owned subsidiary of Denison Mines Corp., a public Company listed on the Candian TSX and USA AMEX. Denison Mines Corp. was formed through the combination of Denison Mines Inc. and International Uranium Corporation on the 1st of December, 2006. Denison is a mid-sized, diversified Uranium producer and exploration Company and has assets in Canada, the United States (U.S.), Mongolia and Zambia. The Company is listed on the Toronto Stock Exchange ("DML") and the American Stock Exchange ("DNN").

Legislative and Legal Framwork

The Project will be locally regulated through the Ministry of Mines and Minerals Development (MMMD), the Environmental Council of Zambia (ECZ) and the Radiation Protection Authority (RPA) as provided for through Mines and Minerals Development Act, Envrinmental Protection and Pollution Control Act and the Ionising Radiation Act respectively. DMZL will also strictly adhere to other relevant Zambian Legislation.

The international principles and standards developed for the Uranium industry through organisations such as the International Atomic Energy Agency (IAEA), the World Nuclear

Transport Institute (WNTI) and World Nuclear Association (WNA) provide guidance principles to the development and management of the Project.

Mineralisation

The first Uranium Mineralization was identified in 1957 by the Geological Survey of Zambia (GSD). The current project focuses on the resources identified at the Mutanga Central and Dibwe prospects. The 2008 exploration program conducted by DMZL used the methods of downhole radiometric logging, riffle splitting reverse circulation (RC) chips, half drill core and scintillometer logging to provide data for CSA Global (UK) Pty Limited to develop a resource estimate of uranium ore resources in December 2007.

Exploration on the Mutanga Prospect consisted of 14,794 metres (50 diamond holes for 6,833m, 119 percussive (wagon drill) holes for 6,998m and 83 percussive (shallow wagon drill) holes for 963m), trenching and pitting. Exploration on Dibwe Prospect consisted of drilling of 40 diamond drill holes (3,644m) and additional percussive (wagon drill) holes. The maximum drilling depth within the Mutanga and Dibwe prospects is one hole at 161mbgl at Dibwe. Hole depths average 55mbgl and are usually less than 100m deep.

CSA Global (UK) Pty Ltd updated the original resource estimates and classification for the Mutanga and Dibwe Main areas on December 31st 2007. The total Measured and Indicated resource estimate for the Mutanga deposit is 10.28Mt (1.88Mt and 8.4Mt respectively). An additional 7.2Mt of Inferred resource was identified for Mutanga. The average grade of the Measured and Indicated resources is 398ppm which will yield approximately 7.81Mlbs of U_3O_8 concentrate. The Dibwe deposit exists as an Inferred resource of 17Mt at approximately 234ppm U_3O_8.

The majority of the Uranium (~95%) at Mutanga is contained in Uranium-calcite-potassium minerals (e.g. Autunite ($Ca(UO_2)_2(PO_4) \cdot (10\text{-}12)H_2O$) and Metaautunite($Ca(UO_2)_2(PO_4) \cdot (0\text{-}6)H_2O$)). Approximately 2% (by volume) of the uranium bearing mineralisation consists of Brannerite and Coffinite. The dominant minerals in the ore are Quartz (37-82%), Micas (7-24%), Feldspars (6-16%) and Clay (2-17%).

A chemical analysis indicated that Uranium in the Ore ranges from 100ppm (0.01%) to 20,000ppm (2%). The expected average ore grade to be transported to the process plant on a truck will range from 250 to 450ppm (0.025-0.045%). Elements that may be abundant in soils of the area would be uranium, aluminium, sodium, potassium and calcium. Uranium mineralisation occurs as disseminated U_3O_8; as deposits along fractures and mineralisation through mud replacement in mud balls and flakes.

Project Components

<u>*Mining*</u>

The Project will develop two open pits, one at Mutanga (33ha) and the other at Dibwe (54.3ha). The Mutanga open pit will be 750m long and 550m wide. The Dibwe open pit will be developed approximately 10km southwest of the Mutanga pit operations and will be 1,550m long and 350m wide.

The waste rock (45.7Mt) will be dumped onto two Waste Rock Dumps adjacent to the Mutanga (25ha) and Dibwe (60ha) open pits. Some Waste Rock may be backfilled where feasible. The ore will be mined using ‘free digging’ mining techniques and equipment chosen to optimise selective mining and reduce dust emissions.

Dewatering of the pit slopes will be conducted by an external pit wellfield. These boreholes will supply a raw water pond (RWP) constructed at Mutanga and Dibwe which will each cover an area of 2ha with a storage capacity of 44,000m^3 and 46,000m^3 respectively. It is proposed to re-inject the surplus raw water back into the ground.

The open pits will be mined over a period of 10 years with the initial development of the Mutanga Open Pit in Year 1 (early 2012). The mining of the Dibwe Open Pit will be initiated in Year 7 of the mine life. The average mining rates of ore will be 1.9Mt per year. The average grade of the mined ore from both pits will be 283ppm.

Ore Processing

The Ore will be trucked from the Open Pits and tipped into the Crusher Hopper or directed onto a small Run-Of-Mine (ROM) pad at Mutanga or Dibwe. During maintenance activities a stockpile may be develop at the ROM Pad. The Ore will be crushed and agglomerated and fed by Conveyors along a Stacking Unit onto the Heap Leach Pads (each approximately 80ha).

Crushing will be conducted in a building to prevent fugitive dust emissions. The heap leach pads will provide a Pregnant Liquor Solution (PLS) to the process plant. The process plant will produce an average of approximately 500t of Uranium Oxide Concentrate per year. The Heap Leach Pads will be lined with a double layer of non-woven geotextile liner with an interlayer leak detection system. The Pregnant Liquor Solution (PLS) from the pads will be stored in the PLS pond and pumped into tankers for transport to the Mutanga process plant.

The Heaps will be drip fed with dilute acid solution to leach the Uranium from the Ore and the leachate will drain through the lined under-drainage system to the lined intermediate and PLS ponds. A lined Emergency Containment Pond (ECP) will collect all overflow from the PLS and intermediate ponds.

The PLS will be pumped from the Mutanga leach pad to the processing plant. The PLS will be further processed to produce a loaded resin product that will be transported to the Mutanga process plant. The PLS will be fed into the continuous ion exchange carousel where absorption, elution, washing and conditioning occurs. Barren liquor will be stored in the process water pond. The concentrated eluant is fed to the concentrator and precipitated using sodium diuranate crystals and sodium hydroxide solution. The solution is thickened and washed through the polishing filters and uranium is recovered from an in-situ leach using sulphuric acid (H_2SO_4). Sodium hydroxide and diluted hydrogen peroxide are added and Uranium Oxide precipitation occurs. An off-white oxide is thickened and washed in a 2-stage decanter centrifuge.

The Oxide is dried using a partial vacuum and de-lumped, sampled and drummed in 200L/500kg drums for storage on the mine site prior to sale. A Process Plant will be constructed approximately 400m southeast of the Mutanga open pit.

Other Infrastructure

The Mine Offices, Workshops and Stores will also be constructed here and will cover a surface area of approximately 7.5ha. A Raw Water Tank will be constructed at the Process Plant with a storage capacity of 150m^3 and will store water for all mine operations. A Process Water Pond will be used for all process or contaminated water. Fuel storage and pumping Facilities will also be constructed within the vicinity Mutanga Process Plant facilities.

An Operations Camp (13.5ha) will be constructed 4km southwest of the Mutanga open pit. The camp will provide accomodation for up to 454 people including all employees on roster at any time.

The Zyiba Meenda route will provide the main access route to the Mutanga Project. The road is approximately 36km long and is accessed from Lusitu Village, approximately 50km north of Siavonga Town. The Zyiba Meenda road will be sealed and routed around the existing villages. The road will be approximately 36km long.

A 65km long 66kV powerline will also be constructed from the main supply grid at Chirundu to Mutanga. Construction of the Zyiba Meenda road and the construction of the Powerline will be the subject of a further Environmental Impact Study (EIS) along the designated routes.

Accessibility in the Mutanga area has been restricted due to the presence of landmines left from the rebel insurgents from Zimbabwe who conducted operations from the Hyiba Meenda area in the 1960s. There are still Unexploded Ordinances (UXOs) in the region some of which the Zambia Mine Action Centre (ZMAC) have scouted and cleared of in LPL 237. The demining process is ongoing.

Project Schedule

The forecast lifespan of the mining activities in the Mutanga Project is 10 years. Regional exploration activities may further the Project lifespan. The Project is anticipated to have a total duration of at least 15 years including relocation, construction, decommissioning and closure phases. A relocation program of the local communities described in a Resettlement Action Plan (RAP) will be one of the first activities to be implemented at an initial stage of the project.

Upon approval of the Project by the relevant Zambian authorities, final design work will commence within the course of 2010. The construction phase of the Mutanga Project will start in mid 2010, for approximately 18 months, with the development of the powerline and the Zyiba Meenda access road. The process plant will be commissioned at the end of 2011 and the project is anticipated to have a mine life of 10 years. Closure and post closure activities will commence after 2022 dependant on the identification of further project resources.

Overview of the Environment

Topography and Landscape

The Southern Province lies predominantly between 1,219m (in the escarpment) and 473m (Lake Kariba) masl. The Mutanga Project lies south of the Zambezi escarpment and is situated in the Zambezi Valley at an altitude of aproximately 598m above sea level (masl). The general topography of the Mutanga region is drained by the Lusitu River with several smaller seasonal streams. The Machinga River flows across the North Road into the Lusitu River. The Nahunwe drains, south of the project area, the Dibwe area into Lake Kariba.

The local topography is dominated by hills and valleys. There are many seasonal runoff gullies that develop during every rainy season as well as enlargement of existing gullies. The Mutanga orebody is located on the edge of a hilly outcrop at 579masl. The Dibwe orebody is located 10km southwest of the Mutanga open pit at elevations of 610 to 625masl.

The permit is fairly vegetated and covered with Mopane or Miombo woodland types. The vegetation consists of thick woodland or thinner woodland stands with bare rocks or soils. A large amount of bare rock occurs on the hilly outcrops or hill faces. Cultivation activities are undertaken by the villagers for food supply by growing rain-fed crops such as maize, millet, and sorghum. The fields generally range in size from 0.5ha to 3ha but can be up to 11ha. Settlements are a small percentage of the landuse.

Animal husbandry activities such as grazing goats and cattle are practiced in the surrounding villages. Fertile wet land adjacent to watercourses is generally cultivated to produce vegetables or fruit. These areas are generally abandoned later in the dry season when the soils dry out. Forestry timber cutting activities are not evident in the exploration license. There was very little charcoal activity and many households collected firewood for fuel. Exploration activities are the only major form of industrial land use in Mutanga.

Climate

The project area experiences a tropical climate with hot, dry weather with mostly clear skies and little precipitation. The region has a distinct dry season (April to October) and hot summers bringing rainfall (November to March). Average annual rainfall at Lusitu Meteorological Station (31km east-north-east of Mutanga) is 529mm.

The temperatures generally range from 14ºC to 38ºC. The lowest minimum and highest maximum temperatures recorded were 12.4ºC (1994) and 40ºC (1996) respectively. Mean annual evaporation is 2009mm. The mean annual wind speed is 5 knots with regular daily highs of 10 knots.

Maximum wind gusts recorded at Lusaka Meteorological Station range from 30 to 57 knots (1967-2000) but there is no data for Lusitu. Thunderstorms in the region during the rainy season are common. The derived maximum 24hr rainfall for 30-year and 100-year return periods are 135mm and 200mm respectively.

Local Hazards

The Mutanga Project lies in a low seismic hazard zone where there is a 10% probability that a peak ground acceleration of 0.4-08.m/s^2 will occur every 50 years.

Geology

The Karoo Supergroup (Late carboniferous to Jurassic) rocks occupy the rift trough of the Zambezi Valley. The Lower Karoo Group comprises a basal conglomerate, tillite and sandstone overlain unconformably by conglomerate, coal, sandstone, carbonaceous siltstones and mudstones (the Gwembe Formation) and finally, fine grained lacustrine sediments of the MMF. The Upper Karoo sediments unconformably overlay the Lower Karoo and comprise a series of arenaceous continental sediments overlain by mudstones capped by basalt. Within the tenement area the Karoo sediments lie in a northeast trending rift valley with large fault-bounded valleys filled with Permian, Triassic and possibly Cretaceous sediments of the Karoo Supergroup.

The sediments have a shallow dip and are displaced by a series of normal faults, which in general, trend parallel to the axis of the valley. The uranium mineralisation identified to date appears to be restricted to the Upper Karoo EGF. The Escarpment Grit Formation (EGF) comprises at least 120m of sandstone and conglomerates with occasional mudstones and silts. The EGF overlies the MMF which comprises a grey to dark grey silty mudstone, with a dark red haematised layer representing either oxidising groundwater or a sub-aerial surface. The contact between MMF and overlying EGF is 2-3m above the dark red hematised layer. Uraniferous mineralisation at Dibwe is hosted by un-faulted meandering facies units of EGF.

Soils

Soil samples were collected and identified using the United States Department of Agriculture, Soil Taxonomy system (USDA ST). The results indicated that the soils are loamy sand and sand soils and are derived from the sandstones and conglomerates that overlie the mudstone basement complex and are comprised of loamy sand and sands. The soils have low levels of clay ranging from 3% to 7%. The clay type was identified to be predominantly kaolinite clay. Total sand in the samples ranges from 87% to 96%. The soils are freely drained with moisture content ranging from 6.6% to 12.2% and total porosities from 41% to 52.5%. Total metal analysis on the collected soil samples indicated that the naturally abundant elements aluminium, calcium, iron and magnesium are all present in the soils. Higher levels of iron, magnesium and manganese occur in some areas around the site. There are very low occurrences of arsenic, lead, mercury, nickel, selenium, vanadium and zinc (>10ppm) at all sites. Mutanga orebody had uranium concentrations up to 487ppm. The average uranium concentrations in soil in other areas of the site ranged from 1.5 to 2.3ppm respectively.

Fauna and Flora

A flora survey was conducted in November 2006 through ground surveying methods. There was dry Miombo woodland identified in the project area occurring in a mixed form with Afzelia (Pod mahogany), Burkea (Wild seringa), Julbernardia glogiflora (Munondo) and Pterocarpus (Wild teak). species in the upper canopy and *Bauhinia petersiana* (Coffee bauhinia), *Diplorynchus condylocarpon* (Horn-pod tree), *Lonchocarpus capassa* (Apple leaf) and *Pseudolacnostylis maprouneifolia* (Kudu-berry) in the lower canopy. Mopane woodland is the dominant woodland form with *Colophospermum mopane* (Mopane) as the main tree species. Associative species include *Adansonia digitata* (Baobab), *Dalbergia nyassae* (Mane-pod), *Kirkia acuminata* (White Seringa), *Terminalia prunoides* (Purple-pod Cluster-leaf) and *Xerroderis stuhlmannii* (Wing bean).

The Acacia thickets are very common and are interspersed between the Miombo and Mopane woodlands. There are bushgrounds on the termitaria and these are scattered within the woodlands. There are large areas of grassland with various grasses that are burnt during seasonal clearance activities. An assessment of Uranium bioavailability in the vegetation indicated that of the four sites that were sampled the *Diplorynchus condylocarpon* (Horn-pod tree) contained higher levels of uranium in two sites. The highest uranium concentration was found the *Burkea africana* (Wild seringa) (4.11mg/kg).

A terrestrial fauna study was conducted in March 2009 through a detailed literature review, a field survey, walking transects, trapping, scouting in vehicles and interviews with the local populations. Historically the project area was inhabited by high numbers of larger mammals such as elephants, lions, wild dogs, jackals and baboons as part of the Middle Zambezi ecosystem. The Project area is located approximately 20km west of the Matulanganga Important Bird Area along the Lusitu-Siavonga Road. Evidence was found during the field survey to indicate that mammals such as bushbuck, Klipspringer, duiker, bush pigs, aardvarks, jackal, hares, baboon, vervet monkeys and greater kudu are present in the Project area. These mammals are of least concern on the IUCN Red List.

Elephants are rarely seen but are active in the area. There were no bats witnessed in the Project area. Snakes and lizards were seen on a rare basis during the site survey. A wide variety of bird species were witnessed during the survey. Paleoarctic migratory birds have been identified in the Mutulanganga Local Forest. Twenty eight (28) different species of butterflies were observed in the Project area. The most frequently observed species of butterflies was the Eurema species with others witnessed including the Colotis and Belenois species.

Noise

A noise survey was conducted and day time and night time measurements were recorded. Generally for all of the measured sites the daytime peak sound levels are higher than the nightime levels, mainly because of influence from settlements, winds, birds etc. The environmental noise levels measured on the C weighted frequency ranged from 45dBC to 113dBC. Audible noise of the A weighted frequency are expected to be lower. At the time of the noise survey the sound levels near Chilundu and Kapita Village were high.

Radiation

A radiation survey using a handheld an Exploranium GR135 handheld spectrometer was conducted around the project area. The results indicated that terrestrial radiation levels are highest at Mutanga, ranging from 182Cps to 420Cps. Some locations that were sampled had extremely high levels of radiation such as M43, with 8,129Cps, which was attributed to high levels of potassium with mineralised uranium rocks. The majority of the sites have an annual dose rate of less than 1mSv/yr from terrestrial radiation, except for M22 and M43.

Air Quality

A program of monthly monitoring of Sulphur Dioxide (SO_2) and Nitrogen Dioxide (NO_2) was initiated on the Project site in April 2009. A program for monitoring environmental radon levels around the Project site was started in November 2008. Field observations indicate that the general air quality in the area is good. Grassland and small bush fires and traditional slash and burn agriculture during the dry season generates smoke and dust which creates a distinctive haze. The haze lasts until the arrival of the rains in November.

Localised and temporal air quality deterioration is also associated with village domestic fires. Field observations indicate that few vehicles travel along the Mutanga road through the license area and therefore exhaust emissions are localised and disperse rapidly. Dust levels increase around exposed surfaces and roads. The high potential for soil erosion in the southern region of Zambia indicates that exposure to wind and surface runoff may be significant to soil quality in the area.

Archaeological

An archaeological study was conducted in October 2006 to identify the presence of any archaeological or cultural sites or artefacts in the project area. A desk study into historical archaeological studies of the Siavonga District revealed that some known archaeological and palaeontological sites in the area include Ing'ombe Ilede and the Chirundu Fossil Forest. The records did not indicate the existence of any heritage resources in the project area and so this study may be the first. Systematic transects on the site of the project area revealed no existence of archaeological sites.

The discovery of no single artefact or site particularly within Dibwe and Mutanga open pit areas led to the inclusion of supplementary surveying of the exploration pits on Dibwe and Mutanga which did not lead to any additional discoveries. There were no signs that iron works were conducted in the project area. No potshards or grinding stones were found during the survey. Two sacred cultural sites were identified called Hapepe and Malende which are located 3km north of Matuba Community School and 5-6km north past Changa Village on the Machinga Stream. These sites are used for worship during the suspected occurrence of droughts and are not affected by the project activities.

Hydrology, Ground and Surface Water Quality

The Mutanga and Dibwe prospects are located on hills incised by seasonal stream channels. The highly permeable nature of the soils and underlying sandstones dictate the low availability of surface water during the dry season. Drainage from the Mutanga open pit and process plant facilities will drain northeasterly into the Lusitu River via the Machinga Stream (MUT/SW/01). Drainage from the Mutanga raw water pond flows easterly into tributaries of the Lusitu River. Drainage from the Dibwe area (open pit, waste rock dumps, leach pads and RWP), including the operations camp will flow in a southwesterly direction towards the Namatelo and Nahunwe Rivers. The Nahunwe River drains into Lake Kariba, approximately 20km south of the project area. Sampling was conducted on the Machinga, Namatelo and Nahunwe Rivers. Two handpumps were monitored to determine drinking water quality for the local communities.

The surface water and groundwater samples displayed compliant results for the physico-chemical parameters when compared to the WHO guidelines 2006. In the groundwater samples, arsenic, aluminium, manganese, total chromium and selenium exceeded their WHO guidelines of 0.01mg/l, 0.2mg/l, 0.4mg/l, 0.05mg/l and 0.01mg/l respectively. The surface water samples exceeded the sampled parameters of arsenic, aluminium, manganese, total chromium, selenium and barium. Selenium exceeded the WHO guideline at MUT/SW/01 in January 2009. The radiological analysis results were compared to the WHO guidelines for radionuclides (radium, uranium, thorium) in drinking water and all of the measured values were compliant with the guideline limits. Gross alpha measurements exceeded the recommended WHO limits below which no remedial methods are required for drinking water in the two groundwater samples during the November and January.

Hydrogeological

The hydrogeological baseline study was conducted by Knight Piésold between July and October 2008. A total of 36 hydrogeological boreholes were developed and 22 were used for aquifer testing. The drilled boreholes had depths ranging from 60m to 100m. The aquifer host rock is the Karoo Supergroup and covers 11% of the Southern province. The majority of the aquifers are fractured and faulted hard-rock systems which is evident in the Mutanga area. The sandstones and conglomerates of the Escarpment Grit Formation in the Mutanga deposit area provide an aquifer type different to the interbedded sandstones and mudstones of the Dibwe deposit area. The aquifers are described as heterogeneous and semi-confined exhibiting dual-porosity with both structural and matrix porosity contributing to overall yield and storativity.

Groundwater quality was monitored from eight boreholes and the results showed generally good water quality with all parameters except for iron and manganese well within WHO guidelines. DIBHP-02 was an exception to this with elevated levels of all parameters but with further testing the causes may be identified. All of the boreholes tested for uranium 238 were within the WHO guidelines of 0.015mg/l. A hydrocensus was conducted in Mutanga with more than 70 boreholes sampled for water levels. The groundwater level is highly variable and the average static water level is 19.94 meters below ground level with a minimum of 2.5m below ground level. Step-up and constant discharge tests were conducted on selected boreholes. The water strikes were at varying depths with an average blow-yield of 3.6l/sec for the entire area. Average hydraulic conductivity (K) values for Mutanga and Dibwe were calculated at 0.63m/day and 0.31m/day respectively. Average storativity values were calculated at 4.24E-02 and 1.05E-02 respectively. Average sustainable yield was calculated at 4.51L/s and 2.67L/s respectively assuming no recharge. These sustainable yield values increase to 6.93l/sec and 3.54l/sec respectively with a recharge of 3.2% of the mean annual precipitation of 529 mm.

Socio – economics and Administration

The capital investment for the Mutanga Project is estimated to be US$118million. The annual operating costs of the mine will be approximately US$38million. The Project will employ approximately 384 people, with the majority being Zambians, where skills are available. A detailed training program will be implemented to phase out specialist trainers over the first 4 years of operations. DMZL will employ Contractors to facilitate Mining, Catering and Cleaning activities, with an emphasis on the employment of Local Contractors.

Siavonga District Council is the local authority in the project area and the highest decision making body at the district level. . The District Commissioner (DC) leads the district administration through the Office of the District Commissioner. All agencies of development operating in the district are members of the District Development Coordinating Committee (DDCC) that is chaired by the DC. Other governmental departments in the area consist of the Siavonga District department of the Office of the President, the District Environment Management Committee, the District Aids Committee, District Health Department and representative offices of government departments from the surrounding districts. The Mutanga Project is located within Chief Sinadambwe's Chiefdom. Traditional leadership in the Mutanga area is governed by village Headmen.

The population in the area is involved in peasant agriculture, with maize, sorghum, millet and cotton constituting the major crops. Livestock consists of cattle, goats, chickens, pigs and ducks. Non-farm income activities include employment by DMZL, beer brewing and grocery sales from small shops. The main ethnic group is Tonga and the main religion is Christianity. Traditional animist beliefs are very strong.

Primary educational facilities in the Mutanga and Dibwe are the Matuba Community School, Dambilo Community School, Manchama Inland Middle Basic School and Dibwe Community school. There are no secondary school facilities. The only health services in the area are provided by the Manchama and Dibwe Rural Health Centres.

There is no electricity to these facilities and medical supplies are scarce. Sanitation is crudely managed through pit latrines by some households. Water supply is generally from rivers or installed handpumps in Chiyobeka and Kapita Villages. Households rely on wood for heating and cooking. Candles and kerosene lamps provide lighting. Accessibility in the Mutanga and Dibwe areas is resticted especially during the rainy season. The communities rely on bicycles or carts for transport. Telecommunications have recently been provided to the Mutanga area by Zain.

The proposed project facilities affects the populations of Chiyobeka, Kasambo, Chilundu, Kapita, Sinangosi and Kumulilansolo Villages. These villages will require relocation and compensation and have been the subject of a detailed Resettlement Action Plan (RAP). Details in the RAP Report.

Projects Biophysical and Socio-economic Impacts

The main **positive biophysical impacts** of the Project are:-

- DMZL will work with local NGOs and government departments on sustainable projects to promote the regeneration of fauna and flora in the project area; and
- The protection of sensitive areas in and around the Project area that may provide conservation areas for existing fauna and flora .

The main **negative biophysical impacts** of the Project are:-

- Land clearance of vegetation leading to a loss of habitat and soil cover. DMZL will only conduct clearance where necessary and will implement a revegetation program as part of its environmental management plans;
- Degradation of the air quality in the region through increased development and activity generating dust. The impacts to air will be monitored through DMZL's Environmental Monitoring Plan and will be minimised through initial design mechanisms;
- Degradation of the surface water resources in the area through accidental spillages from the Project e.g. process plant, contaminated water storage areas, contaminated runoff. These impacts will be managed through the design of infrastructure and the implementation of DMZL's Mine Water Management Plan;
- Degradation of the groundwater sources through accidental spills and releases from the mine. These impacts will be managed through DMZL's Mine Water Management Plan;
- Generation of storage facilities containing radiation-emitting material (waste rock dumps) and which may be acidic (leach pad residue) that may lead to long term contamination of soils, water and air. These will all be managed in accordance with DMZL's Radiation Management Plan. The leach pads will be lined during construction and capped and re-vegetated during closure. The waste rock dumps will be capped with impermeable material and re-vegetated during closure activities;
- Regional lowering of the groundwater table based on the dewatering of the open pits for safe mining may lead to loss of groundwater resources used by the local communities. The majority of users in the area will be relocated to Kashundi Village where they will be provided with water supplies. Other user points in the area will be monitored by DMZL;
- Increased noise in the Project area through all phases of the mine which may disturb the local communities or fauna. The local communities will all be located at least 2km from the project area or 6km away in Kashundi Village;
- Accidental release of radioactive materials into soils, surface water, groundwater or air that may produce ionising radiation that may be harmful to health e.g. dust, water, transport spills. These impacts will be managed through the implementation of the Radiation Management Plan;
- Degradation in air quality in the Project area through the exposure of ore and waste materials that will emit radiation and radon gas into the surrounding air. This impact will be monitored and managed through the Radiation Management Plan.

The main **positive social impacts** of the Project are:-

- The improvement of accessibility through the upgrading of the infrastructure e.g. Zyiba Meenda road, in the project area;
- The improvement of general understanding of uranium mining amongst employees, the local community and the public through the development of educational programs;
- The improvement of the standards of living of the local communities affected by relocation, through the development of Kashundi as described in the RAP;
- The improvement of educational facilities in conjunction with the Ministry of Education based on the development of a school in Kashundi Village;
- The improvement of health facilities in conjunction with the Ministry of Health based on the development of a clinic in Kashundi Village;
- The provision of jobs for 384 people, with the preferential employment of Zambian people wherever possible and the provision of employment training to phase out specialist trainers;
- Expansion of the economy in the Siavonga District which will encourage further service provision from Siavonga and the Southern Province;

- Expand and diversify the national mining industrial sector away from the reliance on individual metals and the Copperbelt; and
- Contribute to national development through the remittance of taxes to the Zambian government.

The main **negative social impacts** of the Project are:-

- The relocation of 342 people from 107 households and the compensation of 62 field owners. Many of the households are anxious about the relocation and compensation activities that will be conducted by DMZL. These activities will be managed through the RAP;
- The public expectations of the Project are high due to the location of the Project in a remote and poorly serviced area. A Sustainable Development Plan will be developed to assist with and identify development projects for the local communities;
- The communities and the general public are concerned about the activities of the uranium industry and may be ill informed;
- The development of surface storage facilities to contain radioactive residues from the processing of the uranium ore. These will be covered and revegetated as described in the Project management plans to reduce health and safety impacts to the environment and the public;
- The influx of people into the area for jobs and other service provision to the Project will impact on the capacity of the services in the local area. This will be identified and managed through the Project management plans;
- The influx of people into the region may create security tensions for private and public properties. This will be monitored through the community liaison and consultation programs developed by the social department;
- The influx of people and increased local movements may lead to an increase in communicable diseases e.g. HIV/Aids, Tuberculosis. This will be monitored through the social departments activities.

Projects Management Plans

The management system has been designed as a series of plans that will be implemented through a Mine Management System. The plans will be reviewed on an annual basis as part of internal review and monitoring activities. The plans include:-

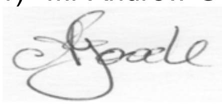
- Resettlement Action Plan;
- Occupational Health and Safety Plan;
- Environmental Monitoring Plan;
- Radiation Management Plan;
- Water Management Plan;
- Handling and Storage Plan;
- Waste Managment Plan;
- Emergency Response Plan;
- Conservation and Vegetation Plan;
- Preliminary Progressive Revegation and Rehabilitation Plan; and
- Sustainable Development Plan.

A Mine Decommissioning and Closure Plan was developed for the Mutanga Project with a Preliminary Mine Rehabilitation and Closure Plan. An assessment of the Mine Closure Costs were conducted for the Project at the time of the EIS. The estimated mine closure costs are **US$11,133,100**.

EIS Experts Team

Details and Signatures of Persons Involved in the Compilation of the Environmental Impact Statement for the Mutanga Project.:-

1) Mr Andrew Goode

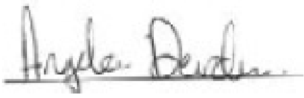


____________________________ Project Director - Africa, Denison Mines

2) Mr Martin Broome

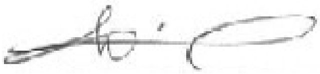
____________________________ Principal Consultant, AMC

3) Miss Angela Duerden



____________________________ Lead Consultant, AMC;

4) Mr Geoffrey Siame

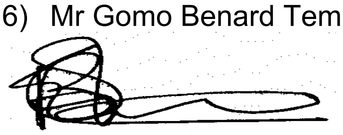


____________________________ Consultant, AMC;

5) Mr Joshua Kambafwile

____________________________ Consultant, AMC;

6) Mr Gomo Benard Tembo



____________________________ Consultant, AMC;

7) Mr Mitulo Silengo

____________________________ Associate Cohort 9
Leadership for Environment and Development (LEAD) Southern Africa/AMC;

8) Mr Lishomwa Mulongwe

____________________________ Principle Research Officer, Division of Forest Research;

9) Mr Keddy Mudingo

____________________________ BSc. Forestry, Division of Forest Research;

10) Mr Felix Chileshe

____________________________ CGLI 735 Analytical Chemistry and Laboratory Management, Division of Forest Research;

11) Mr Jassiel M'soka

____________________________ Zambian Wildlife Authority, Chirundu;

12) Mr Edward Chilufya

____________________________ Zambian Wildlife Authority, Kafue;

13) Mr Daniel Mwizabi

____________________________ Zambian Wildlife Authority, Lusaka; and

14) Mr Collins Chipote

____________________________ Heritage Management and Conservation, National Heritage Conservation Commission.

1. INTRODUCTION

1.1. Background

This report comprises the Environmental Impact Study (EIS) and Environmental Management Plan (EMP) prepared for Denison Mines Zambia Limited's (thereinafter called "DMZL") Mutanga Project in the Siavonga District in the Southern Province of Zambia. This report has been compiled by African Mining Consultants Limited (AMC) based on work carried out between January 2007 and March 2009.

The EIS and EMP form part of a Feasibility Study (FS) conducted during the period January 2008 to March 2009. The reports are a requirement by the regulatory authorities in Zambia in order to apply for a Mining License. They may also be used for Project Financing purposes.

The current exploration license LPL 237 covers an area of 946.3km^2 in the Southern Province of Zambia. Exploration activities focussed on uranium mineralisation were initiated in the area in April 2005 when OmegaCorp Limited (OL) acquired PLLS 237 from Okorusu Fluorspar Pty Limited (Okorusu) through the development of a Memorandum of Understanding (MOU). The MOU stipulated that OL would earn a 70% interest in the Mutanga Project in Kariba, Southern Zambia, by spending US$1 million over the four year period from 2005.

In 2006, OL gained 100% ownership of PLLS 237 from Okorusu. OL, an ASX listed company, was acquired by Denison Mines Corp (DMC), a joint TSX and AMEX listed company, in September 2007. The lease is currently held by Denison Mines Zambia Limited (DMZL).

Exploration activities were carried out by OL from 2005 into early 2007 through a program of Reverse Circulation (RC) drilling, diamond drilling, pitting and trenching. Between January and July 2007 negotiations were entered into between OmegaCorp and Denison for the development of a joint venture agreement. The positive outcome of these negotiations has meant that Denison now owns 100% of OmegaCorp. DMZL conducted an extensive second phase of drilling between October 2007 and November 2008

1.2. The Project Developer

Denison Mines Zambia Limited (DMZL) is a Zambian company, wholly owned subsidiary of Denison Mines Corp., a public Company listed on the Candian TSX and USA AMEX..

Denison Mines Corp. was formed through the combination of Denison Mines Inc. and International Uranium Corporation on the 1st of December, 2006. Denison is a mid-sized, diversified Uranium producer and exploration Company and has assets in Canada, the United States (U.S.), Mongolia and Zambia. The Company is listed on the Toronto Stock Exchange ("DML") and the American Stock Exchange ("DNN").

Denison has interests in two licensed and operating Uranium Mills in North America, with 100% ownership of the White Mesa mill in Utah and 22.5% ownership of the McClean Lake mill in Saskatchewan. The Company also has interests in the Tony M mine in Utah, which started production in 2007, and has JV interests with AREVA Resources Canada and OURD on the Midwest project. This project will be commissioned in 2011 with an anticipated annual production of 2 million pounds of uranium (U_3O_8) concentrate.

Denison is an active Uranium exploration Company with a global portfolio of world-class exploration projects, with properties in close proximity to the Company's mills in the Athabasca Basin in Saskatchewan and other areas in the Colorado Plateau, Henry Mountain and Arizona Strip regions of southwestern U.S. Denison has high potential exploration projects in Mongolia and indirect investment in projects in Australia. Through its ownership of OmegaCorp Limited in Australia, Denison is exploring for Uranium on the Mutanga Project in Zambia. Resource estimates have also been completed for Hairhan in Mongolia, McClean North and Elliot Lake in Canada and the Arizona Strip in the U.S.

Denison is part of the Lundin Group of Companies, which is an internationally accepted group of sixteen publicly traded natural resource companies. The members operate in over 30 countries and are engaged in development, production and exploration activities for oil, gas, gold, copper, cobalt, zinc, lead, silver, uranium, vanadium, diamonds, phosphate, iodine, sulphate and nitrate.

Denison is the manager of Uranium Participation Corporation, which is a publicly traded company that invests in Uranium Oxides (concentrates) and uranium hexafluoride. Denison Environmental Services (DES) is a division of Denison Mines Corp. that is involved in mine decommissioning and environmental services (**Source: www.denisonmines.com**).

1.3. Project Justification

The global demand for energy is increasing due to the rapid world-wide economic growth over the past 20 years. This increased demand is leading to the expansion of alternative energy sources, one of which is Nuclear Power.

Uranium is the principal natural element used in the production of Nuclear Energy. The isotope Uranium 235 (^{235}U) is the unstable isotope (radioisotope) that provides radioactive energy. However, only 0.7% of all natural Uranium is found as Uranium 235 (^{235}U). Uranium 238 (^{238}U) comprises the majority of the remaining Uranium. Hence, to acheive the desired ^{235}U, the process called enrichment is used.

Radioisotopes emit radiation in three forms:-

- Alpha radiation;
- Beta radiation; and
- Gamma radiation.

This radiation can be used in several ways to benefit the modern world. As shown above Nuclear power is the most well known beneficial use of Uranium. Other uses of radioisotopes include (Source: **Uranium Information Centre, 2007**):-

- **Radioactive tracers** – Tracers are used in fertilisers to determine plant uptake efficiencies, hydrological techniques (identification of aquifers, water sources, groundwater flow patterns and detect pollutants), monitor plume formation (contaminated sites, air stacks and pipes) and locating leaks;
- **Genetic variability** – Ionizing radiation can be used to induce mutations in plant species to increase food production;
- **Sterile Insect Technique (SIT)** – Gamma radiation is used in pest control to sterilise males;

- **Food preservation** – Gamma radiation is used to irradiate food after harvesting to kill germs, insects and pests. This increases the lifespan of the food and reduces spoilage;
- **Medical diagnoses** – Gamma radiation and imaging devices are used to supply a small radiation dose to diagnose bone or tissue damage (X-ray machines). Radio-immuno assays are used to conduct bio-chemical analyses for hormones, drugs, hepatitis virus etc.
- **Medical therapy** – Radioisotopes can be used to damage cancerous growths through external or internal exposure (radiation therapy);
- **Medical sterilization** – Medical products, equipment and preparations of bone, nerves and/or tissue for surgery may be sterilized using gamma radiation;
- **Smoke detectors** – Alpha particles ionise the air between two electrodes on the detector and allows a current between them. When a fire occurs smoke particles affect this current and set-off the alarm;
- **Instruments** – Radioisotopes are used in thickness gauges and density gauges;
- **Power sources** – Radioisotopes can be used as power sources in pace makers, beacons, submarinbes and satellites; and
- **Dating** – Radioactive isotopes are used in dating of material for geologists, anthropologists and archaeologists.

The attractive global Uraniun market prices between 2005 and 2008 led to increased exploration activities to develop mineable resources. The justifications for this development include the following:-

- The new development is located in a region where the only other major economic activities are fishing and small scale farming. The project will provide valuable job opportunities for the local communities and encourage regional economic development;

- The development of the mine will induce economic expansion for service providers in Siavonga and may lead to an expansion of the tourism potential in Siavonga;

- The diversification of the mining industry into metals other than copper leads to economic benefits and reduced industrial insecurities. This will strengthen and increase the security of the Zambian economy;

- The new project will benefit local communities through the development of health and educational programs. Water and electricity supplies may be provided during service supply to the project site.

1.4. Denison Mines Zambia Limited Environmental, Health and Safety Policy

DMZL is commited to responsible environmental, health and safety management in all of its activities, including exploration, construction, operation, decommissioning and post-closure project phases. DMZL's Environment, Health and Safety Policy is included in **Appendix 1**.

DMZL will:-

- Comply with applicable national and international environmental laws and regulations;

- Liaise with the appropriate Government authorities and, in particular, the local communities;

- Assess the environmental, socio-economic, health and safety impacts prior to the implementation of any new development;

- Seek environmental, health and safety approvals prior to implementation of any new developments

- Apply appropriate environmental, socio-economic, health and safety standards in all operations;

- Employ adequate skilled, experienced personnel to staff a Radiation Safety Department on the mine;

- Develop appropriate environmental, socio-economic, health and safety management plans for all operations;

- Regularly evaluate all the operational, environmental, social, health and saftey risks of ongoing activities;

- Ensure that all employees and contractors are aware of and abide by applicable environmental regulations;

- Develop the following plans and programs:-
  - "Employee Training Program" focusing on health, safety, education and environmental awareness;
  - "Environment, Health and Safety Education Program" for all persons living in the area adjacent to the Mutanga Project or working for DMZL;
  - "Accidental Release of Radioactive Substances Management Program" incorporating mine employees, the public and government authorities;
  - "Selection, Use and Maintenance of Personal Protective Equipment" plan for protective equipment for employees;
  - "Radiation Safety Worker Training Program";
  - "Storage and Transportation of Radioactive Material" Plan;
  - "Radiation Operation Management Protection Plan";
  - "Waste Management Plan";
  - "Quantitative Radiological Hazard and Safety Assessment"; and
  - "Mine Water Management Plan".

1.5. Denison Mines Zambia Limited Company Policies

DMZL has developed, and will continue to develop, company policies with respect to Zambian and international standards that it will implement throughout Project activities. One of these policies is listed in **Appendix 1**.

1.6. The Consulting Firm

African Mining Consultants (AMC) is a mining, geotechnical and environmental engineering firm based on the Zambian Copperbelt. The Company is affiliated to Golder Associates, a major consulting company to the mining industry with more than 150 offices worldwide.

Since 1994, AMC has conducted environmental scoping studies, environmental impact assessments, environmental management plans and environmental audits in Zambia and the Democratic Republic of Congo (DRC) for Anglo American Corporation, Anglovaal Mining, First Quantum Minerals, Equinox Resources Limited, Anvil Mining Congo sprl, Metorex, Sable Zinc Kabwe and the former Zambia Consolidated Copper Mines Limited. The World Bank and the International Finance Corporation (IFC) have funded some of these projects.

1.7. Layout of the EIS

This EIS has been prepared as part of the Project's FS in compliance with applicable local and international environmental laws and guidelines.

The objective of the EIS is to provide the:-

a. Baseline information of the biophysical and social environment of the Mutanga Project area;

b. Conduct an assessment of the biophysical and social impacts that will occur during the implementation and operation of the project; and

c. Describe the environmental, social, health and safety management actions that DMZL will implement during the construction, operation, closure and post closure phases of the Project;

The structure of the EIS is as follows:-

i. Executive Summary;
ii. Introduction of the Project and the Developer (Chapter 1);
iii. Institutional, Legislative and Legal Framework (Chapter 2);
iv. Project Description (Chapter 3);
v. Project Alternatives (Chapter 4);
vi. Environmental Baseline Study (Chapter 5);
vii. Socio-Economic and Cultural Baseline Study (Chapter 6);
viii. Environmental and Social Impacts (Chapter 7);
ix. Impact Mitigation (Chapter 8);
x. Environmental and Social Management Plans (Chapter 9)
xi. Mine Rehabilitation and Closure Plan (Chapter 10); and
xii. Mine Closure Costs (Sections 11).

2. INSTITUTIONAL, LEGISLATIVE AND LEGAL FRAMEWORK

The Legal Institutions responsible for the management of mining, environmental and radioactive activities in Zambia have been described below. The legislation applicable to the Mutanga Project has also been identified.

The EIS has been conducted with reference to the applicable legislation of the Republic of Zambia, the International Atomic Energy Agency (IAEA) and other relevant international institutions.

2.1. Institutional Framework

The Zambian Ministry of Mines and Minerals Development (MMMD) is responsible for the management of artisanal, exploration and mining activities through the Department of Mines, Geological Survey Department and Department of Mines Safety. In 2008, the Mines and Minerals Development Act, 2008 was developed and passed by Parliament to repeal the Mines and Minerals Act of 1995.

All administrative activities are now coordinated through Cadastre Offices throughout Zambia, with the Central Mining Cadastre Office located in Lusaka, Zambia. The Mining Advisory Committee (MAC), under section 150 of the 2008 Mines and Minerals Development Act, provides consultation and advice to all of the Ministry of Mines Departments in all aspects governed by the implementation of the Act. The ultimate decision for licensing lies with the Directors in the Ministry of Mines.

The National Conservation Strategy (NCS) was adopted by the Zambian Government in 1985 and is the forerunner to environmental legislation in Zambia. The NCS provided guidance for the sustainable development of Zambia through the use and conservation of natural resources within a centrally planned and controlled economy. The NCS led to the enactment of the Environmental Protection and Pollution Control Act (EPPCA) in 1990 and provided for the establishment of the Environmental Council of Zambia (ECZ), which became operational in 1991.

The ECZ oversees the activities of all industrial, mining, agricultural and service companies that may have environmental and social impacts in order to minimise and mitigate these impacts. The ECZ requires the development of Environmental Impact Assessments for all new and existing projects. The ECZ is responsible for the collection and dissemination of environmental and social information and for improving environmental awareness of the public. ECZ also issues annual licences with respect to environmental activities e.g. waste managment, effluent discharge, gas releases.

The Radiation Protection Board (RPB) was established through the Ionising Radiation Act, 1972, which was responsible for the responsible management of all potentially harmful sources of radiation through occupational or environmental exposures. In 2005, the Radiation Protection Authority (RPA) was established through the Ionising Radiation Protection Act, 2005. The RPA is a corporate body and is responsible for advising the Government of Zambia on all policy matters related to ionising radiation, implementing all legislative measures related to ionising radiation to protect employees and the public, and for educating the general public on radiation issues. The RPA is also responsible for issuing licenses for processing, storage, transport, import, export and use of radioactive material within specified levels.

2.2. Legislative and Legal Framework

A number of Acts of Parliament and subsidiary Statutory Instruments (SI) related to environmental protection, health and safety, service provision and use are relevant to the Mutanga Project. Below is a description of legislation applicable to the Mutanga Project.

2.2.1. Mines and Minerals Development Act (MMDA) No. 7 of 2008

This Act describes the administration of the mining industry through the Ministry of Mines. The MMDA discusses the Geological Survey Department, the Department of Mines Safety and the Mining Advisory Committee. The MMDA outlines the different mining permits that can be obtained e.g. small and large scale exploration or mine licenses, small or large-scale gemstone licenses, artisanal licenses and the application requirements for each. The MMDA describes mining royalties and taxes as well as the requirements for a mineral processing license.

As part of the development of Mining in Zambia, the following subsidiary Mining legislation was drafted to govern the Exploration, Mining and Milling of Uranium or other radioactive ores:-

- Statutory Instrument No 85 of 2008 The Mines and Minerals Development (Prospecting, Mining and Milling of Uranium Ores and Other Radioactive Mineral Ores) Regulations, 2008 – forms the basis for mining of Uranium and other radioactive mineral ores in Zambia. The legislation stipulates the stringent requirments of an application for an exploration or mining license in order to ensure the protection of the environment and the health and safety of workers and the general public. The legislation also requires information regarding the security and transportation of finished products.

Other Mining subsidiary legislation was developed in the 1990s to ensure that environmental management practices were carried out within the industry for old, existing and new projects as part of the old Mines and Minerals Act (repealed by the MMDA, 2008).

Below are other subsidiary legislation that are relevant to the Mutanga Project:-

- Statutory Instrument No. 29 of 1997 Mines and Minerals (Environmental) Regulations – forms the framework for conducting and reviewing environmental impact assessments for the mining sector. It also provides regulations for auditing project implementation; and

- Statutory Instrument No 102 of 1998 Mines and Minerals Environmental Protection Fund Regulations – provides the mechanism of setting up and operating the Environmental Protection Fund.

2.2.2. Environmental Protection and Pollution Control Act No 12 of 1990

The Environmental Protection and Pollution Control Act (EPPCA) provides for the establishment of the ECZ to enforce the provisions of the Act and the SIs. The Act provides guidance on the development of environmental assessments in the form of Environmental Project Briefs (EPBs) or Environmental Impact Statements (EISs) dependant on the scale or magnitude of project activities or impacts. All environmental assessments are reviewed and a decision made on project implementation. The EPPCA outlines the requirements of license applications under the following subsidiary legislation:-

- Statutory Instruments No. 28 of 1997 Environmental Impact Assessment Regulations – provides the framework for conducting and reviewing environmental impact assessments for any project. Further to that, it provides regulations for auditing project implementation;

- Statutory Instrument No. 71 of 1993 Waste Management (Licensing of Transporters of Wastes and Waste Disposal Sites) Regulations – The act provides for licensing of solid non-hazardous waste transportation and the operation or management of a non-hazardous waste disposal site;

- Statutory Instrument No. 125 of 2001 Hazardous Waste Management Regulations – provides for licensing of solid hazardous waste transportation and operating/owning of a hazardous waste disposal site;

- Statutory Instrument No. 72 of 1993 Water Pollution Control (Effluent and Wastewater) Regulations – The act discusses licensing requirements for the discharge of liquid waste to the environment and supplies statutory discharge limits for respective parameters;

- Statutory Instrument No. 20 of 1994 Pesticides and Toxic Substances Regulations – provides for licensing of importation, transportation, distribution and storage of pesticides and toxic substances; and

- Statutory Instrument No. 141 of 1996 Air Pollution Control (Licensing and Emission Standards) Regulations – provides for licensing of gaseous waste emission to the environment and also provides for statutory discharge limits for respective parameters.

2.2.3. Ionising Radiation Protection Act, 2005

The Ionising Radiation Protection (IRP) Act, 2005 repealed the Ionising Radiation Act, 1972, and establishes the Radiation Protection Authority (RPA). The Act provides for the protection of the public, workers and the environment from hazards generated by the use of devices or proximity to materials that produce ionising radiation.

The roles of the RPA are similar to those of the ECZ, in that it acts to:-

- promote safety, health and the protection of the environment;
- implement the IRP Act and ensure compliance from licensees;
- conduct all licensing of ionising radiation devices, sources or activities;
- conduct audits of facilities and staff monitoring as required during licensing; and
- provide educational material, workshops and programs to improve public awareness and understanding of ionising radiation.

2.2.4. The Zambia Wildlife Act, 1998

This is the principal legislation regulating wildlife resources management in Zambia. The Act establishes The Zambia Wildlife Authority (ZAWA) and defines its functions as follows:-

- It endeavours to provide for the establishment, control and management of National Parks. It also strives for the conservation of and enhancement of wildlife ecosystems, biodiversity, and of objects of aesthetic, pre-historic, historical, geological, archaeological and scientific interest in the National Parks;

- It provides for the promotion of opportunities for the sustainable use of special qualities of National Parks;

- It provides for the establishment, control and management of Game Management Areas (GMAs);

- It provides for the sustainable use of wildlife and the effective management of the wildlife habitat in GMA.

- The Act further seeks to enhance the benefits of GMA both to local communities and wildlife;

- It attempts to involve local communities in the management of GMA and development and implementation of management plans;

- The law regulates game ranching;

- It provides for licensing of hunting and controls over the processing, sale, import and export of wild animals and trophies;

- It provides for the implementation of the Convention on international Trade in endangered Species of Wild Flora and Fauna – CITES;

- It provides for the implementation of international agreements and conventions, and the Lusaka Agreement on Cooperative Enforcement Operations directed at illegal trade in wild fauna and flora.

2.2.5. The Land Act of 1995 and the Land Acqusition Act of 1970

The Land Act of 1995
The Land Act of 1995 was enacted to guarantee peoples' right to land while enhancing development. The Act recognises the holding of land under customary tenure and the Chief's role has been legally recognised, such that land cannot be converted or alienated without approval of the chief.

The Lands Acquisition Act No. 2 of 1970
Land acquisition is governed by the Lands Acquisition Act No. 2 of 1970. The Act sets out regulations for compulsory acquisition of land and property and compensation for such acquisition. The president (his designated and authorized person) may acquire any property in the interest of the Republic. Notice shall be given in person not less than two months in advance and shall be gazetted.

Compensation for acquired property, losses and damages shall be paid as may be agreed or, finally determined by the National Assembly in case agreement on compensation is not reached within six weeks after publication in the Gazette.

Any disputes except for disputes related to the amount of compensation may be instituted for court proceedings. The Act also provides for compensation to be granted by allocation of new land to the property owner.

The Act instituted a Compensation Advisory Board to advise the Minister of Lands in assessment of compensation payable under the Act. The functions of the Board have been delegated to various committees. Various forms to be used in proceedings of property acquisition are prescribed in the statutory Instrument No. 60 of 1970.

2.2.6. Forest Act, CAP 199

The Forest Act, passed in 1974, provides for the establishment and management of National and Local forests, conservation and protection of forests and trees, and licensing and sale of forest products. The Act prohibits the felling, collecting or injuring of forest products in protected forest areas or forest reserves, unless a license has been obtained to do so. It also prohibits excavation, construction, and operation of machinery within the forest reserves or protected areas. Forest reserves currently cover approximately 10% of the country and are intended for the conservation and development of forest resources, as well as providing protection to watersheds. The Act also provides for the protection of 6 tree species nationally whether in a protected area or outside it. These are as follows:

- *Entandrophragma caudatum* Mountain Mahogany;
- *Khaya nyasica* Red Mahogany;
- *Pterocarpus angolensis* African Teak;
- *Afzelia quanzensis* Pod Mahogany;
- *Faurea saligna* Beechwood; and
- *Baikiaea plurijuga* Teak

2.2.7. Other Applicable Zambian Legistion

Other applicable Zambian Legislations include, but are not limited to those indicated in the table below below. Regulations have not yet been developed in Zambia for most of these Acts below listed.

Table 2.1 Other Applicable Zambian Legislation to the Mutanga Project

Institution of Legislation	Act	Description
Energy	**The Energy Regulation Act No. 23 of 2003**	Provides for the establishment of procedures for the transportation, handling and storage of fuels to minimize negative environmental impacts.
	The Petroleum Act, 1995 (No. 8 of 1995);	The areas of the Petroleum Act of relevance to this project are regulations for the conveyance and storage of petroleum, inflammable oil and liquids e. g. paraffin.
	The Rural Electrification Act, 2003 (No. 20 of 2003)	Establish the Rural Electrification Authority and to define its functions, establish the Rural Electrification Fund. DMZL may be interested in working with the Rural Electrification Authority in increasing access of electricity to Mutanga rural population
	The Electricity Act Cap 433	Regulate the generation, transmission, distribution and supply of electricity.
Wildlife and National Heritage	**The National Heritage Conservation Commission Act, 1989 (No 23 of 1989);**	Provides for the Conservation of Ancient, Cultural and Natural Heritage, relics and objects of aesthetic, historical, pre-historical, archaeological or scientific interest. Previous research has demonstrated prehistoric settlement of islands and riverbanks. Thus in case of any occurrence or suspicious of such should be handled in accordance with the mentioned Act.

Institution of Legislation	Act	Description
	Wildlife Act, 1998 (No. 10 of 1991);	Provides for the conservation and management of ecosystems to preserve them from the impacts of modern man. The Act also regulates the type and extent of tourism activities that may be permitted in a National Park or Game Management area setting.
Water	**The Water Act of 1949 (Cap 312)**	Provides for the control, ownership and use of water excluding the water of the Zambezi, Luapula and Luangwa rivers that form borders with other countries. The Act establishes the Water Board and regulates the use of public water including against pollution.
	The Zambezi River Authority Act of 1987	Provides for the interstate agreement between Zambia and Zimbabwe relating to the utilization of the Zambezi River. The Zambezi River Authority has now in place a committee which monitors pollution of the river from its source (Kaleni hills) to Kanyemba as it enters Mozambique.
Health	**The Pneumoconiosis Act (No. 13 of 1994);**	Provides for the requirement for Certificates of Fitness for all mine employees that work in restricted mine areas – working places where free silica in the respirable dust with particle size less than 5 microns is harmful tohumans if inhaled over a period of time.
	The Public Health Act Cap. 295	Provides for the prevention of diseases, drainage, latrine and disposal of sewerage and treatment systems.
Employment	**The Employment Cap 268**	Provide for the employment of persons on contracts of service and for the form of and enforcement of contracts of service, appointment of officers of the Labour Department and for the conferring of powers on such officers and upon medical officers and protection of wages of employees as well as control of employment agencies
Road Transport	**Road Traffic Act (No. 11 of 2002);**	Establishes the Road Transport and Safety Agency which provide for a system of roads safety and traffic management.
Taxes and Investment	**The Zambia Revenue Authority Act (No. 28 of 1993 and all amendments);**	The Acts provides for the taxation system in zambia for various goods and services .
	Value Added Tax Act (No. 4 of 1995 and all amendments)	
	Investment Act of 1993	Provides a legal framework for investment in Zambia. The Act relates to the environment indirectly by providing incentives for trees planting, soil and water conservation activities. The Act further recognizes the role of other agencies including those responsible for environmental protection in authorities' specific projects.
Country, Town and Local Planning	**The Town and Country Planning Act of 1962**	Provides for the appointment of planning authorities whose main responsibilities are the preparation, approval and revocation of development plans. It also provides for the control of development and subdivision of land.
	The Local Government Act, 1991	Provides for the establishment of Councils or Districts, the functions of local authorities and the local government system. Some of these functions relate to pollution control and the protection of the environment in general.

2.2.8. Compensation and Resettlement Legislation in Zambia

The legislation governing resettlement and compensation in Zambia and applicable for the development of the Mutanga Project has been described in the Relocation Action Plan (RAP) Report submitted together with the EIS.

2.2.9. International Agreements

Zambia is a signatory of a number of regional and international Agreements . Below are some of the agreements related to the environment and relevant to the Mutanga Project:-

- The 1994 Convention to Combat Desertification;
- The International Convention for the Protection of Fauna and Flora in Africa;
- The Convention on Endangered Species;
- The International Convention on Hazardous Wastes;
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES);
- Agreement on the Action Plan for the Environmentally Sound Management of the Common Zambezi River System; and
- Convention concerning the Protection of the World Cultural and Natural Heritage.

2.3. International Atomic Energy Agency (IAEA)

The IAEA promotes safe, secure and peaceful technologies for Nuclear Energy. The Institution was formed in 1957 within the United Nations. The IAEA Secretariat is based in Vienna, Austria. The Secretariat comprises of 2,200 multi-disciplinary professional and support staff from more than 90 countries.

The IAEA has a 35 member Board of Governors and the General Conference of all member states which set the budgets and institutional programmes.

The institution provides many guidelines regarding radioactive materials and activities. The most important of these are the IAEA Standards, Guides and Codes provided for the protection of humans and the environment. These guidelines are usually accepted by member countries for implementation, but the guidelines are not legally binding on the member countries. Member countries can implement these guidelines during the development of their own regulatory organisations.

2.4. World Nuclear Transport Institute (WNTI)

The WNTI was established in 1998 and has grown to Member companies from all sectors of the industry. WNTI operates as a network organisation growing on the expertise of its member companies and external experts.

The WNTI has produced several guideline documents based on the experiences and information gained through member companies.

The most useful of these was:-

- Uranium Concentrates – Industry Good Practices for ISO Containers in Multimodal Transports Rev 0 (Information Paper No. 4 February 2008).

2.5. World Nuclear Association (WNA)

The World Nuclear Association is a global private-sector organisation, based in the United Kingdom, that seeks to promote the peaceful worldwide use of sustainable nuclear energy. The WNA is associated with the generation of nuclear power through the whole nuclear fuel cycle e.g. mining, conversion, enrichment, fuel fabrication, plant manufacture, transport, and the safe disposition of spent fuel.

WNA members mostly consist of companies involved in aspects of the fuel cycle. The WNA facilitates interaction on technical, commercial and policy matters and by promotes wider public understanding of nuclear technology.

The WNA has issued a series of Policy documents to guide members and other parties on the safe use of uranium for nuclear energy.

2.6. African Development Bank

The African Development Bank (AfDB) is a regional multilateral development finance institution active in the provision of resources for economic and social advancement of the Regional Member Countries (RMCs). The headquartes of the AfDB are located in Abidjan, Côte d'Ivoire.

The bank aims to promote development through investments, technical assistance, loans and equity and has developed the following policies for adoption by assisted projects:-

- **Environmental Policy** - enhancing the capacity of RMCs, improving access of environmental resources to the poor, assisting RMCs with institutional changes for sustainable development, strengthening the partnerships with international agencies and networking with international, regional and sub-regional organisations;
- **Poverty Policy** - to reduce poverty in Africa through strategy development that encourages national ownership, participation and a direction of welfare improvements for the poor;
- **Gender Policy** - to promote the mainstreaming of gender in Bank operations and the support of RMCs' efforts to achieve gender equality;
- **Involuntary Resettlement Policy** - Operational Policy 4.12 addresses involuntary displacement or loss of economic assets through Bank-financed development programs and projects. The aim is to ensure that people are treated equitably and share in the benefits of the project that led to their displacement; and
- **Population Policy -** to reduce fertility through the support of programs and direct interventions as it is seen as one of the main constraints on poverty and sustainable development.

2.7. World Bank Group (WB)

The World Bank (WB) Group (is a source of industrial and technical assistance for developing countries. The WB consists of two separate institutions and is owned by 185 member countries (refer to WB website http://www.worldbank.org/).

I. The International Bank for Reconstruction and Development (IBRD) aims to reduce poverty in poorer countries through sustainable development facilitated through loans, guarantees, risk management products, and analytical and advisory services. The funds provided by the IBRD are raised on worldwide financial markets.

II. The International Development Association (IDA) aims to reduce poverty by providing interest-free loans and grants for programs that promote economic growth, reduce inequalities and improve living conditions.

The WB has developed a series of 10 main Environmental and Social safeguard policies that are continuously being updated. The main policies that are applicable to the Mutanga Project are Operational Policies (OP) 4.01 (Environmental Assessment) and OP 4.12 (Involuntary Resettlement).

OP 4.01 dictates that screening be conducted for proposed projects to determine the type and extent of assessment required. This screening is conducted in categories:-

- **Category A** is a project likely to have significant adverse environmental impacts that are sensitive, diverse, or unprecedented. These impacts may affect an area broader than the site or facilities constructed or affected by the project. Category A projects require a full Environmental Impact Assessment (EIA) to identify the potential negative and positive environmental impacts and recommend measures needed to prevent, minimize, mitigate, or compensate for adverse impacts and improve environmental performance;

- **Category B** is a project that has localised and less adverse potential environmental impacts on human populations or environmentally important areas than those of Category A. These projects require environmental analysis; and

- **Category C** is a project that is likely to have minimal or no adverse environmental impacts. Beyond screening, no further environmental assessment action is required.

The Mutanga Project would be classified as a Category A project which requires a full Environmental Impact Assessment (EIA) and an Impact Management Plan.

Generally if funding is required then World Bank Guidelines for Environmental Assessment become important in gaining approval for applications.These guidelines are considered to be the international benchmark for environmental assessment and so an EIA complying with the World Bank Guidelines will satisfy most financial institutions.

The content of a Zambian EIA is analogous to that of a World Bank Environmental Assessment Report for a Category A Project. The content of a Zambian EIA and World Bank environmental assessment are summarized **Table 2.2** in below.

Table 2.2 Content of Zambian EIA and World Bank Environmental Assessment

Zambian EIA	World Bank Environmental Assessment
Executive Summary	Executive Summary
Detailed Project Description	Policy, Legal and Administrative Framework
Baseline Environmental Study	Project Description
Environmental Impacts	Baseline Data Collection
Mitigation Measures	Environmental Impacts & Mitigation Measures
Analysis of Alternatives	Analysis of Alternatives
Environmental Management Plan (EMP)	Environmental Management Plan (EMP)
Appendices	Appendices

World Bank Operational Policies, OP 4.12, describes the measures that should be undertaken when involuntary resettlement would be required before implementation of the proposed project. A Resettlement Action Plan (RAP) should be conducted to identify the population affected, provide means and measures for compensating them for the affected assets (housing, land etc) and describe actions to be conducted during the relocation exercise.

2.8. Equator Principles

The Equator Principles are a set of voluntary guidelines for managing environmental and social issues adopted by many financial institutions worldwide (http://www.equator-principles.com/index.shtml). Their adoption aims at avoiding negative impacts on project-affected ecosystems and communities where possible, and if these impacts are unavoidable, they can be reduced, mitigated and/or compensated for appropriately.

These Principles were adopted in June 2003 by ten international commercial banks and as of June 2006, 41 Equator Principles Financial Institutions (EPFIs) have adopted these Principles, representing approximately 80 percent of global project Financial Institutions. These Equator Principles are:-

- Review and Categorisation;
- Social and Environmental Assessment;
- Applicable Social and Environmental Standards;
- Action Plan and Management System;
- Consultation and Disclosure;
- Grievance Mechanism;
- Independent Review;
- Covenants;
- Independent Monitoring and Reporting; and
- EPFI Reporting

2.9. International Finance Corporation (IFC)

The International Finance Corporation (IFC) provides funding and advisory services for the development of the private sector in developing countries. The development is implemented through the review and acceptance of applications for development projects in various industrial sectors.

The IFC is a member of the World Bank Group and was formed in 1956, currently with over 179 member countries. The IFC has also developed a set of Performance Standards which implement the IFC's commitment to social and environmental sustainability of financed projects in developing countries. These Performance Standards are:-

- PS1: Social and Environmental Assessment and Management System;
- PS2: Labor and Working Conditions;
- PS3: Pollution Prevention and Abatement;
- PS4: Community Health and Safety;
- PS5: Land Acquisition and Involuntary Resettlement;
- PS6: Conservation of Biodiversity and Sustainable Natural Resource Management;
- PS7: Indigenous Peoples; and
- PS8: Cultural Heritage.

The IFC has designed Environmental, Health and Safety (EHS) Guidelines (April, 2007) to replace the documents in Part III of the Pollution Prevention and Abatement Handbook and IFC website publications. The EHS Guidelines offer technical information on the expected Good International Industry Practise (GIIP).

2.10. Occupational, Health and Safety Guidelines

There are various international institutions that have developed similar guidelines on health and safety. Two of the more important are:-

- Occupational Safety and Health Organisation (OSHA); and
- World Health Organisation (WHO).

The WHO provides guidelines on drinking water and the most recent updates to the

OSHA provide guidance to companies and employees on the occupational, health and safety information relevant to them. It is a part of the United States Department of Labour.

3. PROJECT DESCRIPTION

3.1. Introduction

The first Uranium mineralization in the Mutanga area was identified in 1957. Further exploration activities by various title holders have revealed the occurrence of Uranium mineralised areas at Mutanga, Mutanga East, Mutanga West, Dibwe and Bungua. Currently activities have focused on converting Mutanga and Dibwe into mineable economic orebodies.

A series of investigations were conducted during the development of the FS to design infrastructure requirements for the Mutanga Project operation such as; processing methods, hydrogeological studies, environmental and social impacts and health and safety conditions. The outcome of the FS has indicated that Acid Leaching is the preferred treatment process compared with an Alkali Leach, and the preferred operational method is Acid Heap Leaching.

3.2. Project Location

The Mutanga Project is located in the Mutanga area of the Siavonga District in the Southern Province of Zambia. The project is approximately 175km south of Lusaka and approximately 39km Northwest of the Siavonga Township. The site is accessed from Lusaka via the Lusaka-Chirundu and Chirundu-Siavonga tarmac roads and then the Mutuwa-Mutanga dirt track..

There are three routes to the site that branch off the Siavonga-Chirundu road, all of which are dirt/gravel tracks (refer to **Figure 3.1** below).

The “North Road” branches west off the Siavonga road approximately 8km from the Siavonga-Chirundu Road junction. This road is 42km long, crosses the Lusitu River as well as other seasonal drainage channels and is generally impassable during the rainy season. There are villages along this road with estimated populations exceeding 200 people.

The ‘Lakeshore’ or South route is accessed from Siavonga town or from the Matuwa village. It is approximately 38km long and does not cross any major rivers but there are several seasonal stream gulleys that make accessibility difficult. There are several villages along the route.

The existing Zyiba Meenda route is the chosen road to be the main access route to the Mutanga Project and is located 50km north of Siavonga Town. The road is approximately 36km long and follows the main watershed boundaries in the area. There are two villages along the existing road but DMZL proposes to divert the access road away from these villages to prevent any negative impacts from dust or traffic safety concerns. The access road will also be diverted around the Zyiba Meenda Pan or Dambo area.

Accessibility to the Mutanga area is somewhat restricted by historical disputes and it is believed that there may be some remnants of landmines in the area dating from the border disputes between Zimbabwe and Zambia during the 1960s. Landmines were placed along the borders to prevent access. It is believed that there are still Unexploded Ordinances (UXOs) in the region. The Zambia Mine Action Centre (ZMAC), in conjunction with DMZL, have conducted large scale scouting and clearance of UXOs in LPL 237. These areas initially focused on future exploration areas and initial clearance of the Zyiba Meenda route. This survey will be extended.

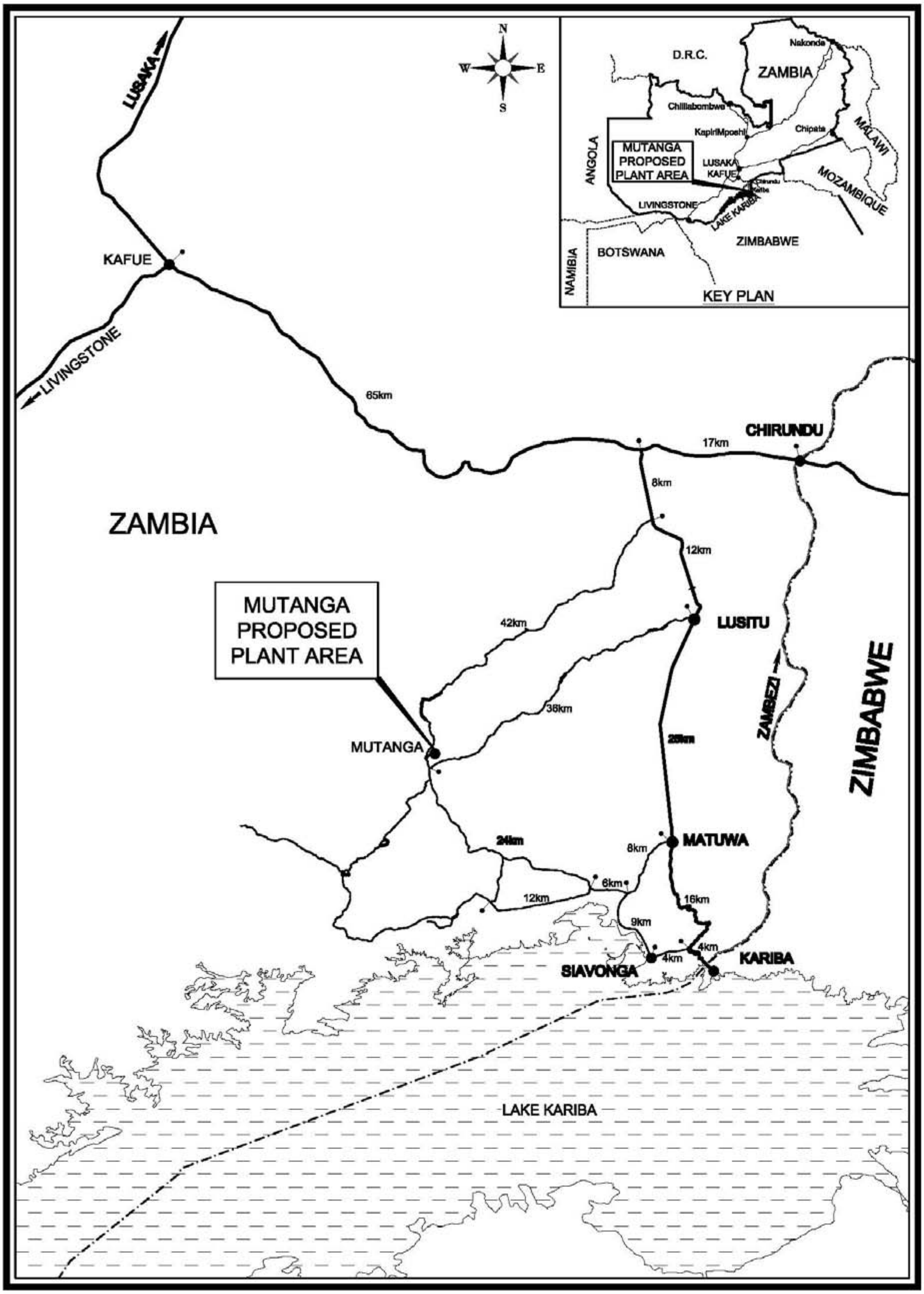


Figure 3.1 Location of the Mutanga Project (Source: MDM, 2009)

3.3. Historical Activities

3.3.1. Site History

The historical milestones in regard to Uranium discovery are:-

- The first Uranium mineralization was identified in 1957 by the Geological Survey of Zambia (GSZ) when a Car borne Survey identified five anomalies around Bungua Hill, 40km northwest of Siavonga Town;

- Chartered Exploration conducted exploration activities between 1958 and 1959 that identified low grade Uranium mineralisation over 800m strike length;

- Ground investigation was conducted by GSZ from 1973 to 1977;

- Regional airborne Magnetic and Radiometric surveys were flown by Geometrics in 1974;

- A second ground survey was conducted by AGIP SPA (AGIP), an Italian Oil Company, from 1974 to 1984. These surveys identified the occurrence of four potentially economic deposits;

- OL obtained 70% ownership of PLLS 237 with Okorusu in April 2005. OL invested US$1million into an exploration program from 2005 onwards and gained 100% ownership of PLLS 237 in 2006;

- Geoquest conducted exploration activities on behalf of OL during the 2006 exploration season, based on information gathered from AGIP. Eleven diamond drillholes broadly confirmed the historical U_3O_8 data at Mutanga. Exploration was also conducted at Bungua, Mutanga and Dibwe;

- Denison obtained 100% interest of OL in 2007 and furthered exploration programs in the Mutanga and Dibwe prospects from 2007 to 2008 through its Zambian representative company DMZL;

- DMZL submitted an application to the Ministry of Mines and Minerals Development (MMMD) for the conversion of PLLS 237 into a Large-scale Prospecting License (LPL) under the Mines and Minerals Development Act 2008. LPL 237 was granted; and

- From August to November 2008 exploration activities were conducted for other prospects in LPL 237.

3.3.2. Exploration History

LPL 237 covers approximately 946.3km^2 and was granted to explore for Uranium, Copper, Cobalt, Zinc, Gold and Nickel for a period of two years from 6th January 2007.

The data and materials that exist to date comprise of:-

- Airborne radiometric-geophysics;
- Ground radiometric survey data;
- Regional geology maps;
- Topographic maps;

- Down-hole geophysical gamma plots;
- Drill hole logs from RC and Diamond Drill holes; and
- Drill core and chips from Diamond and RC holes respectively.

The main Uranium mineralised areas that have been identified are:-

- Mutanga Prospect (Mutanga Central, Mutanga West and Mutanga East);
- Dibwe Prospect (Dibwe, Dibwe West and Dibwe North);
- Mutanga-Dibwe Corridor (the regional AGIP work outside of main 'concentrated' activity); and
- Bungua Prospect (Kaumpwe West, Kaumpwe Central, Lutele and Chizwabowa).

The historical airborne geophysics surveys identified three mineralised areas in the Mutanga Prospect, with the same number identified in the Dibwe Prospect area where Uranium counts were elevated. This focused exploration and led to favourable identification of many of the identified prospect areas (refer to **Figure 3.2**).

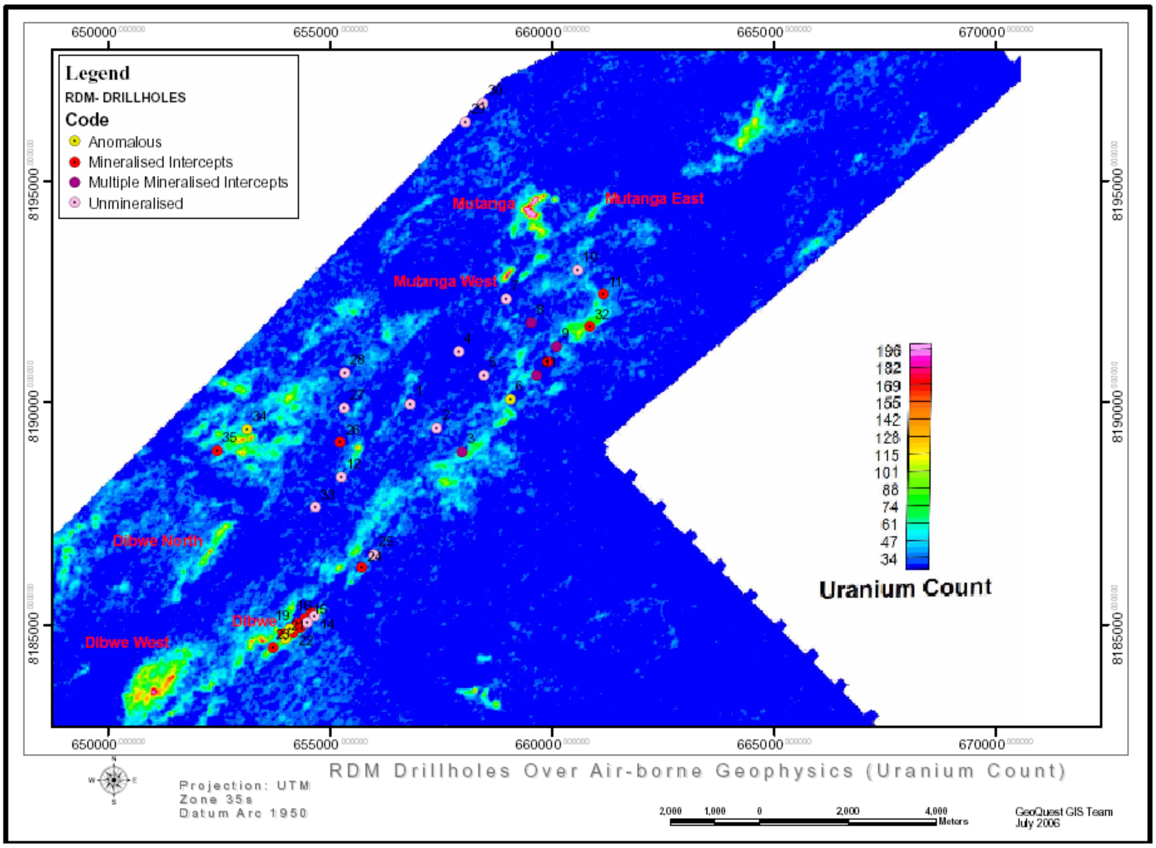


Figure 3.2 Historical Airborne Geophysics for Uranium Count and RDM Drillhole locations (Source: CSA Global, 2009)

The current project focuses on the resources identified at the Mutanga Central and Dibwe prospects (refer to **Figure 3.3**). The 2008 exploration program conducted by DMZL on LPL 237 used the following methods through CSA Global (UK) Pty Limited to conduct a resource estimate from the drill cores:-

- Downhole radiometric logging;
- Riffle splitting reverse circulation (RC) chips;
- Half drill core; and
- Scintillometer logging.

The maximum drilling depth within the Mutanga and Dibwe prospects is one hole to 161m at Dibwe. Hole depths average 55m and are usually less than 100m deep.

Mutanga Prospect

The Mutanga Prospect (Mutanga Central, Mutanga West and Mutanga East) is located approximately 31km north-west of Siavonga Town and approximately 10-15km northeast of the Dibwe prospect.

AGIP data identified the three different areas in the Mutanga Prospect by:-

- Outcropping mineralisation;
- Ground radiometric surveys; and
- Air-borne photographic and geophysical surveys.

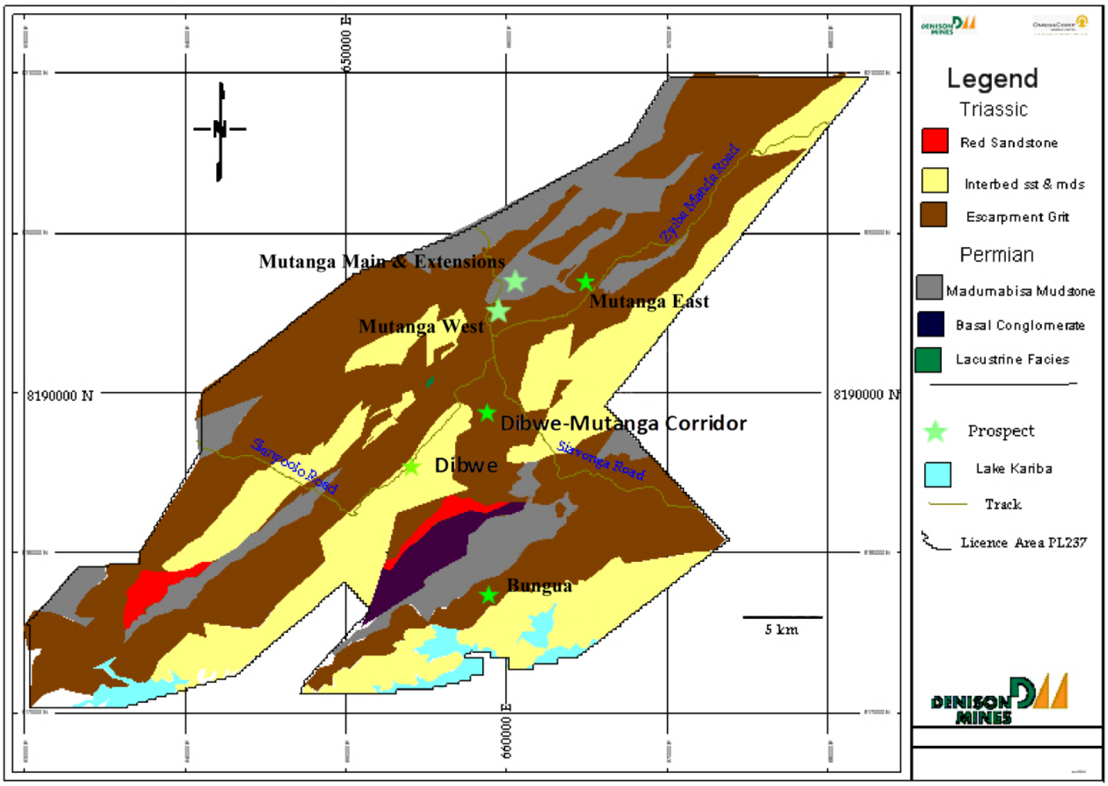


Figure 3.3 Mutanga Project Location Plan and Geology (Source: CSA Global, 2009)

AGIP carried out systematic exploration up to and including a resource estimation phase. This exploration activity included:-

- Drilling of 14,794 metres (50 Diamond holes for 6,833m, 119 Percussive (wagon drill) holes for 6,998m and 83 Percussive (shallow wagon drill) holes for 963m);
- Trenching;
- Pitting;
- A trial heap leach facility on site and material tested at at what is now the National Institute for Scientific and Industrial Research (NISIR) facility in Lusaka;
- A Kriged resource estimation using unknown internal company classification criteria.

Figure 3.4 shows the location of the Mutanga Central prospect with AGIP drill locations. Scintillometer readings were measured on the ground and contours are illustrated.

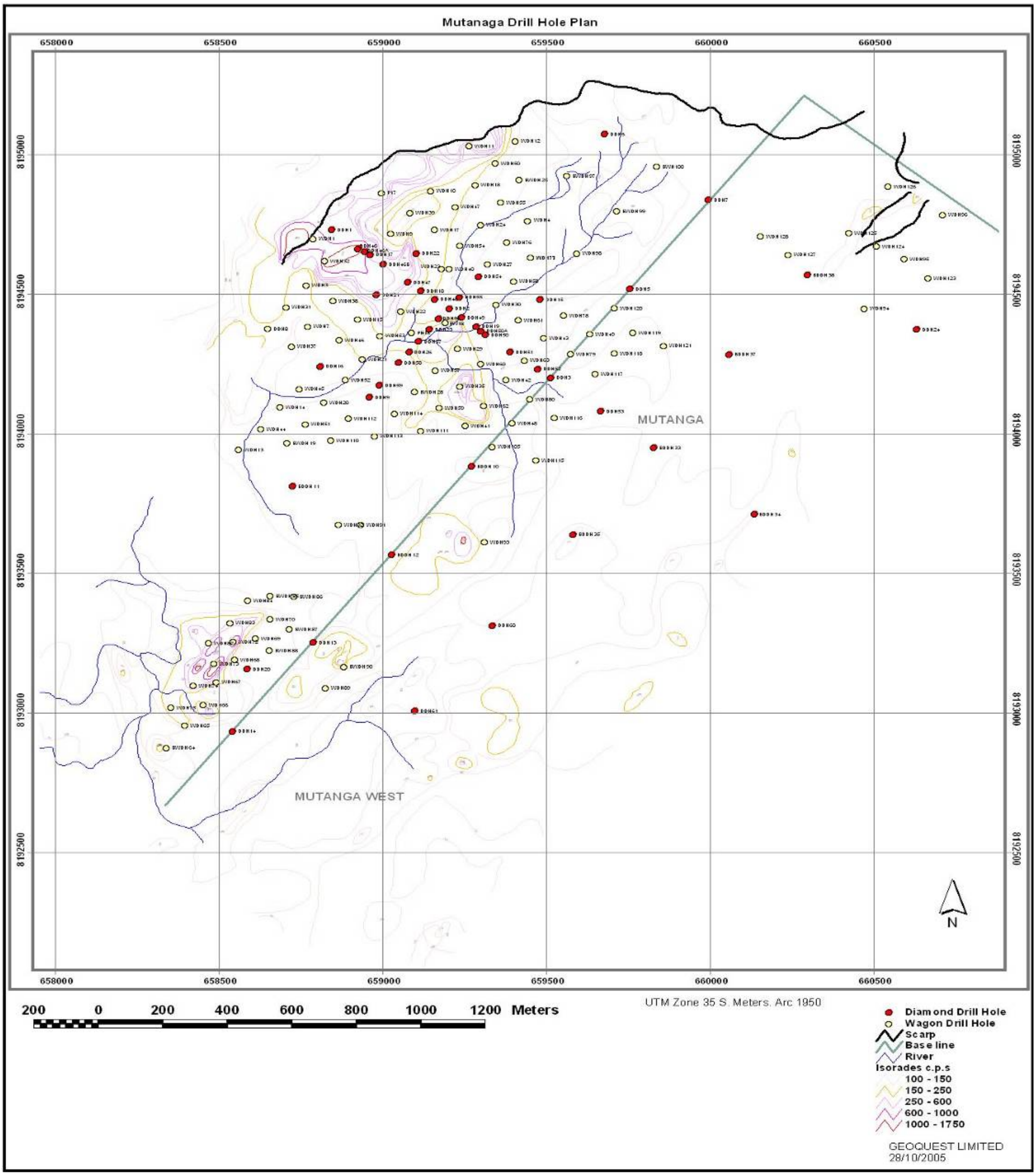


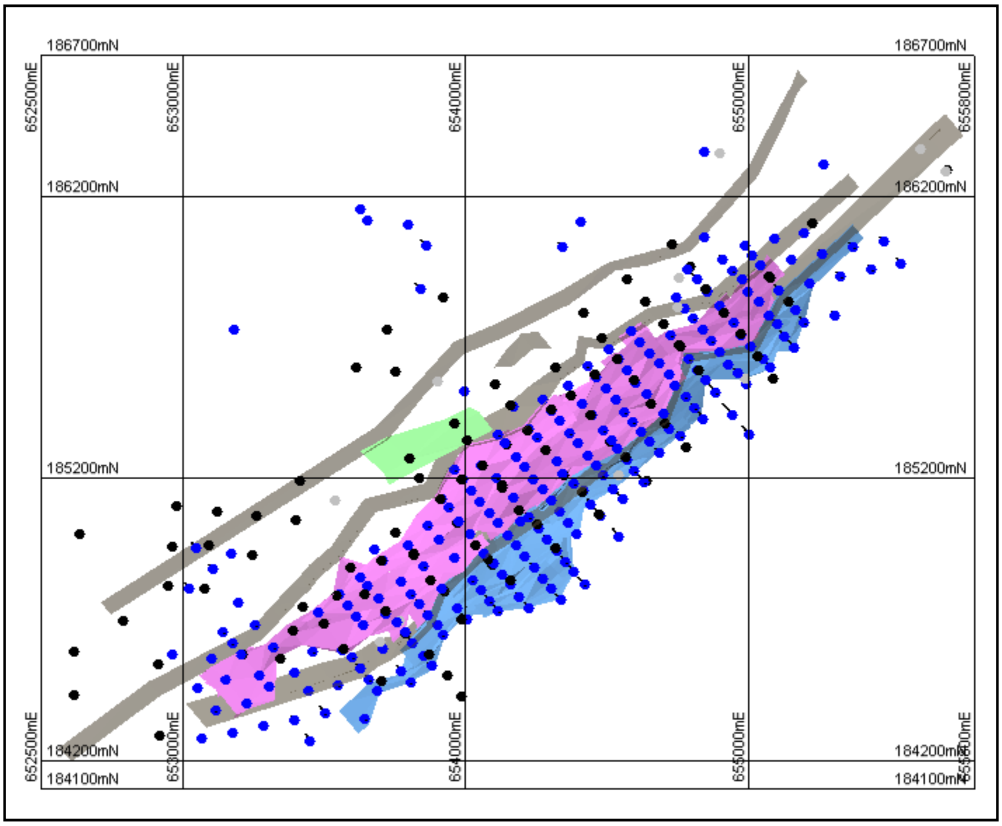
Figure 3.4 Location of Mutanga Central Prospect with AGIP Diamond and Wagon Drill Holes (Source: CSA, 2009)

Dibwe Prospect

The Dibwe Prospect (Dibwe, Dibwe West and Dibwe North) is located approximately 10-15km southwest of the Mutanga Prospect. There is little data available for the Dibwe West and North areas(refer to **Figure 3.5**). **Figure 3.6** illustrates the locations of the Dibwe West and Dibwe North areas.

AGIP identified the Dibwe Prospect through:-

- Outcropping mineralisation;
- Ground radiometric surveys; and
- Air-borne photographic and geophysical surveys.



Historical drill collars in black. Recent drill collars in blue.

Figure 3.5 Dibwe Area of Dibwe Prospect (Source: CSA Global, 2009)

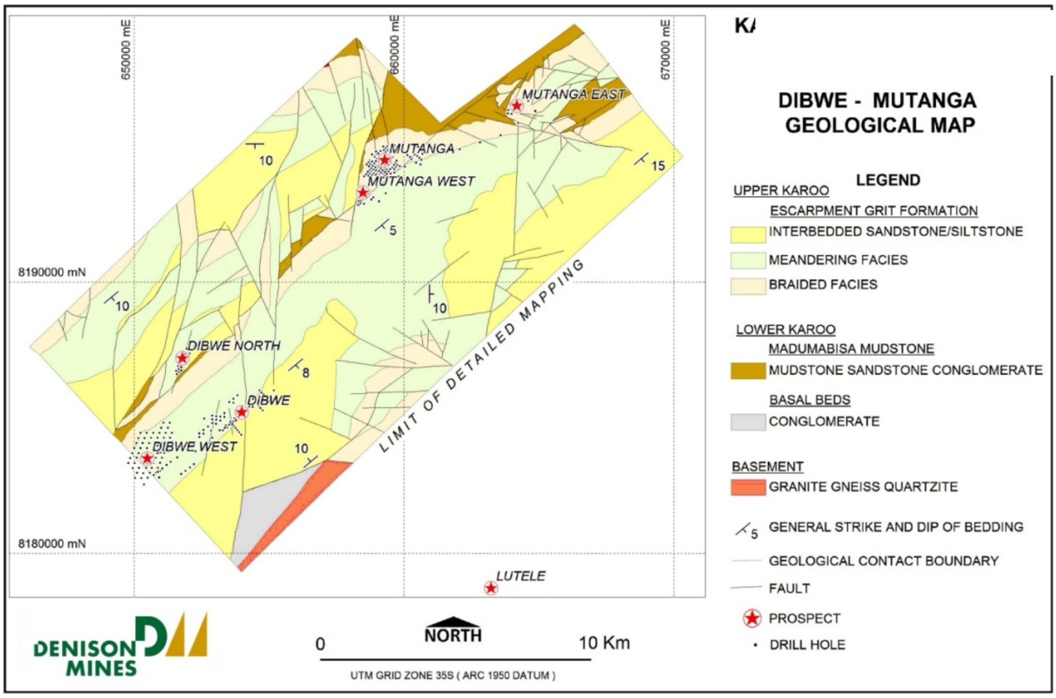


Figure 3.6 Location of the Dibwe North and West Areas in the Dibwe Prospect (Source: CSA Global, 2009)

AGIP carried out systematic exploration, up to and including a resource estimation phase on the Dibwe project area. This work included:-

- Drilling of 40 diamond drill holes (3,644m) and additional unknown number and metreage of percussive (wagon drill) at Dibwe;
- A resource estimation using unknown internal company criteria for Dibwe;
- Drilling of 70 percussive drill holes (metreage unknown) for Dibwe West but data non-existent to date; and
- Drilling of 20 percussive drill holes (metreage unknown) for Dibwe North but data non-existent to date.

3.4. Mine Development Plan and Mine Production

3.4.1. Project Schedule

The basic project timeline is:-

- Completion of the Environmental Impact Study (EIS) in May 2009;
- Submission of review of EIS (June 2009 onwards);
- Application for Mine License in July 2009;
- Approval of the relevant authorities e.g. ECZ, MMMD and RPA (June 2009 onwards);
- Follow-up and finalisation of project designs (end 2009 to mid 2010);
- Application for Processing License in July 2010;
- Relocation activities for affected populations in mid 2010;
- Development of powerline and access road in mid to late 2010;
- Construction phase from mid 2010 to end of 2011;
- Commissioning of process plant at end of 2011;
- Completion of mining activities in 2021;
- Mine closure activities in 2021-2022; and

- Ongoing post-closure monitoring activities (2022 onwards).

3.4.2. Mine Development Stages

Once all of the relevant approvals have been obtained for the Mutanga Project then the following staged mine construction and development will occur:-

1) Relocation and Compensation of the Affected Communities;
2) Powerline and acces road development;
3) Development of operations camp (housing and supplies);
4) Site clearance and preparation;
5) Construction Phase;
6) Mining Phase;
7) Commissioning Phase;
8) Operational Phase;
9) Decommissioning and Closure Phase; and
10) Post-closure Environmental and Social Monitoring Phase.

Relocation and Compensation

Resettlement will be one of the first activities to be undertaken before full implementation of the project. A Resettlement Action Plan (RAP) was developed by African Mining Consultants (AMC) in March 2009 and is discussed in the RAP Report submitted with the EIS. Compensation will be provided to the affected communities and field owners in accordance with the World Bank Operational Policy 4.12 for Involuntary Resettlement and the IFC's Performance Standard 5.

Development of Powerline and Access Road

The current state of accessibility to the site is very low and there is currently no supply of electricity to the Project area. In order for construction activities to commence, the development of these two main infrastructure will be implemented once the 2009-2010 wet season is finished.

Development of Operations Camp

The Operations Camp will house the temporary and permanent accommodation for the project activities. All temporary construction personnel will be housed in temporary Pre-fabriacted Structures.

Permanent accommodation will be designed for the following housing types:-

- Two-bedroomed flatlet (11 units);
- Single-roomed single quarters (14 units); and
- Twin-roomed single quarters (10 units).

There will be a recreational area with a pool, tennis court and gym as well as a dining area. The permanent operations camp will provide accommodation for all employees on roster at any time.

Engineered wastewater management system, water supply and electricity supply will be installed at the Operations camp. Waste will be generated from packaging of construction materials, wash houses and the kitchens. Medical waste may be produced in small amounts as well until the mine clinic is operational at the mine operational stage.

The licenced waste disposal site and incinerator plant will be used for all non-reusable or recyclable material will be used at this stage.

Site Clearance and Preparation

Clearance and preparation activities will occur in all areas where mine infrastructure will be developed (i.e. open pits, waste rock dumps, raw water ponds, heap leach pads, process plant, operations camp, mine access roads and the relocated Kashundi Village). Approximately 314.8ha of land will be affected by mining activities. A further 416.5ha of land will be required for relocation and compensation activities.

Clearance activities will involve the following activities:-

- Felling of large trees to be stockpiled for carpentry, construction or sale;
- Bulldozing of smaller trees and scrub vegetation using a scraper to prevent loss of soil resources;
- Sale of valuable timber to the Forestry Department or local timber merchants;
- Provision for the local communities to collect non-valuable timber for personal use; and
- Removal and storage of topsoil for future re-vegetation programs.

Scheduled land clearance will be done to coincide with procurement and construction schedules. Clearance activities will be restricted to dry season months. This will reduce impacts of soil erosion, surface water and groundwater contamination and siltation of watercourses.

If possible to obtain the equipment, the topsoil will be removed according to horizons (A and B) and will be stockpiled in dedicated areas. These soils will be used for future revegetation programs. The seed resource will be stored in the A horizon as well as seeds from representative species on the site collected during pre-construction surveys of specialists.

Preparation activities will include the following:-

- Profiling requirements for each infrastructure site;
- Laying of base requirements for each facility (waste rock, clay material); and
- Foundation requirements for each facility.

Construction Phase

The construction phase is expected to last from 12 to 18 months (mid 2010 to end 2011). The following activities will occur:-

- Development of mine access roads and drains;
- Development of mine drains, runoff channels, sediment traps, sedimentation ponds and soakaways;
- Construction of the Heap Leach Pad at Mutanga and ponds;
- Preparation of the Mutanga Waste Rock Dump (WRD);
- Initial mining of the Mutanga open pit;
- The Dibwe Leach Pad and Open Pit will be developed later on during the mine operations.
- Construction of the Process Plant, Mine Offices, Workshops, General Stores, Reagent Stores, Mobile Equipment Stores, Security Fencing and Offices;
- Construction of the Raw Water Ponds (RWP); and

- All other activities to develop the mine.

Mining Phase

The intial ore mined from the Mutanga open pit will be hauled and prepared before being taken to the Mutanga Leach Pad and prepare the leach heaps. The pads will be commissioned prior to the commissioning of the process plant in order to stock the Pregnant Liquor Solution (PLS) in the PLS pond.

Commissioning Phase

This is the early stage of operations where the process plant will be tested for initial processing activities. All of the operations of the mine will be tested during this time to improve on the final design and schedules in preparation for full mining and processing operations. The plant is anticipated to be commissioned towards the end of 2011.

Operational Phase

The open pits will be mined to extract 64.5Mt of total estimated material. 18.8Mt will be Ore which will be expected to be leached and processed to produce 4,812t of U_3O_8 from an average annual throughput of 2Mt of Ore.

Exploration activities will continue in the area in an effort to prolong the Project lifespan. Ongoing monitoring of the environmental and social environments will be implemented, with specific focus on the operations and relocated communitties.

Decommissioning and Closure Phase

Once the mineable mineral reserves have been exhausted, the project will be decommissioned and closed in around 2021, unless further mineable resources are located during the continuing exploration program.

The built-up mine infrastructure (i.e. process plant, mine offices, workshops etc) will be demolished and removed from site for sale. All scrap and re-usable materials will also be removed and sold or disposed off once declared safe. A detailed Decommissioning and Closure Plan has been included in **Chapter 10** below, which will be updated annually during the Project life.

Post-closure Environmental and Social Monitoring Phase

After mine, a long term monitoring of the Closure Rehabilitation and Re-vegetation activities will be implemented in line with the Closure plan. The aim of these activities will be to ensure that there is long term stability in the rehabilitated areas, re-vegetation activities are successful and and the area safely secured to avoid public and environmental dangers.

3.4.3. Mine Production

The two Open Pits will be mined over a period of 10 years with the initial development of the Mutanga Open Pit in Year 1 (early 2011). The mining of the Dibwe Open Pit will be initiated in Year 2 of the production schedule.

The average mining rates of ore will be 1.9Mt per year. Initial rates will be lower in Year 1 but rapidly exceed 2Mt/a during the ramp up of production from Year 2 to Year 4 with a gradual decrease in annual mining rates to 0.9Mt in Year 10 of production. The average grade of the mined ore from both pits will be 283ppm U_3O_8.

The ore will be mined to feed the process plant which will operate to produce an average of approximately 500t of U_3O_8 concentrate per year.

Approximately 45.7Mt of waste rock will be produced from the Dibwe and Mutanga open pits. This waste material will be stored in specially designated Waste Rock Dumps (WRDs). Key Project information is summarised in **Table 3.1** below.

Table 3.1 Key Project Information

Aspect/Activity	Total
Years of mining activity	10 years
Number of open pits	2 (Mutanga and Dibwe)
Total material removed from open pits	64.5Mt
Total ore mined	18.8Mt
Total waste disposed	45.7Mt
Average annual mining rate	1.9Mt
Average strip ratio	2.3
Average annual processing rate	2Mt
Dry bulk density of ore	2.1-2.2g/cm^3
Ore resource at Mutanga	27.76Mt (Measured, Indicated and Inferred)
Average Grade	334ppm
Ore resource at Dibwe	17.0Mt (Inferred)
Average grade	234ppm
Project Capital Investment	US$114million
Employment	384 people

3.5. Project Capital Costs, Employment and Project Life

Project Capital Costs

The financial assessment in the feasibility study for the Mutanga Project indicated that the capital investment will be approximately US$118million. The annual operating costs of the mine will be approximately US$38million. Part of the revenue generated by the sale of the U_3O_8 concentrate will be expected to meet the mine operational expenses.

Employment

It is expected that the mine will employ approximately 384 people with an emphasis on employment of Zambians. With consideration to the availability of the required skills in Zambia a detailed program for training the workforce will be developed to phase out specialist trainers over the first 4 years of operations. **Table 3.2** describes the mine personnel requirements.

Table 3.2 Mine Personnel and Department Design

Site Personnel	Total
Process Plant	**149**
Senior/Supervisory	6
Skilled	45
Semi-skilled	98
Mining (Owner)	**21**
Management	2

Site Personnel	Total
Senior/Supervisory	19
Mining (Contractor)	**123**
Management	1
Senior/Supervisory	8
Skilled/Semi-skilled	114
General Administration	**33**
Management	1
Senior/Supervisory	2
Skilled	18
Semi-skilled	12
Catering and Cleaning (Contractor)	**58**
Management	2
Skilled	8
Semi-skilled	48
TOTAL	**384**

Project Life

The initial lifespan of the mining activities in the Mutanga Project is 10 years. The Project will have a duration of approximately 15 years including relocation, construction, decommissioning and closure phases.

With the continuation of regional exploration activities, there is a possibility of increasing the project lifespan once further Uranium Mineralisation is found to provide future feed to the Mutanga Project beyong the current 10 years lifespan.

3.6. Mineral Resource

There have been several resource estimations for Oxidised Uranium (U_3O_8) conducted for the Project Area. CSA Global Pty Ltd were commissioned in 2006 to undertake a Resource estimation on the results obtained from the Geoquest campaign. **Table 3.3** below outlines the historical resource estimates and classifications.

Table 3.3 Historical Resource Estimates and Classifications

Company Name/ Year	Resource Category	Lower Cut (ppm U_3O_8)	Tonnes (Mt)	Grade (ppm U_3O_8)	U_3O_8 (Mlbs)
AGIP (1970's)	Inferred	700	2.4	1,000	5.3
AGIP (1970's)	Inferred	600	3.2	870	6.1
AGIP (1970's)	Inferred	500	4.3	740	7.0
AGIP (1970's)	Inferred	400	4.9	600	6.5
AGIP (1970's)	Inferred	300	7.8	530	9.1
AGIP (1970's)	Inferred	200	9.7	480	10.3
CRM Apr 2005	Indicated	200	7	400	6.2
CRM Apr 2005	Inferred	200	0.9	400	0.8
CRM Nov 2005 Deposit	**Inferred**	200	**6.5**	**375**	**5.4**
Mutanga East	Inferred	200	0.30	400	0.29
Mutanga West	Inferred	200	0.65	350	0.53
Dibwe	Inferred	200	5.00	430	4.70
	Total		***12.45***	***396***	***10.92***
CSA (June 2006) Deposit					
Mutanga	Inferred	200	7.0	400	6.2

Company Name/ Year	Resource Category	Lower Cut (ppm U_3O_8)	Tonnes (Mt)	Grade (ppm U_3O_8)	U_3O_8 (Mlbs)
Mutanga Extensions	Inferred	200	0.5	340	0.4
Mutanga East	Inferred	200	0. 2	320	0.1
Mutanga West	Inferred	200	0. 5	340	0.4
Dibwe	Inferred	200	8.2	370	6.6
	Total		***16.4***	***380***	***13.7***

CSA Global (UK) Pty Ltd then updated the resource estimates and classification for the Mutanga and Dibwe main areas on December 31st 2007. The update was based on the results of expanded drilling to provide an Indicated Resource (refer to **Table 3.4**).

Table 3.4 Estimate of the Mutanga and Dibwe U_3O_8 Resources (Source: CSA, 2007)

Deposit	Lower Cut-off ppm	Measured			Indicated			Inferred			Total Potential Resource Mt
		Tonnes Mt	ppm	Mlbs	Tonnes Mt	ppm	Mlbs	Tonnes Mt	ppm	Mlbs	
Mutanga	100	1.88	481	1.99	8.4	314	5.82	7.2	206	3.3	17.48
Dibwe	100				-	-	-	17.0	234	9.0	17.0
Total		**1.88**	**481**	**1.99**	**8.4**	**344**	**5.82**	**24.2**	**220**	**12.3**	**34.48**

The total Measured and Indicated resource estimates for the Mutanga deposit are 10.28Mt (1.88Mt and 8.4Mt respectively). The average grade of these resources is 398ppm which will yield approximately 7.81Mlbs of U_3O_8 concentrate. An additional 7.2Mt of Inferred resource at 206ppm has also been identified for the Mutanga deposit.

The Dibwe deposit exists as an Inferred resource of 17Mt at approximately 234ppm U_3O_8. The dry bulk density of the ore ranges from 2.1 to 2.2g/cm^3.

3.7. Mineralisation

The element uranium was first discovered in pitchblende in 1789 in the form of Uranium Dioxide (UO_2) (*Jefferson Lab, 2006*). Uranium is obtained from mineral ores such as Pitchblende, Uraninite (UO_2), Carnotite ($K_2(UO_2)_2VO_4 \cdot 1\text{-}3H_2O$), Autunite ($Ca(UO_2)_2(PO_4)_2 \cdot 10H_2O$), Phosphate Rock ($Ca_3(PO_4)_2$), Lignite or "Brown Coal" and Monazite Sand ($(Ce,La,Th,Nd,Y)PO_4$).

Test work (QEMSCAN 2006) indicates that the majority of the Uranium (~95%) at Mutanga is contained in Uranium-Calcite-Potassium Minerals (e.g. Autunite and Metaautunite). Approximately 2% (by volume) of the Uranium bearing mineralisation consists of Brannerite and Coffinite. The Uranium bearing minerals exist as discrete grains and are not intergrown with other minerals.

The main mineral containing Uranium is Autunite ($Ca(UO_2)_2(PO_4) \cdot (10\text{-}12)H_2O$) with very minor Meta-Autunite ($Ca(UO_2)_2(PO_4) \cdot (0\text{-}6)H_2O$). Some other Uranium minerals that were identified are Coffinite, Brannerite and Uranium Oxides. **Table 3.5** below illustrates the results of the mineralogical assessment.

The dominant minerals in the ore are Quartz (37-82%), Micas (7-24%), Feldspars (6-16%) and Clay (2-17%).

A chemical analysis of the ore indicated that Uranium in the ore ranges from 100ppm (0.01%) to 20,000ppm (2%). The expected average ore grade to be transported to the process plant will range from 250 to 450ppm (0.025-0.045%). Based on the mineralogical assessment of the ore, it is expected that elements that may be abundant in soils of the area would be Uranium, Aluminium, Sodium, Potassium and Calcium.

The Uranium was eroded from the surrounding Gneissic and Plutonic basement rocks during weathering and deposition of the immature Grits and Sandstones. The weathering environment was presumably arid and the Uranium was transported with the weathered material. The Uranium was deposited under reducing conditions in specific geological units.

Table 3.5 Mineralogical Composition of the Uranium Ore from Kariba (QEMSCAN Data from Continental Resource Management (CRM) Pty Ltd)

Mineral	Combined	-3000/+1180	-1180/+300	-300/+150
Autunite	0.64	0.24	0.48	1.13
Autunite/Si Bndry	0.01	0.01	0.01	0.02
Other Uranium Minerals	0.01	0.01	0.00	0.01
Quartz	67.18	78.03	81.77	37.10
Silicates	0.61	0.48	0.32	1.15
Sulphides	0.06	0.02	0.03	0.13
Fe Oxides	0.78	0.33	0.23	1.92
Clays	6.85	3.55	1.96	16.73
Micas	13.34	10.73	7.82	23.89
Feldspars	9.59	6.09	6.82	16.12
Monazite	0.08	0.01	0.00	0.25
Resistates	0.76	0.35	0.55	1.35
Others	0.10	0.17	0.02	0.19
TOTAL	100.00	100.00	100.00	100.00

The Uranium was remobilised with continual fluctuations in the groundwater table and it re-deposited in reducing clay-rich areas. Mineralisation now occurs in iron-rich areas (Goethite) and secondary Uranium is distributed within mud flakes, mud balls, in pore spaces, joints and other fractures.

The Uranium mineralisation occurs at various horizons within the EGF unit. The Dibwe mineralisation is found in the upper Meandering Facies G2 unit. At Mutanga the mineralisation is within the lower Braided Facies G2 unit. The base of the significant mineralisation at Mutanga is about 60m above the underlying MMF unit. The mineralisation at Mutanga appears later than the normal faults found in the EGF unit.

Mineralisation Styles

The mineralisation styles recorded are:-

- Disseminated U_3O_8;
- Fracture related; and
- Mud-replacement related.

The disseminated U_3O_8 occurs in sandstones, conglomerates and within mud layers, mud balls and mud flakes. The U_3O_8 is seen as interstitial crystals of generally fine but varying size and or amorphous material to grains. Sulphides (pyrite) occur alongside uranium oxides may indicate a transitional zone or preferential reduction of uranium by one chemical route over another (i.e. decaying organic matter over oxidation of sulphides) as groundwater seeped through the lithology.

Fractures intersected during core logging were generally steep with rare shallow angled fractures. U_3O_8 mineralisation exists as crystal coatings on surfaces and concentrated close to surfaces.

Mud replacement occurs where mud balls and mud flakes are contained within conglomerates, sandstones and mud layers. The Uranium Mineralisation replaces these structures to varying degrees.

Mineralisation Controls

There are several controls on the distribution of mineralisation. These controls are dominated by fractures, bedding, joints and cross beds. However, redox boundaries, mud clasts and reduced rocks are also important for mineralisation precipitation and are recognised in iron cemented zones, micas, iron oxide layers and mud balls. Vertical fracture zones associated with graben block faulting of the Karoo Sandstone units can provide locations of re-deposited uranium along the faults.

3.8. Project Components

The proposed mine infrastructure on the site will consist of the following:-

- Two open pits (Mutanga and Dibwe pits) (33ha and 54.3ha respectively);
- Two heap leach pads (Mutanga and Dibwe) (125ha in total);
- Two Waste Rock Dumps (Mutanga and Dibwe) (25ha and 60ha respectively)
- A process plant, workshops and mine offices (7.5ha);
- Raw Water Tank (150m^3) at the process plant;
- Accommodation camp (Operations Camp)(13.5ha);
- Fuel storage tanks and pumps;
- An upgraded access road (Zyiba Meenda road);
- A 65km long 66kV power supply line from the main grid at Chirundu with a substation;
- Two Raw Water Ponds (Mutanga (2ha) and Dibwe (2ha));
- Resettlement village for affected communities (Kashundi Village) (approximately 300ha); and
- Allocated parcels of land for compensated fields (approximately 116.5ha).

The site infrastructure is indicated in **Figure A** in **Appendix 8**

3.8.1. Open Pits

The Mutanga open pit will be developed on an outcrop of mineralisation and will be approximately 750m long and 550m wide. The Dibwe open pit will be developed approximately 10km southwest of the Mutanga pit operations and will be 1,550m long and 350m wide.

A Fence will be erected around each open pit to prevent inadvertent access and a drain will be dug to divert surface runoff away from the edge of the pit. A sedimentation pond will receive all runoff and solids will be settled. Water sampling will be conducted to monitor the water quality.

Contaminated pit water will be pumped from the pits during dewatering activities from a pump mounted on a raft. The water will be stored in a tank or lined pond for use in the crushing sections at each leach pad or to reduce dust in the open pits. This water will not be used in other dust suppression areas as it is likely to contain amounts of Uranium (solids or dissolved).

3.8.2. Waste Rock Dumps

Two waste rock dumps (85ha total) will be developed adjacent to each open pit. This will minimise haulage distances. The dumps will be designed according to best industrial practise through a series of 10m lifts and 10m wide berms with an overall slope angle of 14º. The inter-berm slope angle will be 18º.

The base of the Waste Rock Dumps will be graded and a fine layer of clay or consolidated material laid prior to dumping activities.

The waste rock will contain residual amounts of radiation from Uranium, its decay products or radon. The profiling and re-vegetation of dump walls and surfaces will start in Year 2 of the project to reduce the areas of exposed rock or soil.

A diversion drain uphill of the dumps will direct uncontaminated surface runoff away from the foot of the dumps. A lined toe drain at the base of the waste rock dumps will collect all potentially contaminated runoff and direct it to a concrete lined sedimentation pond, in series with an adjacent pond. The design pond capacity for each pond will be sufficient for the 1:50 year storm event to prevent spill over of contaminated water into the environment.

The water quality from the Sedimentation Ponds will determine any potential use. Some possibilities are for dust suppression in the process plant after treatment, make-up water for the sulphuric acid solutions, storage in the clean water pond at the process plant for processing and in-situ evaporation from the ponds (especially during the wet season).

Water sampling will monitor the water quality of the runoff. Suspended solids will settle out in the ponds which will be periodically cleaned. The solids will be returned to the waste rock dumps.

3.8.2.1. Acid Base Accounting for Waste Rock

Knight Piésold initiated an Acid Base Accounting (ABA) analysis for some ore and waste rock samples for the Mutanga Project. Ten Ore and ten Waste Rock samples were collected by the on-site geologists as representative of the material to be placed in the WRDs and on the leach pads. The Ore samples will be leached mine operation stage and so only the waste rock samples are described.

Natural oxidation of sulphide minerals in rocks and tailings by a combination of chemical and biological weathering can result in the formation of sulphuric acid. This lowers the pH of seepage and causes increased levels of dissolved trace metals. This process generates Acid Rock Drainage (ARD).

Acid–base analysis (ABA) is an analytical procedure that is developed to assess the acid-producing and acid-neutralizing potential of overburden rocks prior to large scale excavations. It is also used to predict the mine drainage water quality (often in combination with kinetic weathering and leaching tests).

In ABA, the acid generating potential (AP) from the oxidation of sulphur minerals in a rock sample and the acid neutralizing potential (NP) of a rock sample are subtracted to obtain a Net Neutralization Potential (NNP)

NNP = NP – AP.

The results, in tons per thousand tons of overburden or parts per thousand, describe negative NNP values which indicates there is potential to generate acid and therefore a predicted net acid drainage water quality from the rock. Positive NNP values indicate acid-neutralising potential or a predicted net alkaline drainage water quality from a rock sample.

Alternatively the neutralising potential ratio (NPR = NP : AP) can be used to identify potentially acid producing rock, with a ratio of at least 2 needed for complete acid neutralization (Cravotta, Brady, Smith, & Beam, 1990). In case of preferential exposure or reactivity of sulphides the required ratio needed for complete acid neutralization might go up to four (Price, Morin, & Hutt, 1997).

The samples that were collected are indicated in **Table 3.6** below. Knight Piésold submitted the samples to Waterlab (Pty) Ltd for ABA according to the EPA-600 modified Sobek method in order to determine the Acid Generation Potential of the waste rock or ore.

Table 3.6 ABA Samples Collected for Each Open Pit (Knight Piésold, 2009)

SAMPLE ID	Depth From (m)	Depth To (m)	Sample No	Pit Area	Approx. Weight (kg)	Comments
DBD69900-07	29	29.12	24201	Dibwe	0.57	Waste Rock
DBD69900-07	34.55	34.65	24202	Dibwe	0.57	Ore
DBD69900-02	19.4	19.5	24203	Dibwe	0.57	Waste Rock
DBD69900-02	22.4	22.5	24204	Dibwe	0.57	Ore
DBD69300-01	6.3	6.4	24205	Dibwe	0.57	Waste Rock
DBD69300-01	38.5	38.6	24206	Dibwe	0.57	Ore
DBD69100-01	31.91	32	24207	Dibwe	0.57	Waste Rock
DBD69100-01	39.28	39.38	24208	Dibwe	0.57	Ore
DBD68000-04	23.98	24.09	24209	Dibwe	0.57	Waste Rock
DBD68000-04	35	35.1	24210	Dibwe	0.57	Ore
MTD51350-04	36.88	36.96	24211	Mutanga	0.57	Waste Rock
MTD51350-04	38.45	38.55	24212	Mutanga	0.57	Ore
MTD51250-04	15.9	16.01	24213	Mutanga	0.57	Waste Rock
MTD51250-04	32.45	32.55	24214	Mutanga	0.57	Ore
MTD51550-06	18	18.1	24215	Mutanga	0.57	Waste Rock
MTD51550-06	23.2	23.31	24216	Mutanga	0.57	Ore
MTD51750-07	8.9	9	24217	Mutanga	0.57	Waste Rock
MTD51750-07	24.82	24.92	24218	Mutanga	0.57	Ore
MTD51300-01	11.5	11.6	24219	Mutanga	0.57	Waste Rock
MTD51300-01	30.9	31.02	24220	Mutanga	0.57	Ore

Results

The results of the static ABA tests on the waste rock samples by Waterlab (Pty) Ltd as well as the predicted drainage water quality are shown in **Table 3.7** below.

Table 3.7 ABA Testwork Results for Waste Rock

Sample No.	Total S [%]	AP [$CaCO_3$ kg/t]	NP [$CaCO_3$ kg/t]	NNP [$CaCO_3$ kg/t]	NPR [-]	Predicted water quality
24201	0.132	4.13	2.75	-1.38	0.67	**net acid**
24203	0.145	4.53	1.00	-3.53	0.22	**net acid**
24205	0.180	5.63	-0.50	-6.13	-0.09	**net acid**
24207	0.140	4.38	1.00	-3.38	0.23	**net acid**
24209	0.100	3.13	3.25	0.125	1.04	**likely net acid**
24211	0.132	4.13	1.75	-2.38	0.42	**net acid**
24213	0.045	1.41	0.500	-0.91	0.36	**net acid**
24215	0.012	0.375	-1.25	-1.63	-3.33	**net acid**
24217	0.001	0.031	-2.75	-2.78	-88.00	**net acid**
24219	0.001	0.031	0.500	0.469	16.00	**net alkaline**

The NNP and NPR values obtained indicate that the waste rock samples tested produce a **net acid water quality**. Sample number 24209 is borderline acid producing and sample number 24219 has a clear net neutralising potential and a predicted alkaline water quality are exceptions. The limited representative thickness of the samples dictates that the waste rock body must be considered as net acid producing and waste rock placement management methods will need to be implemented.

It has been shown that for sustainable long-term acid generation, at least 0.3 % Total-S is needed. Since acid potential is related directly to total sulphur, and all samples show values below 0.3% Total-S content, they are therefore regarded as having insufficient oxidisable Sulphide-S to sustain acid generation. This suggests a limited time span of acid production and further kinetic tests are recommended to estimate the duration of acid production.

Management measures to be implemented on the waste rock dumps will ensure that there is no ponding of runoff on the dumps and slopes will be profiled to encourage runoff and prevent seepage. Capping, profiling and re-vegetating inactive dump areas will also control seepage.

3.8.3. Heap Leach Pads

A heap leach pad area of approximately 125ha will be divided into two pads, one at Mutanga and the second one at Dibwe (refer to **Figures 1061-LO-002A** and **1061-LO-002B** in **Appendix 8**. The area will be used for leaching of the mined ore for the life of mine.

The Leach pad will store three lifts of agglomerated ore, each 4m in height (12m high), subject to final designwork. A geo-textile non-woven impermeable layer will be laid at the base of the leach pads consisting of two layers with an internal leak detection system.

The ore will be deposited on the heaps via a mobile stacking system of conveyors and feed chutes. Moisture content of the agglomerated Ore will be maximised as much as possible to reduce dust, but maintain competency of the agglomerated Ore. This will be done by mist sprinkling systems overhead, along the conveyors.

Sulphuric acid solution will be dispensed through a series of drip lines spaced across the Ore Heaps. The Pregnant Liquor Solution (PLS) will gravitate to the base of the Pads and will be channelled into lined drains. The drains will direct the PLS into the PLS Storage Pond designed with a storage capacity to cope with the 1:100 year storm event.

An intermediate PLS pond will act as a sediment trap for suspended material in the PLS. A barren water pond will act as a reservoir and collect contaminated runoff from the PLS ponds to prevent spills. The three ponds will be lined with impermeable geo-textile non-woven liner.

The potential generation of dust from the leach pads during operations is considered to be low due to the damp nature of the material, the mineral crust that will probably form at the surface of the dumps and shielding measures from surrounding vegetation. Capillary action based on high solar influxes will lead to surface evaporation of water from the heaps. The leach pads will be monitored, visually and quantitatively as part of the monitoring program.

A fence will be erected around the two leach pads to prohibit public access. Security will be provided at the entrance to the facility by the mine security contracted for the Project.

3.8.4. Process Plant, Workshops, Fuel Storage Facilities and Mine Offices

The process plant, workshops and mine offices will be located approximately 350m south of the Mutanga open pit. The layout of the Processing Facilities, Workshops, Fuel Storage Facilities and Mine Offices is shown in **Figure 1061-LO-002A** in **Appendix 8**. The site will cover approximately 7.5ha. The main offices and workshops will be enclosed within a security fence and the process plant and uranium oxide concentrate storage shed will be enclosed within an internal security area.

3.8.5. Raw Water Tank

A Raw Water Tank (RWT) will be installed at the process plant to store water for all activities in the Plant, the administration offices, workshops and stores. The water will be used to make-up process water for the process plant. The tank will have a storage capacity of 150m^3.

3.8.6. Operations Camp

An operations camp will be constructed at the mine site, approximately 4km from Mutanga open pit, to accommodate all mine employees while they are on roster. The Operations Camp will cover an area of 13.5ha and will provide accommodation for a maximum of 454 people including employees (refer to **Figure A and Figure 1061-LO-101-A** in **Appendix 8**). A total of 35 accommodation units will be developed. The camp will be accessed via a 6m wide sealed road.

The dining area will be located at the Operations Camp with a kitchen. A recreation centre will also be developed with a pool, common TV and games area, tennis court and gym.

A network of water supply and sewage treatment will be developed during construction.

3.8.7. Zyiba Meenda Access Road

The Zyiba Meenda road will access the mine site from Lusitu Village along the Siavonga road. The Zyiba Meenda road has undergone an initial de-mining exercise in conjunction with ZMAC. The road will be sealed and routed around the existing villages.

There are two villages which could potentially be affected along the road. The road will be re-directed from these villages to reduce impacts of dust, noise and safety on the communities. Access routes will be developed to the villages to maintain mobility of the communities along the road.

An EIS will be conducted by Consultant on behalf of DMZL prior to the development of the road (and powerline) in line with the provisions of the EPPCA, read together with SI No 28 of 1997 (EPPC Environmental Impact Assessement Regulations, 1997).

3.8.8. Powerline and Substation

The main Kariba electricity supply lines to Lusaka and the Copperbelt lie approximately 60km east of the Project site. The project will require approximately 9 MVA of electricity. A step-down substation will produce feed to transmit along a 66kV powerline along a similar route to the Zyiba Meenda access road. The powerline and substation Technical Assessments have been conducted by UtiLink in Lusaka. An EIS will be conducted for the designated route of the powerline prior to development activities.

3.8.9. Raw Water Ponds (RWP)

The RWPs will be developed to store approximately 44,000m^3 and 46,000m^3 of raw water at the Mutanga and Dibwe ponds respectively. The water in the ponds will be obtained from direct rainfall and dewatering boreholes. This water will be pumped to the water treatment facility near the process plant for purification and treatment. Drinking water is required for all offices and ablutions and clean water is required for the process plant.

The water pipelines will be laid into an unsealed drain incorporated with a series of troughs and reservoirs to collect spilled water. Daily inspections will be conducted along the pipelines to monitor leaks or failures.

The dewatering water from the boreholes will be stored in the unlined RWPs to enable reinjection into the groundwater system.

3.9. Mining Method

The Mutanga and Dibwe open pits will be developed using standard ‘free digging’ open pit techniques. The Ores and Overburden material are very friable to pressure , hence blasting is not necessary.

The Mutanga Open Pit generally has higher U_3O_8 grades than Dibwe and will be developed first. The total amount of material removed from the two Pits will be approximately 64.5Mt. This will comprise of 18.8Mt of ore and 45.7Mt of waste with an average strip ratio of 2.3 over mining operations.

The Pit areas will be cleared of vegetation and the topsoil stockpiled in a prepared area for re-vegetation activities at Mine Closure Stage. The Mineralisation in Mutanga is near surface and very little stripping will be required.

The Mutanga pit will be approximately 750m long by 550m wide and orientated Northeast-southwest. The pit will have an average depth of 60m. **Figure 3.7** shows the designed layout of the Mutanga pit.

The Dibwe pit will be approximately 1,550m long by 350m wide and orientated in the same direction as the Mutanga pit. The Dibwe pit will slightly deeper with an average depth of 120m. The Dibwe pit is approximately 10km southwest of the Mutanga pit. **Figure 3.8** shows the designed layout of the Dibwe pit.

The mining will be done using machinery suitable for selective mining and to keep dust emissions to a minimum. The ore will be dumped into trucks and hauled to the crusher and agglomerator. At the exit of the pit ramps a mist sprayer and radiation meter will be installed through which ore and waste trucks will be screened to ensure appropriate dumping of near barren material. The ore will be directed into the crusher or stockpiled on a small run-of-mine (ROM) pad.

The average ore mining rate will be approximately 2Mtpa and an approximate feed grade of 315ppm U_3O_8 will supply the process plant.

The waste rock will be transported to the Mutanga or Dibwe WRDs and dumped in accordance with a dump development program, designed to industrial best practice (refer to **Section 3.8.2**).

Some waste rock may be backfilled into the pits during later operations. This will reduce the amount of material stored in the dumps.

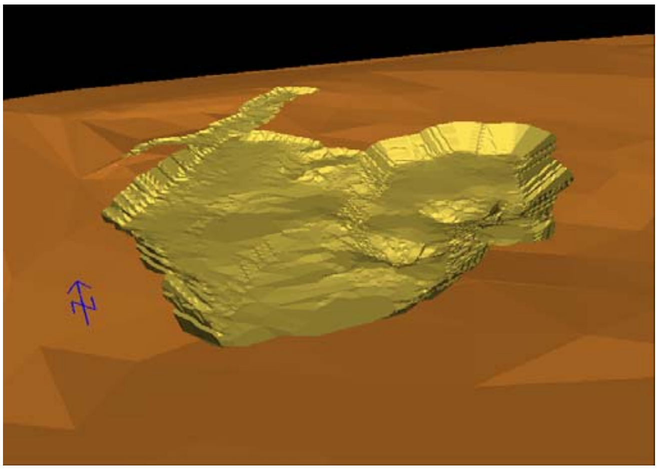


Figure 3.7 Mutanga Open Pit (Source: MDM, 2007)

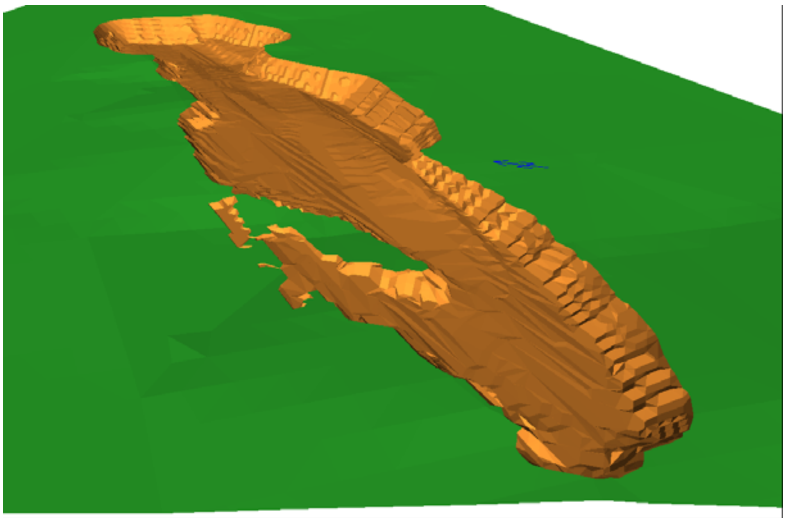


Figure 3.8 Dibwe Open Pit (Source: MDM, 2007)

3.10. Process Description

The detailed layout of the processing facilities are shown in **Figure 1061-LO-002A in Appendix 8**. The PLS solution will be delivered to the process plant PLS storage tank. A process flow sheet is shown in **Figure 3.9** below.

Primary Crushing

The ROM ore will be fed into the ROM hopper by direct tipping. The ore will be fed from the ROM bin by an apron feeder into an MMD sizer. The oversize from the Sizer feeds into a Bunker where a Mobile Rock Breaker reduces the size and the material is returned to the circuit. The undersize is fed to the Cone Crusher Feed Conveyor.

Tramp metal will be removed using magnets prior to Ore feeding into the Cone Crusher. When metal is detected the Feed Conveyor will bypass the Pebble Crusher for a set period and bypass ore will feed into the recycle Crusher Surge Bin.

The feed to the Pebble Crusher will be controlled by a Vibrating Feeder. The ore will be crushed from a maximum of 100mm diameter to P_{80} of 25mm.

All Ore transfer points and operator areas will be provided with low energy Venturi Type Wet Scrubbers. The dust scrubbed will be recycled to the Agglomerator.

Agglomeration

The Recycle Crusher product discharges onto the Agglomerator Feed Conveyor with the new feed and acid leach solution is used to agglomerate the dry crushed Ore. The Agglomerator will operate on a variable speed control to allow cost effective and consistent processing of the different ores types and blends.

The agglomerated product will discharge onto a Vibrating Screen and undersize (<25mm) will be recycled to the Agglomerator. The agglomerated product will feed onto the Stacker Conveyor on the Mobile Stacker Unit on the Leach Pad.

Heap Leaching

The Mobile Stacker Unit will consist of a series of hooded Conveyors that will transport the agglomerated Ore to the Leach Pad and stack the ore into heaps. The Conveyors will be wetted with a fine mist spray system to reduce dust generation.

The Leach Pads will cover a total area of 125ha and will operate in four month units (one pad leaching and the other in operation). The heaps will be constructed using a herring bone under-drainage system of HDPE perforated pipelines to collect the PLS. The perforated pipe will be covered with coarse stone and sand to prevent clogging. The pads will have a double liner containment system, with an intermediate leak detection. The liner will consist of geo-textile non-woven material.

The PLS will drain through the under-drainage system to the PLS storage dam. An intermediate PLS storage dam and a barren solution Storage Dam will be adjacent to the PLS storage dam. The 3 ponds will be designed with a storage capacity to cope with a 1:100 year storm event and will be double lined to prevent leaks. The PLS solution will be pumped from the PLS storage dam into tankers and transported to the process plant at Mutanga.

An Emergency Containment Pond (ECP) will be constructed adjacent to the leach pads to contain emergency overflows during rainfall events.

Clarification and Adsorption

A hopper clarifier system will remove entrained solids in the PLS prior to feed into the Continuous Ion Exchange (CIX) circuit.

The PLS will be clarified and fed to an Ion Exchange Carousel where absorption, elution, washing and conditioning occurs. The process is controlled by step frequencies based on Uranium Concentration, which is monitored by the in-line XRF unit.

Barren liquor will be used to hydrate flocculants and provide sealing fluid for slurry pumps.The containers will be made of carbon steel or low grade stainless steel dependent on the solution properties.

The flooring in the ion exchange facility and the elution tank farm will lined with acid resistant materials. All spilled solutions will be captured in plant sumps and returned to the process solutions.

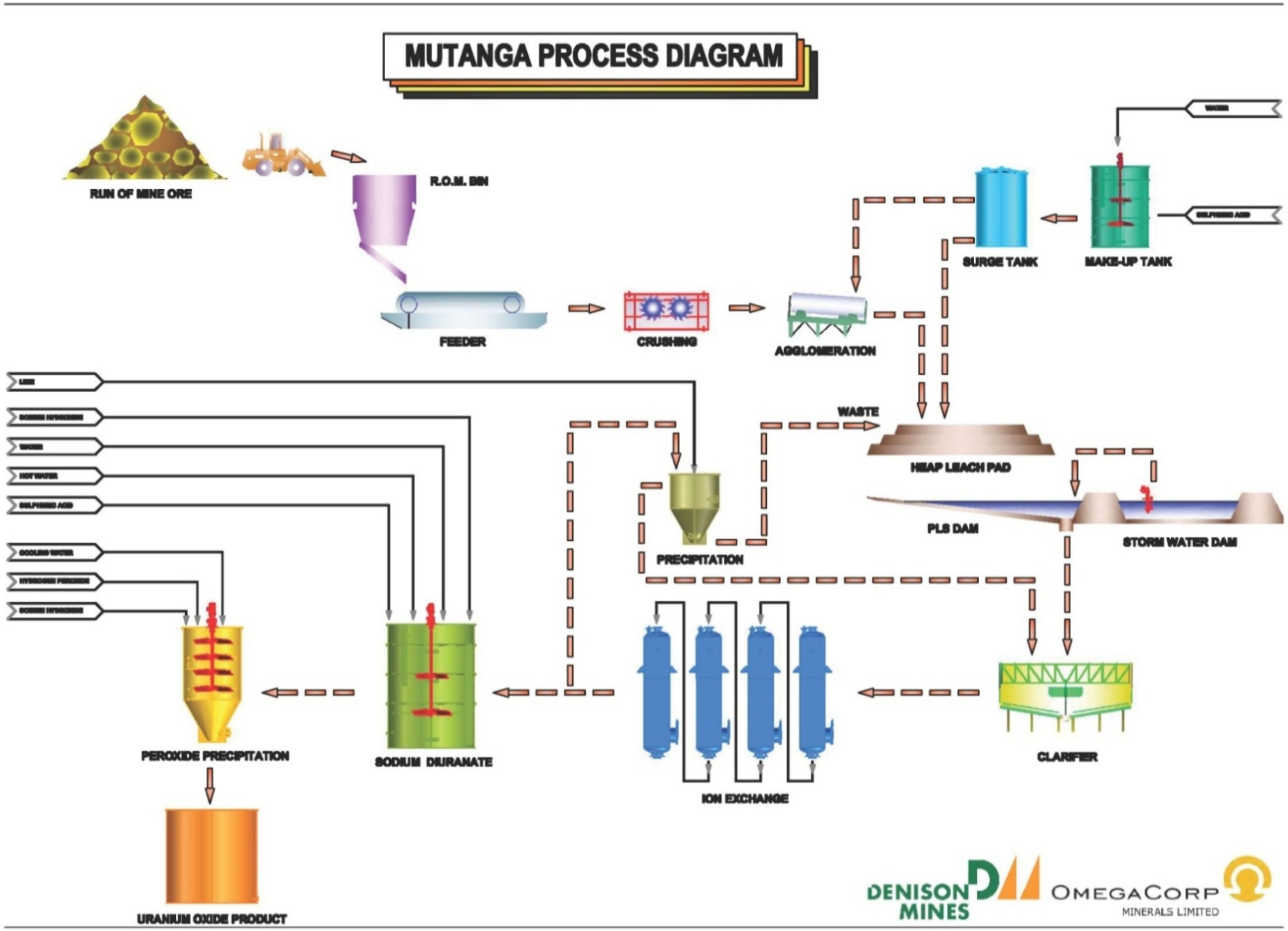


Figure 3.9 Process Plant Flow Sheet

Primary, Secondary, Tertiary PLS and CIX Elution

The PLS is passed through a clarification Circuit where the feed liquors are polish filtered. The Primary PLS (from scrub circuit) and the Secondary PLS (from Leach Circuit) are clarified and fed continuously to an Ion Exchange Carousel where adsorption, elution, washing and conditioning occurs in stages. The controls are similar to the Stage 1 Clarification and Adsorption.

The concentrated eluant is fed to the refinery. The barren liquor is used to hydrate flocculants and provide sealing fluid for slurry pumps.The Stage 2 Clarification circuit will reduce the concentration of impurities such as vanadium.The concentration ratio of PLS feed to concentrated eluate has been designed to exceed 70.

CIX Resin Handling

The CIX resin from the elution circuit will be washed and re-cycled in the process plant. The used resin is washed via a Vibrating Screen and new resin is released via the Venturi System.

Sodium Diuranate Precipitation

The Dissolved Uranium in the concentrated eluate is precipitated using Sodium Hydroxide at a fixed temperature. Sodium Di-Uranate (SDU) crystals are added to the Precipitation Tank. The SDU slurry is then pumped to the SDU thickener.

The SDU is thickened and washed in Settlers. The barren SDU Liquor is combined with Carbon Dioxide (CO_2) to form fresh eluate which is added to the Primary PLS and returned to the Ion Exchange Carousel.

The process liquors from the thickening and washing Circuits are filtered through the Polishing Filters and Uranium is recovered from an in-situ leach using Sulphuric Acid (H_2SO_4).

The refinery circuit is in an enclosed secure area designed using the ‘bottle and cork’ principle. This improves employee health, safety and product security.

Extractor air equipment will have a target air quality index (AQI) of 2mg/m^3.

The SDU washing circuit consists of 4 Wash Settler units using raw water.

SDU Polishing Filtration

The washed SDU is filtered and rinsed with SDU thickener to remove impurities. This produces an SDU Filter Cake.

SDU Resolution Circuit

The SDU filter cake is re-pulped and re-dissolved with sulphuric acid.

Uranium Oxide Precipitation

The dissolved SDU solution is then oxidised and precipitated with the addition of Hydrogen Peroxide.

An Off-White Oxide is produced which is thickened and washed in a 2-stage Decanter Centrifuge. The Oxide is dried using a Partial Vacuum and De-lumped, sampled and drummed in 200lt/500kg Drums.

The barren SDU solution will be polish filtered and returned to the leach circuit for Uranium recovery.

Other Facilities

Other facilities at the process plant include:-

- Primary Centrifuge – moisture removal;
- Secondary Centrifuge – moisture removal;
- Concentrate polishing filtration;
- Vacuum Pan Drier – final moisture removal;
- Recovery and Refinery Vent Scrubber – removal of mineralised dust (uranium and SDU);
- Raw water – sourced from mine borefield and water used to make-up process water and reagents;
- Process water – all water used in the process plant or contaminated sources;
- Water treatment plant – raw water will be filtered for potable water and polishing water, process water will be treated by limestone precipitation to remove ion build-ups in the circuit, gland water will be produced through filtration of raw water, potable water will be produced after demineralization (polishing water) and chlorination (potable water) by a reverse osmosis plant;
- Plant cooling water – water from an evaporative cooling system;
- Plant Hot Water Generator – passing raw or process water over a heat exchanger;
- Sewerage Treatment Plant – will facilitate the mine and the plant and will have aerobic and anaerobic digesters followed by filtration and chlorination. Treated water will be released to the environment.

3.10.1. Plant Water

Raw water will be obtained from the mine borefield and stored in the Raw Water Tank. Raw water will feed the potable, gland and fire water systems. Raw water will be pumped to the process and clean water ponds at the Process Plant.

The following water circuits will be reticulated:

- Raw water recovery;
- Fire water (employing raw water);
- Raw water filtration;
- Potable water (for ablutions, safety showers, etc.);
- Demineraliser plant (reverse osmosis);
- Cooling water (employing potable water); and
- Process water.

Process water will be returned from the barren CIX solution and be utilised in the agglomeration circuit.

Raw water for make-up will be delivered to the HDPE lined raw water pond at the process plant. Raw water will be pumped to areas of usage:-

- Crusher area for dust suppression;
- Elution circuit for making up eluant and eluate solutions and resin transfer;
- Reagent make up for making up fresh carbonate and bicarbonate solution.

Potable water will be generated by demineralisation and chlorination of raw water. It will also be used for fire fightng and safety showers.

Contaminated site run-off will be contained in one or more attenuation ponds. The ponds will have a storage capacity for a 1:100 year storm event. The ponds will be emptied periodically. The water will be returned to the process water system and solids will be disposed of on the leach pad.

3.10.2. Plant, Instrument Air and Gases

A compressor will provide plant and instrument air with a backup compressor. Instrument air and process air will be reticulated. Oxygen can be produced from low grade ~94% product from molecular sieve process or cryogenic.

Radon will be emitted from the ore fed into the process plant and gas levels will be monitored throughout the plant to ensure employee safety.

3.10.3. Chemicals and Reagents

The reagents that will be used in the process plant are shown in **Table 3.8** below. Annual consumptions will be determined during the definitive project design. The Material Safety Data Sheets (MSDSs) are attached in **Appendix 3**.
Hydrogen peroxide will be transported and stored in iso-tainers and pumped to the refinery as required.

Table 3.8 Reagent List for the Mutanga Plant

Reagent	Common Name	Formula	Form for Storage
Sodium Carbonate		Na_2CO_3	Granular
Sodium Bicarbonate			
Sodium Hydroxide	Caustic Soda	NaOH	Pearl
Sulphuric Acid		H_2SO_4	
Calcium Oxide	Hydrated lime	CaO	
Hydrogen Peroxide (60%)		H_2O_2	Liquid
Sulphuric Acid		H_2SO_4	Liquid
Flocculant			Solid

Sulphuric acid is received at 98% grade. The standard storage and dispensing system will be used for this reagent. All incoming vehicles will be subjected to a wheel wash.

Hydrated lime will be available in the event of a spill and will be used to neutralise the acid and minimise environmental damage.

Flocculant will be hydrated in a flocculation plant in the reagents make-up facility.

3.10.4. Plant Products

The processing of the U_3O_8 ore through the CIX plant produces a Uranium Oxide precipitate concentrate in the form of an ‘off-white’ solid. The concentrate produced is an oxidised form of Uranium and it is dried in the primary and secondary centrifuges and packed into 200L (500kg) drums with secure fastening devices for sale and export. The drums will be stored on site in a secure area awaiting transportation. The Zambian Uranium Mining Regulation of 2008 requires the development of a ‘Procedure for the Storage of Uranium Concentrate’. This procedure was developed by Mr Koatane of Zimkile Consulting and is attached in **Appendix 4**.

There are important security aspects associated with the transportation of Uranium Oxide Concentrate across international borders. Therefore in compliance with the Zambian Uranium Mining Regulation of 2008, a ‘Procedure for the Off-site Transport of Radioactive Materials’ was developed by Mr Mogwera Koatane of Zimkile Consulting T/A and is attached in **Appendix 5**.

Appendix 2 shows an IAEA Implementation Guide for Security in the Transportation of Radioactive Materials. DMZL is in the process of discussing with the Government and all the Stakeholders in developing a dedicated plan for security in Transport for Uranium Concentrates from Mutanga once the mine is in Operation.

The isotope U^{235} is the main provider of the energy in a Nuclear Power Plant but it has low natural concentrations. Therefore an enrichment process using Uranium Oxide Concentrate is carried out to increase the natural levels from 0.71% to 3%.

3.10.5. Waste Products

Several types of waste will be generated by the process plant during construction, operations and closure of the Mutanga Project (see **Section 3.12**). Mining activities for Uranium (a radioactive material) may release this material to the environment. The low concentration of U_3O_8 in the ore limits the doses of exposure but potential contamination may occur.

Radiological Waste

The potential sources/forms of radiological waste are:-

- Contaminated scrap from processing equipment;
- Leached ore material from the leach pads;
- Contaminated process water solutions;
- Contaminated sludge generated during water treatment at the plant;
- Fines generated from the SDU precipitation and polishing circuits;
- Slightly mineralised waste rock; and
- Dust emissions from ore transfer points and storage areas.

The management of radioactive waste generated during the project will be done in accordance with the ‘Radioactive Waste Management Programme’ in **Appendix 6**.

3.11. Mine Services

3.11.1. Security

Mine security main offices will be located on the administrative and process plant site. The mine security will control access to the mine offices as well as the processing areas. Security posts will be erected at all gates.

Security will be stationed at various locations throughout the project site to monitor safety and security issues. The leach pads will be equipped with security personnel.

All visitors to site will undergo an induction training course on safety and health at Mutanga and will be issued with identification tags. Visitors will be escorted around the process plant and storage areas and be supplied with protective equipment where necessary. No unauthorised persons will be allowed access to mine facilities and security will remove any violators.

3.11.2. Stores

General Store

A general store will be constructed with a roof and impermeable flooring. Emergency equipment, e.g. fire fighting eqipment, will be installed in the facility.

Mobile Equipment Store

A mobile equipment store will be constructed with a roof and impermeable flooring and will be attached to the mobile equipment workshop. Emergency equipment, e.g. fire fighting eqipment, will be installed in the facility.

Reagent Store

A reagent store will be constructed with a roof and impermeable flooring. The reagents will be stored out of direct sunlight and provided with bunded areas for storage of liquids. Emergency equipment, e.g. fire fighting eqipment, will be installed in the facility

Uranium Oxide Concentrate Store

The concentrate store will be a sealed building with strict access control to employees and the public to reduce exposure to ionising radiation. The concentrate drums will be stored in bunded areas and stacking minimised to prevent damage to the concentrate drums. The concentrate storage and management will be done in accordance with the Storage Procedure attached in **Appendix 4**.

3.11.3. Medical Facility

A mine medical facility will be staffed with qualified personnel. The facility will be located within the administration area. The mine will have an ambulance to be utilised in emergencies.

3.11.4. Fire Fighting

DMZL will purchase water cannons for the water bowsers that will be used for general water delivery and dust suppression. A volunteer emergency team will be developed to manage all emergencies.

3.11.5. Laboratory

DMZL will design and construct a Laboratory to accommodate the necessary testing of materials as required for the operation. The laboratory will consists of a sample preparation area, wet laboratory, atomic absorption spectrum room, balance room and sample store

3.11.6. Communications

A satellite communications network will be installed at the Mutanga Mine. The Very Small Aperture Terminal ("VSAT") system with a 2.4 metre antenna, will provide a permanent, reliable, cost effective solution for internet and voice communications. This system will also provide connectivity to the Denison Canadian Head Office and access to the international voice gateway in Europe. The VSAT system will provide wireless links to all the relevant infrastructure at the project site. .

Operational communications at site will be facilitated by the use of radios. The radio system will be a multi-channel VHF radio system catering for:-

- Security Channel;
- Mining Channel;
- Plant Channel; and
- Co-ordination Channel.

Portable radios, with external mast antennas, will be installed in the main office complex. Fixed radios will be installed in the light vehicles that will be operating in the pit. Handheld radios will be issued to all staff down to foreman level. A license and an application for frequency space will be made to the Communications Authority (CA) once construction commences.

Mobile telephone communications are possible around the majority of the project area due to the expansion of the Zain network in the area.

3.12. Site Water Management

Site water management is important to prevent adverse impacts on the quality of adjacent watercourses and groundwater. DMZL will implement a Mine Water Management Plan which is attached in **Appendix 7**.

The management plan will focus on the following:-

- Separation of clean and dirty water;
- Treatment of mine effluent and surface run-off prior to discharge to the environment;
- Where practicable, reduce raw water consumption, maximise re-cycling of waste water and reduce the volume of effluent discharged to the environment;
- Regular inspection and maintenance of the mine site drainage system and pollution control facilities;
- Regular monitoring of surface water, effluent streams and flow rates, and groundwater quality;
- Compliance with the Zambian drinking and effluent water quality standards and other relevant guidelines for effluent discharge to surface waters;
- Preparation of formal emergency response procedures in the event of a plant spill; and
- Development, and regular updating of the site water balance in order to effectively and efficiently manage the water resources across the mine site.

A detailed site water balance was developed during the feasibility study to attempt to quantify the main water pathways, storage areas, consuming activities, system losses etc.

3.13. Waste Management

All waste will be separated and classified. These classes will determine the management requirements to be implemented. The main categories of waste that will be generated by the Mutanga Project are:-

- Radiological;
- Hazardous; and
- Non-hazardous.

Further discussion of the waste management classes are described in Section waste classification and management descriptions are described in **Section 9.4**.

Radiological Waste

This is waste that is contaminated with radioactive materials and may pose a threat to the environment or human safety. Types of this waste are, and not limited to:-

- Slightly mineralised Waste Rock;
- Leached ore on the leach pads;
- Contaminated scrap;
- PLS solution from the leaching circuit;
- Contaminated runoff from the project facilities;
- Sludge from the water treatment plant cleaning contaminated mine water;
- Wash residue from the SDU precipitator and polishing sections; and
- Damaged uranium Oxide Concentrate Storage Drums.

This waste will be characterised and managed in accordance with the Radioactive Waste Management Programme (**Appendix 6**)

Hazardous Waste

This waste is toxic waste that is not contaminated with radioactive material. Examples of this waste are:-

- Used oil, fuel pumps, batteries and contaminated sand/sawdust and cloth from workshops;
- Oil contaminated surface runoff;
- Sewage and contaminated effluent; and
- Medical waste from the clinic.

Non-hazardous Waste

Non-hazardous waste is considered to be inert, biodegradeable or recyclable. Examples of this waste are:-

- Plastic, glass, paper, wood and rubber products;
- Bio-degradeable organic matter, waste food;
- Uncontaminated scrap metal;
- Spare reagent containers; and
- Treated sewage sludge.

3.14. Mine Contractors and Services

Contractors will be employed by DMZL for the catering, mining and transport activities. Where feasible local contractors with the capacity to conduct the service will be employed and the contractor's agreement will emphasise the employment of Zambian personnel. All contractors and subcontractors will be expected to comply with the DMZL's corporate Environment, Health and Safety Plan (**Appendix 1**)

During construction the requirement for skilled contractors will be high. Based on the initial low levels of mining skills in the project area some expat contractors may be required for initial training purposes.

A budget will be allocated by DMZL to the training and localisation of the use of contractors. Training will begin in the construction year. An annual review of the progress of the localisation training will be conducted and submitted to the Ministry of Mines.

3.15. Infrastructure

3.15.1. Roads

The site can be accessed from Lusaka via the main Kariba North road which branches from the Lusaka-Chirundu road at the base of the Zambezi Escarpment. The Lusaka Chirundu road is a major route connecting South Africa, Zimbabwe, Zambia and the Democratic Republic of Congo. As such it is usually heavily congested especially during daylight hours.

The roads within the permit area are in a state of disrepair and access is difficult especially during the rainy season. All access routes are dirt tracks after the Siavonga Road.

The Kariba North road is less congested and in a fairly good state of repair. Access to site from the south is via the district road to Changa Village (off the Kariba North road), locally called the Lakeshore Road for 39km. This route is not tarred or graded and access can be difficult especially during the rainy season.

The Zyiba Meenda has recently undergone de-mining activities and clearance of the road was successful. This road is approximately 36km but is inaccessible in the rainy season.

3.15.2. Electricity

There is no electricity supply at the project area but power is available in Siavonga and Chirundu. The main 330kV supply cables pass to the east of the permit area and at their closest are approximately 20km from Mutanga. Discussions with ZESCO have confirmed that power is available from Chirundu. A 65km 66kV powerline will be constructed from Chirundu to Mutanga.

3.15.3. Water Supply

There is no water supply system onsite and very little surface water flowing throughout the year. Currently villages rely on boreholes with handpumps or hand dug pits. The villagers in the Mutanga area have dammed seasonal channels to store rainfall for livestock and vegetables.The water supply for the project will be provided by a groundwater bore field.

3.15.4. Local Services

The nearest town is Siavonga, approximately 38km southeast of the site. There are two service stations, a post office, local hospital and several small shops, including a bakery, that provide basic supplies.

There are few services in the villages affected by the project. Matuba Community School provides primary education. There are a few shops and a private small hotel/lodge in the villages. There are no clinics or Rural Health Centre's (RHC's) in the Mutanga area.

4. PROJECT ALTERNATIVES

4.1. Mining Method

There are two options to consider when developing a mining project:-

Underground mining is usually carried out with an access box-cut from the surface. A decline is mined to access the orebody and mining may be carried out through several methods (e.g benching and stoping method). Underground mining is usually undertaken where an identified orebody is deep under the surface which would lead to high strip ratios for open pit mining methods, and there are reasonably competent ground conditions.

Open pit mining is carried out using load and haul excavation methods to access outcropping or near surface orebodies. The Dibwe and Mutanga orebodies lie close to the surface and further exploration at Dibwe West, Dibwe North, Mutanga East and Mutanga West have identified these areas to have fairly shallow mineralisation.

For the Mutanga Project the open Pit Mining methods are more viable and suitable. The Uranium mineralisation is present as very friable rock and blasting will not be required. The general location of the open pits is pre-determined by the location of the Uranium Orebodies. The size and shape of the open pit is determined by characteristics of the orebody and the surrounding geology.

4.2. Metallurgy

Historically, the preferred metallurgical process for the extraction of Uranium has been Acid Leaching. Hydrogen Peroxide can be used to oxidise the Uranium once it is in solution to produce an 'off-white' concentrate which can be packed into sealed drums for sale. This method was initially shelved based on the potential environmental impacts and the availability of reagents. Acidic Leaching can mobilize other toxic heavy metals as well as Uranium and these could be highly contaminating once spilled into the environment. There are very low concentrations of heavy metals at Mutanga.

The alternative process uses an alkaline leach solution. Sodium Carbonate and Bicarbonate are used to leach the Uranium from the Oxide Ore and then Hydrogen Peroxide is used to precipitate the Uranium into a concentrate suitable for transport in drums. This choice was initially preffered based on environmental benefits and availability of reagents. However, testwork has shown that the project becomes very expensive in the process plant, recoveries are very low and the tailings generated do not drain. Therefore the Acidic Heap Leaching on Heap Leach Pads will be conducted.

4.3. Waste Rock Dumps

Two waste rock dumps will be produced from the Mutanga and Dibwe open pits. One Waste Rock Dumps will be located at each of the two, Mutanga and Dibwe.The dumps will cover approximately 85ha. The dumps will be designed with best industrial practice in mind and proximity to the open pits to reduce the high costs of haulage. The dumps could become sources of contamination of heavy metals to the soils in situ (e.g Uranium, Iron, Phosphate, Aluminium etc) and may contaminate surface runoff. The footprint of the dumps will be reduced as far as possible by conducting in-pit dumping or backfilling, where possible.

Several locations were considered to identify the optimal locations for the waste rock dumps.

4.4. Leach Pads

Two Leach Pads will cover a total area of 125ha, with one Pad at Mutanga and another at Dibbwe. The current locations have been chosen based on their proximity to the open pit, and topography. Further assessment of the location and the design are to be conducted.

4.5. Raw Water Ponds

The sites chosen for the location of the Raw Water Pond (RWP) are located in the ideal location for a cross-valley dam. The location of the sites has proved to be favourable during assessments of foundation and structural integrity. There are faults identified under these structures so that excess water can be injected underground. The RWPs will not be lined.

4.6. Access Route

There were three possible access routes identified through initial site visits for planning the mine layout as described in section 3.2 above.

The northern access route stems from the Kariba North road and travels southwest towards the village of Changa. This road branches to the southeast before reaching Changa Village and then travels past the Mutanga outcrop (42km).

The southern access route is termed as the “Lakeshore Road” and can be accessed 2kms out of Siavonga along the Kariba North route or from further north approximately 24km north of Siavonga along the road to Simamba Village. There are some villages located along this route and has fairly frequent traffic along the “Lakeshore Road”.

The Zyiba Meenda (36km long) route is located approximately 42km north of Siavonga and branches from the Kariba North road past Lusitu River. This route has undergone inital de-mining activities and is the preferred access option. There are two villages along the route which will be diverted around during construction of the road. DMZL discussions with these villages about the diversion being conducted to prevent dust and noise led to their agreement.

4.7. Mine Village

The alternatives for mine employee housing for the project were identified as:-

- Option 1 - The development of an Operations Camp onsite to house mine employees. Houses and facilities would be developed in Siavonga for weekly recreational use for senior staff;

- Option 2 – Construction of the Operations Camp where all employees will be accommodated on site on a single basis and sufficient recreational facilities provided; and

- Option 3 - Development of housing in Siavonga and daily transport provided to the mine site. Houses would be purchased and renovated for mine employees or new houses would be constructed. It is more likely that houses would need to be built in Siavonga due to its small existing population.

Option 2 was considered to be the viable option due to the time savings incurred by the onsite status of the employees, through efficient use of operational hours. The trip from Mutanga to Siavonga takes approximately 2 hours or more on the current status of the road and the "Lakeshore Road" will not be the main access road.

4.8. "No Project" Option

If the "no project" is opted for, then there would be less growth and development in the mining industry in the southern region. The existing road infrastructure in the area is poor and would not attract investment into the area. There are no service industries in Siavonga with few shops and a small tourism industry. HIV/AIDS is a problem in the area due to the import and export of goods through Chirundu and Kariba. The local municipal services are overstretched at present.

The project will inject a comparatively large investment into the area through the employment of the local population, payment of salaries and the purchasing of local goods (some fresh foods and work clothing). The upgrading of the roads that will be used by the mine, the potential to allow easier access to water and electricity and the encouragement for the development of further service industries in the local region will lead to massive economies of scale and benefits will be felt regionally and nationally. Active community development projects will be developed during the lifetime of the mine to encourage sustainable development of the region.

5. ENVIRONMENTAL BASELINE STUDY

5.1. Environmental Baseline Study Area

The Environmental Baseline Study area is the are over which environmental and social data collection was conducted for the development of the EIS. This is the area shown in **Figure B** in (**Appendix 8**)

The social area of influence of the Mutanga Project is larger than the bio-physical area of influence. Consultations with the local Communities affected by the Project as well as local Government administration and stakeholders in Siavonga was conducted.

As part of the EIS study, the baseline environmental mornitoring was carried out between January 2008 and March 2009.

5.2. Scope of Work

The scope of work for the Environmental Baseline Study (EBS) included:-

- A desk study of all the available information on the project area;
- Visits to Government Departments, Non-Government Organisations, Local Authorities and other relevant Authorities; and
- A survey/study of the physical, chemical, biological, socio-economic and cultural environment including: -
  - ⇒ Topography;
  - ⇒ Climate;
  - ⇒ Local Hazards;
  - ⇒ Noise and Vibration;
  - ⇒ Air Quality;
  - ⇒ Radiation;
  - ⇒ Local Traffic;
  - ⇒ Geology;
  - ⇒ Soils;
  - ⇒ Hydrology;
  - ⇒ Hydrogeology;
  - ⇒ Flora and fauna; and
  - ⇒ Socio-economic and cultural aspects, including infrastructure and communications.

AMC developed the Terms of Reference (TORs) document for the EIS in 2007, which was subsequently approved by the Environmental Council of Zambia (ECZ) (TORs are attached in **Appendix 9**.

5.3. Environmental Team

The environmental and social study team consisted of:-

- Miss Angela Duerden - BSc. Environmental Science, AMC;
- Mr Geoffrey Siame - MSc. Environmental Engineering, AMC;

- Mr Joshua Kambafwile – Post Grad Dip. Environmental Management, AMC;
- Mr Benard Gomo Tembo – BEng. Environmental Engineering, AMC;
- Mr Mitulo Silengo – PhD Environmental Resources, LEAD, Southern Africa;
- Mr Lishomwa Mulongwe - BSc. Forestry, Division of Forest Research;
- Mr Keddy Mudingo - BSc. Forestry, Division of Forest Research;
- Mr Felix Chileshe – CGLI 735 Analytical Chemistry and Laboratory Management, Division of Forest Research;
- Mr Jassiel M'soka – Zambian Wildlife Authority, Chirundu;
- Mr Edward Chilufya – Zambian Wildlife Authority, Kafue;
- Mr Daniel Mwizabi - Zambian Wildlife Authority, Lusaka; and
- Mr Collins Chipote – MPhill Heritage Management and Conservation, National Heritage Conservation Commission.

5.4. Study Difficulties

The studies undertaken during the baseline data collection of the EIS experienced some of the following difficulties during implementation:-

- The timeframe for some of the initial studies conducted for flora, soils, archaeology was limited and shortened the available timeframe for the assessments to be undertaken;
- The literature review for many of the studies was restricted by the low representation of historical data for the Project area.;
- Field studies were short and dependant on availability of the experts; and
- The availability of appropriate analytical laboratories in Zambia for some of the parameters that were to be assessed was low.

5.5. Landscape and Topography

Topographic maps and satellite data were used to support field observations to describe the topography and landscape of the project area.

Regional Topography

The Southern Province lies predominantly between 1,219m (in the escarpment) and 473m (Lake Kariba) masl. The Mutanga Project lies south of the Zambezi escarpment and is situated in the Zambezi Valley at an altitude of aproximately 598m above sea level (masl). The topography of the Muchinga Escarpment is very pronounced with hills going as high as approximately 1,219m. The hills are inundated with seasonal drainage gullies and have marked visual impact on the hill slopes.

The general topography of the Mutanga region is drained by the Lusitu River with several smaller seasonal streams. The Machinga River flows across the North Road into the Lusitu River. The Nahunwe drains, south of the project area, the Dibwe area into Lake Kariba. The Zambezi River flows from west to east approximately 10.5km south of the project area.

Local Topography

The local topography is dominated by hills and valleys. There are many seasonal runoff gullies that develop during every rainy season as well as enlargement of existing gullies.

The Mutanga orebody is located on the edge of a hilly outcrop at 579masl**.** The hill trends southwest-northeast and is inundated with small seasonal drainage channels. There are few stream in this valley and they run mostlly on season basis. Machinga Stream is 2km north of the Mutanga open pit. The leach pad is located to the northwest of the pit.

The Dibwe orebody is located 10km southwest of the Mutanga open pit. The elevations for Dibwe range from 610 to 625masl. The leach pad and waste rock dumps are all located downhill from the pit.

The process plant is located on the same scarp as the Mutanga open pit in a shallow runoff area 1km from the scarp edge at 597amsl. Surface runoff flows from this area during the rainy season.

The Mutanga RWP (610m) is located in a runoff valley approximately 2km northeast of the process plant. The valley topography will be used as natural storage profile for raw water. The Dibwe RWP will be located approximately 2km southeast of the Dibwe pit.

Figure B Appendix 8 is a topographical map of the project area showing elevation and the main drainage. The Namatelo River receives drainage from the Dibwe hill from the Southern and Northern slopes which flows into the Nahunwe River. The Nahunwe River flows south into Lake Kariba. The drainage around the Mutanga pits flows into the Namatelo or in a northeasterly direction into tributaries of the Lusitu River. The Lusitu River then flows into the Zambezi River downstream of the Kariba Dam Wall.

5.6. Climate

There is no historical climate data for the site. Historical climate information was obtained from the Metorological Department, Lusaka for the Lusitu and Lusaka weather stations. Lusitu weather station is the nearest to represent the project site. A 30-year data set was available for the Lusaka Meteorological Station and a 9-year data set was available for Lusitu.

5.6.1. Regional Climate

The project area experiences a tropical climate. Hot and dry weather with mostly clear skies and little precipitation in the area is prevalent.The region has a distinct dry season (April to October) and hot summers bringing rainfall (November to March). The average annual rainfall in this region of Southern Province between 1977 to 2008 was 875mm.

5.6.2. Local Climate

The Lusitu Meterological Station was chosen as the closest station for determining weather conditions for Mutanga. Data was for the period between 1988 to 1997. Mutanga project is approximately 31km west-south-west of the Lusitu Station.

Rainfall

The region experiences rainfall between September and April.The highest rainfall occurs in January and February with the mean annual rainfall of approximately 529mm. **Figure 5.1** illustrates the precipitation statistics for the Lusitu Meteorological Station.

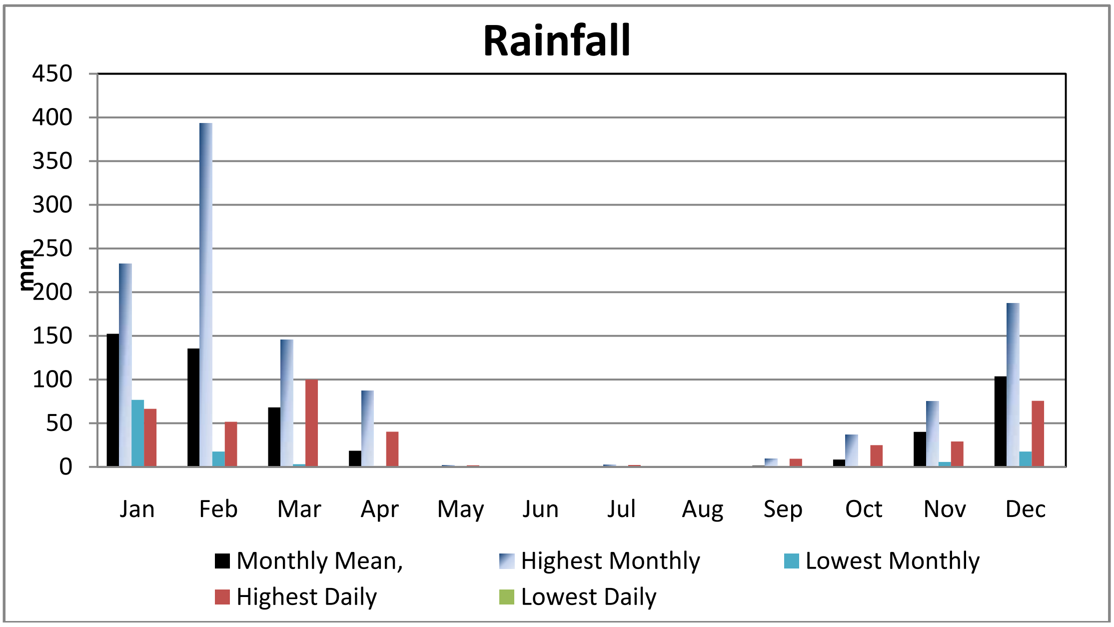


Figure 5.1 Precipitation Statistics for the Lusitu Meteorological Site

Maximum and Minimum Temperatures

The average annual minimum temperature is 20ºC whilst the average annual maximum temperature is 34ºC. The lowest minimum temperature recorded was measured in June 1994 at 12.4ºC. The highest maximum temperature recorded was 40ºC in October 1996. **Figure 5.2** below displays the temperature statistics for the Lusitu site.

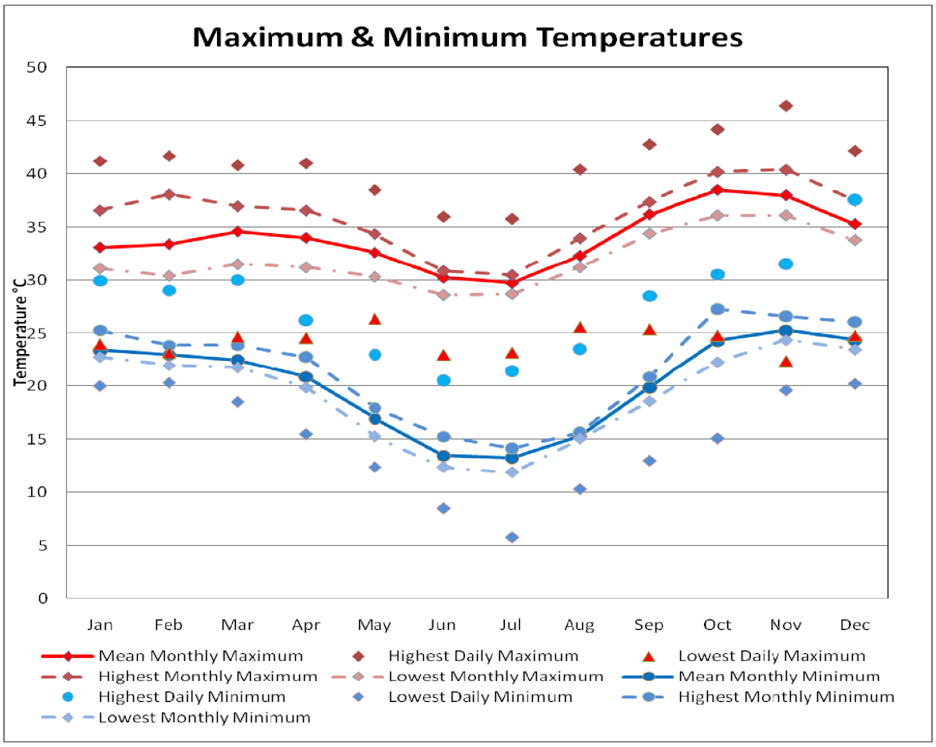


Figure 5.2 Maximum and Minimum Temperatures for Meteological Site (1988 – 1997)

Evaporation

The highest daily evaporation was recorded as 19.3mm in March 1989, with the lowest daily evaporation of 0mm in 1990 in January and February and 0mm in March 1992. The average total annual evaporation is estimated at 2009mm. **Figure 5.3** displays the evaporation statistics for Lusitu.

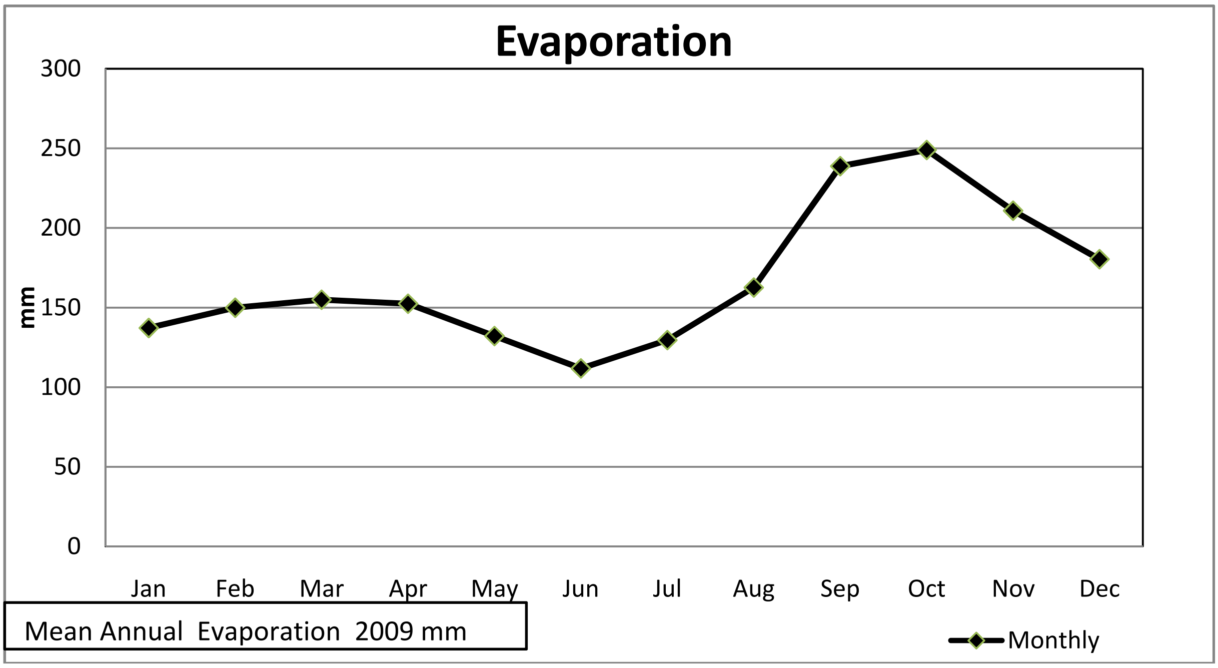


Figure 5.3 Evaporation Statistics for Lusitu Meteorological Station (1988 to 2000)

Wind Speed and Wind Gusts

The annual wind speed measured at Lusitu averages 5 knots. Highest daily wind speed regularly exceeded 10 knots in 1989, 1993 and 1995. The highest monthly wind speed was recorded as 8 knots in October 1993. The lowest monthly windspeed recorded was 2 knots in February 1990. **Figure 5.4** displays the monthly mean, maximum and minimum wind speeds.

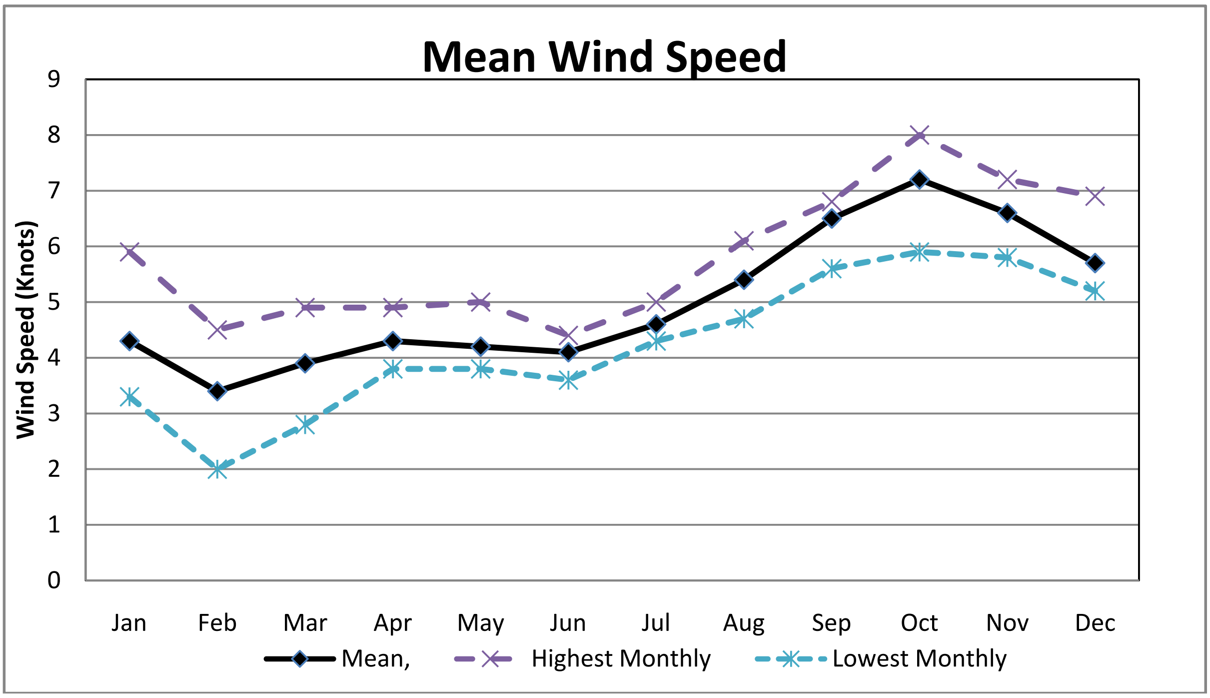


Figure 5.4 Wind Speed Statistics for Lusitu Meteorological Station (1989 to 1995)

Atmospheric Pressure

There is no data available for atmospheric pressure for Lusitu Met Station.

5.7. Local Hazards

Local hazards are associated with heavy winds, thunderstorms and fires, both natural and man-made.

Wind Gusts

Winds can cause large amounts of damage when their velocities are high and the bursts of energy are short. These are generally referred to as wind gusts. **Figure 5.5** shows the highest daily wind gusts recorded at the Lusaka Meteorological Station. The highest recorded wind gust was recorded in December 1976.

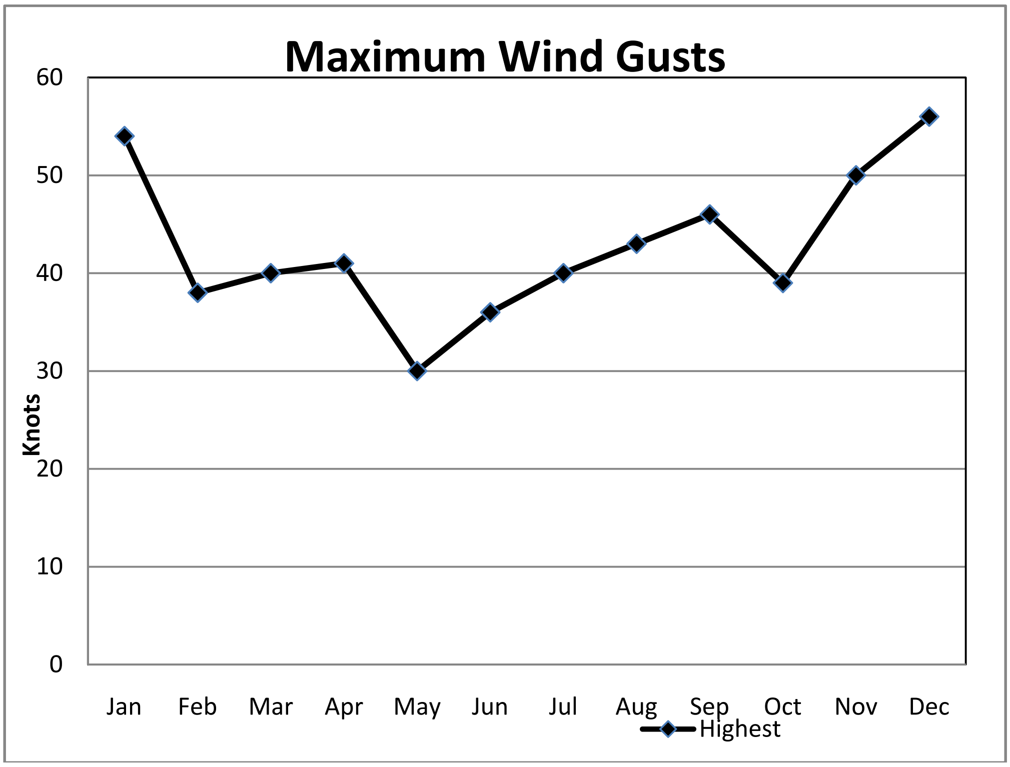


Figure 5.5 Highest Daily Wind Gusts Recorded at the Lusaka Meteorological Station (1967 to 2000)

Thunderstorms

Thunderstorms may occur in the rainy months such as November to March. Thunderstorms generally bring strong winds, lightning and heavy rainfall. Hail may occur in severe storms.

The strong winds may damage crops, huts and houses. Lightning strikes set off bush fires and occasionally cause death. Heavy rainfall results in flash floods along watercourses damaging crops, wooden structures and buildings.

The maximum daily rainfall with a 30 year and 100-year occurrence are shown in **Table 5.1** below. These were identified through industry experience using extrapolation methods and were obtained from MDM design information for the process plant. The data record in the regional area is only 8 years long and indicated the highest rainfall experienced as 100mm.

Table 5.1 Daily Rainfall and Return Periods for Lusitu

Return Period Years	Lusitu mm
30	135
100	200

Fire

Bush fires may be caused by lightning strikes or shifting cultivation. The vegetation is generally dry once the rainy season has finished and bush fires start easily. The cleared vegetation for new fields is cleared by burning. These fires may become uncontrollable and result in property damage and/or personal injury.

Seismicity

According to the Seismic Hazard Map of Africa in **Figure 5.6** (G. Grünthal, C. Bosse, Geoforschungs Zentrum, Potsdam, Germany) there is a 10% probability of a peak ground acceleration of between 0.4 to 0.8 m/s^2 being exceeded every 50 years in the project area. This is considered to be a low seismic hazard for the Mutanga Project.

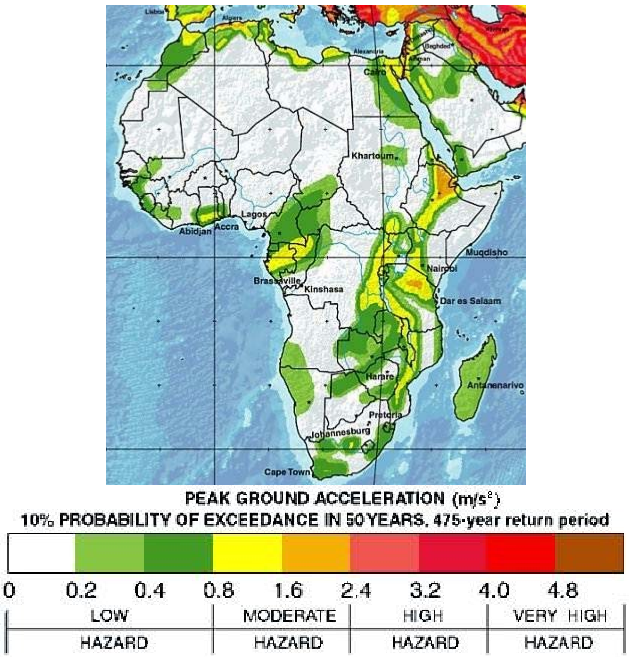


Figure 5.6 Seismic Hazard Map of Africa

(G. Grünthal, C. Bosse, Geoforschungs Zentrum, Potsdam, Germany)

However, Lake Kariba is an artificial lake and low magnitude seismic events are common in the area as a result of readjustments to the superincumbent water loads.

5.8. Geology

The geology description was taken from the CSA Global resource estimate documentation for the Feasibility Study (2009).

5.8.1. Regional Geology

On a regional scale the rocks of the Karoo Supergroup (Late carboniferous to Jurassic) occupy the rift trough of the Zambezi Valley (refer to **Figure 5.7**). The rifting is understood to be associated with the break-up of Gondwanaland during the Permian, followed by opening of the proto-Indian Ocean in the Jurassic; with a final episode related to the development of the East African Rift system in late Cretaceous and early Tertiary times. The significant uranium mineralisation in the area, including that of the Mutanga Project area, occurs within the Upper Karoo sandstones of the EGF.

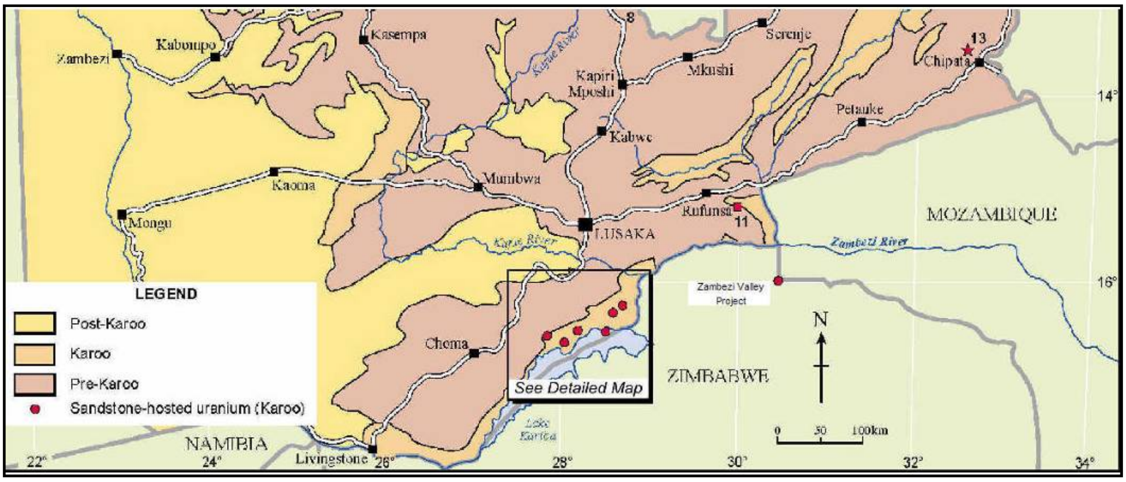


Figure 5.7 Mutanga Project Location and Regional Geological Setting

(Source: CSA Global, 2009)

The stratigraphic sequence is presented in **Figure 5.8**. The Lower Karoo Group comprises a basal conglomerate, tillite and sandstone overlain unconformably by conglomerate, coal, sandstone, carbonaceous siltstones and mudstones (the Gwembe Formation) and finally, fine grained lacustrine sediments of the MMF. The Upper Karoo sediments unconformably overlay the Lower Karoo and comprise a series of arenaceous continental sediments overlain by mudstones capped by basalt.

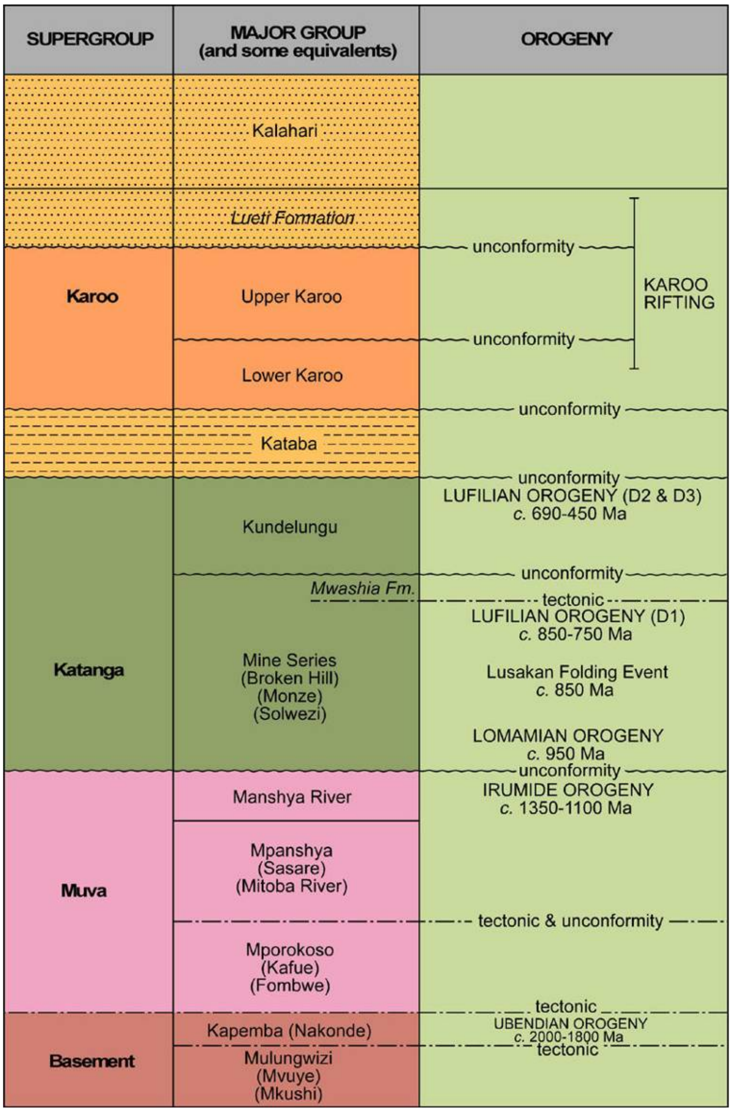


Figure 5.8 Stratigraphic Sequence of Mutanga Project

(Source: CSA Global, 2009)

5.8.2. Local Geology

Within the tenement area the Karoo sediments lie in a northeast trending rift valley (refer to **Figure 5.9**). Locally the rift valley is hilly with large fault-bounded valleys filled with Permian, Triassic and possibly Cretaceous sediments of the Karoo Supergroup. The sediments have a shallow dip and are displaced by a series of normal faults, which in general, trend parallel to the axis of the valley. Mapping of the Mutanga-Dibwe area delineated normal faults with throws of the order of 100m at intervals of between 100 and 1,500m. The uranium mineralisation identified to date appears to be restricted to the EGF.

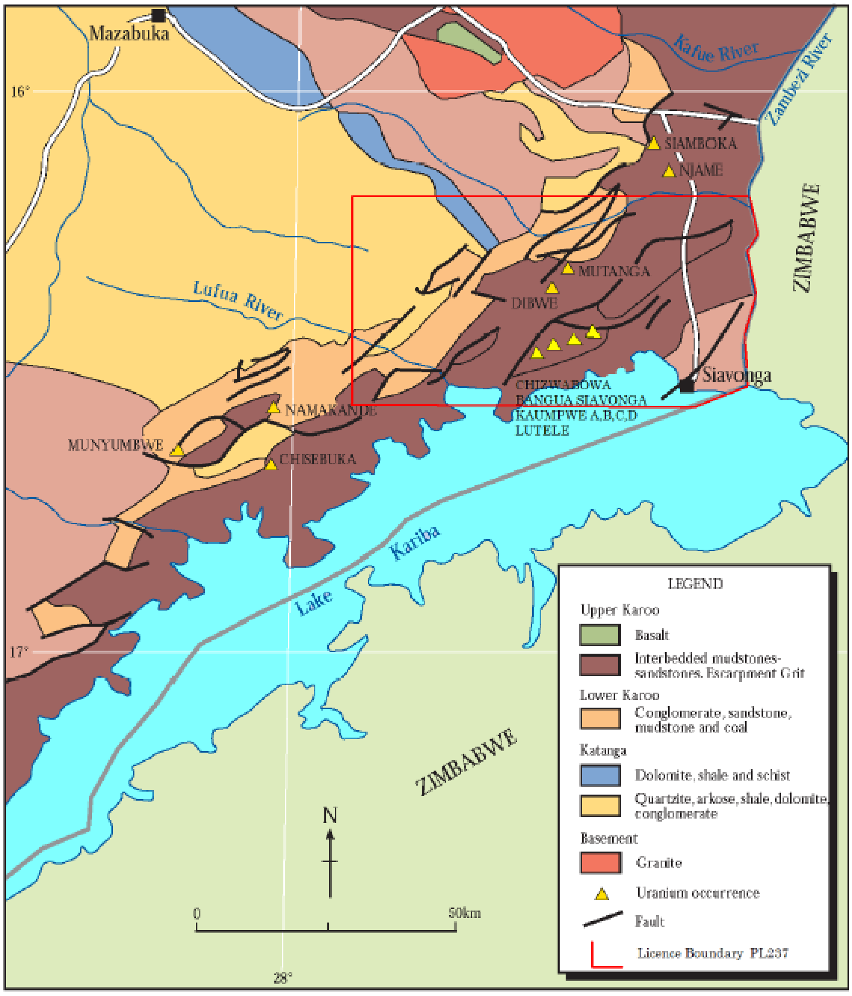


Figure 5.9 Local Geology and Geological Setting of the of the Mutanga and Dibwe Depsits

(Source: CSA Global, 2009)

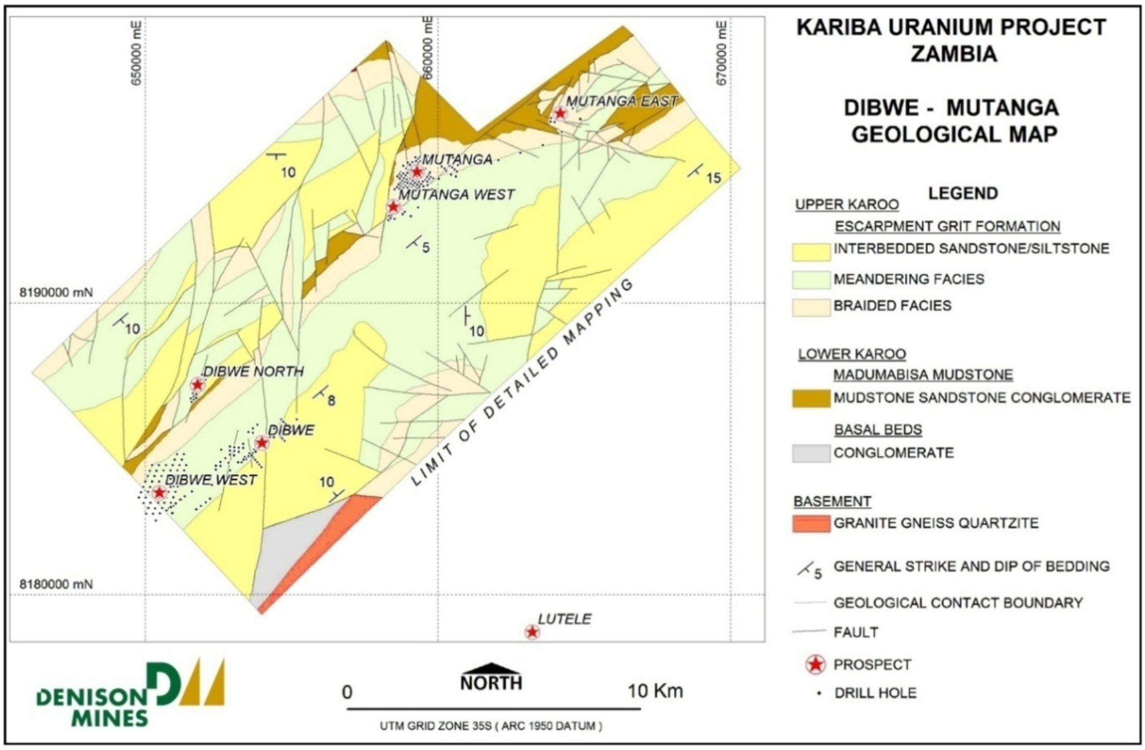


Figure 5.10 Dibwe – Mutanga Geological Map

The EGF sequence at the Mutanga deposit comprises at least 120m of sandstone and conglomerates with occasional mudstones and silts. The EGF overlies the MMF which comprises a grey to dark grey silty mudstone, with a dark red haematised layer representing either oxidising groundwater or a sub-aerial surface. The mudstone forms an impermeable unit and is thought to have prevented uranium mineralisation from moving further down through stratigraphy.

The contact between MMF and overlying EGF is 2-3m above the dark red hematised layer.

5.8.3. Mutanga

The Mutanga Prospect is located 31km northwest of Siavonga (refer to **Figure 5.11**).

Three stratigraphic zones ("Packages") have been identified from core logging and were utilised as geological boundaries during the resource evaluation phase at Mutanga. The stratigraphic sequence for these packages commences with Package A as the Basal Zone, overlain by Package B and Package C at the top.

<u>'Package A'</u>

Thickness is approximately 24m. The package overlies the MMF and is a thick, dark grey mudstone coarsening upwards into pyritic, coarse grained sandstones. Small scale slump structures and occasional possible dewatering features are observed. Occasional iron oxides occur. 'Package A' is capped by an approximately 5m thick, coarse matrix-supported conglomerate. This conglomerate marks a sudden, high energy event, possibly a channel. The sequence is thought to be representative of a prograding, possibly deltaic system.

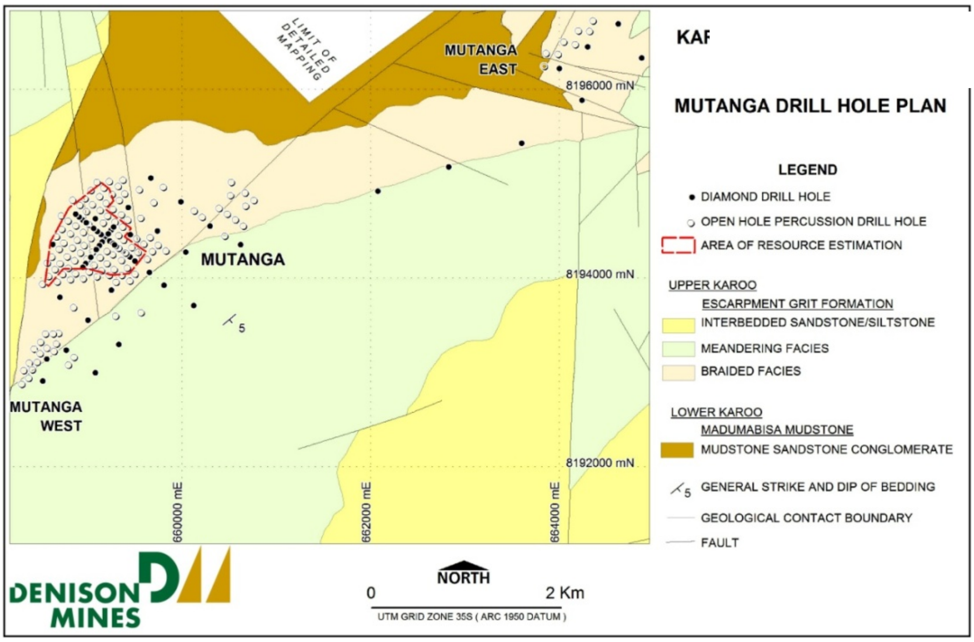


Figure 5.11 Surface Geology and Drilling Plan of Mutanga Deposit (Source: CSA Global, 2009)

‘Package B’

Thickness is approximately 70m. Overlying ‘Package A’ and it is a sequence of repeated fining up cycles that, as a whole, coarsen upwards. Each fining up unit starts with a very coarse grained sandstone or conglomerate and fines up to a mudstone or siltstone. The units contain a variety of sedimentary structures including trough and tabular cross bedding and laminations.

The fining up cycles are thought to be representative of a fluvial, possibly meandering system, in which mudstones were laid down in calm lacustrine, bow lake or overbank deposits. The deposits laid down in such hiatal periods could give a series of laterally continuous deposits that could be used as marker bands. Their role in mineralisation is discussed below.

Sulphides are observed to within an approximate depth of 50m from surface. Above this depth oxidization and weathering are evidenced by reddish brown and orange iron oxides and breakdown of micaceous and feldspathic minerals. For drill hole logging purposes, the top of the EGF Package B is taken as being the first down hole presence of mudstone.

‘Package C’

Thickness is approximately 25m thick. Overlying ‘Package B’, it is interpreted from recent drilling as the uppermost unit within the EGF in the area. ‘Package C’, although in sedimentological terms possibly related to ‘Package B’, is distinguished by grain size and structural differences. ‘Package C’ comprises bedded, generally very coarse grained sandstones with occasional conglomerates. Both sandstones and conglomerates contain less sedimentary structures than ‘Package B’ and display smaller variation in grain size with little or no cyclic variation (although individual beds can display sedimentary structures). Mudstones are generally absent, although conglomerates often contain mud balls. ‘Package C’ may represent a less ordered environment than Package ‘B’, possibly a braided channel system.

5.8.4. Dibwe Geology

The Dibwe prospect (Dibwe, Dibwe West and Dibwe North) is located approximately 10 to 15km west of the Mutanga area (refer to **Figure 5.12**). Uraniferous mineralisation in the Dibwe area appears to be hosted by relatively un-faulted meandering facies units of the EGF.

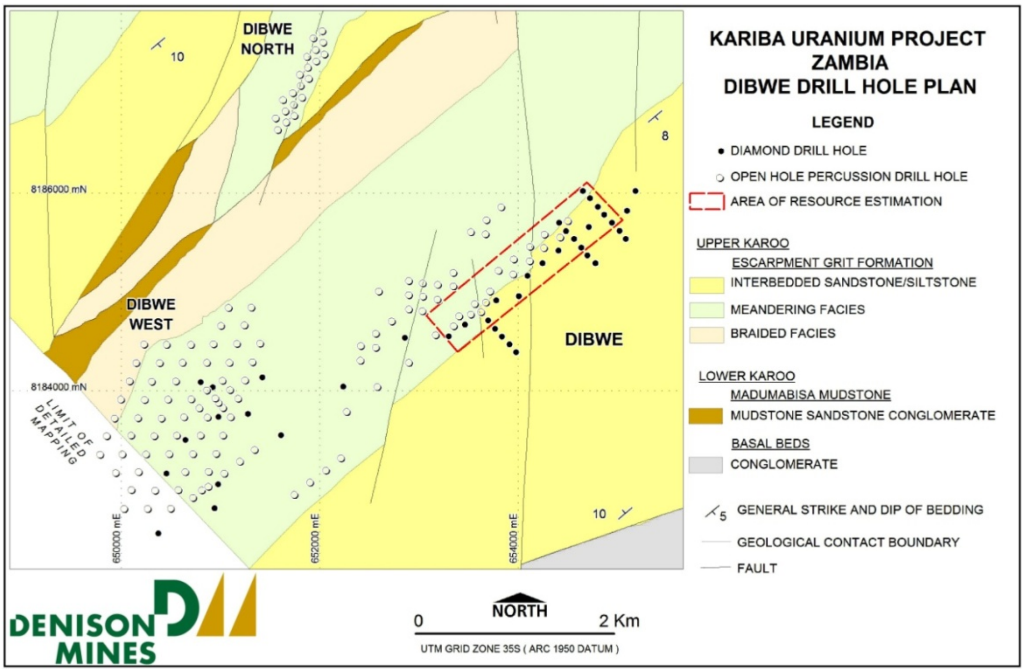


Figure 5.12 Dibwe, Dibwe West and Dibwe North Surface Geology and Drill hole Plan

5.9. Soils

Mr Felix Chileshe carried out a soil survey between December 2006 and January 2007 on potential sites for mining infrastructure. The results indicated that the soils are derived from the sandstones and conglomerates which overlie the mudstone basement complex. The soils were identified using the United States Department of Agriculture, Soil Taxonomy system (USDA ST) and results indicated that the soils are **loamy sand** and **sand** soils. The soils have low clay content (3-7%) and kaolinite clays are predominant.

5.9.1. Sampling Materials and Methods

<u>Field Mapping</u>

Field mapping was carried out on the sampling sites. Test pits were dug (approximately 60cm x 50cm and 40cm deep as shown in **Plate 5.1**) to carry out a soil profile description. Existing exploration pits were also utilized to determine the soil profile.

<u>Soil Sampling</u>

Soil sampling was carried out from the profile pits at 19 sites and two different samples were collected from each site:-

- A core sampler (refer to **Plate 5.2**) was hammered into the ground to collect a core from surface. This sample was used for a bulk density analysis; and

- A 1kg sample was collected at a depth of 12.5cm from the surface using a hand-spade and packed into labelled bags for laboratory analysis.

Plate 5.1 Soil Test Pit

Plate 5.2 Soil Core Borer

Profile Description

A soil profile description (**Plate 5.3**) was made for all of the test pits. The profile was divided up into horizons through visible characteristics and a Munsell colour chart was used to identify each horizon (refer to **Plate 5.4** below). The description for each horizon included:-

- Horizon or layer name (**A**, **B_1**, **B_2** or **C**) with depth and clarity of definition;
- Colour using the Munsell notation;
- Nature and distribution of Organic matter;
- Nature and distribution of roots;
- Texture and structure;
- Drainage and water regime;
- Faunal influence; and
- Soil reaction.

More details on the characteristics of the sampled sites are in **Appendix 10.**

Plate 5.3 Soil Profile in a Test Pit

Plate 5.4 Munsell Soil Colour Charts

Analytical Assessment

Physical analysis was conducted on the samples taken in the field. These soil samples were then air-dried at room temperature in a well-ventilated room. The soil samples were pulverized using a mortar and pestle and passed through a 2 mm sieve to remove debris and particles larger than 2 mm. The samples were then subjected to the following physical and chemical analyses:-

- **Physical properties** - Bulk density, total pore space, moisture content, soil texture and soil colour.
- **Chemical properties**
  - Soil reaction (pH) – $\log_{10}[\ H^+]$ was analysed using soil to water ratio (1: 2.5) on an Accumet Fisher pH meter;
  - Total Nitrogen by Kjeldahl. The wet oxidation procedure for total N. the amount of total N in Kg/ha was calculated to a depth of 20cm. Total N results were also used to calculate the carbon nitrogen ratio;
  - Cation Exchange Capacity in milliequivalent per 100g of soil using sodium as an index ion. Exchange sites were saturated with an index cation, the soil was then washed free of excess saturating salt, and the amount of the index cation adsorbed by the soil was displaced and determined by fame emission spectrometry;

- Exchangeable Basic cations (Ca, Mg, K, Na,) - Exchangeable calcium and magnesium by titration with ethylene di-amine-tetra acetic acid (EDTA) after extraction with Normal ammonium acetate buffered at pH 7. Exchangeable Potassium and sodium were determined by flame emission spectrophotometer, using air-propane flame.1N ammonium acetate pH 7 was used as extractant.

The soil texture was determined using the hydrometer method. Sodium hexa-meta-phosphate was used as a dispersing agent to separate and quantitatively determine the percentages of clay, silt, coarse sand and fine sand in the soil. The soil texture was classified using the USDA soil texture triangle

The organic carbon content was determined using the Walkley-Black method. The organic matter and total carbon were calculated from Organic Carbon %.

The parameters that were calculated using the results of the laboratory analysis are the Cation Exchange Capacity (CEC), Carbon to Nitrogen ratio (C:N), Clay Mineralogy, Exchangeable Sodium Percent (ESP), Sodium Absorption Ratio (SAR), Base Saturation (which was taken as the sum of the values for Ca^{2+}, Mg^{2+} and Na^{+}, expressed as a percentage of the Cation Exchange Capacity) and Exchangeable Basic Cations (converted from me/100g of soil to 20cm depth into kg/ha).

5.9.2. Sample Sites

There were 19 soil pits sampled and described. Fourteen pits were sampled at 12.5cm depth and at the surface using the core borer.

Table 5.2 Soil Pit Locations

Sample Name	Soil Pit Profile	Chemical Analysis	Location (UTM ARC 1950 35S)	
			Eastings	Northings
D1	*		654463	8185487
D2	*	*	654630	8185404
D3	*		653551	8184175
D4	*	*	654347	8184772
RW1	*	*	659693	8189800
RW2	*	*	659554	8189679
RW3	*	*	659430	8199982
TD1	*	*	659578	8192085
TD2	*		659758	8191803
TD3	*	*	659440	8191606
MP1	*		658548	8193945
MP2	*	*	658837	8194037
MP3	*		659129	8194150
MP4	*	*	659519	8193965
PP1	*	*	659339	8193049
PP2	*	*	659288	8193144
PP3	*	*	659285	8192879
MC1	*	*	659051	8192518
MC2	*	*	659020	8192404

5.9.3. Results

The results of this study have shown that the soils of the sampled sites are derived from the sandstones and conglomerates that overlie the mudstone basement complex and are comprised of loamy sand and sands. The soils have low levels of clay ranging from

3% to 7%. The clay type, in the absence of X-ray diffraction and differential thermal analysis, was identified to be predominantly kaolinite clay.

The amount of total sand in the samples ranges from 87% to 96%. These soils are freely drained sandy soils with moisture content ranging from 6.6% to 12.2%. The bulk density of all the sampled soils was optimal, ranging from 1.2g/cm^3 (in D1-D4) to 1.56g/cm^3 (at TD1-TD3). The total porosity ranged from 41% to 52.5%. These are ideal conditions to support soil ventilation and the conduction of heat used in microbial and root respiration.

Table 5.3 Soil Physical Properties

Sample Name	Moisture Content %	Bulk Density	Total Pore Space %	Solid Particles %
D1	6.7	1.55	41.2	58.8
D4	8.3	1.26	52.5	47.5
RW4	6.6	1.52	42.6	57.4
RD1	7.2	1.56	41.1	58.9
MP1	12.2	1.26	52.5	47.5
PP1	8.5	1.54	41.9	58.1
PP3	6.6	1.49	43.8	56.2

5.9.4. Potential Impacts on Soil Properties

The proposed mining activities may have the following impacts on the soils of the project area:-

- **Soil compaction** may occur through movements of heavy equipment and light vehicles, which increases the soil bulk density. At present the bulk density of the soils are optimal for aeration (porosity values range from 25 to 55 %), which allows root and microbial respiration, soil temperature regulation and infiltration of surface runoff. The compaction will break down surface aggregates, decreasing the macropore volume and increasing the volume proportion of solids. Compaction is more likely on moist clay soils than on sandy dry soils but can be less permanent in clay soils due to their swelling and shrinking properties. It is unlikely that the soil bulk density will be significantly impacted due to the dominance of sand in the soils and the low clay content.

- **Soil fertility** will be affected through vegetation removal for mine infrastructure. The removal of vegetation will disturb the leaf litter and grasses which provide food and habitation for many micro flora and fauna which are involved in the maintenance of nutrient cycles (nitrogen, phosphorous and sulphur). Soil fertility is dictated by the amount and composition of organic matter on the floor, which is influenced by the vegetation, climate, mineral soil and time.

- **Soil erosion** on exposed surfaces and steep slopes will be high. The Erosion Hazard Map of Zambia indicates that the Siavonga area has a rate of erosion of 1,000-2,000 tons/km^2/year based on the aggressiveness of the regional climate and the topography. This rate is high on the Zambian map and is much higher than erosion levels experienced in the Copperbelt. Erosion on site roads and bare soils will be high and surface runoff on these locations may lead to sedimentation in watercourses of the area.

5.9.5. Soil Chemical Assessment

Sampling Personnel and Procedures

AMC collected soil samples in December 2006 during Mr. Chileshe's survey. The soil samples were collected according to internationally acceptable guidelines.

The samples were submitted to A. H. Knight for total metal analysis. A.H.K is an accredited BSI 9002 laboratory in Kitwe, Zambia. The soil sample sites are shown in **Table 5.4** below.

Table 5.4 Soil Monitoring Sites for Metal Analysis

Monitoring Site	Site GPS Coordinates UTM Arc 1950 35S	
	Eastings	Northings
KAR/MT/01	659321	8194112
KAR/MT/02	659105	8194579
KAR/MT/03	659527	8193894
KAR/CP/01	658989	8192551
KAR/PP/01	659339	8193049
KAR/TD/01	659578	8192085
KAR/TD/02	659758	8191803
KAR/TD/03	659440	8191606
KAR/RW/01	659693	8189800
KAR/RW/02	659554	8189679
KAR/RW/03	659430	8189982

Analytical Parameters

The samples were taken for future reference of soil quality assessments as baseline soil conditions. The following parameters were analysed for:-

Aluminium	Mercury
Arsenic	Magnesium
Barium	Manganese
Calcium	Nickel
Cadmium	Lead
Chromium	Selenium
Cobalt	Vanadium
Copper	Zinc
Iron	Uranium

Sampling Results

The results of the total metal analysis on the soil samples are shown in **Appendix 10**.. The results indicated that the naturally abundant elements aluminium, calcium, iron and magnesium are all present in the soils. Higher background levels of iron are present at the KAR/TD/01-KAR/TD/03 and higher background levels of magnesium occur at the KAR/RW/01-KAR/RW/03.

There are very low occurrences of arsenic, lead, mercury, nickel, selenium, vanadium and zinc (>10ppm) at all sites. However, manganese is more abundant at KAR/RW/01-KAR/RW/03 than at the other sites sampled.

Uranium concentrations were assessed in soil samples. Mutanga orebody (KAR/MT/01-KAR/MT/03) had Uranium Concentrations up to 487ppm. The average Uranium Concentrations in Soil from KAR/TD/01-03 and KAR/RW/01-03 were 2.3ppm and 1.5ppm respectively. KAR/CP/01 had a uranium concentration of 1.5ppm in the soil.

5.10. Land Use

The Mutanga exploration permit has traditional settlements with people involved in field cultivation, dirt access roads, vegetation cover and exploration activities. Exploration activities are conducted in particular locations.

The area is fairly vegetated and covered with Mopane or Miombo woodland types. The difference between these two vegetation types is the predominance of different tree species. The vegetation consists of thick woodland or thinner woodland stands with bare rocks or soils. A large amount of bare rock occurs on the hilly outcrops or hill faces.

Cultivation activities are undertaken by the villagers for food supply by growing rain-fed crops such as maize, millet, and sorghum. These fields are harvested and the produce is generally stored in the owners graneries. The fields generally range in size from 0.5ha to 3ha but can be up to 11ha. Some farmers grow cotton which they harvest and sell to local Merchants.

Settlements in the project area contribute a small percentage of the landuse. Animal husbandry activities such as grazing goats and cattle are practiced in the surrounding villages.

Fertile wet land adjacent to watercourses is generally cultivated to produce vegetables or fruit e.g. bananas by women from the villages. These areas are generally abandoned later in the dry season when the soils dry out.

Forestry timber cutting activities are not evident in the exploration license. There was very little charcoal activity and many households collected firewood rather than use charcoal.

Some of the areas along the access routes were identified as bare land which usually consisted of rocky outcrops, especially along the ‘South’ road which had areas sparsely vegetated.

Exploration activities are the only major form of industrial land use in Mutanga. The clearing of vegetation when planning and cutting drill lines leads to loss of vegetation, as was identified in the Mutanga open pit area during the land classification site visits. DMZL will ensure that no unnecessary clearance of vegetation is allowed.

5.11. Noise

Noise is sound that is considered to be socially or medically undesirable such that it intrudes, disturbs or annoys. The human ear has a logarithmic scale over which detection of sound is possible.

The decibel (dB) was first developed to describe the reduction in audio level over a length of 1.6km of standard telephone cable. The term was created in honour of Alexander Graham Bell in 1923 or 1924. It is a unit that can be used to measure logarithmic relationships in acoustics, physics, electronics etc. A dB is defined as:-

$$X_{dB} = 10\log_{10}(X/X_0)$$

Where X = a measured value
X_0 = a specified/implied reference level
X_{dB} = is the value represented in decibels relative to X_0.

The measurement of noise is very complex and the range over which the human ear can detect sound pressure and sound pressure levels is very large. Very high noise levels may lead to hearing damage especially when exposure time is increased. The measurement is complicated by the fact that the ear is more sensitive to certain frequencies within the spectrum (middle A and its higher harmonics between 2 and 4 kHz). Therefore frequency weightings are used e.g. A, B, C. When considering occupational exposures and safety risks the A weighting is used. The C weighting is used to monitor environmental noise.

Specific references in decibels are referred to when measuring noise:-

- dB(SPL) – this is used for sound in air and other gases relative to 20 micropascals (20μPa or $2x10^{-5}$pa), which is the lowest level a human ear can hear;
- dBSIL – this is the sound intensity level which is relative to 10^{-12}W/m^2 and roughly the threshold of human hearing;
- dB(A),dB(B),dB(C) – this is the sound in decibels related to a specific frequency rating even though the measurement is still in dB(SPL). Frequency rating A is most commonly used when referring to occupational noise.

The organisation responsible for the specifications of technical requirements for instruments measuring sound levels is the International Electro-technical Commission (IEC) in Geneva. There are no existing environmental noise standards in Zambia so occupational noise standards may be used as guidelines. The globally accepted guideline standards are those issued in the Hearing Conservation Amendment to the OSHA Occupational Noise Exposure Standards (1969). These standards are weighted to the Frequency A noise levels as well as a time weighting for an 8 hour shift. The time weighting incorporates the damage that would be done to hearing if a person was exposed to levels of noise over a working shift. The time weighted average (TWA_8) of 85dB is considered to be the level at which measures should be implemented to protect employee hearing.

Noise levels are expected to vary depending on the time of day. Daytime levels are expected to range between 80-100dB and night time levels will be lower at 40-60dB. The noise in rural settings is much less than it would be in an urban environment with large volumes of traffic.

5.11.1. Methods

AMC conducted a noise survey in July 2007. A handheld Class 2 noise meter was used to obtain peak noise measurements using the slow measurement feature. The peak noise measurement is the highest dB(SPL) measured sound level over the last second. Readings were taken over a minute and 3 samples collected for each site of infrastructure. The C weighting (which mimics the human ear) was applied to the readings which detects more environmental noise than the A weighting.

5.11.2. Results

Table 5.5 indicates the locations that were sampled. The sampling sites were chosen based on the probable layout of mine infrastructure at the time of sampling.

Table 5.5 Noise Survey Sites and Location

Site Name	Location (UTM ARC 1950 35S)		Day/Night
	Eastings	Northings	
KAR/NS/D1	654124	8185564	Day
KAR/NS/D2	655067	8186134	Day
KAR/NS/D3	654124	8185564	Night
KAR/NS/DW1	651012	8183575	Day
KAR/NS/DW2	651553	8183474	Day
KAR/NS/RW1	660579	8188498	Day
KAR/NS/RW2	660467	8188713	Day
KAR/NS/RW3	-	-	Night
KAR/NS/TSF1	660561	8191433	Day
KAR/NS/TSF2	659162	8192202	Day
KAR/NS/TSF3	-	-	Night
KAR/NS/MT1	659182	8195023	Day
KAR/NS/MT2	“	“	Night
KAR/NS/MC1	659649	8195159	Day
KAR/NS/MC2	“	“	Night
KAR/NS/PP1	659572	8193540	Day
KAR/NS/PP2	-	-	Night

Table 5.6 below shows the average highest and lowest peak noises that occurred while sampling and the range over which the most frequent noise readings occurred. Generally for all of the measured sites the daytime peak sound levels are higher than the nightime levels, mainly because of influence from settlements, winds, birds etc. The environmental noise levels measured on the C weighted frequency ranged from 45dBC to 113dBC. Audible noise of the A weighted frequency are expected to be lower. At the time of the noise survey the sound levels near Chilundu and Kapita Village were high (KAR/NS/RW1-RW3). The location with lowest noise level was the KAR/NS/TSF3 site. This may also be due to shielding from the wind by the presence of trees.

Table 5.6 Highest and Lowest Peak Noise Measurements and Most Frequent Range of Noise of the Mutanga Project area

Site Name	Day/Night	Highest Peak Noise (dBC)	Lowest Peak Noise (dBC)	Range of Most Frequent Peak Noise Readings (dBC)
KAR/NS/D1	Day	113.2	71.9	83-95
KAR/NS/D2	Day	102.3	58.3	72-83
KAR/NS/D3	Night	71.5	45.9	50-62
KAR/NS/DW1	Day	104.2	60.3	82-97
KAR/NS/DW2	Day	102.0	59.7	75-90
KAR/NS/RW1	Day	99.5	61.9	75-92
KAR/NS/RW2	Day	104.8	74.1	83-97
KAR/NS/RW3	Night	74.8	58.1	63-72
KAR/NS/TSF1	Day	84.8	53.4	60-72
KAR/NS/TSF2	Day	82.0	59.9	57-67
KAR/NS/TSF3	Night	65.8	44.6	52-62
KAR/NS/MT1	Day	84.4	76.8	75-85
KAR/NS/MT2	Night	95.3	83.3	78-93
KAR/NS/MC1	Day	103.9	78.0	78-88
KAR/NS/MC2	Night	80.3	73.9	70-78
KAR/NS/PP1	Day	88.6	59.8	68-78
KAR/NS/PP2	Night	63.0	48.9	48-60

The noise levels that would be produced from an A weighted noise measurement would be approximately 5-10dB lower than the readings measured in **Table 5.6**.

5.12. Radiation

Radiation is naturally present as background levels and is dependant on topography, location and human influence. Radiation occurs when unstable radionuclides release electrons as they break down, resulting in the release of energy. When the electron is released this energy is called radiation and the radionuclides decay into other isotopes, based on a series of daughter products. The half-life of a radionuclide is defined as the time between the decay products. **Figure 5.13** illustrates the decay series for Uranium 238. Uranium exists mostly as two isotopes: U^{238} or U^{235}. The U^{235} is the most common form but nuclear reactors are powered using U^{238} fuel rods. Therefore U^{235} is mined and concentrated for further processing for its use in generating nuclear energy.

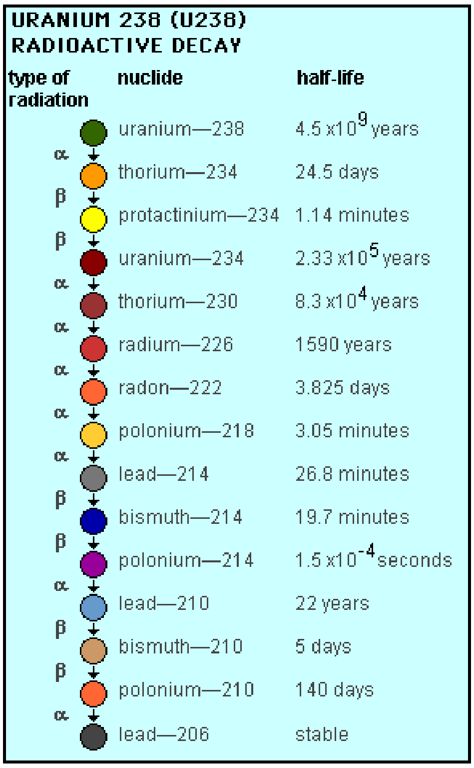


Figure 5.13 Decay Series for Uranium 238

Radiation is generated in three forms based on the energy of the electron:-

- Alpha radiation;
- Beta radiation; and
- Gamma radiation.

Exposure pathways are:-

- External (skin, clothes, or proximity to high sources);
- Internal (ingestion through food, water etc); and
- Internal (inhalation of dust, gases).

An assessment of radiation through all of these pathways is conducted prior to describing the annual exposure of an individual.

All of these forms of radiation can be hazardous but different methods are needed to prevent or reduce exposure to these forms. Alpha and beta radiation are the most shortlived with lower energy than gamma radiation and so unless ingested or inhaled pose less of an impact on health. Gamma radiation is called ionising radiation because it can penetrate through the body and affect DNA structures in the body. Shielding methods and management of exposure times are used to reduce the effects of gamma radiation.

Sources of radiation are both natural and artificial and include cosmic rays, atmospheric dust and particulates, natural sources in food and water, the nuclear power industry, global contamination from nuclear testing and nuclear medicine.

The main mineral containing uranium at site is Autunite ($Ca(UO_2)_2(PO_4) \cdot (10\text{-}12)H_2O$) with very minor Meta-autunite ($Ca(UO_2)_2(PO_4)\cdot(0\text{-}6)H_2O$). Some other Uranium Minerals that were identified are Coffinite, Brannerite and Uranium Oxides.

Radiation is traditionally measured in **becquerels**, which is defined in SI No 85 of 2008 (Uranium) as:-

“the SI unit of measurement of radioactivity defined as one radioactive disintegration per second”.

When it was understood that radiation had impacts on organisms that were exposed to it then it became necessary to quantify the intensity of radiation and the amounts that were being absorbed by the body. The **dose** is defined in SI No 85 of 2008 (Uranium) as:-

“the quantity of radiation or energy absorbed in a specific mass”.

It then became necessary to regulate radiation levels and determine **dose limit**s, which are defined in SI No 85 of 2008 (Uranium) as:-

“the value of the effective dose or the equivalent dose to individuals from controlled practices that shall not be exceeded”.

Sieverts (Sv) are defined as:-

“the unit that describes the biological effect of radiation exposure to man as a dose equivalent unit”.

A survey was conducted to determine the background radiation (counts per second cps) and dose rates (mSv/hr), using an Exploranium GR135 handheld spectrometer (2009).

The GR135 measures micro Sieverts per hour (Sv/hr), which would be the average dose that a human being would be exposed to when working in these areas. Sieverts (Sv) is the unit that describes the biological effect of radiation exposure to man as a dose equivalent unit. A Sievert is a large dose of radiation and so millisieverts (mSv) are usually used. Occupational exposures are usually described in millisieverts per year (mSv/yr). Generally when calculating occupational dose exposures the number of hours in a working year are 2000.

The equation below was used to convert μSv/hr into mSv/yr:-

$$mSv/yr = (X * 2000)/1000$$

where X is in μSv/hr.

Average global annual background radiation exposure is approximately 2.4 millisieverts (mSv) per year. Some locations have much higher naturally occurring radiation levels e.g. Ramsar in Iran has experienced a peak dose of 260mSv per year.

The Exploranium GR135 measures radiation in counts per second (cps) and dose rate (μS/hr). The formula above was also applied.

5.12.1. Methods and Techniques

AMC conducted a radiation survey using a handheld an Exploranium GR135 handheld spectrometer. The survey was conducted on four proposed infrastructure locations for the proposed facilities: process plant, TSF, Mutanga Pit and Dibwe Pit. Measurements were taken between the sites. The Exploranium GR135 handheld spectrometer was held at waist height facing away from the body.

5.12.2. Survey Sites

Table 5.7 shows the locations of the sites sampled in March 2009. These sites were sampled based on their expected high levels of ionising radiation due to the expected exposure from radioactive material at present or during the mine project.

Table 5.7 Radiation Sampling Sites

Site Name	Location UTM ARC 1950 35S		Location
	Eastings	Northings	
M11	658700	8195000	Mutanga Open Pit
M12	658700	8194700	
M13	658700	8194400	
M14	658700	8194100	
M21	659002	8194978	
M22	659000	8194700	
M23	659000	8194400	
M24	659008	8194102	
M25	659000	8193800	
M31	659300	8195000	
M32	659300	8194700	
M33	659300	8194400	
M34	659300	8194100	
M41	659600	8194700	
M42	659600	8194400	
M43	659095	8194970	
D41	654350	8185650	Dibwe Open Pit (wet season made accessibility difficult)
D42	654350	8185450	
D61	654850	8186050	
D62	654850	8185750	
D63	654850	8185450	
P11	659150	8193900	Process Plant
P13	659150	8193600	
P15	659150	8193300	
P31	659450	8193900	
P33	659450	8193600	
P35	659450	8193300	
P51	659750	8193900	
P53	659750	8193600	
P55	659750	8193300	
P61	659338	8193573	

5.12.3. Results

The results from the 2009 survey are indicated in **Table 5.8**. The terrestrial radiation levels are highest at Mutanga, ranging from 182Cps to 420Cps. Some locations that were sampled had extremely high levels of radiation such as M43, with 8,129Cps, which was attributed to high levels of potassium with mineralised uranium rocks. M43 was located near the main surface exposure of uranium mineralised rocks at the crest of the Mutanga outcrop. The annual dose was calculated for each sampled site. The majority of the sites have an annual dose of less than 1mSv/yr from terrestrial radiation, except for M22 and M43.

Table 5.8 Radiation Counts and Annual Dose Rate in 2009

Site Name	Location UTM ARC 1950 35S		Radiation	Annual Dose Rate
	Eastings	Northings	Cps	mSv/yr
M11	658700	8195000	247	0.34
M12	658700	8194700	230	0.27
M13	658700	8194400	277	0.354
M14	658700	8194100	183	0.262
M21	659002	8194978	342	0.322
M22	659000	8194700	2179	2.82
M23	659000	8194400	395	0.508
M24	659008	8194102	182	0.276
M25	659000	8193800	182	0.272
M31	659300	8195000	420	0.512
M32	659300	8194700	242	0.326
M33	659300	8194400	381	0.5
M34	659300	8194100	306	0.39
M41	659600	8194700	190	0.286
M42	659600	8194400	205	0.292
M43	659095	8194970	8129	11000
D41	654350	8185650	216	0.312
D42	654350	8185450	437	0.6
D61	654850	8186050	168	0.276
D62	654850	8185750	175	0.26
D63	654850	8185450	134	0.194
P11	659150	8193900	278	0.4
P13	659150	8193600	247	0.346
P15	659150	8193300	185	0.258
P31	659450	8193900	197	0.28
P33	659450	8193600	251	0.342
P35	659450	8193300	200	0.268
P51	659750	8193900	197	0.302
P53	659750	8193600	223	0.32
P55	659750	8193300	200	0.298
P61	659338	8193573	580	0.8

5.13. Air Quality

No air quality data is currently available for the Mutanga Project area due to its remoteness and the absence of industry and infrastructure. A program of monthly monitoring of Sulphur Dioxide (SO_2) and Nitrogen Dioxide (NO_2) was initiated on the Project site in April 2009 but there are no results currently available.

A program for monitoring environmental radon levels around the Project site was started in November 2008 (refer to **Section 5.13.2**).

Field observations indicate that the general air quality in the area is good. However, seasonal variation as well as localized and temporal deterioration in air quality does occur.

Grassland and small bush fires and traditional slash and burn agriculture during the dry season generates smoke and dust which creates a distinctive haze. The haze layer is mainly visible from the air and worst during the coolest months (June and July) when temperature inversions tend to trap the smoke near ground level. The haze lasts until the arrival of the rains in November. Localised and temporal air quality deterioration is also associated with village domestic fires.

Field observations indicate that few vehicles travel along the Mutanga road through the license area. Exhaust emissions from vehicles are localised and disperse rapidly. Other than project vehicles it is estimated that less than two vehicles pass along the Mutanga road daily. The number of vehicles passing along the Lakeshore Road daily is estimated to be from 5 to 10 cars a day. The area is very rural with households along the shores of Lake Kariba and small villages further inland.

Dust levels increase around exposed surfaces and roads. The high potential for soil erosion in the southern region of Zambia indicates that exposure to wind and surface runoff may be significant to soil quality in the area. This is especially important during the construction phase of the project.

5.13.1. Sampling Sites

Table 5.9 lists the sampling sites for the NO_2 and SO_2 passive samplers. One of each sampler type is located at each site. The locations were chosen based on the planned mine layout at the time.

The samplers were deployed along with the radon samplers as shown in **Plate 5.5 and Plate 5.6**. The samplers will be exposed at the sampling site for a month and then sealed into a container for analysis in the laboratory.

Table 5.9 NO_2 and SO_2 Passive Sampler Sites

Site ID	UTM Arc 1950 S		Elevation m
	Eastings	Northings	
PP1	659542	8193633	578
RW1	660350	8189200	678
TSF1	658321	8189843	618
DIB1	653771	8185161	576
EC1	659591	8195142	602
MUT1	659068	8194923	593
MC1	656650	8189850	-

Plate 5.5 Layout of NO_2 and SO_2 Passive Samplers

5.13.2. Radon

Radon is a radioactive gas emitted during the breakdown of the uranium and thorium isotopes. It has no odour or colour and is radioactive. It has a very low half-life of 3.8 days (US. Geological Survey http://energy.cr.usgs.gov/radon/georadon/2.html).

There are many different methods of measuring radon levels. The two most important are activated charcoal adsorption and alpha track detection. For activated charcoal adsorption, an airtight container with activated charcoal is opened in the area to be sampled, and radon in the air adsorbs onto the charcoal granules. At the end of the sampling period, the container is sealed and may be sent to a laboratory for analysis.

In alpha track detection, the detector is a small piece of special plastic or film inside a small container. Air being tested diffuses through a filter covering a hole in the container. When alpha particles from radon and its decay products strike the detector, they cause damage tracks. At the end of the test the container is sealed and returned to a laboratory for reading. The Alpha track detector is the method used at the Mutanga project

Methods and Techniques

Passive alpha track radon samplers were obtained for deployment in the project area to measure the radon. The samplers were kept out of direct sunlight and were deployed for a period of 1 to 3 months. The samplers were hung in a shelter (to prevent water damage), usually in a tree and sited inconspicuously (refer to **Plate 5.6**). DMZL provided support when the study team were offsite in terms of security of the samplers.

Plate 5.6 Radon Samplers Deployed for Passive Monitoring

Results

The radon results indicated that the background radon levels at the sampled locations were not above the normal background environmental levels (refer to **Table 5.12**). The Coreshed monitor did register the highest concentration and this should be realised when considering exposure times of employees dealing with the core.

Table 5.10 Monitoring Results of Radon Samplers

Monitor	Site	UTM ARC 1950 S		Radon Exposure $Bq.m^{-3}.h$	Average Radon Exposure for Monitoring Period$Bq.m^{-3}$
		Eastings	Northings		
88359	DIB 1 Dibwe	653771	8185161	54,000	54
88361	CS 1 Coreshed	659665	8195182	74,000	74
88362	RW 1 Raw Water Dam	659852	8189948	63,000	63

The radon sampling was conducted during the rainy season (November) and rainfall has a significant reducing impact on the amount of radon in the atmosphere. The radon monitoring program will be continued to monitor seasonal changes. **Table 5.11** below shows the Air Quality measurements results

Table 5.11 Air Quality Measurements

4 Months average concentrations						
Date	Location	UTM ARC 1950 S		ID	SO_2 $\mu g/m^3$)	NO_2 $\mu g/m^3$)
		EASTING	NORTHING			
02/04/09	DIBBWI PIT	653771	8185161	BIB1	34.7	38.4
02/04/09	EXPLORATION CAMP	659591	8195142	EC1*		
02/04/09	MUTANGA PIT	659068	8194923	MUT1*		
02/04/09	MINE CAMP	656630	8189850	MC1	33.4	38.5
02/04/09	TAILING DAM	658321	8189843	TSF1	36.8	41.7
02/04/09	RAW WATER DAM	660350	8189200	RW1	28.8	39.5
02/04/09	PROCESS PLANT	659542	8193633	PP1	35.3	33.5

*Passive Samplers stolen or destroyed (NO RESULTS)

From the air quality results, it can be deduced that all the concentration levels of pollutants were within the prescribed Zambian guideline limits listed in **Table 5.12**

Table 5.12 Zambian Guideline Limits for Ambient Air Pollutants

Parameter	Reference time		Guideline limit
Sulphur dioxide (SO_2)	10 minutes		500 µg/m³
	1 hour		350 µg/m³
Sulphur dioxide (SO_2) in combination with Total Suspended Particles (TSP) and PM10	SO2	24 hour	125 µg/m³
		6 months	50 µg/m³
	TSP	24 hours	120 µg/m³
		6 months	50 µg/m³
	PM10	24 hours	70 µg/m³
Respirable particulate matter PM10	PM10	24 hours	70 µg/m³
Oxide of nitrogen (NOX) as nitrogen dioxide (NO_2)	1 hour		400 µg/m³
	24 hours		150 µg/m³
Carbon Monoxide (CO)	15 minutes		100 mg/m³
	30 minutes		60 mg/m³
	1 hour		30 mg/m³
	8 hours		10 mg/m³
Ambient Lead (Pb)	3 months		1.5µg/m³
	12 months		1.0µg/m³
Dust fall	30 days		7.5 tonnes/km2

5.14. Traffic

There is very little traffic that travels along the tracks in the Project area based on their poor state. The traffic at the time of the study is related to the DMZL exploration activitiies. The development of the project will have serious effects of greater traffic on the roads and movements of local population may affect the spread of disease..

5.15. Archaeology

An onsite archaeological and cultural survey was carried out in October 2006. Mr Collins Chipote, Senior Conservation Officer from the National Heritage Conservation Commission in Lusaka, was commissioned to undertake the survey.

5.15.1. Scope of Work

Under the requirements of the environmental legislation of Zambia and concerns for the need of archaeological and cultural resources to be identified and where possible protected, the following were the specific terms of reference for this study:-

- Identify and evaluate any important archaeological or any cultural sites found within the project area;
- Assess the impact of the proposed mining project, with its associated activities on any areas of archaeological or cultural importance;
- Evaluate the impact of the mining project together with its associated activities, on the sites of traditional significance; and
- Recommend mitigatory measures to be undertaken in order to lessen any negative impacts, if any, on any archaeological or cultural sites.

5.15.2. Assumptions and Limitations

The identification of archaeological remains can be difficult to undertake as they are usually found as single artefacts or are buried. The following instances are examples of archaeological discoveries related to mining activities:-

- Archaeological remains of great importance have been discovered during mining operations. For example, the famous skull of Broken Hill Man *a.k.a* Homo rhodensiesis, was discovered during mining activities in Kabwe in 1921 (Roberts 1976);
- Massive earth removals can uncover sites. For example, the famous Ing'ombe Ilede Archaeological Site (dubbed as the ancient COMESA) was discovered during the erection of a water reservoir in Lusitu area in Siavonga (NHCC, 2005).

Mining operations have led to the disturbance or removal of archaeological resources. Examples of mining related disturbance to archaeological and cultural sites include:-

1) The Lumwana Mine in the North Western Province of Zambia will impact on pre-historic rock engravings that were identified during the environmental study and management measures were requested for the protection of the site; and
2) Expansion of the mining operations at Kansanshi Mine Plc in Solwezi, North Western Province, required the salvage of an old burial site.

Specific archaeological sites that have been identified in the region are:-

- The Chirundu Fossil Forest and Ing'ombe Ilede, which cover wide stretches of land; and
- Cultural sites that exist where there are human settlements that are used for traditional practises that are part of local culture.

Some limitations of this study were:-

- Length of study period - the period over which the study was conducted was short compared to the area over which work had to be completed;
- Some parts of the project area particularly Dibwe open pit, raw water dam and the tailings storage facility were overgrown with grass and thickets. This affected ground visibility and archaeological resources could have been missed;
- Some of the boundaries for the mining infrastructure were not definite due to the early stage of the design. It is possible therefore that some areas could not have been traversed as a result.

5.15.3. Methods and Materials

Desktop research was conducted to determine whether any known sites of traditional or archaeological nature existed in the study area prior to the site assessment. The desktop study covered the Siavonga District, with particular focus on the project area.

During the site assessment, interviews were conducted with the employees and local population within the project area. At the time of the study many of the employees were part of the drilling program and had commitments. Inquiries were made with the district administration.

In order to conduct methodical and systematic transect walks on the project area, key operational areas were identified, which were the Mutanga and Dibwe open pits, the process plant, mine camp, tailings storage facility and the raw water dam. A thorough survey was done on foot in linear transects between two pacers which were spaced in relation to the ground visibility. In locations where grass and thick vegetation cover occurred, the distance between the pacers was reduced.

In the case of the Kariba project ground survey methods could be adopted to make use of the exploration pits of Mutanga and Dibwe. Soil samples had been collected during the geological exploration from small pits approximately 2m wide by 2m long. These pits were used to supplement the site assessment through:-

- Examination of the soil stratigraphy on the pit walls;
- Examination of the pit walls for protruding artefacts; and
- Examination of the soil removed during the excavation of the pits for the presence of any artefacts or remains.

5.15.4. Results and Discussion

Interviews with the local population identified that the area around Mutanga had only been populated during the relocation phases of the construction of Kariba Dam. The small community occupying the area consists of the six main villages called Chiyobeka, Kasambo, Chilundu, Kapita, Kumulilansolo and Sinangosi and they are mainly involved in subsistence agriculture and livestock grazing.

Historical Studies

A desk study into historical studies of the Siavonga District revealed that some known archaeological and palaeontological sites in the area include Ing'ombe Ilede and the Chirundu Fossil Forest. There are other sites in the district (Katanekwa 1984) but these are the most significant. The records did not indicate the existence of any heritage resources in the project area and so this study may be the first.

Archaeological Resources in the Project Area

Systematic transects on the infrastructure sites of the project area revealed no existence of archaeological sites. The discovery of no single artefact or site particularly within Dibwe and Mutanga Open Pit areas led to the inclusion of the supplementary survey method through the examination of soil sample pits.

Nine old exploration pits were examined on the Dibwe orebody. These pits were identified through the old drilling ID tags and are listed in **Table 5.13** below.

Table 5.13 Sampled Exploration Pits at Dibwe used in the Survey

Pit Number	Description
DRC 018	single pit
PLDH 005	twin pits
DRC 016	twin pits
DRC 015	single pit
DRC 004	single pit
DRC 005	single pit
DRC 010	single pit
DRC 011	single pit
DRC 012	single pit

On average the pit dimensions were 3.2m x 3.2m with an average depth of approximately 0.3m. In the case of twin pits, they were separated by approximately 0.7m, were smaller in size but approximately 1.1m deep. The soil was mainly sand to sandy silt. A closer examination of the pit walls and soil was carried out but did not reveal anything of archaeological significance.

Twenty six pits were assessed on the Mutanga orebody. Historic trenches and pits from the 1970s as well as some from the recent exploration campaign of 2005-2006 were examined. This examination did not identify the presence of any archaeological artefacts. The pits that were sampled were identified using the ID tags from the exploration program and are shown in **Table 5.14**.

Table 5.14 Sampled Exploration Pits at Mutanga used in the Survey

Pit Number	Pit Number
PLRC 075	PLRC 134
PLRC 04	PLRC 123
PLRC 047	PLRC 102
PLRC 054	PLRC 105
PLRC 051	PLRC 089
PLRC 044	PLRC 099
PLRC 065	PLRC 080
PLRC 057	PLRC 082
PLRC 068	PLRC 076
PLRC 077	PLRC 070
PLRC 098	PLRC 072

Pit Number	Pit Number
PLRC 110 PLRC 122	PLRC 087 PLRC 081

The sampled exploration pits on the Mutanga orebody measured between 2 - 2.5m long by 3-3.8m wide. The depth of the soil pits ranged from 0.4 - 0.65m. There was no evidence of any archaeological artefacts on the Mutanga orebody.

The surveys conducted on the tailings storage facility, the raw water dam, the mine camp and the fuel storage facilities did not identify any archaeological resources.

A transect was conducted on the processing plant area, which identified the presence of precipitated iron over a large area. The iron site was sampled at UTM 35 659667E 8192636N or 16º 20' 61" S 28° 29' 68" E. The site is located close to the southern boundary of the processing plant area. After the discovery of the precipitated iron a strategy involving the methodical examination of all ant hills in and around the site was conducted. Most historic iron smelting activities were conducted on anthills (Chikumbi 2003) where there was suitable soil (clay) used for making a furnace. No evidence was identified to show any indication that there were any archaeologically important sites in the area.

Even though no archaeological sites were discovered during the survey the possibility remains for their presence. The discovery of iron, which in some ancient communities may have been used in making tools, could imply that iron works were carried out in the region. However, within the project area, there are no signs that iron works were conducted. No potsherds or grinding stones were found during the survey. Such findings are usually associated with remains of iron works such as tuyeres, iron slag and furnaces.

Traditional or Cultural Resources in the Project Area

The two affected villages on the Mutanga open pit area, Chiyobeka and Kasambo, fall under the jurisdiction of Chief Sinadambwe. Interviews were held with some local people who indicated the existence of some sacred shrines used for offering rain prayers. According to Senior Village Headman for Chiyobeka Village Mr. Alick Mweemba, and Mr. Froddy Haakajika, secretary to senior village headman Haachibozi of Manyika Village, the sacred shrines are called Hapepe and Malende. Hapepe is located about 3km north of the local community school (or north-west of Mutanga open pit site) while Malende is approximately 5-6km north of Mutanga Camp after Changa village and close to Machinga Stream. The Hapepe ritual is conducted at the Hapepe Spring and the Malende is conducted close to the Machinga Stream and is led by an old traditional priest called Haadoobelo.

The shrines are used especially when it is suspected that there will be a drought. The sites are revered by the local communities and are a living example of the resilience of old traditional practices. These sites are unlikely to be affected by the mining activities.

Description of “Significance” of Cultural Resources

The cultural significance of a site is the value that it holds for the community or sections of the community. The estimation of value is still contested but it refers to the degree of significance humans attach to something in as far as they derive economic, spiritual, material and recreational benefits from a site. However, there are other values that are beyond human understanding elaborated in the principle of existence.

The principle of existence value is that people will share certain values in something beyond the benefits they derive from it. Without the community attaching value to the site, the importance of conserving such a site is eroded. At times this value may be assigned to a site where this value may not be inherent at the site.

In as far as assigning significance is concerned and in accordance with the National Heritage Conservation Commission, Management Policies, Standards and Guidelines of 1996, the significance is assigned to a heritage sites or resources by *inter alia:*-

- A historic or pre-historic structure, site or object possesses integrity. Integrity requires authenticity in design, location, workmanship and elements of feeling and association;

- Archaeological sites that produce information of major scientific importance. The site reveals new cultures or information of periods of occupation over large areas of the country. These sites are likely to produce or which may reasonably be expected to produce data affecting theories, concepts and ideas;

- Birth places, graves and cemeteries a of historical figures of transcendent importance;

- Heritage that is associated with events that significantly contributed to or represent the broad cultural, political, economic, military or social history of the nation. An understanding and appreciation of the large patterns of Zambian heritage may be gained from this heritage.

With regard to the levels of significance, any heritage site proposed for its cultural values must possess outstanding international, national, regional or local significance.

International or universal significance is assigned to heritage resources that possess an outstanding value or interest that transcends national borders (UNESCO 1999) and these sites are nominated as world heritage sites. National significance is normally assigned to a heritage resource that possesses national importance and is proposed for declaration as a national monument. Regional significance of heritage resources is used when nominating or listing sites in the National Register. ‘Regional’ implies province or inter-provincial level but should not be national. As for heritage that has local significance, it implies heritage that meets the basic criteria for listing in the national register. Local refers to district or sub-district level or an area considered to be a unit of geographical, functional, social and cultural importance at inter-district level within a specific geographical area.

The archaeological resources found on the Mutanga Project site do not meet any of these criteria. It is important to understand that the scientific or research value of a site is dependant on the importance of the data identified or the rarity, quality or representation of the find. The degree to which a site may contribute further substantial information must be considered as well. A site will have low significance is none of these parameters are identified.

Evaluation of Potential Impacts of the Project

Archaeological resources worldwide are negatively impacted upon by development projects. Large scale or small scale mining activities can potentially negatively affect the state of any archaeological resources through this ground disturbance. Consideration for the need to conserve archaeological resources is premised on the realisation that the archaeological record is a scarce non-renewable resource which is quickly disappearing (Cleere 1989). The potential impacts that may occur are:-

The removal of soil and vegetation during construction may lead to the revelation of buried archaeological remains. The survey incorporated the examination of soil sample pits which yielded no findings;

The chosen relocation site should be assessed for archaeological remains to prevent any negative impacts on these artefacts; and

Any north-eastern expansion of the mining activities may impact negatively on the two shrine sites. These sites would need to be conserved and where their destruction is inevitable consultation with local leadership will identify the best practises.

Mitigation Measures for Impacts

The following mitigation measures to prevent negative impact on any archaeological sites on the project area have been identified:-

- **Assessment of the Identified Relocation Area** – when the relocation site has been identified a survey should be conducted to identify any archaeological artefacts or remains on the site;
- **Reporting of Heritage Findings** – During operations any heritage resource that may be uncovered by mine employees or operators should be reported to the relevant authorities. Heritage Act Cap 173, provides legal penalties if there is failure to report any discovered heritage resource; and
- **Sacred Shrines** – If any north-eastward expansion of the mining activities towards the shrines occurs, then consultation will be carried out with the relevant and affected communities to identify suitable safe access routes for the local population to the shrines.

5.15.5. Conclusion

There are no indications that the proposed mining developments would take place on an area once occupied by either stone age or iron age communities. The discovery of precipitated iron on the processing plant site is not considered significant and there was no evidence of the remains of iron workings on the site. The absence of any ceramic materials in the project area may imply that the Mutanga Project area was not settled by iron age people, though this was common in other parts of Southern Province (Vogel 1971). As a result, no sites in the project area of archaeological (national) significance were identified.

5.16. Flora

A study of the vegetation of the project area was carried out by Mr. Lishomwa Mulongwe, Principal Research Officer at the Forestry Research Department in Kitwe, Zambia in November 2006. He was assisted by Mr Keddy Mubindo, who is also based at the Forestry Research Department.

The Gwembe valley is considered to be the 370km long expanse of land area between the Upper Gorges of the Zambezi River and the confluence of the Zambezi and Kafue rivers (Thomas, 1960). The Mutanga Project lies within the Gwembe valley 39km northwest of Siavonga by road. Climatically, the area lies in the less than 800mm rainfall zone. The soils are generally derived from Karroo sandstone but are modified by effects of weathering and vegetation

According to Magadza (1960) the original vegetation of the Kariba area belonged to the *Colophospermum mopane* (Mopane) catena type with various *Combretum* species, specifically *Combretum elaeagnoides* (Oleaster bushwillow),, *C. apiculatum* (Red bushwillow),, *C. celatroides* (Trailing bushwillow/Jesse-bush Combretum),, *C. obovatum* (Spiny White-leaved Combretum) and *C. mossambicense* (Knobbly Climbing Bushwillow/Shaving-bush Combretum). On the hills surrounding the lake the vegetation included elements of *Croton* (*C. gratissimus, C. madandensis* (Limpopo Croton), and *C menyhartii* (Rough leaved-croton)*), Commiphora (C. mossambicense* (Pepper-leaved Corkwood)*, C. karibensis* (Angular-stem Corkwood)*, C. Africana* (Poison-grub Corkwood)*, C. merkeri* (Zebra-bark Corkwood) and *C. mollis*(Velvet-leaved Corkwood*))*, with large specimens of *Kirkia acuminata* (White seringa), *Sterculia africana (*African Star-chestnut) and *S. quinqueloba* (Large-leaved star-chestnut). Occasionally, the vegetation incorporated *Adansonia digitata* (Baobab).

The vegetation of the area has been historically collected, studied and documented. The various species, vegetation types and their relationships to the different soil types are also well known (Fanshawe, 1969). Uranium mineralization of the Kariba area has been known since the exploration carried out by Agip.

The bioavailability of Uranium in the vegetation of the area has not been studied. Therefore, the study and publication of phyto-geochemical information constitutes an important source for current and future comparative documentation of plant/metal interactions (Malaisse *et al*, 1999). This is because metal uptake is a function of many factors such as root length, rate of water uptake and microbial activity in a vegetated mineralized area (Mbila & Thompson, 2004).

The major vegetation of the project area was largely made up of legumes, both nitrogen fixing – Mimosoideae, comprising various species of *Acacia, Bauhinia, Afzelia*, and non nitrogen fixing Ceasalpinalceae such as *Colophospermum mopane* and *Julbernardia globiflora* (Munondo). The Burseraceae and Combretaceae species mainly of *Commiphora* and *Terminalia* and *Combretum* were highly frequent. The unique valley vegetation association species of *Adansonia digitata*, *Kirkia acuminata* and *Xerroderris stuhlmannii* (Wing bean) were highly definitive of the various vegetation types found in the project area. These different species assemblages are associated with different soil types, topographical formations and moisture regimes.

5.16.1. Purpose of the Study

The approach that was adopted is meant to create a familiarization with the flora found on the uranium project area, to define metal accumulators, and specialist plants (refer to Malaisse *et al,* 1999). This forms a basis for assessing levels of contamination and potential future bioremediation. The dry nature of the area and the high movement of materials, both of soil and plant origin, especially during the rainy season necessitated this approach to uranium bioavailability. In addition, the area has been settled since the construction of the Kariba Dam.

In November 2006 a study was undertaken to characterize the vegetation of the Mutanga and Dibwe Uranium deposits and other infrastructure sites. Specifically the objectives of the study were:-

- To describe the woody vegetation of the two sites in terms of composition and structure in order to categorize it according to site;

- To determine the woody biomass using the volumetric approach for all trees greater than 5cm in order to calculate the quantities to be removed per hectare; and

- To determine Uranium bioavailability in the woody vegetation in order to set comparative and monitoring standards.

5.16.2. Materials and Methods

The study sites were similiar to the areas covered by the soil sampling assessment in **Section 5.9.2**.

A line transect was used to record all the woody vegetation in each area of interest. The line transect was interspaced with plots of 20m or 0.134 hectare at every 150m interval. The number of plots depended on the longest length of the area of interest. All woody vegetation, defined as having stems of at least 5cm or larger, was recorded for structure and composition using a structural – physiognomical survey method (Fanshawe, 1969). In addition, the following variables diameter, height (total and merchantable), presence or absence of fire scars and growth habit were recorded to determine stand structure and productivity.

For chemical analysis to determine bioavailability of Uranium, the plant materials (root samples) were pounded in a mill and the resultant powder dried at 60°C in a drying oven. The samples were then submitted to ALS Chemex in South Africa, for analysis in their environmental laboratory in Canada. The samples were homogenised mechanically or manually prior to acid digestion. The hotplate or block digestion used Nitric Acid repeated by additions of Hydrogen Peroxide. The solution was analysed using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). The two methods for this were procedures adopted from the "Recommended Guidelines for Measuring Metals in Puget Sound Marine Water, Sediment and Tissue Samples" which were prepared for the United States Environmental Protection Agency and the Puget Sound Water Quality Authority in 1995 and the ICP-MS procedures in EPA Method 6020A.

5.16.3. Results and Discussion

1) Vegetation Description

The description of the vegetation was based on the location of potential infrastructure in order to provide information for later re-vegetation activities.

<u>Mutanga Orebody (sites MP1-MP4)</u>

The Mutanga ore body is located on a hilly outcrop that begins in the south east rising gently towards the seasonal runoff channel and the dambo. The soil of the area was generally sandy with occasional dark patches where old termite mounds still exist. Old termite mounds are usually found around the roots of mainly *Pseudolacnostylis maprouneifolia* and *Diospyros kirkii*.

The vegetation of the Mutanga ore body was a mixture of *Burkea africana*, *Julbernardia globiflora, Terminalia prunoides, Pseudolacnostylis maprouneifolia, Dalbergialla nyassae, Diplorynchus condylocarpon, Kirkia acuminata* and *Pterocarpus angolensis*. Towards the stream bed the vegetation included specimens of *Afzelia quanzensis. Diospyros mespiliformis* occurred on the anthills along the banks of the stream along with *Colophospermum mopane* and the occasional *Boscia*. At the north-eastern edge of the ore body the same vegetation existed with a number of settlements and old cleared fields.

The vegetation ranged between 4-14m in height and grew without any distinctive strata as the trees were scattered over a large area. *Afzelia quanzensis*, *Burkea africana* and *Pterocarpus angolensis* were the tallest trees on the site, averaging between 12-14m. *Burkea africana* was the most frequent tree species in the area, and occasionally grew in groups of 6-10 trees, especially in sheltered low lying areas.

The vegetation was highly disturbed with most of the trees having either been cleared for settlements or for poles and fire-wood. Evidence was found of browsing on the small shrubs by livestock. The regeneration of the vegetation was not evident due to the dryness of the site, but old stumps were noticeably coppiced especially *Julbernardia globiflora, Dalbergialla nyasae* and *Colophospermum mopane*, species which are commonly used in the construction of homesteads and for fire wood.

Dibwe Orebody (sites D1-D4)

The Dibwe orebody is located approximately 10km south west of Mutanga. There are two identified orebodies in this area being Dibwe and Dibwe West. The Dibwe West orebody was not considered in this ecological survey.

The vegetation of the Dibwe orebody at its furthest point from Mutanga was mainly made up of *Commiphora karibensis, Schrebera trichoclada, Strychnos innocua, Pteleopsis anisoptera, Terminalia prunoides, Boscia mossambicensis,* and scattered *Adansonia digitata*. This vegetation occurred at a height range of 6-10m with most of the trees at the time of the survey having shed their leaves. There was very little regeneration, but the area generally appeared to be affected by fire every year.

The second type of vegetation on Dibwe mainly consisted of the papery barked *Commiphora marlothi* with a few scattered species of *Boscia angustifolia* and *B. mossambicensis*. This vegetation was confined to a raised area in appearance like a sand dune. It was located between two dried up streams and may be a result of eroded soil washed away from upstream and deposited in the area over time. These sandy deposits supported the *Commiphora marlothi* vegetation.

Towards the middle of the ore body was a dry stream lined by rock outcrops where many specimens of cactus or *Euphorbia* species grew in rock crevices. When breaks in the outcrop occurred *Acacia nigrescens* and *Garcinia huillensis* were found. Slightly above the slope a large population of *Colophospermum mopane* with associated species of *Diplorynchus condylocarpon, Bauhinia petersiana* and *Pseudolachnostylis maprouneifolia*.

Towards the end of the ore body there is a large area covered by *Julbernardia globiflora* and a number of scattered *Afzelia quanzensis*. A few human settlements are found on the route to Dibwe. Tree heights were generally between 4-8m.

Process Plant Area (sites PP1-PP3)

The vegetation is largely Mopane woodland in a slight depression with *Adansonia digitata* towards the middle of the site. The Mopane woodland is found on sandy loams to dark clayish soils which are mainly alkaline. The upper storey is found at between 14-16m and is made up of a single storey of *Colophospermum mopane* over much of the area. Associated with this species are *Xerroderis stuhlmannii*, *Afzelia quanzensis*, and

Terminalia prunoides. *Afzelia quanzensis* was usually found growing in small groups of four to seven large individuals, isolated from other species.

Mopane trees in this area are shallow-rooted, with large exposed roots being characteristic of old tree growth. Within this woodland type are big Baobab trees around which clumps of *Sansevieria deserti, S. kirkii, Boscia mossambicensis* and small trees such as *Schrebra trichoclada*, *Combretum apiculatum* and *C. ghalense* are found. Above the depression, towards the south, it is common to find *Kirkia acuminata* growing in association with *Julbernardia globiflora*.
The upper eastern end of the depression is occupied by *Julbernardia globiflora* in association with *Combretum celatroides, C. apiculatum, C. elaeagnoides, Lannea stuhmannii, Diplorynchus condylocarpon* and *Lonchocarpus capassa* mostly growing as shrubs or small trees on mainly pale colored sandy soils. The *Julbernardia globiflora* vegetation appeared to have been disturbed previously and was in a regenerative phase with most of the tree stumps having two to three coppice shoots.

Fuel Storage Site

The site is mainly on a slope opposite the process plant site with part of it on a flat area in an old dambo. The slope and flat is partially covered by *Colophospermum mopane* with associated species of *Lannea discolor, Julbernardia globiflora, Combretum apiculatum, Diplorynchus condylocarpon, Schrebera trichoclada*, and *Dalbergiella nyassae*. The trees on the slope are of a short stunted stature amongst burnt grassy patches and sandy stones in a mainly mopane woodland. The height class range for the dominant species is 4-8m.

Sites TD1 to TD3

The northern end of this site is made up of elements of mixed Mopane woodland with a high presence of *Burkea africana*. The presence of termitaria emphasized the prominence of associated vegetation in the area with tree species such as *Colophospermum mopane, Commiphora karibensis, Garcinia livingstonei, Kirkia acuminata* and *Lannea stuhlmanni*, in the upper storey and *Boscia matabelensis, Euclea divinorum*, *Euphorbia espinosa* and *Ximenia Americana* in the understorey. In the open spaces between the termite mounds there is burnt regeneration of *Diplorynchus condylocarpon, Pseudolacnostylis maprouneifolia, Combretum ghalense* and *Lannea stuhlmannii*.

The centre of this site has a high presence of *Bauhinia petersiana* extending towards the western edge with a few termite mounds covered by vegetation as described above. Large specimens of *Afzelia quanzensis, Xerroderis stuhlmannii, Colophospermum mopane and Kirkia acuminata* dominate in the centre and extend towards the eastern end of the site. This type of vegetation occurrs on the relatively flat areas and is usually edged by rock outcrops and ravines. Regeneration was restricted to scattered species of *Combretum, Commiphora, Colophospermum* and *Kirkia*. There was no visible regeneration of *Afzelia quanzensis* despite its prominence. The area had equally been affected by fire, with fire scars marking most tree and shrub stems almost up to a third of the height of the tall trees.

The southern end of the site was covered by a number of vegetation types, ranging from thickets dominated by various Acacias, *Friesodielsia obovatum* and *Bauhinia petersiana* to almost pure regenerating stands of *Julbernardia globiflora*. The triangular south-eastern end of the tailings dam site is occupied by scattered large specimens of *Colophospermum mopane*. *Julbernardia globiflora* prefers relatively fertile sites that are generally used by the local people for cultivation of crops (there were no identified fields on the TSF). The species is highly disturbed and almost always occurs in a regenerative phase, with the pole size growth stage predominating. Although not resistant to termites or wood borers, the poles of *Julbernardia globiflora* are heavily utilized for construction purposes. The species therefore, on sites where there are no annual hot bush fires regenerates from seed, coppice and root suckers making it a rapid colonizer of abandoned agricultural sites.

Sites RW1 to RW3

The site appears to have been extensively cultivated in the past. It is triangular in shape and generally flat with a few scattered large specimens of *Afzelia quanzensis, Burkea Africana, Colophospermum mopane, Lonchocarpus capassa, Tamarindus indica, Xerroderis stuhlmannii, Pteleopsis anisoptera*, and *Pseudolacnostylis maprouneifolia*. The rest of the area is taken up by small trees and shrubs in what appears to be old cultivation ridges. The canopy species reach a height of 8-10m but the canopy is not well defined or distinctive. Towards the end of the site there is a gentle slope into an old dambo area.

The common small trees are *Boscia mossambicensis, Combretum ghalense, Diplorynchus condylocarpon, Julbernardia globiflora, and Schrebera trichoclada.* The shrub layer consists of *Baphia massaiensis, Lannea discolor, Kirkia acuminata Hibiscus* species and various *Combretum* species at a height range of 2-4m including the sub-canopy. Between the shrubs and small trees were patches of burnt or harvested grass.

The small trees exhibited an interesting phenomenon through sprouting stress shoots at the base of the stem. This occurred where part of the stem had been damaged. Two to six sprouts were counted for most of the damaged small trees that exhibited this pattern of growth. The sprouts were only present on trees that appeared to have been damaged during plowing and not those affected by fire.

Settlement Area (Chiyobeka and Kasambo Villages)

The vegetation is a mixed *Colophospermum mopane* and *Kirkia acuminata* woodland with associations of *Combretum apiculatum, C. collinum, Julbernardia globiflora, Adansonia digitata, Afzelia quanzensis, Xerroderris stuhlmannii, Commiphora karibensis, Boscia angustifolia* and *Schrebera Trichoclada*. The area had been severely burnt by fire and most of the trees had been scorched. The height class range of the dominant tree species is between 4-10m.

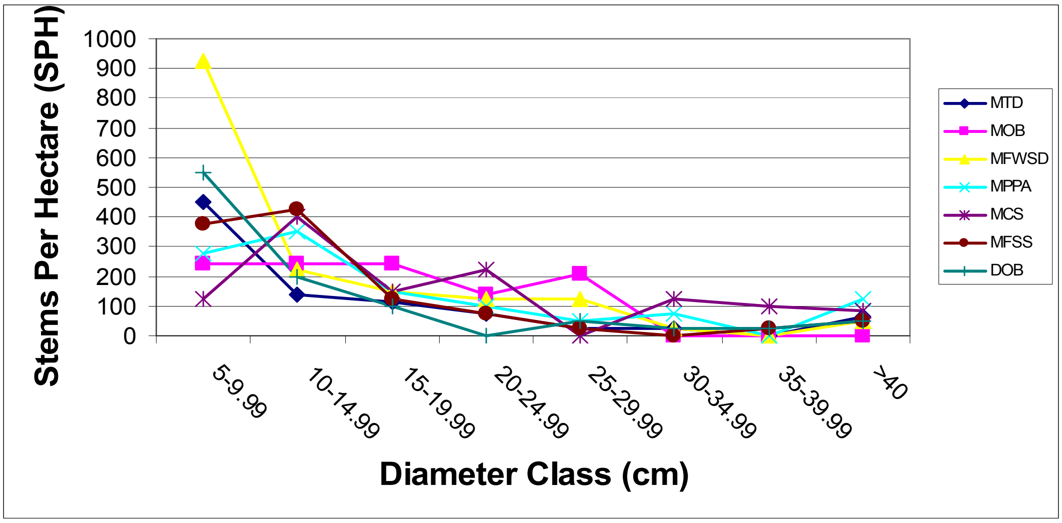
2) Vegetation Growth and Productivity

The Gwembe valley is considered a low rainfall area and the vegetation is well adapted to these conditions. Most of the trees were deep rooted especially on the very dry sites. On low lying inundated sites that are flooded every year, the trees were shallow rooted and in some cases exposed. Some of the trees conserve water in their trunks i.e. the baobab, while most of the species lose their leaves during the dry season to conserve moisture.

The productivity of these woodlands is considered to be low to medium, based on the existing tree species, soil type, moisture regime and organic matter content of the soils. Biomass accumulation per hectare can be approximately 25 tons per hectare (tph) for high productivity areas or 3tph for low productivity areas. Species density is highest in thickets, where up to 160 species per hectare (sph) were counted. In open woodlands species density was 42sph.

Diameter Distributions

Diameter and height distribution curves are important for determining the status of a woodland in relation to the different formations i.e. seedling, juvenile, shrub, small, medium or large sized tree. **Figure 5.16** indicates the number of trees on a hectare and their respective diameters for all of the sampled sites.



N.B. MTD – Tailings Storage Facility, MOB – Mutanga Orebody, MPWSD – Raw Water Storage Facility, MPPA – Process Plant, MCS – Mine Camp, MPSS – Chiyobeka and Kasambo, DOB – Dibwe Orebody

Figure 5.14 Diameter Distribution Curves for the Surveyed Sites

Volume Production

Volume production for the seven sites was determined by use of the volumetric method. The formula used was:-

$$V = \pi D^2/40000*H*FF$$

where V = volume
D = diameter
H = height
FF = a form factor.

Form factor which is 0.7 was determined for *Colophospermum mopane* and *Julbernardia globiflora*, while that for *Kirkia acuminata* was adopted from another study (Mulongwe, 2005). The volume production figures given in **Table 5.15** represent the volume of wood available for sale at each site for merchantable heights only. The highest volume of wood that can be sold during site clearance occurs on the site of the process plant.

Table 5.15 Volume of Merchantable Wood Produced during Site Clearance

Sample	Location	Average Diameter cm	Average Height m	Bore Area m^2	Volume per tree m^3	Volume per hectare m^3
MPPA	Process Plant	26.45	2.88	0.0253	0.1839	25.76
MCS	Mine Camp	27.04	3.43	0.0188	0.1231	17.24
MOB	Mutanga Orebody	16.68	3.63	0.0070	0.0476	6.66
MFSS	Chiyobeka and Kasambo Settlements	15.05	2.00	0.0117	0.0464	6.50

Sample	Location	Average Diameter cm	Average Height m	Bore Area m^2	Volume per tree m^3	Volume per hectare m^3
MFWSD	Raw Water Storage Facility	22.50	1.74	0.0076	0.0246	3.44
DOB	Dibwe Orebody	12.75	1.90	0.0053	0.0208	2.92
MTDS	Tailings Storage Facility	16.33	2.57	0.0067	0.0336	4.70

Height Distribution

The height distributions (**Table 5.15** above) are according to each site and are indicative of the stage of growth of each formation. For purposes of volume calculation heights were divided into merchantable height (utilizable part of the tree) and total height (height of tree from base to the tip). This in turn affected volume production per tree and per hectare.

Woodland Fire Adaptation Mechanisms

Most of the trees were generally able to resist fire, exhibiting thick stringy bark. Some preferential adaptions to the prevailing activities of seasonal fires are due to the bark being thin, thick and fleshy or thick and fissured/cracked. Other factors influencing survival include fire avoidance by growing among rocks.

Growth Habits

Growth habit is the term used to describe the formations of growth that vegetation may adopt. Woody species in dry areas may exhibit growth habits that may differ to those exhibited by vegetation in high rainfall areas. **Figures 5.17** to **5.23** below are examples of growth habits observed on the different sites.

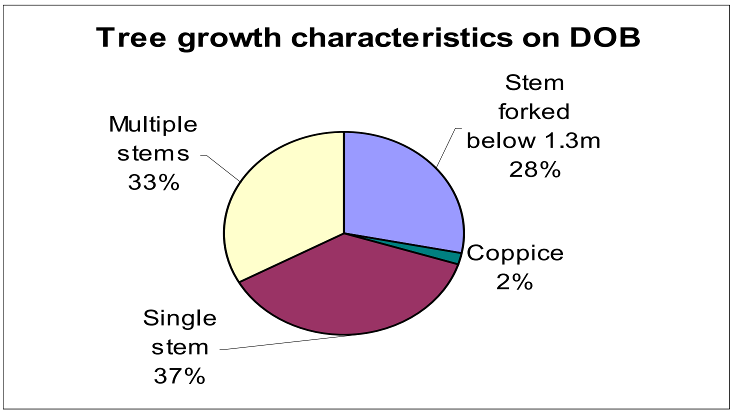


Figure 5.15 Proportions of Different Growth Habits Identified for trees Sampled on Dibwe Orebody

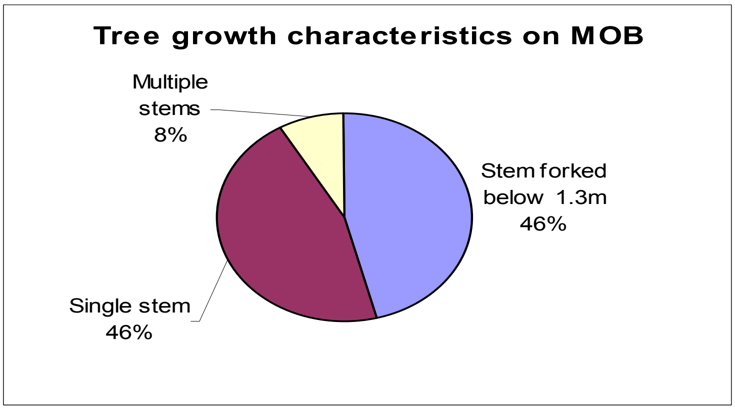


Figure 5.16 Proportions of Different Growth Habits Identified for Trees Sampled on the Mutanga Orebody

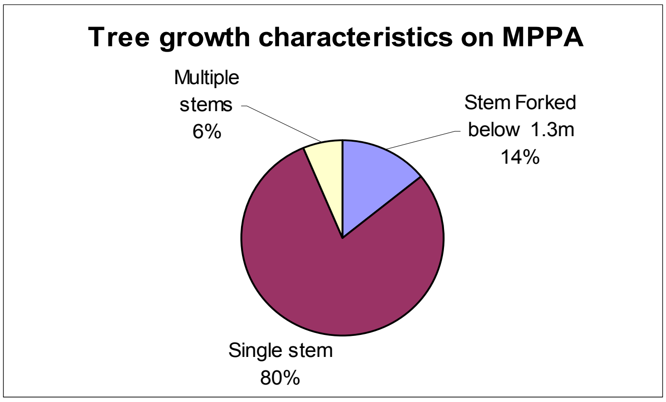


Figure 5.17 Proportions of Different Growth Habits Identified for Trees Sampled on Sites MP1-MP4

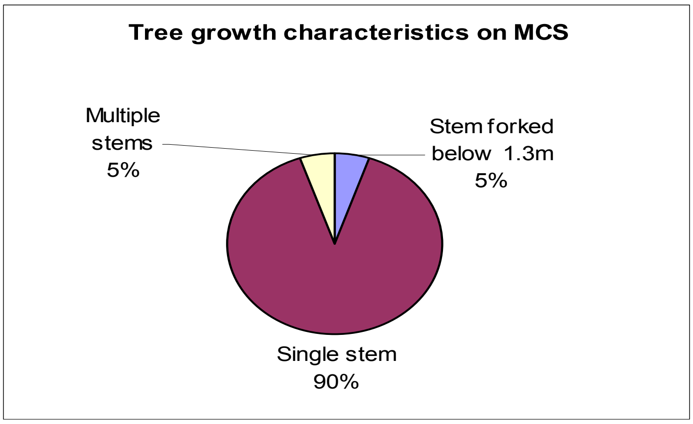


Figure 5.18 Proportions of Different Growth Habits Identified for Trees Sampled on Sites MC1 and MC2

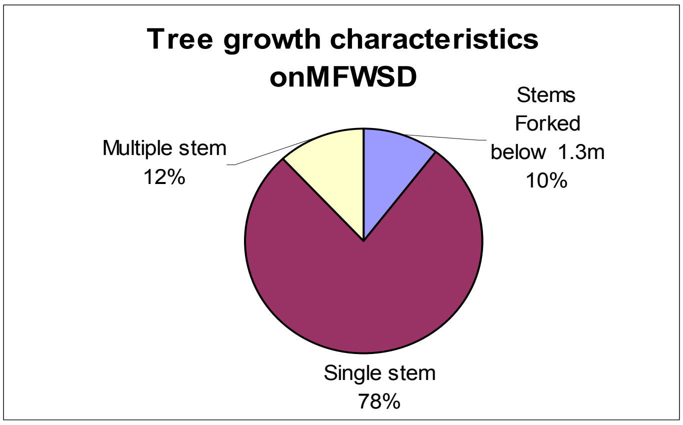


Figure 5.19 Proportions of Different Growth Habits Identified for Trees Sampled on Sites RW1 to RW3

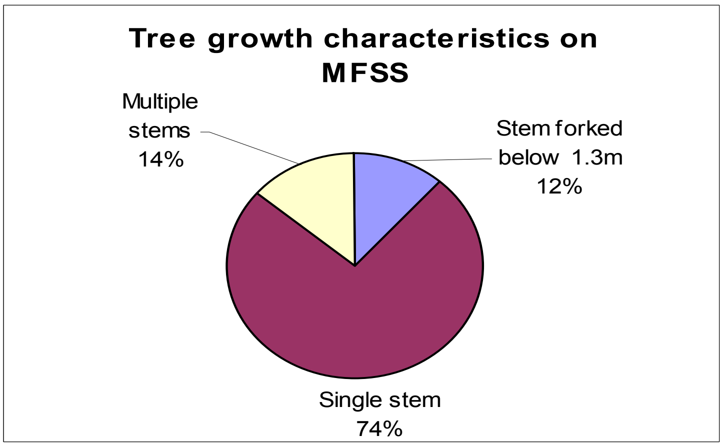


Figure 5.20 Proportions of Different Growth Habits Identified for Trees Sampled on the Sites of Chiyobeka and Kasambo Villages

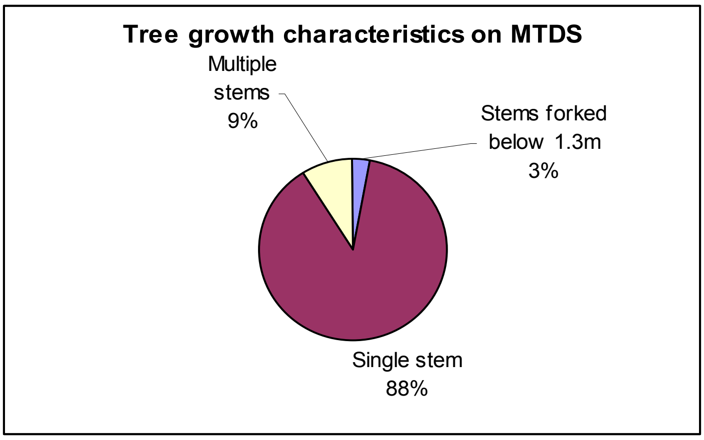


Figure 5.21 Proportions of Different Growth Habits Identified for Trees Sampled at TD1 to TD3

Some of the identified prevalent growth habits in the area were:-

- **Multiple stemming** – this type of growth can arise from coppice regeneration or frequent die-back in plants originating from seeds during the establishment stage. Die-back can be caused by severe drought, animal browsing or bush fires;
- **Formation of thickets** – thickets are dense stands of small trees or shrubs that grow closely together to form impenetrable vegetation. Branching is usually very close to the ground and thorns line the stem for protection. Thickets are characteristic in Northern Province (Itigi thickets), South-Western Province (Kalahari forests on sand) and the Gwembe valley (edges of woodlands in dry zones);
- **Branching habits** – most of the trees in the area are branched at less than 2m or just above 2.5m. Low level branching is characteristic of forests/woodlands in dry zones. This kind of branching tends to form heavy crowns consistent with most species in the area.

Table 5.16 shows the relative proportions of each type of growth habit for all the locations sampled. Trees with single stem growth habits are most common on all the sites that were sampled. The forking of stems below 1.3m is quite common on all the sites as well. The coppicing growth habit was only noticed for the sampled vegetation on the Dibwe orebody. It must also be recognised here that the number of samples that were collected would influence these percentages.

Table 5.16 Percentages of Evident Growth Habits of Trees on Sampled Sites

Location	Multiple Stem (%)	Single Stem (%)	Coppice (%)	Forked Stems below 1.3m (%)
Dibwe Orebody	33	37	2	28
Mutanga Orebody	8	46	0	46
Process Plant	6	80	0	14
Mine Camp	5	90	0	5
Raw Water Dam	12	78	0	10
Chiyobeka and Kasambo Settlements	14	74	0	12
Tailings Storage Facility	9	88	0	3

3) Uranium Bioavailability

Three sets of samples were collected from identified trees. These were root, bark and stem samples. The root samples were sent to ALS Chemex for assessment of the Uranium content in the plant matter. The roots were chosen for their proximity to the soil. The results are displayed in **Tables 5.15** to **5.20** below.

Table 5.17 Uranium Content of Root Samples from Tree Species on the Mutanga Orebody

Site	Plot No.	Specimen No.	Species	Common Names	Total Uranium mg/kg	Average Uranium Content mg/kg	Average Uranium Content of all the Samples mg/kg
Mutanga Orebody	1	0	*Burkea africana*	Wild seringa	0.060	1.071	0.268
	2	4			0.012		
	3	11			0.102		
	7	26			4.11		
	1	2	*Pseudolachnostylis maprouneifolia*	Kudu-berry	0.024	0.128	
	2	7			0.047		
	5	19			0.064		

Site	Plot No.	Specimen No.	Species	Common Names	Total Uranium mg/kg	Average Uranium Content mg/kg	Average Uranium Content of all the Samples mg/kg
	6	24			0.078		
	7	27			0.428		
	1	3	*Julbernardia globiflora*	Munondo	0.035	0.190	
	3	12			0.294		
	3	13			0.037		
	3	15			0.024		
	4	16			<0.010		
	4	17			0.030		
	4	18			0.014		
	5	21			0.287		
	9	30			1.03		
	10	31			0.135		
	2	5	*Terminalia sericea*	Purple-pod Cluster-leaf	0.078		
	2	6	*Diplorynchus condylocarpon*	Horn-pod tree	0.036	0.036	
	6	25	*Diplorynchus condylocarpon*	Horn-pod tree	0.135	0.135	0.268
	3	8	*Pterocarpus angolensis*	Wild teak	0.068	0.068	
	3	9	*Kirkia Acuminata*	White Seringa	0.039	0.039	
	3	10	*Dalbegiallia nyassae*	Mane-pod	0.231	0.231	
	5	20	*Afzelia quanzensis*	Pod mahogany	0.103	0.103	
	5	22	*Combretum ghalense*		0.053	0.053	
	6	23	*Euclea divinorum*	Magic guarri	0.079	0.079	
	8	28	*Colophospernum mopane*	Mopane	1.060	1.060	
	8	29	*Boscia mossabicensis*	Broad-leaved shepherd's tree	0.252	0.252	

Three tree individual species had high uranium content, which were *Colophospermum mopane* (1.06mg/kg), *Julbernardia globiflora* (1.03mg/kg) and *Burkea africana* (4.11mg/kg). The Uranium orebody at Mutanga outcrops at the surface and this may have contaminated the sample or the indivival species may have naturally accumulated these levels.

Table 5.18 Uranium Content of Root Samples of Species on Dibwe Orebody

Location	Plot No.	Specimen No.	Species	Common Names	Total Uranium mg/kg	Average Uranium Content mg/kg	Average Uranium Content of all Samples mg/kg
Dibwe Orebody	1	1	*Schrebera trichoclada*	Sand jasmine	0.011	0.044	0.138
	1	4			0.077		
	2	8	*Combretum apiculatum*	Red bushwillow	0.498	0.498	
	3	10	*Julbernardia*	Munondo	0.395	0.134	

Location	Plot No.	Specimen No.	Species	Common Names	Total Uranium mg/kg	Average Uranium Content mg/kg	Average Uranium Content of all Samples mg/kg
	4	12	*globiflora*		0.057		
	7	25			0.094		
	9	36			0.072		
	10	40			0.053		
	5	15	*Diplorynchus condylcarpon*	Horn-pod tree	0.059	0.129	
	9	35			0.199		
	6	22	*Colophospernum mopane*	Mopane	0.100	0.068	
	8	29			0.036		

Two tree individuals from separate species had occurrences of higher uranium content than other samples, which were *Combretum apiculatum* (0.498mg/kg) and *Julbernardia globiflora* (0.395mg/kg). *Diplorynchus condylocarpon* and *Colophospermum mopane* had Uranium content of 0.199mg/kg and 0.100mg/kg respectively. Uranium levels in the soil sample that was analysed was lower than the uranium soil levels at Mutanga.

In general, the soil content of the sample collected during the soil survey in **Section 5.9.5** above did not indicate much presence of uranium. The uranium content of the tree samples in **Table 5.19** (Process Plant) did not indicate any identifiable accumulations of uranium.

Table 5.19 Uranium Content of Root Samples of Species Sampled at MP1 to MP4

Site	Plot No.	Specimen No.	Species	Common Names	Total Uranium mg/kg	Average Uranium Content of all Samples mg/kg
Process Plant	1	6	*Adansonia digitata*	Baobab	0.093	0.055
	2	7	*Alfzelia quanzensis*	Pod mahogany	0.013	
	3	21	*Colophospermum Mopane*	Mopane	0.032	
	3	26	*Kirkia acuminata*	White Seringa	0.044	
	5	37	*Combretum karibensis*	Angular-stem Corkwood	0.042	
	6	51	*Euclea divinorum*	Magic guarri	0.070	
	7	56	*Diplorynchus condylocarpon*	Horn-pod tree	0.091	
	7	60	*Lannea stulhmannii*	False Marula	0.053	

Of the samples analysed on the tailings storage facility in **Table 5.20** below two tree species had higher uranium content than others sampled. These were *Diplorynchus condylocarpon* (0.129mg/kg) and *Lonchocarpus capassa* (0.582mg/kg).

Table 5.20 Uranium Content of Root Samples of Species Sampled at TD1 to TD3

Site	Plot No.	Specimen No.	Species	Common Names	Total Uranium mg/kg	Average Uranium Content of all Samples mg/kg
Tailings Storage Facility	1	4	*Diplorynchus condylocarpon*	Horn-pod tree	0.129	0.139
	1	11	*Combretum ghalense*		0.039	
	1	19	*Pseudolachnostylis maprouneifolia*	Kudu-berry	0.058	
	1	31	*Colophospermum mopane*	Mopane	0.052	
	4	11	*Lonchocarpus capassa*	Apple leaf	0.582	
	4	35	*Afzelia quanzensis*	Pod mahogany	0.078	
	4	37	*Erythrina livingstoniana*		0.034	

Of the four sites that were sampled (Mutanga Orebody, Dibwe Orebody, Process Plant and Tailings Storage Facility) the *Diplorynchus condylocarpon* has indicated higher levels of uranium content in two locations. The highest uranium concentration occurred in the species Burkea africana which may only have been related to concentrations in the soil.

5.17. Terrestrial Fauna

A terrestrial fauna study of the project area based on a desk study (literature review) and a site visit was undertaken from 31st March to 3rd April, 2009, managed by Jassiel M'soka in conjunction with Daniel Mwizabi and Edward Chilufya (ZAWA).

5.17.1. Objectives

The main objectives of the terrestrial fauna study were:-

I. To identify the pre-existing species that were present in the region;
II. To identify existing fauna species in the project area;
III. To evaluate the diversity of the terrestrial fauna in the study area;
IV. To prepare and provide lists of the existing rare, endangered and migratory species.
V. To identify migration routes of any species existing or known to have existed in the area; and
VI. To identify endangered habitats and describe management actions to prevent further habitat degradation of these sites.

5.17.2. Methodology

The following methods were employed during the assessment:-

i. Literature review: review of various resource materials that included books, journals,publications and internet;
ii. Field survey (March 31 to April 3, 2009);
iii. Walked Transects and Trapping;

iv. Driving along the main roads observing and recording the variety of fauna observed; and
v. Interviews with the local people.

Transects and Trapping

The study area was divided into a series of transects which were walked in several areas and at various times of the day.

The team walked along meandering transects in the study area from morning till about mid day identifying different types of fauna.

Birds were intensively spotted during these transect exercises. Mixed foraging parties of birds were followed until the full species composition of each group had been ascertained, before moving along to the next area of feeding activity. Species both seen and heard were recorded, using Bushnell binoculars.

Reptiles were surveyed by actively searching through leaf litter and dead logs along the transects and by constructing five pitfall traps and drift fences. Twenty litre (20L) buckets were used for the pitfalls and 5m wide lengths of plastic sheeting were erected as drift fences guiding reptiles or amphibians into the pitfall. Incidental observations of frogs were made during transects.

Small mammals were recorded incidentally, either visually or through indirect evidence such as spoor and droppings. There was insufficient time to conduct a comprehensive trapping exercise, although this would have been preferable for reptiles and small mammals.

Interviews

The local people were interviewed to establish the different animal species that had been sited in the area in the recent past, some of which probably no longer exist in the Project area. This helped capture information that could have been missed during the field observations as well as verification of collected data.

5.17.3. Study Limitations

The major limitations were:-

i. The time frame in which all the field survey was conducted was very limited;

ii. Limited visibility due to the tall grass (since the study was conducted towards the end of the rainy season when the grass and foliage were dense. However, this is the period when biodiversity is expected to be at its peak);

iii. Spoor could not be traced easily as it would be washed away by the rains easily;

iv. The survey team failed to reach the wetlands or water bodies in the study area due to difficulties associated with accessing the area during the rain season;

v. It was not possible to determine seasonal variations in the species activities as only one site visit during one season was carried out.

5.17.4. Historical Occurrence of Wildlife in the Study Area

The prospect area is part of the Lower Zambezi Ecosystem in the Zambian context, which stretches from the Lake Kariba Dam Wall to the Luangwa – Zambezi River Confluence in Feira. On a regional scale the area is part of the middle Zambezi stretching from the Victoria Falls to the Cabora Bassa dam in Mozambique (refer to **Figure 5.22** below).

This area has a many protected areas both on the Zambian side and the Zimbabwean side. On the Zambian side the major protected areas are the Lower Zambezi National Park and Chiawa and Rufunsa GMA. On the Zimbabwean side the protected areas include the Mana Pools National Park and Charara, Hurungwe, Sapi and Chewore Safari Areas. The main physiological feature of the area is the Zambezi River and the Muchinga Escarpment which, runs in an east-west direction through the whole Lower Zambezi from Lake Kariba to Feira. These two features determine the distribution of large mammals in the area.

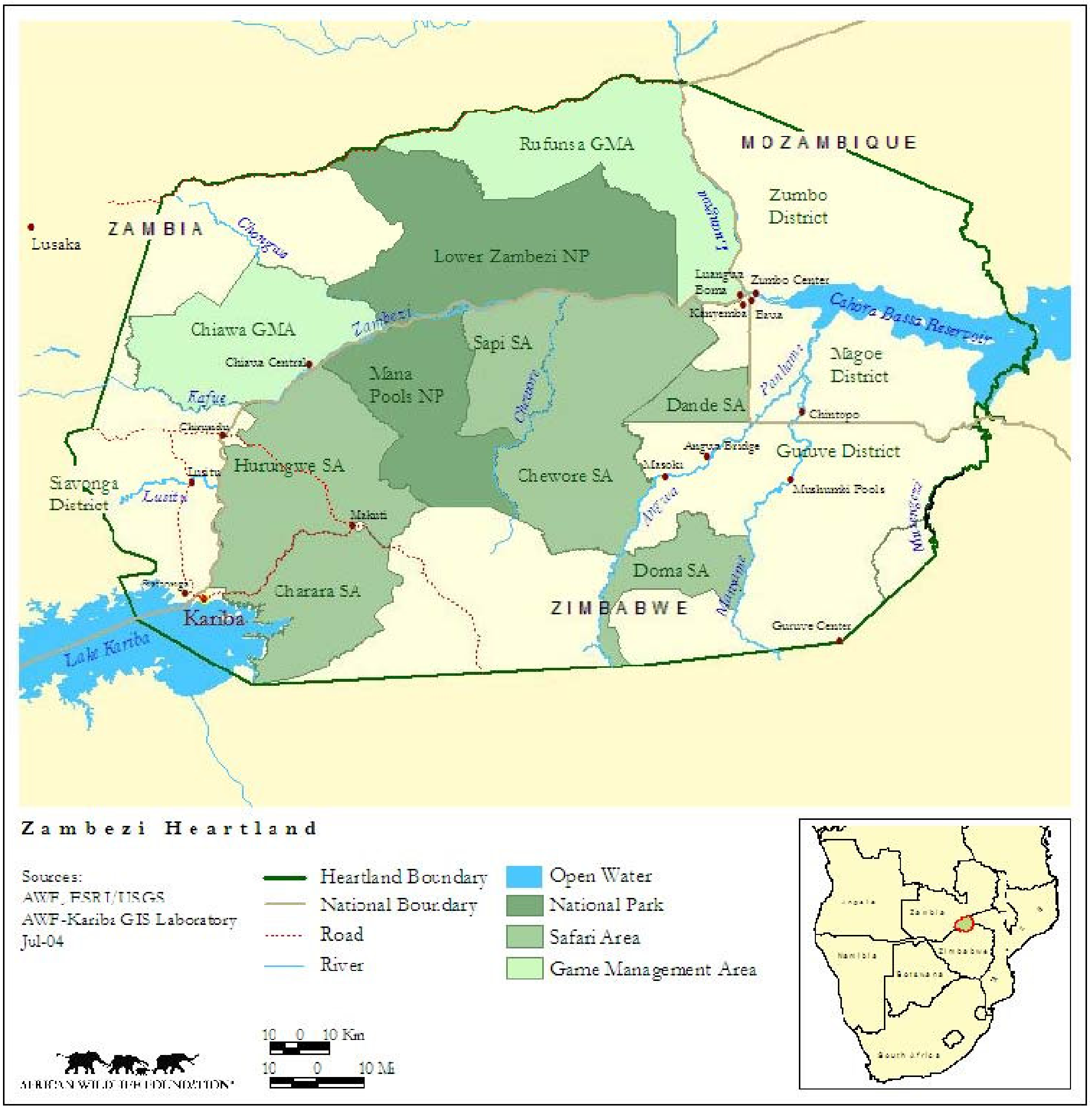


Figure 5.22 Protected Areas in the Lower (Middle) Zambezi Ecosystem

(Source: AWF Zambezi Heartlands)

Maps used with the courtesy of AWF Zambezi Heartlands office. The damming of the Zambezi River to create Lake Kariba and the subsequent relocation of people has had a great impact on the wildlife distribution and survival of the area. The flooding of the Middle Zambezi Valley above the Kariba Dam compelled the large mammals to forsake part of the range they had formerly occupied.

The flooded area had contained a variety of vegetation types, largely riverine, which were not represented above the final lake level. Hence mammals which had been living in the area of the present Lake Kariba suffered a decrease, not only in area of terrain, but also in range of habitat types available to them (Jarman, 1972) (refer to .

Today there is virtually no big game left on the Zambian side of Lake Kariba. Occasionally, elephants and old lions still swim the Zambezi below the dam to forage in Tonga gardens or feed on Tonga cattle respectively. Safari operators have also introduced game on Kota Kota and leased islands. Besides these, one rarely sees mammals larger than Mopane squirrels or the occasional small antelope (Scuder, 2005).

Because Lake Kariba was the first major reservoir formed in the tropics, there was little awareness even among scientists as to what actions should be taken before flooding or the nature of the environmental impacts that would follow inundation. That was the case even where some pre-Kariba surveys had been done, examples including what to do, if anything, with wildlife living in the future reservoir basin and the range of estimates as to the future productivity of the fishery (Scuder: 2005).

Charles Lagus in his book Operation Noah, which gives an account of animals rescued from the Lake Kariba after damming. The following animal species list indicates the animals that were rescued on the Northern Rhodesia (Now Zambia); side Aardvark, Bush buck, Dassies, Duiker, Hare, Impala, Klipspringer, Mongoose, Porcupine, Warthog, Waterbuck and Zebra.

Common Name	Latin Name	Common Name	Latin Name
Vervet monkey	*Cercopithecus aethiops.*	Buffalo	*Syncerus caffer*
Baboon	*Papio ursinus*	Black rhino	*Diceros bicornis*
Jackal	*Canis adustus*	Zebra	*Equus burchelli*
Wild dog	*Lycaon pictus*	Bush pig	*Potamochoerus porcus*
Spotted hyena	*Crocuta crocuta*	Warthog	*Phacochoerus aethiopicus*
Leopard	*Panthera pardus*	Hippopotamus	*Hippopotamus amphibius*
Lion	*Panthera leo*	Waterbuck	*Kobus ellipsiprymnus*
Elephant	*Loxodonta africana*	Impala	*Aepycevos melampus*
Common duiker	*Sylvicapra grimmia*	Roan antelope	*Hippotragus equinus*
Grysbok	*Raphicerus sharpei*	Sable antelope	*Hippotragus niger*
Klipspringer	*Oveotragus oveotragus*	Bushbuck	*Tragelaphus scriptus*
Reedbuck	*Redunca arundinum*	Greater kudu	*Tragelaphus strepsiceros*
Eland	*Taurotragus oryx*		

Table 5.21 Large Mammals in the Middle Zambezi (Source: Jarman, 1972)

N.B. should be taken that such animals as the Black Rhino are since extinct in this part of the middle Zambezi on the Zambian side.

5.17.5. Different Species of Wildlife Occurring in the Project Area

5.17.5.1. General Findings

The study area is sparsely populated, with the proposed Mutanga open pit showing the highest levels of human habitation. The main social economic activities observed in the area were farming and rearing of livestock, with goats and cattle being in abundance. Other domestic animals included sheep and pigs.

It is very unlikely that wild animal species would coexist with human habitation in the area. Very little human activity was observed in the Dibwe open pit site area. The site, which consists of mainly Mopane woodland, had very little activity and the transect walk across the site did not record any human habitation, till the end were some fields were recorded. Despite the lack of activity the team did not record many mammal sighting.

The area had a high diversity of bird life, as is indicated in the inventory. The Project area is located less than 20km from the Mutulanganga Important Bird Area along the Lusitu-Siavonga Road.

5.17.5.2. Reptiles

The Zambezi River (including Lake Kariba) is host to large concentrations of the Nile crocodile. The species is commercially important and eggs and adults have been removed from the area since the 1960s (Fergusson 2005). The Kariba shoreline is the most important source of wild eggs and accounts for over 70% of the eggs collected by crocodile farmers in Zimbabwe (ZPWMA, 2006).

The average crocodile population densities from the Kariba Dam wall to the Luangwa – Zambezi River Confluence varies between 5.61 and 9.90 per river km stretch. The Lower Zambezi National Park and areas contiguous to it have the highest concentrations of crocodiles, with variations of 8.84 and 15.61 per river km stretch. The lowest population concentrations were in the Siavonga open areas stretch with 1.13 – 2.00 per river km stretch (Nyirenda. V, Sichone. P and M'soka. J, 2007).

In the areas with high restrictions on the use of water and entry into the water, as is the case with Lower Zambezi National Park and the eastern part of Chiawa, where the number of boats and water activities have been regulated, the status of the crocodiles has been enhanced. Areas where little form of regulation is enforced, particularly the western part of the GMA and Siavonga open areas the population status has degraded. Factors that influence the estimates, structure, and distribution of crocodiles can also indirectly be illustrated by increased interaction with human activities.

5.17.5.3. Birds

Along the main road from Lusaka to Siavonga, approximately 20km from the Mutanga Project activities, is the Mutulanganga Local Forest. This forest reserve is a designated Important Bird Area (IBA) through the Zambia Ornithological Society (ZOS).

The forest is described as 'probably the largest remaining block of undisturbed lowland deciduous thicket in Zambia' (Peter Leonard, 2005). The Mutulanganga area is best known as a regular breeding ground for the migratory African Pita.

Three palaearctic migrants are represented in this area, and include the thrush-nightingale, river warbler and the marsh warbler.

Other species of interest include the western banded snake eagle, crested guinea fowl, purple-crested turaco, african broadbill, sombre bulbul, white-throated nicator and Livingstone's fly catcher. A total of 198 bird species have been recorded in this area (Leonard P, 2005).

5.17.5.4. Reptiles and Birds

Snakes and lizards were evidently rare. No snake tracks were noticed but there was one snake sighted on the Mutanga open pit, but it quickly disappeared into the tall grass.

A single terrapin was seen on the South Road from Matuwa to the DMZL exploration camp on the first day, but none were sighted in the field survey areas.

The scales, without skeleton, of a lizard were observed in the process plant survey area. The following brief descriptions outline the birdlife in the six surveyed sites, including the exploration camp.

Omega Exploration Camp

Early during the mornings, the white-browed sparrow-weaver (*Plocepasser mahali*) and the fork-tailed drongo (*Dicrurus adsimilis*) rest and call from tree to tree in the Miombo vegetation around the camp. The african golden oriole (*Oriolus auratus*) perched in a Julbernardia globiflora tree close to the dining tent. The southern red-billed hornbill (*Tockus rufirostris*) was also observed.

Mutanga Open Pit

This area is covered by Miombo vegetation interspersed with *Colophospermum mopane* in some areas except on riverine terrains. This combination of vegetation favours a variety of bird species. Most of the bird species recorded around this area were spotted except for a barn owl (*Tyto alba)*, barred owlet (*Glaucidium capenis)* and wood owl (*Strix woodfordii*) which were recorded through the evening and night calls. Other species recorded through calls include trumpeter hornbill, southern ground hornbill, cardinal woodpecker, Angola pitta, bleating bush warbler and arrow-marked babbler.

Waste Rock Area

The waste rock area has varied vegetation communities ranging from dambo to open and dense Miombo woodland into closed canopy Mopane and some Acacia woodlands as well as grasslands. By having this type of vegetation combination the area supports a wider variety of birdlife than the Mutanga open pit site. Bird species recorded included; most of the owls except the spotted eagle owl (*Bubo africanus*), the helmeted guineafowl, laughing dove, purple-crested turaco, striped kingfisher and golden-tailed woodpecker.

Raw Water Dam

Most of the area is characterized by a combination of Miombo, a seasonal stream and Mushitu type thicket. Cultivation of maize and other crops are done around this area. Bird species recorded in this area included the shikra, laughing dove, cape turtle dove, red-eyed dove, little swift and the little bee-eater.

Process Plant

The area is covered by Miombo woodland. During the time of the survey the species recorded by calls were laughing dove, Namakwa dove, paradise flycatcher, cardinal woodpecker and golden-tailed woodpecker and the rest were recorded by sight.

Dibwe Open Pit

The habitat of Dibwe is characterized by a different type of vegetation which is Mopane woodland (middle of open pit area to the north-western part) and the Mutemwa or Mushitu thickets (north-eastern to eastern part). Different species of birds such as owls, woodpeckers, trumpeter hornbill and southern ground hornbill were heard. Some mixed vegetation of a few acacia and Miombo could be found with a lot of bird calls as well as sightings observed. Recognised calls included the rattling cisticola, bleating warbler and cardinal woodpecker.

The Dibwe open pit area supports a lot of terrestrial birdlife because of different habitat characteristics as well as the isolation of the area from major settlements.

5.17.5.5. Mammals

Literature Review

On the Zambian side, from the Kariba Dam wall to the confluence of the Kafue and Zambezi Rivers, the area is heavily settled and is considered to be an open area. Unlike, the Zimbabwean side which has a series of protected areas. This international agreement on fauna migrations and co-development of GMA's and nature reserves has ensured the continuous presence of the large mammal herds in the Lower Zambezi region. Animals that undertake international migration are elephants; that cross the Zambezi River from Zimbabwe during the harvest and fruiting season; lions and buffalos, refer to **Figure 5.23**.

The area forms a major corridor for elephants and it is important that efforts are put in place to see how the area can be protected. Recent surveys by ZAWA have recorded elephants and common duikers.

Such livestock as cattle and sheep and goats are found within the area too (Simwanza, 2005). In 2003, Dunham K. conducted a survey to determine the wet season distribution of wild animals. Further, the Zambia Wildlife Authority conducted surveys in the area to determine the wet and dry season distribution of large mammals between 2004 and 2005. **Table 5.22** shows the elephant distribution in the Tonga-Sikoongo Open Area in the wet season of 2004. **Table 5.23** shows the dry season population distributions of large mammals in the Tonga-Sikoongo Open Area in 2005. **Table 5.24** shows the 2005 dry season large mammal population distributions in the Tonga-Sikoongo Open Area Escarpment Blocks. Large mammals also include livestock.

Table 5.22 Wet Season Population Estimates and Statistics for Elephant in the Tonga – Sikongo Open Area Valley Floor, 2004 (Source: Simwanza, 2004)

Species	Estimate	No. Seen	Variance	% CL	Lower CL	Upper CL	Density km^{-2}
Elephant (males)	12	2	34.8	105.7	0.00	23.7	0.010
Elephant (Cows)		0					

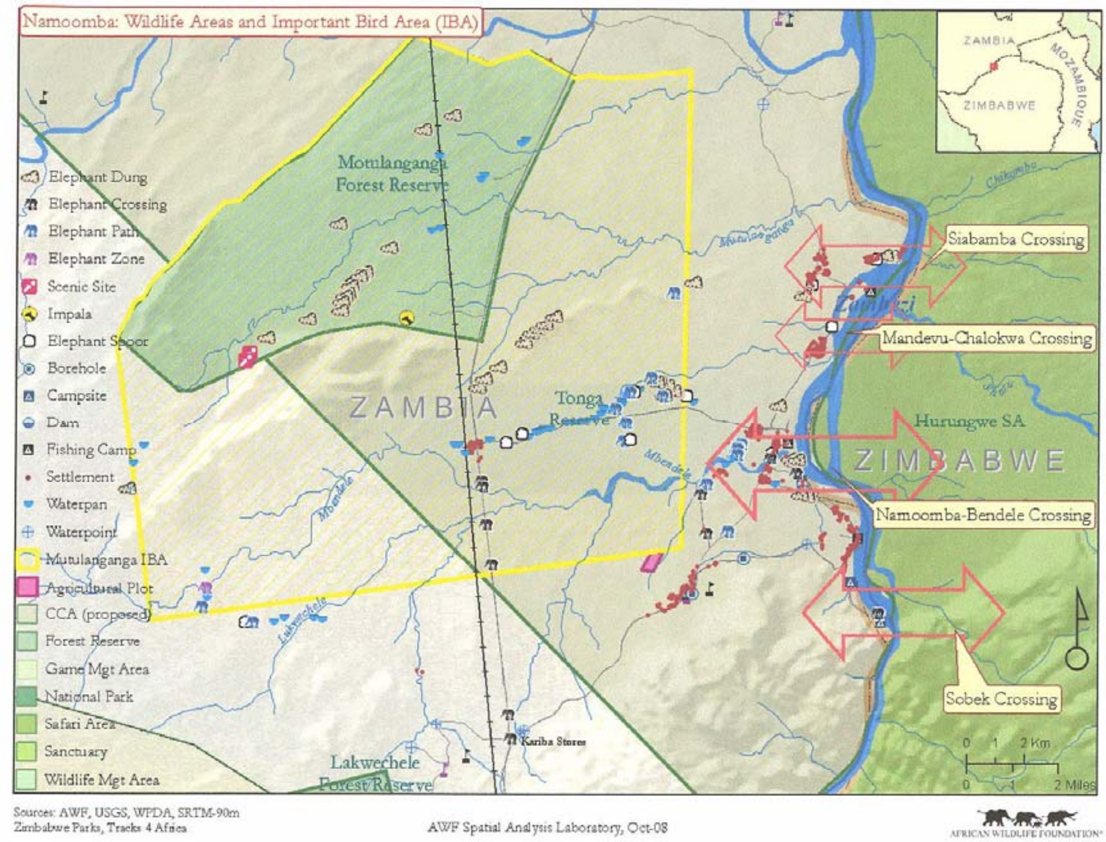


Figure 5.23 Elephant Movement Routes in the Siavonga Area

Table 5.23 Dry Season Population Estimates and Statistics for Large Mammals and Carcasses for the Tonga – Sikongo Open Area Valley Floor, 2005 (Source Simwanza, 2005)

Species	Estimate	No. Seen	Variance	% CL	Lower CL	Upper CL	Density km^{-2}
Elephant (males)	5	1	17.1	175.5	0.00	13.4	0.005
Elephant (Cows)							
Common Duiker	15	3	49.3	99.0	0.1	29.1	0.010
Sheep and Goats	5844	1197	3003781.7	61.2	2266.4	9420.9	5.850
Cattle	4306	882	544941.2	35.4	2782.2	5829.5	4.310

Table 5.24 Dry Season Population Estimates and Statistics for Large Mammals and Carcasses for the Tonga – Sikoongo Open Area Blocks (Escarpment), 2005 (Source: Simwanza, 2005)

Species	Estimate	No. Seen	Variance	% CL	Lower CL	Upper CL	Density km^{-2}
Elephant (males)	0	0	0	0	0	0	0
Elephant (Cows)	49	11	947.8	63.0	0.0	181.0	0.056
Sheep and Goats	1747	394	298600.0	31.0	0.0	4098.0	2.002
Cattle	2869	647	236559.0	17.0	776.0	4962.0	3.288

The ZAWA surveys indicate that the numbers of large mammals are generally low and concentrated in the valley section of the prospect area.

Field Research Results (March - April, 2009)

The following evidence of the presence of mammals provided through physical indicators were:-

- Spoor of bushbuck (*Tragelaphus scriptus*), was found in the Mutanga area on the March 30th which appeared to be from the previous night;
- Droppings possibly a month old were identified as belonging to Klipspringer;
- Spoor of the common duiker (*Syvicapra grimmia*) was observed in all the studied areas and the species appeared to be widely distributed;
- Diggings of bush pigs (*Potamochoerus porcus*) were identified at the Dibwe open pit area;
- Burrows developed by aardvark (*Orycteropus afer*) were observed in the Dibwe and waste rock dump areas; and
- Scat of a jackal was seen in the waste rock dump area.

It was very difficult to pick out animal prints in the ground as it had just rained in the night clearing out any prints that may have been made.

Aardvark burrows provide refuges and shelters for carnivores from the size of hyenas and leopards downwards and for herbivores up to the size of steenbok and warthogs.

All these sightings were deep in the bush of the surveyed areas away from the roads.

The only sightings that were recorded along the road during night surveying were of the scrub hare, on the 30th of March, 2009 on the Zyiba Meenda road. Three hares were sighted during the field survey, with one located 100m outside the gate of the Denison exploration camp.

In addition to the physical evidence of the presence of animal species, the study team endeavoured to interview people from the local community about the presence or absence of certain animal species. The persons interviewed were:-

- Froody Hakajika – Changa Village;
- Jericho Mangilazi – Chilundu Village;
- Benson Moonde – Kapita Village;
- Gordon McDonald – DMZL staff.

The various interviews conducted in the villages presented the common animal species indicated in **Table 5.25** below. **Table 5.26** describes mammal IUCN status.

Table 5.25 Animals Sighted During Field Survey March - April 2009

Animal Species	Sighted/Spoor seen on this visit	Regularly seen by locals	Rarely seen
Vervet monkey			√
Baboon			√
Bush pig	√		
Jackal	√		
Common duiker	√	√	
Grysbok	√	√	
Klipspringer	√		
Bushbuck	√		
Greater kudu			√

Table 5.26 Conservation Status of Mammals on IUCN Redlist

Local Name	Latin Name	Common Name	IUCN Status Red list
Baboon	*Papio ursinus*	Sokwe	LC
Bushbuck	*Tragelaphus scriptus*	Mbabala	LC
Bushpig	*Potamochoerus larvatus.*	Uluube/Sichipoongo	LC
Common Duiker	*Sylvicapra grimmia.*	Numusya	LC
Greater Kudu	*Tragelaphus strepsiceros*	Hambololo	LC
Grysbok	*Raphicerus sharpei*	Timba	LC
Klipspringer	*Oreotragus oreotragus*		LC
Jackal	*Canis adustus*	Mwaaba	LC
Velvet Monkey	*Cercopithecus aethiops*	Cheta	LC

LC – Least Concern

It is a possible that the Mutanga Project area forms the tip of the elephant corridor from Zimbabwe through Lusitu. Interviews with camp staff and the locals indicated that elephants were sighted to the west of Mutanga between August and November, 2008. They spent a week in the area and left. Another two bulls were also recorded in the area between March and May 2006. Other animals species that could occur in very small numbers in the area include kudu, baboons and vervet monkeys. No bats were seen or recorded in the area during the study trip.

5.17.5.6. Insects (Lepidoptera)

Butterflies and a few moth groups are the only insects where meaningful invertebrate information can be obtained for environmental impact studies in Zambia. This is because most other groups are either difficult to sample quantitatively (e.g. termites) or have little taxonomic information. In addition this survey requires a group which can be sampled in a relatively short time period. For this reason butterflies were chosen as the focus study group. It however must be remembered that other groups such as termites may be of significant ecological importance.

Twenty eight (28) different species of butterflies where observed in the study area. The most frequently seen species of butterflies, five in every eight butterflies, was the Eurema species. The other butterfly species which were commonly observed were Colotis and Belenois species. Out of the 28 species of butterflies, only 24 species were identified up to genus level while four species were not identified. **Table 5.27** below shows a list of identified species of butterflies observed.

Table 5.27 List of Butterflies

No.	Species	Common Name
1	*Colotis danae*	Scarlet Tip*
2	*Acraea induna*	
3	*Eurema brigitta brigatta*	Broad-bordered Grass Yellow
4	*Mylothris agathina agathina*	
5	*Belenois gidica mv*	Brownveined White
6	Colotis *antevippe*	Red Tip
7	*Bicyclus anynana anynana*	
8	*Hyalites igola*	Duskyveined Acraea
9	*Danaus chrysippus aegyptius*	
10	*Junonia natalica*	Brown Pansy
11	*Junonia orithya*	Eyed Pansy
12	*Colotis evagore*	Small Orange Tip
13	*Lepidochrysops plebeia*	
14	*Junonia hierta cebrene*	
15	*Acraea ancaea*	
16	*Hylites eponina*	Small orange Acraea
17	*Colotis spp*	
18	*Colotis spp*	
19	*Catopsilia florella*	African Migrant
20	*Mylothris spp*	
21	*Belenois spp*	
22	*Melanitis spp*	
23	*Acraea spp*	
24	*Colotis spp*	
25	*Cyligramma latona*	Owl Moth

*only observed in the field, no photos taken

5.17.6. Sensitive Habitats Identified in the Project Area

5.17.6.1. Mutulanganga Local Forest

This forest reserve is a designated Important Bird Area (IBA). The local forest is described as ‘probably the largest remaining block of undisturbed lowland deciduous thicket in Zambia’ (Peter Leonard, 2005). The area is best known as a regular breeding ground for the migratory African pita.

Palaeoarctic migrants represented in this area include thrush-nightingale, river warbler and marsh warbler.

Other species of interest include the western banded snake eagle, crested guinea fowl, purple-crested turaco, African broadbill, sombre bulbul, white-throated nicator and Livingstone’s fly catcher. A total of 198 bird species have been recorded in this IBA (Leonard P, 2005).

5.17.7. Potential Impacts of the Project on Terrestrial Fauna

i. Loss of habitat for fauna during clearance of the Project infrastructure footprints will result in the destruction of vegetation. While birds, some reptiles and some small mammals will be able to vacate the site during initial clearing, it is likely that fossorial (species adapted to digging that spend much of their lives below the soil surface) reptiles and mammals, as well as most frogs, will be destroyed along with their habitats;

ii. Disturbance of fauna through increased noise levels from increased vehicle traffic, construction, mining and other noise-producing activities will most likely have detrimental impacts on breeding activities of bird communities in the vicinity of the mine.

iii. Increased poaching of small mammals and birds due to the influx of people to Mutanga Mine;

iv. Pollution of surrounding watercourse may eventually affect Lake Kariba and the Zambezi River although this is unlikely over the distance of the project from the lakeshore. Pollution would not only impact the fish but all fauna that depend on the lake and river for water;

v. Blockage and/or destruction of the animal corridors and migratory routes. This will consequently cut off the animals from accessing part of their habitat and disturb their existence. It will also limit migration which may result in the loss of large mammals on the Zambian side of the Zambezi River; and

vi. Loss of the Mutulanganga local forest - a designated Important Bird Area (IBA) and the largest remaining block of undisturbed lowland deciduous thicket in Zambia. This IBA is approximately 20km east of the Mutanga Project. Impacts could be from exploration or mining activities or wood collection. This will endanger the birds and wildlife which live in this forest. It will also threaten the existence of this important IBA.

5.17.8. Impact Management

i. Establish and Manage Biodiversity Offset Programme. The International Council on Mining and Metals has developed guidelines for biodiversity protection for mining (ICMM 2005). The guidelines stress that mines need to acknowledge the importance of biodiversity off-sets as a central component of successful mine operations, and that areas of high conservation value should be protected and degraded areas rehabilitated. The areas may include off-site mitigation areas that are beyond the mining lease boundaries. There are a number of areas within and around the Project area that are of particular significance in terms of aquatic & terrestrial biodiversity, and which may receive priority conservation status. It is proposed that Denison enters into an agreement to support a protected area to offset the destruction and fragmentation of vegetation that has, and will be, caused by the Mutanga Project. Such an area should be bigger than the area lost to development if the principle of “no-net loss” is applied. The area should also contain a similar diversity of habitats to those being lost, and also incorporate degraded areas that can be rehabilitated to off-set the losses. The tenure and management of such an area is a key consideration for effective mitigation, so it would be preferable to choose an area within a complete drainage unit, and one which falls under the same management or ownership. A suitable area is the Mutulanganga Local Forest and the surrounding environs that form the northern sections of the elephant corridor from Zimbabwe.

ii. Denison could investigate the possibility of reintroduction of game in the proposed conservation area, as the habitat is still very intact to support game;

iii. Denison can enter into agreements with the local communities, Zambia Wildlife Authority, the forest department and other interested NGOs, such as AWF and ZOS, to employ personnel to patrol the surface right areas. The personnel should be given environmental training that includes protection of fauna and flora;

iv. Denison will not conduct prospecting or mining activities close to the Zambezi River and Lake Kariba in order to avoid disturbance to the large mammals that are more prevalent in these areas as well as preventing pollution to aquatic environment; and

v. Noise levels will be reduced by all means where feasible to prevent impact on the surrounding fauna communities.

5.18. Hydrology

An investigation was conducted into the hydrology of the Mutanga Project site. This included the Dibwe open pit, which is located 10km southwest of the Mutanga open pit.

The aims of the hydrological investigations were to:-

- Identify all areas of surface drainage on the project footprint
- Establish baseline element concentrations and flows through a continuous monitoring program;
- Identify monitoring sites in the areas surrounding the project that could act as water quality background sampling points.

The scope of work included:-

- Conduct a desk study/review of all existing data;
- Identify an accredited laboratory that can monitor all the necessary parameters;
- Conduct monthly sampling of surface water monitoring points and collecting samples for chemical, physical, total and dissolved metal analyses; and
- Conducting monitoring of the flows and seasonal variability.

5.18.1. Surface Water Drainage

The Mutanga and Dibwe prospects are located on hills incised by seasonal stream channels. The highly permeable nature of the soils and underlying sandstones dictate the low availability of surface water during the dry season.

The proposed Mutanga open pit area is incised by a small seasonal stream that has been used by the communities of Chiyobeka and Kasambo for water supply for livestock and small vegetable gardens . This stream flows northwards into the valley bottom at the base of the Mutanga hills. This drainage flows into the Machinga Stream (MUT/SW/01), which flows easterly and feeds into the Lusitu River (**Plate 5.7** below). Changa Village is located on the banks of the Machinga Stream, to the north of the DMZL Exploration Camp.

Plate 5.7 Lusitu River to the North of Mutanga

The process plant is proposed to be located about 400m away from the proposed Mutanga open pit area in the southwards direction. A seasonal stream flows from the lowpoints in this area and feeds into the runoff from Mutanga Pit.

The Mutanga RWP is proposed to be located in a runoff valley approximately 2km northeast of the proposed process plant area. The drainage from the RWP flows easterly and eventually into the Lusitu River. The Dibwe RWP is proposed to be located approximately 2km southeast of the Dibwe pit. The drainage from the RWP flows southwesterly into the Nahunwe River.

The surface runoff drians southwesterly towards the Dibwe Open Pit and Leach Pad Area. There are three fairly small seasonal runoff channels on the Dibwe open pit. Engineered drains at site will prevent water from crossing the Dibwe open pit. The Leach Pad and Waste Rock Dumps may be affected by the rainfall runoff during the rainy season. The surface drainage from the Southern side of the Dibwe Pit Hill drains in a southwesterly direction feeding into the Nahunwe River. The Namatelo River is a tributary of the Nahunwe River and it receives drainage from the western extremities of the exploration license. The Nahunwe River drains into Lake Kariba, approximately 20km south of the Project Area.

5.18.2. Surface Water Usage

The local communities use two handpumps (Chiyobeka and Kapita Villages) to obtain potable water for household consumption. Both of these handpumps are likely to be destroyed during mining construction activities for the Mutanga open pit and the raw water dam.

Surface water is mostly used for irrigation in the Project area. Hand dug wells, pits and irrigation channels were evident in the villages and were used to supply vegetable gardens.

5.18.3. Surface Water Monitoring Program

5.18.3.1. Sampling Frequency

There were 3 representative reliable surface Water Sampling Sites that were chosen (refer to **Table 5.28**) to ensure results would be produced for 12 months of the year.

A monthly surface water monitoring frequency was adopted. Monthly monitoring is considered practical and adequate to monitor seasonal variations in surface water quality.

Full suite chemical, physical and bacteriological analyses were performed on surface water samples for the first 6 months. These would be continued on a quarterly basis. Key parameters were chosen for monthly analysis.

River flow rate measurements were carried out monthly using the stream velocity multiplied by cross sectional area method at all three sites. A float was used to determine the flow.

Table 5.28 Surface Water and Well Monitoring Sites

Monitoring Site	UTM ARC 1950 S		Description of Location
	Eastings	Northings	
MUT/GW/01	660096	8189282	Handpump installed for water supply to Kasambo and Chiyobeka
MUT/GW/02	658891	8194292	Handpump at Dibwe
MUT/SW/01	651769	8180975	Nahunwe River to the southwest of the Dibwe Pit, upstream of runoff from surface drainage from areas near proposed mining activities
MUT/SW/02	659068	8198024	Machinga River located north of Mutanga open pit and receives runoff from the pit and proposed process plant areas.
MUT/SW/03	649927	8182482	Namatelo River is located southwest of Dibwe open pit and is fed by the Nahunwe River and drainage from the Dibwe hill

The **Plate 5.8**, **Plate 5.9** and **Plate 5.10** below depict the watercourses sampled.

Plate 5.8 Nahunwe River Upstream of Drainage from the Proposed Dibwe Pit

Plate 5.9 Namatelo River Southwest of the Dibwe Area

Plate 5.10 Machinga Stream

5.18.3.2. Field Water Quality Measurements

The field water quality was measured at each site, prior to the sampling activities being undertaken, using a Horiba U-10 Water Quality Checker.

Table 5.29 Field Water Quality Summary of Results from September 2008 to April 2009

Monitoring Site	Flow Rate m/s	pH	EC (mS/cm)	Salinity	Temp °C	Dissolved Oxygen
MUT/GW/01	NA	7.0	0.3	0.0	29.4	8.1
MUT/GW/02	NA	5.7	16.7	0.0	28.9	9.0
MUT/SW/01		8.0	0.1	0.0	28.6	5.7
MUT/SW/02	0.5	8.0	0.3	0.0	25.9	6.9
MUT/SW/03	<0.1	7.9	0.1	0.0	31.3	5.7

The flow rates measured in the streams were typically very low for the majority of the sampling which was conducted prior to the effects of the surface runoff from rainfall affecting the streams.

The pH of the surface water streams was generally within natural environment pH ranges of 6.5 to 8.5. The groundwater monitored

5.18.3.3. Sampling Personnel and Procedures

The sampling activities were undertaken by Miss Angela Duerden and Mr Benard Gomo from September 2008 to April 2009. Samples were collected in September, November, January, February and March. The sampling procedures are provided in **Appendix 11**. The samples were collected and stored in cool boxes for shipment to Inspectorate ML in Johanesburg, South Africa. Inspectorate ML conducted physico-chemical, total and dissolved metal analysis on the water samples. A radiological analysis was also conducted on the water samples for Uranium, Thorium and Radium.

5.18.3.4. Sample Parameters

The parameters tested for during the physico-chemical analysis are indicated in **Table 5.30** below.

Table 5.30 Physico-chemical Analytical Parameters

Parameter	Parameter
pH Value @ 23°C	Nitrate,NO3
Conductivity mS/m @ 25°C	Nitrate,N
Total Dissolved Solids	Nitrite as N
Calcium,Ca	Free and Saline Ammonia as N
Calcium Hardness as CaCO3	Total Kjeldahl Nitrogen as N
Magnesium, Mg	Total Suspened Solids
Magnesium Hardness as CaCO3	Sulfide S
Total Hardness as CaCO3	Dissolved Oxygen O2
Sodium,Na	Fluoride,F
Potassium,K	Biochemical Oxygen Demand O2
Total Alkalinity as CaCO3	Total Organic Carbon C
P Alk as CaCO3	Oil and Grease
Bicarbonate,HCO3	Sum of Cationsmeq/l
Carbonate, CO3	Sum of Anions meq/l
Chloride,Cl	Silicon
Sulphate,SO4	Boron

The parameters that were analysed for during the total metal and dissolved metal analysis are illustrated in **Table 5.31** below.

Table 5.31 Total and Dissolved Metal Analysis Parameters

Parameter	Parameter
Arsenic, As	Tin, Sn
Selenium, Se	Zirconium, Zr
Titanium, Ti	Bismuth, Bi
Aluminium, Al	Thallium, Tl
Nickel, Ni	Beryllium, Be
Manganese, Mn	Cadmium, Cd
Iron, Fe	Strontium, Sr
Vanadium, V	Phosphorus, P
Zinc, Zn	Uranium, U
Antimony, Sb	Molybdenum, Mo
Lead, Pb	Barium, Ba

Parameter	Parameter
Cobalt, Co	Silver, Ag
Copper, Cu	Thorium, Th
Total Chromium, Cr	Mercury, Hg

The parameters analysed for during the radiological assessment are shown in **Table 5.32** below.

Table 5.32 Radiological Analytical Parameters

Parameter	Parameter
U-238	Ra-223
U-234	Th-232
Th-230	Th-228
Ra-226	Ra-224
U-235	Gross Alpha
Th-227	Gross Beta

5.18.3.5. Sampling Results

The complete set of sampling results is included in **Appendix 11**. The results obtained for the sampled sites were all compared to the World Health Organisation (WHO) Guidelines for Drinking Water Quality that were updated in 2006.

The surface water and groundwater samples collected displayed compliant results for the physico-chemical parameters when compared to the WHO guidelines. pH in the groundwater samples was lower than the surface water samples, with pH ranging from 6.5 to 8.7 for MUT/GW/01 and MUT/GW/02 when compared to ranges from 7.0 to 8.8 in MUT/SW/01, MUT/SW/02 and MUT/SW/03. MUT/GW/02 had an average pH of 6.8 compared to MUT/GW/01 with a pH of 7.8.

There are generally very low concentrations of dissolved or total constituents in the sampled waters. The waters are considered to be hard due to high levels of calcium and magnesium hardness. There are low levels of suspended solids in the surface water and groundwater samples however total dissolved solids can exceed 400mg/l in groundwater.

Some parameters measured in the total and dissolved metal analysis are naturally non-compliant with the WHO guidelines. In the groundwater samples, arsenic, aluminium, manganese, total chromium and selenium exceeded their WHO guidelines of 0.01mg/l, 0.2mg/l, 0.4mg/l, 0.05mg/l and 0.01mg/l respectively. The elevated levels of aluminium are considered to be based on the underlying geology of the site. Selenium only exceeded the WHO limit at MUT/GW/01.

The surface water samples exceeded the sampled parameters of arsenic, aluminium, manganese, total chromium, selenium and barium. Selenium exceeded the WHO guideline at MUT/SW/01 in January 2009. This is possibly linked to rainfall runoff diluting soils and sediments and entering watercourses. Barium was elevated at all three surface water sites in January 2009 alone. This is probably related to seasonal runoff. Long term sampling of the monitoring sites will establish seasonal patterns in water chemistry.

Other parameters such as iron, lead, zinc and mercury were sampled in fairly low natural concentrations and were compliant with WHO guidelines.

Dissolved metal concentrations generally reflect total metal concentrations during events measured with high concentrations. However, where overall chemistry of the water varied such as increased pH, then dissolved concentrations are generally much lower.This is dependant on the type of metal.

The water sampling was not conducted for bacteria as it was considered through historical testwork that all samples would more than likely contain total or faecal coliform. This is probable through the use of surface water as bathing areas, water points for livestock and receptors for all sewage contaminated runoff during the rainy season due to the lack of adequate facilities in the houses or villages. The lag time for the samples to arrive at Inspectorate ML laboratory exceeded the recommended storage times for analysis of bacterial parameters.

The results of the radiological analysis of the groundwater and surface water samples are in **Appendix 11**. The results were compared to the WHO guidelines for radionuclides in drinking water and all of the measured values were compliant with the guideline limits. The radionuclides tested were of the radium, thorium and uranium series. Gross alpha and beta measurements were conducted. Gross alpha measurements exceeded the recommended **WHO limits** below which no remedial methods are required for drinking water in the groundwater samples during the November and January sample sessions.

The WHO limit of 500mBq/L was exceeded by the sampled water from MUT/GW/02 in November (1,800mBq/L) and January (1,510mBq/L). Sampled water from MUT/GW/01 exceeded the WHO guidelines in January (520mBq/L). The WHO gross beta activity guideline is 1,000mBq/L and this was exceed at MUT/GW/02 in November 2008 (2,610mBq/L). It is difficult to determine the reason for these readings but at present it may be attributed to seepage of rainfall into the groundwater system and changing the equilibrium. The first sample collected in September 2008 was obtained at the end of the dry season.

5.19. Hydrogeology

Hydrogeological baseline investigations for the Mutanga Project were conducted by Knight Piésold (Pty) Ltd between July 2008 and October 2008. A detailed report was developed as part of the FS for the Mutanga Project, with the main findings summarised below.

A total of 36 hydrogeological boreholes were drilled comprising a total of 3,240 m drilled. There were 22 boreholes used for aquifer testing. Hydrogeological data such as lithologies encountered, water strikes encountered and physical properties were obtained during the drilling of each hole. The drilled depths of the holes ranged from 60m to 100m and diameter of 8” (203mm), with a casing diameter of 6.5” (165mm).

After drilling and testing, the boreholes were secured with a concrete block and lockable cap protection to prevent contamination for future monitoring programs.

5.19.1. Conceptual Hydrogeology

The regional aquifer host rock comprises primarily sediments of the Karoo Supergroup. The rocks of the Karoo Supergroup are a significant aquifer in the Southern Province covering 11% of the total province (Bäumle, Nkhoma, Silembo, & Neukum, 2007). Bäumle, et al., 2007 also shows that the majority of the aquifers are in the form of fractured and faulted hard-rock systems, and this is particularly evident in the Mutanga area.

The investigation conducted by Knight Piésold of the Mutanga Project area determined the presence of two aquifer host rock types – firstly the sandstones and conglomerates of the Escarpment Grit Formation in the Mutanga deposit area, and secondly the interbedded sandstones and mudstones of the Dibwe deposit area.

The aquifer types in the Mutanga and Dibwe areas are described as semi-confined, heterogeneous dual-porosity aquifers with both structural features (fractures, faults and bedding plane fractures) and matrix porosity contributing to groundwater flow and storage.

5.19.2. Ground Water Quality

Sampes for ground water quality sampling were collected at the time water level measurements were conducted by Knight Piésold (Pty) Ltd at the the boreholes. Groundwater samples were collected before, during and after aquifer tests in order to detect any quality changes during the aquifer test.

The samples were delivered to a SANAS accredited laboratory in South Africa where they were analysed for the physical parameters and chemical constituents.The sites for Hydrogeological Monitoring are shown in **Figure C** in **Appendix 8**. The results are summarised below (details in the Knight Piésold (Pty) Ltd Report for Mutanga Project):-

- The pH values measured from the water samples collected indicated that water quality is within pH range of 6.5-9.5 and can be described as good quality;
- Total dissolved solids (TDS) in most of the samples, except for DIBHP-02, were within the recommended target value of 450 mg/L and suitable for drinking;
- The EC recommended target value is 70 mS/m which was only exceeded in DIBHP-02. Water from DIBHP-02 experienced elevated EC and TDS values and was deemed as unfit for drinking water usage;
- The tested boreholes, except for DIBHP-02 showed low levels of fluoride (e.g. <150 mg/L);
- All of the boreholes, except DIBHP-02, had low concentrations of sodium (i.e. <200 mg/L);
- The boreholes tested show low levels (i.e. <400 mg/l) of sulphates, except for DIBHP-02;
- The boreholes tested showed low levels of chlorides (i.e. <200 mg/l), except for DIBHP-02;
- All boreholes tested low levels of calcium (i.e. <150 mg/l) except for DIBHP-02;
- Nitrate concentrations in all of the boreholes in the region were low;
- Elevated levels of Fe and Mn were observed in September during sampling and levels were lower during November 2008. This may be due to borehole construction conditions and also because the November samples were collected during the pumping tests;
- The boreholes showed arsenic concentrations below the detection levels (less than 2 µg/L or 0.002 mg/L) as well as below the WHO Guideline of 0.01 mg/L (10 µg/L);
- All of the boreholes sampled for thorium have concentrations below detectable levels but there is no WHO guideline set for thorium concentrations;
- Only four of the boreholes sampled indicated levels of uranium 238 (^{238}U), which were all compliant with the WHO Guideline of 0.015 mg/L

5.19.3. Groundwater Levels

A hydrocensus was conducted in Mutanga with more than 70 boreholes sampled for water levels. A correlation conducted between the surface topography and the Static

Water Level (SWL) elevation in the area showed a relatively poor correlation of 33.2%. This indicated that the aquifers are semi-confined, and are therefore relatively insensitive to atmospheric pressure conditions.

The static water level depth in the project area varies substantially with an average of 19.94 mbgl (meters below ground level), with a minimum of 0.54 mbgl and a maximum of 59.14 mbgl. The maximum is, however, confounded as holes were encountered with water levels at depths greater than the maximum extent of the water level meter (60 m). This high variation in the water levels further corroborates the description of the aquifers as semi-confined and highly heterogeneous.

5.19.4. Aquifer Testing

Aquifer testing was conducted by means of step-up and constant discharge tests on the selected boreholes and yielded aquifer parameters for the Mutanga and Dibwe areas. The boreholes encountered water strikes at varying depths with blow-yields ranging from 0.3 L/sec to 22.9l/sec with an average blow-yield of 3.6 L/sec for the entire area.

Average hydraulic conductivity (K) values for these areas were calculated at 0.63 m/day and 0.31 m/day respectively, and average storativity (s) values were calculated at 4.24E-02 and 1.05E-02 respectively. Average sustainable yield (susQ) values were calculated at 4.51 L/sec and 2.67 L/sec for each site, assuming a worst case scenario of no recharge to the aquifers.

Assuming a recharge to the aquifers of 3.2% of the mean annual precipitation of 529 mm, these sustainable yield values increase to 6.93 L/sec and 3.54 L/sec for the Mutanga and Dibwe areas respectively.
The aquifers on site are described as heterogeneous, semi-confined aquifers exhibiting dual-porosity with both structural and matrix porosity contributing to overall yield and storativity of the aquifer itself.

6. SOCIO-ECONOMIC AND CULTURAL BASELINE

The socio-economic and cultural baseline study of the project area was conducted Dr. Mitulo Silengo, the academic coordinator for Leadership for Environment and Development (LEAD), Southern Africa, Lusaka. Miss Angela Duerden, AMC Environmental Scientist, assisted Dr Silengo. The field aspect of the study was conducted in November 2006, with follow-up visits in 2007 and September 2008.

6.1. Approach and Methodology

The collection of baseline socio-economic data was conducted in three phases. The initial phase of investigation involved the review of any secondary documentation of the area. The second phase incorporated Participatory Rural Appraisal (PRA) methods to collect socio-economic data. This included the collection of census information for the purposes of identification of the population that would be affected by the project.

The third phase of the social study has been initiated with the development of the Resettlement Action Plan (RAP) for the relocation of project impacted communities to a safe location from the mining operations. Public consultation based on the finalised project design will also need to be conducted.

The scope of work consisted of the following:-

- Conduct a desk study to collect and review all existing secondary data;
- Conduct a site visit to survey the area and undertake PRA methods to collect data from the local population;
- Conduct a population census of the project area;
- Conduct meetings with the village headmen; and
- Conduct interviews with household owners during the census.

Qualitative means such as transect walks were used to understand the information obtained in structured interviews.

A socio-economic census of the households located in the Mutanga Project area was undertaken. The exploration that had been conducted to the date of the survey was predominantly in Chief Sinadambwe's area. Fieldwork was conducted to collect the social data mainly through interviews with people in the project area. The census concentrated on the Mutanga and Dibwe areas and a minor survey of some of the Dibwe West area was conducted. The census was undertaken to consider some of the following issues:-

- Potential numbers of people that could be employed during the mine project;
- Potential displacement of villagers in the prospect area;
- Household structures and composition;
- Land use and settlement in the Mutanga Project;
- Economic and livelihood activities;
- Non-farm based activities;
- Health and welfare issues;
- Social services provision; and
- Public infrastructure.

6.2. Country Overview

The Republic of Zambia is governed by a multi-party democracy. The National Assembly, elected by universal suffrage, represents the national legislature. The Head of State is the President who governs through his appointed Cabinet. The legal system is based on English common law and customary law. The country is divided into 9 political subdivisions called Provinces.

The Zambian economy has always been dependent on foreign exchange revenue from its extractive industry. Copper accounts for over 75% of export earnings.

The Republic of Zambia is divided into 9 administrative provinces (Copperbelt, North Western, Central, Western, Northern, Southern, Eastern, Luapula and Lusaka Provinces). Southern Province covers an area of 85,283km^2 and the provincial capital is Livingstone. The Mutanga Project is located in the Southern Province.

6.3. Local Administration

The Southern Province is divided into 11 districts (Choma, Gwembe, Itezhi-tezhi, Kalomo, Kazungula, Livingstone, Mazabuka, Monze, Namwala, Siavonga and Sinazongwe). The Mutanga Project lies within the Siavonga District, which covers an area of 3,871km^2. The district administration is based in Siavonga.

The Siavonga District Council is the local authority in the project area. It is a semi-autonomous institution operating as an agent of Central Government authorized to perform specific functions on their behalf. The council is the highest decision making body at the district level. It formulates policies in the form of by-laws. The local authority provides a forum for local representation of the population by way of electing their local leadership to represent their interests to Central Government. The Ministry of Local Government and Housing as a wing of Central Government is in charge of the statutory powers of the Local Authority to make laws and regulations.

The District Commissioner (DC) leads the district administration through the Office of the District Commissioner. Mrs Emily Striedl is the DC of Siavonga District. The DC is assisted in these activities by the District Administrator (DA), Mr Aaron Siamuzulu.

The major function of the office of District Commissioner is to co-ordinate the activities of all government departments in the district. The office also harmonizes the functions of Central Government with those of Local Government. All agencies of development operating in the district are members of the District Development Coordinating Committee (DDCC) that is chaired by the DC. The District council provides the secretariat.

Other governmental departments in the area consist of the Siavonga District department of the Office of the President, the District Environment Management Committee, the District Aids Committee, District Health Department and representative offices of government departments from the surrounding districts.

6.4. Traditional Administration

The Mutanga Project exploration license LPL 237 covers an area of approximately 946.3km^2. The Chiefs in the project license or surrounding areas are Chief Sinadambwe, Chief Simamba and Chief Sikoongo. Senior Chief Chipepo resides over the traditional administration of the Siavonga District. Exploration activities have been concentrated in Chief Sinadambwe's Chiefdom.

In the Mutanga area traditional leadership in Chiyobeka village is provided by Senior Headman Alick Mweemba; in Kasambo Village by Headman Sailos Kasambo; in Chilundu village by Headman Wilfred Chilundu and in Kapita Village by Headman Steven Kapita. Kumulilansolo and Sinangosi Villages are located near Dibwe and are led by Simon Namulela and Shadreck Mungoni respectively.

6.5. Local Economy

In the 1980s, Southern Province was the leading province for maize production in Zambia. However, frequent droughts since then have led to a significant decline in regional food production and livestock populations (Southern Province, Census 2000). There is the potential for the production of dry rice, wheat, maize, vegetables, sorghum, cotton, tobacco and beans.

Manufacturing activities in Southern Province have declined since the 1990's (Southern Province, Census 2000) and consists of textiles, dairy production, wood processing, agro-processing and sugar processing industries. Dairy and game ranching occurs. Ginneries operate in Kalomo and Sinazongwe to support the local cotton farmers. Sugar is produced for national supply at Nakambala Sugar Plc in Mazabuka. Current mining activities in Southern Province are related to coal Maamba Collieries), amethyst (Mapatizya Mine, Kalomo) and tin (Choma).

Tourism is an important section of the services sector for the Government in Southern Province. The important tourist attractions in the province are shown in **Table 6.1** below.

Table 6.1 Tourist Attractions in Southern Province (Southern Province, Census 2000)

Name	Location	Activities
Victoria Falls	Livingstone	Rafting, speed boating, micro-lighting, souvenirs, bungi jumping, canoeing, shopping, booze cruises
Itezhi-tezhi and Lake Kariba Dam	North-eastern and south-eastern part of province	Man-made dams
Zambezi, Kalomo, Kafue and Ngwezi Rivers	Zambezi, Kalomo and Kafue Towns	Fishing, boating, camping
Lake Kariba	Siavonga (south-western part of province)	Fishing, sailing, safaris
Sichifulo/Mulobezi Game Management Areas	Mulobezi	Game viewing, safaris

6.6. Population Distribution

Siavonga District has a size of approximately 3,871km^2 and a population density of 15.2 persons per square kilometre (**Southern Province, Census 2000**). In 2000 there was an estimated population of 58,864, representing 5% of the total population on the Southern Province (**Southern Province, Census 2000**).

One elected Member of Parliament, Honourable Douglas Syiakalima of the United Party for National Development (UPND) exists for the Siavonga Constituency. Other parties represented in the District include the Movement for Multiparty Democracy (MMD), United National Independence Party (UNIP), Forum for Democracy and Development (FDD), Patriotic Front (PF) and the Heritage Party (HP).

6.7. Land Tenure

Two types of land ownership operate in Zambia, which are customary ownership and state ownership. Customary ownership is managed through the traditional administration of the local chiefs and their headmen where as state ownership is managed by the local authorities through the Commissioner of Lands. The Commissioner of Lands allocates land to applicants for development through a lease. The local authorities recommend to the Commissioner applications for residential, commercial and agricultural plots. These two forms of land tenure are found in Siavonga District.

Leasehold Land Tenure System (State Ownership)

In accordance with the Lands Act. No. 29 of 1995, the President of Zambia has rights to all the land of Zambia. The Commissioner of Lands is an agent of the President and the Local Council administrates the Commissioners activities.

The Council administers the land delivery systems in the District. The land delivery system includes interviewing and recommending prospective developers to the Commissioner of Lands for allocation of plots of land. As part of its duties, the Council has the responsibility of development control. This is done to ensure appropriate use of land and orderly development. Two forms of leases occur in Siavonga under the state leasehold system:-

- **Fourteen (14) year lease** - A 14 year lease ownership is given to a titleholder for land which is subject to renewal after the expiry date; and

- **Ninety-nine (99) year lease** – A 99 year lease ownership is given to a titleholder for land which is subject to renewal after the expiry date.

Traditional Land Tenure System

Under the traditional land tenure system the Chief with his or her clansmen communally own the land. The Chief has the responsibility of allocating land and this is done through the village headmen. There is no need for title deeds.

In an instance where the conversion of a traditional lease into a title deed lease is required, then the applicant seeks the consent of the Chief through the Headmen and his subjects within the area. If the Chief has no objection, the Local Council processes the application and recommends the application to the Commissioner of Lands for final approval and offer of a lease.

6.8. Socio-economic Background of the Project Area

The socio-economic study concentrated on the populations near and on the Mutanga orebody (Chiyobeka and Kasambo Villages) and the households near Dibwe orebody (Sinanjosi and Kumulilansolo Villages). The location of Kapita and Chilundu Villages on the southern access route and their proximity to the raw water dam qualified them for inclusion in the social census.

6.8.1. Population Characteristics

The 6 villages that are within the Mutanga Project zone are Chiyobeka, Kasambo, Chilundu, Kapita, Sinangosi and Kumulilansolo. The populations of these villages are described in **Table 6.2** below. The villagers in the villages near Mutanga were part of the original relocated population of the Kariba Dam Project conducted in the 1960s. The settlements located along the Dibwe Open Pit access road and near the open pit settled in the area after migrating away from the villages in the Dibwe region, to the southwest of the Dibwe Open Pit.

Table 6.2 Summary of Affected Population

Village	Homesteads	Households	Adults (>15 years)		Children (<15 years)		Population
			M	F	M	F	
Chiyobeka	7	39	28	26	37	23	114
Kasambo	7	15	15	12	22	8	57
Chilundu	13	22	14	14	15	27	70
Kapita	15	18	14	15	14	10	53
Sinangosi	2	11	6	7	15	6	34
Kumulilansolo	1	2	1	1	7	5	14
Totals	**45**	**107**	**78**	**75**	**110**	**79**	**342**

The population census that was conducted initially in 2006 and then updated in 2008, identified the following statistics:-

- Chiyobeka Village - There are 7 homesteads and 39 households. The total population is 114 people. There are 3 people over the age of 60 that are resident in the village;

- Kasambo Village - The village has 15 households with a total population of 57 people. There are 6 people over the age of 60 residing in Kasambo Village;

- Chilundu Village - The village has 22 households with a total population of 70 people. There are 2 people over the age of 60 residing in Chilundu Village;

- Kapita Village - The village has 18 households with a total population of 53 people. The population of Kapita is youthful;

- Sinanjosi Village - There are 11 households in the village, consisting of 34 people. There are no people over the age of 60 and the majority of the population is below 15 (66%); and

- Kumulilansolo Village - The village has 2 households with a total population of 14 people. There is one person with a disability in this village.

The total population in the affected villages is 342 individuals. The population below 15 years of age is 55% indicating that a high proportion of young people exist in the affected population. There are high dependency ratios in the Siavonga District. This reflects the fact that persons in productive ages (12+) are supporting a large number of dependants, for instance, 104.1 dependants for every 100 persons in Siavonga District (refer to **Table 6.3** below).

Table 6.3 Dependency Ratios of Selected Southern Province Districts

District	Overall Dependency Ratios	Child Dependency Ratios	Aged Dependency Ratios
Livingstone	73.1	70.1	3.0
Mazabuaka	98.6	94.0	4.6
Monze	113.7	107.	6.6
Namwala	116.3	99.9	6.4
Siavonga	104.1	99.2	4.9

Source: Adapted from CSO, 2004

The population distribution is illustrated in **Figure 6.3** below.

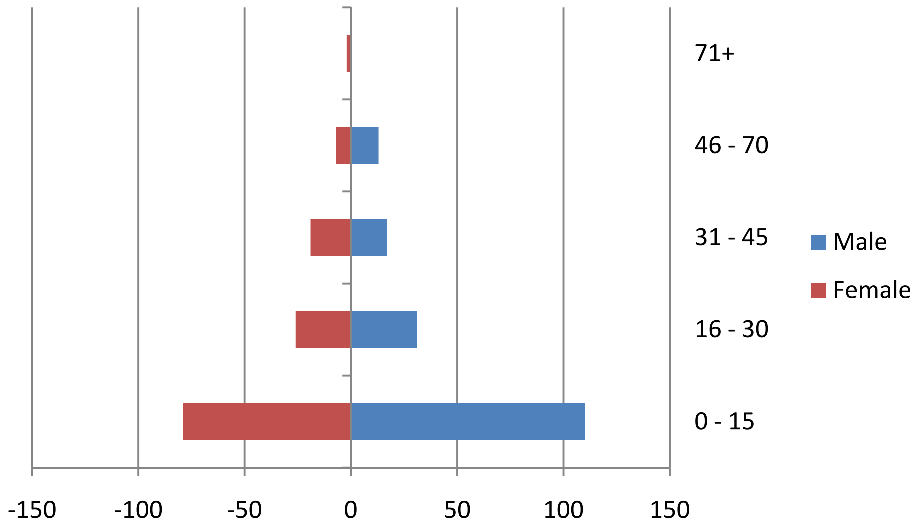


Figure 6.1 Population Age Pyramid for the Affected Villages

An assessment of the vulnerability of the affected communities indicated that there are 11 persons over the age of 60 and 1 person with a disability. Along with the young children, these individuals are considered to be vulnerable based on their age and physical capabilities. Particular monitoring and assistance will be provided to these households during the relocation activities.

Table 6.4 Vulnerable Persons in the Affected Communities

Village	Persons Over 60 Years	Persons With Disability
Chiyobeka	3	0
Kapita	0	0
Kasambo	6	0
Chilundu	2	0
Kumulilansolo	0	1
Sinangosi	0	0
Total	**11**	**1**

6.8.2. Settlement Areas

In the Mutanga area, immediately affected by mine infrastructure the villages of Chiyobeka and Kasambo were identified. The two villages have been located in the area for 17 years. The Senior Headman of the area is Mr Alick Mweemba. He leads the households that form Chiyobeka Village and Mr Sailos Kasambo is the headman of

Kasambo Village. A village name usually represents the surname of the family that is considered to be in control of the village.

Kapita and Chilundu Villages are located along the 'South Road' to the mine and have been in the area for 12 years. Mr Wilfred Chilundu is the village headman for the settlement. The two villages are located in such close proximity that they appear to be one. Kapita Village is led by Mr Steven Kapita.

On the access route southwest to Dibwe two villages were located. These were Sinangosi and Kumulilansolo Villages. These villages are based around families having moved away from larger villages to start up their own village and consist of single or multiple family units. Mr Shadreck Mungoni is the Headman for Sinangosi Village and Mr Simon Namulela is the Headman for Kumulilansolo Village. Kumulilansolo Village consists of just one family unit.

6.8.3. Household Organization

The layout of houses in the villages is organic in nature and not based around the standard grid iron pattern. This settlement pattern reflects the structure of polygamous and extended family systems which are typical of Southern Zambia. A household is based around a family unit usually led by the head of the household.

The households usually consist of a group of sleeping quarters and grain stores reflecting in part the size and ages of family members. Most households have an extended family, in some instances three generations living together. Each extended family is typically composed of individuals from more than one related nuclear family or household. Some male headed households have more than one wife. The average number of residents per household is 5 persons.

6.8.4. Housing Types

Households own a variety of residential and non-residential structures. The majority of these structures are built using traditional methods and materials. They feature earth floors, mud brick walls, and grass thatch or iron sheet roofs.

The census of housing infrastructure and other buildings relied on classification based on the materials used and the nature of construction. There were three classes of housing categorized during the census of the six villages.

Other permanent structures identified for households in the villages include pit latrines, storage huts, granaries, chicken coups, goat pens and cattle kraals amongst others.

The different types of structure are indicated in **Table 6.5** below. **Plates 6.1** to **6.6** below identify some of the different structures in the villages. These structures use different materials, the predominant inputs being mud (molded into bricks or used as plaster), iron sheets (roofing sheets), grass (used for thatching roofs) and poles (used as stilts and props for supporting the structures).

Table 6.5 Types of Structures Identified in the Villages

Type of Structures	Number of Structures
Sleeping huts/houses	99
Kitchen or Kitchen/Granary – A round open pole grass thatched roof structure or round mud brick structure	38
Resting Shelter – a round open pole grass thatch roof structure	22
Bathing Shelter – Round or square thatch pole structure, no roof	22
Storage rooms – Round mud pole thatched roof structure	1
Plate drier – Small pole structure near the kitchen	6
Latrine – Open pit, grass pole structure	19
Granaries – Raised round mud pole thatched structures	62
Granaries/Goat House – A granary that is used as a goat house on the ground	1
Maize Barn – Mud pole thatch structure	1
Maize Barn/Granaries – Multi-purpose storage mud pole thatch structure	5
Sorghum/Millet Sun Drier –Pole structure	1
Maize Drier – Raised pole structure	5
Orchard – Fruit tree garden	1
Cattle kraal – Pole structure to enclose cattle at night	13
Goat house – Pole structure of variable sizes to enclose goats	22
Chicken shelter – Pole thatch structure to shelter chickens	31
Egg-laying shelter – Pole structure to collect eggs	1
Piggery – Pole structure to enclose pigs at night	6
Chicken run – Pole enclosure to enclose chickens	1
Churches – Mud brick thatch or mud pole and thatch structures	4
Shrine – Pole and thatch structure	2
Shop – Mud brick structure and iron sheet roof	5
Guesthouse – Mud brick structure and iron sheet roof	1

Plate 6.1 Rectangular shaped iron-roofed house

Plate 6.2 Open Sided Rest Area Used as Kitchen

Plate 6.3 Pole and Grass Storage Shelter

Plate 6.4 Mud-brick House with Grass Thatch

Plate 6.5 Mud-brick House with Iron Sheet Roof

Plate 6.6 Grain Bin Used to Store Maize/Millet

Plate 6.7 Grass Shelter Used for Sanitation

6.8.5. Economic Activities

The majority of the population in the area is involved in peasant agriculture, with maize constituting the major crop. Sorghum and finger millet are also important crops in this drought prone region of Southern Zambia. Other crops include cotton and vegetables. Cotton farming is usually conducted by farmers on a small holders outgrowing program. Nearly all households consider farming as their primary livelihood activity. There are no vegetable gardens or fruit trees in the village. The vegetable gardens are generally located adjacent to water sources or high groundwater where small water pits can be dug.

Households rear a range of livestock, the sales of which, constitute an important income source when emergences arise. Children usually herd livestock that their families own, which constitutes cattle or goats. Other livestock in the village includes chickens, pigs and ducks. Cattle are a symbol of wealth in this part of the country. It also used for paying bride price. Some families keep dogs and cats.

Plate 6.8 Cattle Herding

Non-farm income activities include employment by DMZL and its exploration sub-contractors. The brewing of local beer is a source of income for some women in the village. Other activities such as grocery sales or small shops occur within the Community. A single room guesthouse has been constructed in Chiyobeka Village.

6.8.6. Ethnic Groups

The main ethnic group is Tonga, although there are other ethnic groups in the Siavonga District. Tonga is the most commonly spoken language in the area. English is spoken by some of the population that completed basic education.

6.8.7. Religious Practices and Beliefs

The main religion in the region is Christianity. The Catholic Church dominates with a minor Protestant following. Other denominations include Methodists, Pentecostals and Jehovah's Witness's. Animist beliefs form a part of the local Christian traditions.

There are 3 churches in the Mutanga area. These are an African Apostolic Church built and owned by Nelson Hamakanda in Chiyobeka Village, a Roman Catholic Church (Matuba) owned and constructed by John Kasambo in Kasambo Village and a First Apostolic Church built and owned by Joseph Chiteba in Kapita Village. Sinanjosi and Kumulilansolo Villages are not facilitated by any churches but there are two private shrines in Kumulilansolo Village.

There are no public burial grounds or cemeteries around the villages because the deceased are buried behind their homesteads.

6.9. Educational Facilities

Educational services in the area are provided by local government through the District Education Board.

Matuba Community School (**Plate 6.9**) was constructed in Mutanga to service Chiyobeka and Kasambo Villages. The school is managed by a volunteer teacher, Mr Steven Kapita. The School has two classroom blocks. One class for Grade 1 to Grade 4 classes are held. The school is attended by 80 pupils.

Generally most of the population in the surveyed villages have only spent 5 years in primary school and therefore there is an overall low level of education. This implies that there are high levels of illiteracy and innumeracy in the population.

Plate 6.9 Matuba Community School

Dambilo Community School is located 15km by road northwest of Chiyobeka Village. Access is possible from the Dibwe road.

Manchama Inland Middle Basic School (**Plate 6.10**) is located in the Dibwe West area. It has an attendance of 247 pupils (100 girls and 147 boys). Classes are from Grade 1 to Grade 7 and there are six staff members. There is an average of approximately 25 pupils per class. The catchment of the student population covers 12 villages being Manchisi, Hajipa, Matandabala, Sinangosi, Singililele, Namawamba, Njawe, Sinachilomba, Namatelo, Kapuku, Kasikili, and Muchalenga Villages. These are all further west and northwest of the Dibwe West area.

Dibwe Community School was opened in 2001. The school has one classroom block, a thatched rondavel which is used as a second classroom and an additional dining hall block, which was under construction during the survey. The school offers a School Health Nutrition program (SHEN). This dining hall is part of the feeding program being carried out in all the government schools. There are 3 male teachers that a total of 216 pupils (92 girls and 124 boys). There are 2 classes for Grades 1 to Grade 7. The Grade 1, 5 and 7 classes attend morning session classes from 7:30 – 10:30 hours. The Grade 2, 3 and 4 classes are conducted in the afternoon. The school has a catchment area of 10 of the surrounding villages. These are Dibwe, Hankamba, Hamalala, Sinjobeka, Chikumbula, Kalilo, Hanyangola, Munangombe and Magutoma Villages. School attendance is often halted due to early marriages. The chief has actively discouraged people from removing their children from school.

Plate 6.10 Manchama Middle Basic School

Plate 6.11 Classroom Block at Dibwi Community School

6.10. Health Care Facilities

Two health care facilities are located in Dibwe West. These are Dibwe and Manchama Rural Health Centres (RHC).

The RHC at Manchama was built in 1990. There is no Environmental Health Technician (EHT) or nurse. The centre is run by a Community Health Worker. The main diseases are malaria, diarrhoea, and pneumonia.

Plate 6.12 Manchama Rural Health Centre

The RHC is not electrified so no refrigeration is available for drugs. The RHC has a solar panel but there has been no maintenance supplied for it. Drugs and bandages are in short supply and generally the most available drugs are pain killers. The RHC has a six-bed ward for admitted patients. Serious referral cases are sent to Siavonga Hospital however there is no ambulance at the Manchama RHC. Sick patients are usually transported in wheel barrows or on ox carts by their families to Siavonga. The lack of a well or source of water at the RHC makes it difficult to maintain hygiene. Water is sourced from the nearby Ganya Stream and the Namatelo River. The RHC provides primary health services and ante-natal clinics on Wednesdays.

The Dibwe Rural Health Centre was opened in 1986. It is run by a Community Health Worker. The services that are provided include primary health care and environmental sanitation awareness. There are no wards or beds to admit patients. The main ailments are malaria, diarrhoea (no blood), sore eyes, coughing, bilharzia and worms.

6.11. Sanitation

Residents in the villages use uncovered pit latrines or have no formal toilet facilities. There are no covered pit latrines or ventilated improved pit (VIP) latrines in the area.

6.12. Water Supply

Water supply for all the villages in the region is mainly from rivers. The inhabitants of Chiyobeka and Kasambo Villages were assisted with a borehole and handpump by Denison and rely on the Mutanga dambo for livestock.

Chilundu and Kapita Villages are supplied by a hand pump that was installed near the location of the proposed raw water dam.

6.13. Energy Supply

There is no electricity supply in the rural areas of the Siavonga District. A small 11kV power line services part of the Lake Shore road. Residents in the villages use candles and kerosene for lighting. Almost all households in the villages use firewood for heating and cooking. A small amount use charcoal.

6.14. Transportation

All the villages have a network of tracks and foot / bicycle paths between them, which link fields to homesteads. There is extremely little public transport provision within the area. Some tructs used for public transport go to chief Sinadambwe few villagers own bicycles, an important form of transport in the isolated area.

Carts drawn by oxen are used for transporting goods, especially maize when being harvested.

6.15. Telecommunications

A cell tower, approximately 800m from the exploration camp, with data capacity has already been installed by a Zambian Cell Provider (Zain Zambia, formerly Celtel) with a coverage over a 30 km radius from the Mutanga site. This has greatly improved communications locally.

6.16. Socio-Economic Impacts of the Proposed Project

The project will have the following socio-economic and cultural impacts:-

- **Employment Creation** - The proposed project will generate 364 new jobs. It will be important to maximize local employment and economic opportunities during construction and operation of the project. Maximizing local employment opportunities will generate an overall benefit to local economic development;

- **Land use and settlement in Mine Prospecting Area** - For many households living in mine prospecting area, the land is a major source of livelihood from the cultivation of subsistence crops. Therefore, should the project be implemented, the result will be displacement of the population in the villages;

- **Local economic development** - The project has potential to promote local economic development by employing people from the area and by creating economic linkages for local entrepreneurs and contractors in the Siavonga District;

- **Health and welfare issues** - The health and welfare issues as they relate to contractors and new employees for the proposed project are of great importance, especially with respect to the spread of HIV/AIDS pandemic. Awareness and prevention campaigns on HIV/AIDS amongst workers and contractors should be undertaken for the project, especially in conjunction with the District Aids Task Force;

- **Population influx** - Population influx management should be taken into consideration to include enforcing new settlement of population in designated localities. This will discourage any unauthorized settlements near the proposed project area. Security concerns that are associated to the project concern the potential for theft and protection of mine property;

- **Resettlement Concerns** - The major concern expressed by the households during the socio-economic surveys (November 2006) was displacement or resettlement from their current locations. Issues related to compensation for lost land and properties were also foremost concerns.

6.17. Conclusions and Recommendations

For almost all the households living in mine prospect area, the land is the main resource for subsistence maize crop cultivation. Thus, should the mine development proceed, the result will be displacement of the population in Chiyobeka village. Since agricultural activities are the predominant economic occupation of the households, that will result in the loss of their livelihoods.

For project development to occur a comprehensive Resettlement Action Plan (RAP) will need to be developed to address issues related to displacement, relocation, resettlement, expropriation of land and compensation in line with the legal provisions of Zambia and international best practice.

6.18. Feedback of the Local Populations on the Development of the Mining Project

Denison have been conducting exploration activities in the Mutanga area since 2008. They have consulted widely with Local Government Administration and the Communities about displacement and relocation.

The forms of consultation that have been undertaken are:-

- Individual interviews within the communities;
- The development of the RCC and regular meetings;
- A series of meetings with the traditional leaders in the Project region;
- A series of meetings with the local administration, particularly the Siavonga District offices; and
- A series of meetings with stakeholders e.g. MMMD, ECZ and RPA.

6.18.1. Public Consultation Meeting

A final public consultation to inform all of the communities about the finalised mine design and impacts was conducted prior to the submission of the final EIS. The minutes recorded have been included in **Appendix 13**.

6.18.2. Perception of the Mining Project by the Local Populations

The expectations of the population for the Mutanga Project are very high and very optimistic. These impressions lead the communities astray from the concept of a mine to a means of developing the community. All of their expectations may not be met based on unreasonable requests.

6.18.3. Recommendations for the Project Acceptance and Integration

The prospects of development and the creation of jobs by the Mutanga Project conjures hopeful attitudes from the local communities. However, the nature of the expression of the expectations of the project can lead to misunderstandings.

During the interviews with the Headmen, the youth and the women it was determined that they view the project as a means to eliminate their development problems. Therefore any contradictory message regarding their expectations is perceived as a statement against the local communities.

Denison may also perceive the expression of these expectations as demands and therefore feel that the communities are being unfair. There is the potential that these misunderstandings present friction in the negotiations for social investment and development in the project area.

It is therefore important that favourable conditions are created in order for the project to develop. Therefore the approach that should be adopted:-

- Improve the awareness of the different social groups (youth, women, notables, intellectuals, the communities) in the project area to the experiences and realities of villages and localities near mining projects;
- Create a transparent and confident relationship between itself and the populations in the project impacting area; and
- Promote its image to the local populations and the local administrative authorities.

Project Consultation Approach

Six main measures to implement a successful public community campaign have been discussed below.

- **Schedule of Consultation Framework**

A Community Consulting Committee (CCC) will be developed by DMZL to manage the implementation of a consultation framework. DMZL will drive the management of the CCC. A framework of the committee shall be developed which will consider:-

- The mandate of the CCC;
- The structure and number of members in the CCC should be organised in such a way that it is operational as well as representative of the whole community;
- The means by which efficient functionality will occur;
- The duties of the CCC towards Denison; and
- The duties of Denison towards the CCC; and
- How shortfalls will be addressed.

- **Open and Transparent Information Exchange of the Project**

The relationship that will be developed with the local communities through various forums (e.g. the Community Consulting Committee) will be open and transparent. Clear information will be issued by the company on its schedules and social development programs in order to build and maintain confidence with the local communities.

The expectations of the communities are very high. Some of the projects are also to be driven by the government services. Therefore through the CCC negotiations will be conducted with the communities to agree on those projects that are of highest importance. These agreements will then be communicated to the communities with an improvement of company image when agreements are met.

Denison will promote the sharing of information regarding activities through the local administration, the populations and the political authorities which will reassure them of the commitments to these communities and prevent anxieties.

- **Promote the Image of Denison**

The regular interaction of Denison with the local community will indicate that it will be involved in local activities. These activities will be identified through negotiations with the CCC. Some of the projects that were identified are:-

- Educational facilities and assistance;
- Sporting facilities;
- Transport assistance;
- Infrastructure development in the villages; and
- Drinking water supply in the Project area.

Some of these problems are expected to increase based on the increased immigration to the area during the project.

- **Advertise Denison Social Responsibilities and Achievements**

The goal of this measure is to inform all of the people in Zambia about the social activities Denison is conducting and achievements to date. This will be done through various media events, invitations of the media to key ceremonies for the social projects. This will generate awareness of Denison's positive contribution to society.

- **Schedule of Implementation of Social Projects**

A development schedule for implementation of agreed social projects through liaison with the CCC will be done. This will assist with monitoring the progress of these projects. The schedule will include a description of the responsible parties for each part of a project and identify non-compliance by any project partners. Through the CCC Denison will regularly inform the communities of the success of projects to date, the new projects to come and any difficulties that the company has/is facing with these projects.

- **Sustainably Manage the Compensation and Displacement Program**

The most vulnerable population will be those people affected directly by displacement or land loss. This affected population will need to be closely managed and reassured during the compensation process to ensure that the inconvenience to their lives is minimised and that they are not adversely affected by their displacement. Etruscan has developed a Displacement and Relocation Plan (DRP) to manage the compensation program.

6.18.4. Sustainable Development Plan (SDP)

Based on the public communication through the social study it is important that DMZL formalises their social development program. This can be done by the development of a Sustainable Development Plan (SDP).

7. ENVIRONMENTAL IMPACTS

The identification of the potential environmental and social impacts that may result from project development is based on a review of the project design and industry experience. The impacts were identified through site visits during the collection of baseline data and feedback from the local communities during the socio-economic study.

7.1. Project Components

An impact assessment table was drafted relating specific mine infrastructure to the environmental and social components that may be impacted on. The impacts were identified and classified according to the classification criteria in **Table 7.1** below.

The impact assessment involved the significance rating of each impact (refer to **Table 7.2**). This was calculated by the multiple of a risk rating and a likelihood rating. The risk rating was determined as an average of ratings provided for the intensity and extent of an impact. The likelihood rating was developed as a sum of the rating of frequency rating of the impact occurring and the frequency rating of the activity generating the impact. The significance was rated for positive and negative impacts to assist with prioritising management actions for mine management.

The environmental impacts were described according to environmental or social aspects at each mine component. These components are:-

- Resettlement and compensation (Kashundi Village and fields, approximately 416.5ha);
- Two open pits (Mutanga and Dibwe pits) (33ha and 54.3ha respectively);
- Ore crushing and transfer facilities (ROM pad) (mobile stackers);
- Two heap leach pads (Mutanga and Dibwe) (125ha in total);
- Two waste rock dumps (Mutanga and Dibwe) (25ha and 60ha respectively)
- A process plant, workshops and mine offices (7.5ha);
- Accommodation camp (Operations Camp)(13.5ha);
- Two Raw Water Ponds (Mutanga (2ha) and Dibwe (2ha));
- Fuel Handling and Storage;
- Transport;
- Infrastructure;
- Contractor Activities; and
- Socio-economic aspects.

7.2. Environmental and Socio-economic Aspects

The environmental and socio-economic aspects that were identified as important for the project were:-

- Land Use;
- Visual Aesthetics and Scenery of the Project Area;
- Geology and Formations;
- Soils;
- Surface Water;
- Groundwater;
- Air Quality;
- Radon;
- Radiation;
- Flora and Fauna;

- Noise and Vibrations;
- Archaeology;
- Displacement and Compensation;
- Migration;
- Employment and Training;
- Enhancements to Local Businesses and Projects;
- Economic Expansion and Diversification;
- Information Exchange and Public Consultation; and
- Public Accessibility, Health and Education.

Tables 7.3 and **7.4** provides the detailed potential environmental and socio-economic issues, impacts and characterisation that may occur during the project. The impacts were also described in relation to their timing during the project e.g. construction, operational and post closure phases, and their duration. This description uses both quantitative and qualitative assessment, where there is relevant available data.

The potential positive impacts are:-

- Provision of jobs to the local communities and contractors;
- Economic diversification in a remote area of Southern Province;
- Expansion of the local and national economy;
- Remittance of taxes and fees to the local and national Government Offices;
- Expansion of the local skills base through training and technical skills;
- Improvement in health and education of Denison employees; and
- The implementation of a sustainable development plan for the development of targetted social projects.

The important negative impacts are:-

- Displacement of the 342 people in 6 villages affected by the project activities;
- Displacement of the 62 fields requiring compensation;
- Increased exposure of employees and local communities to radiation and radon through mobilisation of the Uranium Ore;
- Loss of vegetation and habitat through land clearance activities;
- Deterioration in visual aesthetics of the project area;
- Pollution of soils, surface water, groundwater, air;
- Disturbance from increased noise and vibrations;
- Disturbance to archaeological sites;
- Disturbance and loss of geological resources;
- Predominance of HIV/Aids and other communicable diseases;
- Strain on local infrastructure and services (if any);
- Struggle and maladjustment of the relocated communities to Kashundi Village; and
- Social tension between job-seeking immigrants and the local communities.

The mitigation measures in **Chapter 8** and the Environmental and Social Management Plans in **Chapter 9** aim to mitigate and prevent these impacts.

Table 7.1 Impact Assessment Criteria

Item No.	Impact / Activity Criterion	Description	Criterion Classification		
			Term	**Rating**	**Description**
1.	Positive / Negative	Will the impact have a positive or negative effect on the environment?	Negative	5	A negative impact.
			Positive	1	A positive impact.
2.	Intensity or Amplitude	What is the likely level of impact with regard to physical disturbance; sensitivity; vulnerability; uniqueness or rarity of component?	Low	1	The impact has small potential for harm/benefit.
			Moderate	2	The impact is potentially harmfull /beneficial.
			High	3	The impact is highly harmful / beneficial.
			Very High	4	The impact is disastrous/very beneficial.
3.	Extent	What is the geographical extent of the impact?	Project Area	1	Impact will affect the mine area.
			Regional	2	Impact will affect areas outside the mine area.
			National	3	The impact will affect the country.
4.	Duration	What is the likely duration or time over which the impact will occur / be felt?	Short-term	1	Impact will cease once activity stops.
			Medium-term	2	Impact will continue for the lifetime of the mine.
			Long-term	3	Impacts will continue beyond mine closure.
			Permanent	4	Impact will be permanent and irreversible.
5.	Frequency of Activity	What is the likely frequency of the activity causing the impact to occur?	Rarely	1	The activity is almost impossible.
			Infrequent	2	The activity will occur seldom/unlikely.
			Frequent	3	The activity will occur regularly/likely.
			Continuous	4	The activity will occur daily/definitely.
6.	Frequency of Impact	What is the likely frequency of impact occurrence?	Rarely	1	The impact is almost impossible.
			Infrequent	2	The impact will occur seldom/unlikely.
			Frequent	3	The impact will occur regularly/likely.

Table 7.1 Impact Assessment Criteria

Item No.	Impact / Activity Criterion	Description	Criterion Classification		
			Term	**Rating**	**Description**
			Continuous	4	The impact will occur daily/definitely.
7.	Likelihood (Frequency of Activity + Frequency of Impact)	What are the likelihood / certainty associated with a potential impact?	Unlikely	2	The impact is highly unlikely.
			Possible	3-4	The impact is unlikely.
			Probable	5-7	The impact is highly likely.
			Certain	8	The impact is certain.
8.	Effect on Human Population	What is the likely level of risk for the safety and well being of the affected people?	Very Low	0	Very low effect on human population from impact.
			Low	1	Low effect on human population from impact.
			Moderate	2	Moderate effect on human population from impact.
			High	3	High effect on human population from impact.
9.	Cumulative 'Knock On' Effect of Impact?	(a) What other environmental physical / biological components are affected by the impact?	Surface Water (+ve/-ve)	-	Cumulative impact on aquatic resources.
			Groundwater (+ve/-ve)	-	Cumulative effect on groundwater resources.
			Air (+ve/-ve)	-	Cumulative effect on air quality and dust.
			Soils (+ve/-ve)	-	Cumulative effect on soil quality and use.
			Fauna and Flora (+ve/-ve)	-	The impact may affect the biodiversity of the region.
			Land Use (+ve/-ve)	-	The impact may affect the land use in the region.
			None	-	None of the above impacts will be affected.
10.	Cumulative 'Knock On' Effect of Impact?	(b) What other key social / economic components are affected by the impact?	Economy (R) (+ve/-ve)	-	The impact may affect the regional (including local) economy.
			Economy (L) (+ve/-ve)	-	The impact may affect the local economy.
			Culture (+ve/-ve)	-	The impact may affect the local traditional cultures and livelihood.

Table 7.1 Impact Assessment Criteria

Item No.	Impact / Activity Criterion	Description	Criterion Classification		
			Term	**Rating**	**Description**
			Tolerance (+ve/-ve)	-	The impact may affect the levels of social tolerance between communities.
			Health and Safety (+ve/-ve)	-	The impact may affect the health and safety of the local populations.
			Water Supply (+ve/-ve)	-	The impact may affect the water supplies of the local population.
			Local Services/Utilities (+ve/-ve)	-	The impact may affect the local services and housing of the local population.
			Social Welfare (+ve/-ve)	-	The impact may affect the social welfare of the local and regional populations.
			None	-	None of the above impacts will be affected.

Table 7.2 Significance Rating of Identified Environmental and Social Impacts

Significance	Value	Colour Code	Negative Impact Management Recommendation	Significance	Value	Colour Code	Positive Impact Management Recommendation
Very High	25-30		Requires Further Management	Very High	25 - 30		Maintain Management Activities
High	16-24		Requires Further Management	High	16 - 24		Requires Further Management
Medium	6-15		Requires Further Management	Medium	6 – 15		Requires Further Management
Low	0-5		Maintain Management Activities	Low	0 - 5		Requires Further Management

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
1. MINE COMPONENT: MUTANGA AND DIBWE OPEN PITS													
1.1 OPEN PITS - CONSTRUCTION PHASE													
Land Use	1	Loss of agricultural land being used by the local populations.	5	2	1	3	2.75	4	4	8	None	Econ (R) Soc Welfare	22
Aesthetics	2	Visible impact in the area due to clearance of vegetation from the site where the resource is located.	5	1	2	4	3	4	4	8	None	None	24
Geology	3	The loss of mineable uranium ore from the area due to mining activities.	5	1	1	4	2.75	4	4	8	None	None	22
Soils	4	Cleared vegetation will expose soils to erosion processes.	5	1	1	1	2	3	2	5	Surface Water Flora & Fauna	None	10
	5	Leaks of oil, fuel and hydraulic fluid from the construction machinery may contaminate soils.	5	1	1	1	2	2	3	5	Surface Water	None	10
Surface Water	6	Exposed surfaces are prone to erosion and solids removal by water. This may affect local watercourses.	5	2	2	1	2.5	3	3	6	Flora & Fauna	Water Supply	15
	7	Leaks of oil, fuel and hydraulic fluid from the construction machinery may contaminate local watercourses.	5	1	1	1	2	2	3	5	Flora & Fauna	None	10
Groundwater	8	Lowering of the local water table in the vicinity of the open pits due to mine dewatering.	5	1	1	2	2.25	4	4	8	None	Water Supply	18
Air Quality	9	Movements of machinery around the cleared sites will generate dust and exhaust fumes.	5	1	1	1	2	4	4	8	Flora & Fauna	None	16
Radon	10	Radon may be more concentrated around the disturbed deposits.	5	4	1	3	3.25	4	3	7	Health and Safety	Health and Safety	22.75

Table 7.3 Environmental Impact Characterization Table														
Environmental Aspect/Issue	**Item No.**	**Potential Environmental Impact**	**Environmental Impact Characterisation**											
			Pos / Neg Impact	**Intens.**	**Extent**	**Duration.**	**Risk**	**Frequ. of Activity**	**Frequ. of Impact**	**Likelihood**	**Cum. Impact Environment**	**Cum. Impact Social**	**Total Impact**
Color Code of Impact			**Positive**						**Negative**				
Flora and Fauna	11	The clearance of vegetation leads to the loss of habitat and biodiversity.	5	1	1	2	2.25	2	4	6	Soils	Social Welfare	13.5
Noise and Vibrations	12	Construction machinery during the pre-strips of the open pits will cause increased noise and vibrations.	5	1	1	1	2	4	4	8	Flora & Fauna	Health & Safety	16
Archaeology	13	The loss of archaeological and cultural sites may occur during site clearance.	5	1	1	4	2.75	2	2	4	None	Culture	11
1. MINE COMPONENT: MUTANGA AND DIBWE OPEN PITS **1.2 OPEN PITS - OPERATIONAL PHASE**													
Aesthetics	14	The mining of the Mutanga and Dibwe resources will permanently alter the local topography.	5	1	2	4	3	4	4	8	None	None	24
Soil	15	Soils will be contaminated with radioactive minerals during uranium mining, from dust blow or contaminated water.	5	1	1	1	2	3	2	5	Surface Water	None	10
Air Quality	16	Air borne dust is generated from haul trucks and other heavy equipment and ore handling.	5	1	1	2	2.25	4	4	8	Flora & Fauna	Health & Safety	18
	17	Exhaust fumes and smoke are produced by heavy equipment and haul trucks.	5	2	1	1	2.25	4	3	7	None	Health & Safety	17.5
Noise	18	Noise nuisance from mine heavy plant equipment and open pit mining.	5	2	2	1	2	3	3	6	Flora & Fauna	Health & Safety	12
Surface water	19	Contamination of surface water will occur by water dewatered from the open pits.	5	2	2	1	2.5	3	3	6	Flora & Fauna	Water Supply	23
	20	Effluent discharged from the open pit workshops may contaminate the surface waters	5	2	2	1	2.5	3	3	6	Flora & Fauna	Water Supply	15
Groundwater	21	Lowering of the local water table in the vicinity of the open pits due to mine dewatering.	5	1	1	2	2.25	4	4	8	None	Water Supply	18
Radiation	22	Mineralisation of the soil and rock around Mutanga confirms there is the potential for workers to exposed to ionizing radiation	5	4	1	3	3.25	4	3	7	Health and Safety	Health and Safety	22.75

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
Radon	23	There is potential for radon gas to be emitted from the remains of the disturbed deposits	5	4	1	3	3.25	4	3	7	Health and Safety	Health and Safety	22.75
1. MINE COMPONENT: MUTANGA AND DIBWE OPEN PITS **1.3 OPEN PITS - POST CLOSURE PHASE**													
Surface water	24	Natural flooding of the open pits by groundwater and rainfall will create a new lake resource.	1	2	1	4	2	4	3	7	Ground Water	Econ (L) Social Welfare	14
	25	Contamination of water in flooded pits with uranium	5	3	1	3	3	3	2	5	Ground Water	None	15
Groundwater	26	Rebound of the watertable after the dewatering has ceased may affect water quality.	5	2	1	4	3	3	2	5	Surface Water	Health and Safety	15
Pit Stability	27	The groundwater inflows on the pit walls may lead to instability.	5	2	1	3	2.75	3	2	5	None	Health and Safety	15
Radiation	28	Mineralisation of the soil and rock around Mutanga confirms there is the potential for workers to exposed to ionizing radiation	5	2	1	3	2.75	4	3	7	Health and Safety	Health and Safety	19.25
Radon	29	There is potential for radon gas to be emitted from the remains of the disturbed deposits	5	2	1	3	2.75	4	3	7	Health and Safety	Health and Safety	19.25
2. MINE COMPONENT: WASTE ROCK DUMPS (MUTANGA AND DIBWE) **2.1 WASTE ROCK DUMPS - CONSTRUCTION PHASE**													
Land Use	30	Loss of agricultural land being used by the local populations.	5	2	1	3	2.75	4	4	8	None	Econ (R) Soc Welfare	22
Aesthetics	31	Visible impact of the cleared areas during construction activities.	5	1	2	4	3	4	4	8	None	None	24
Soils	32	Cleared vegetation will expose soils to erosion processes.	5	1	1	1	2	3	2	5	Surface Water Flora & Fauna	None	10

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
	33	Leaks and spills of oil, fuel and hydraulic fluids from heavy equipment may contaminate soils.	5	1	1	1	2	2	3	5	Surface Water	Water Supply Health & Safety	10
Surface water	34	Exposed surfaces are prone to erosion and solids removal by water. This may affect the surface water.	5	1	1	1	2	4	3	7	Flora & Fauna	Water Supply	14
	35	Leaks of oil, fuel, and hydraulic fluids may contaminate surface runoff.	5	1	1	1	2	2	3	5	Flora & Fauna	Water Supply Health & Safety	10
Flora & Fauna	36	The clearance of vegetation leads to the loss of habitat and biodiversity.	5	2	1	1	2.25	4	4	8	Soils	None	18
Air Quality	37	Wind erosion on exposed surfaces will generate dust.	5	1	1	1	2	3	2	5	Flora & Fauna	None	10
	38	Movements of machinery around the cleared sites will generate dust and exhaust fumes.	5	1	1	1	2	4	3	7	Flora & Fauna	None	14
Noise and Vibrations	39	Noise and vibrations are increased by the movements of construction vehicles.	5	2	1	1	2.25	3	3	6	Flora & Fauna	Health & Safety	13.5
Archaeology	40	The loss of archaeological and cultural sites during site clearance.	5	1	1	4	2.75	3	2	5	None	Culture	13.75
2. MINE COMPONENT: WASTE ROCK DUMPS (MUTANGA AND DIBWE) **2.2 WASTE ROCK DUMPS - OPERATIONAL PHASE**													
Air Quality	41	Airborne dust is generated from haul trucks and bulldozers working on the dumps.	5	1	1	2	2.25	4	3	7	Flora & Fauna Soils	None	15.75
Air Quality	42	Generation of airborne dust from exposed surfaces on the dump walls.	5	1	1	3	2.5	3	2	5	Flora & Fauna	None	12.5

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
	43	Exhaust fumes and smoke are produced by heavy equipment and haul trucks.	5	1	1	1	2	3	3	6	None	Health & Safety	12
Noise & Vibration	44	Increased noise from haul trucks and bulldozers operating on the dumps becomes a nuisance.	5	1	1	1	2	4	3	7	Flora & Fauna	None	14
	45	Vibrations from haul trucks and bulldozers.	5	1	1	1	2	4	3	7	Flora & Fauna	None	14
Soils	46	Exposed surfaces are prone to erosion.	5	1	1	1	2	3	3	6	Surface Water	Water Supply	12
	47	Contaminated surface runoff may contaminate surrounding soils.	5	1	1	2	2.25	3	3	6	Surface Water	None	13.5
	48	Leaks and spills of oil, fuel and hydraulic fluid from haul trucks may contaminate soils.	5	2	1	1	2.25	2	3	5	Surface Water	None	11.25
Surface water	49	Contamination of the Surface water due to run-off and erosion of dump walls.	5	1	1	2	2.25	3	3	6	None	Water Supply	13.5
	50	Contamination of water due to inappropriate waste disposal practices.	5	1	1	1	2	3	2	5	None	Water Supply	10
	51	Leaks of oil, fuel and hydraulic fluids from heavy equipment may contaminate soils.	5	2	1	1	2.25	2	3	5	None	Water Supply	11.25
Groundwater	52	Acid rock drainage or contaminated seepage may contaminate groundwater.	5	3	1	3	3	3	1	4	None	Water Supply	12
Aesthetics	53	Detraction from the natural beauty of the physical landscape.	5	1	2	4	3	4	3	7	None	None	21
Radon	54	Radon may be released from the waste rock dumps	5	4	1	3	3.25	4	3	7	Health and Safety	Health and Safety	22.75
Radiation	55	Mineralisation of the soil and rock around Mutanga confirms there is the potential for workers to exposed to ionizing radiation	5	4	1	3	3.25	4	3	7	Health and Safety	Health and Safety	22.75
2. MINE COMPONENT: WASTE ROCK DUMPS MUTANGA AND DIBWE													

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
2.3 WASTE ROCK DUMPS - POST CLOSURE PHASE													
Soils	56	Contaminated surface runoff from exposed dump walls may contaminate surrounding soils.	5	2	1	3	2.75	3	3	6	Surface Water	None	16.5
Air Quality	57	Dust erosion on exposed dump walls will reduce the local air quality.	5	2	1	3	2.75	2	3	5	None	None	13.5
Surface water	58	Contamination of the Surface water from run-off and erosion of exposed dump walls after mine closure.	5	2	1	3	2.75	3	2	5	Flora & Fauna	Water Supply	13.75
Groundwater	59	Contamination of the groundwater underneath the dumps after mine closure.	5	3	1	3	3	2	2	4	None	Water Supply	12
Health and Safety	60	The safety of the public may be affected by inadvertent access to the dumps.	5	2	1	3	2.75	4	3	7	None	Health & Safety	19.25
Radiation	61	Mineralisation of the soil and rock around Mutanga confirms there is the potential for workers to exposed to ionizing radiation	5	2	1	3	2.75	4	3	7	Health and Safety	Health and Safety	19.25
Radon	62	Radon may be more concentrated around the disturbed deposits	5	2	1	3	2.75	4	3	7	Health and Safety	Health and Safety	19.25
3. MINE COMPONENT: PROCESSING FACILITIES **3.1 PROCESSING FACILITIES (ORE PREPARATION, LEACHING AND CONCENTRATION) - CONSTRUCTION PHASE**													
Land Use	63	Loss of agricultural land being used by the local populations.	5	2	1	3	2.75	4	4	8	None	Econ (L) Social Welfare	22
Aesthetics	64	Visible impact of the cleared slopes from the surrounding areas.	5	1	2	2	2.5	4	3	7	None	None	17.5
Soils	65	Cleared vegetation will expose soils to erosion processes.	5	2	1	1	2.25	3	2	5	Flora & Fauna	Social Welfare	11.25
	66	Leaks and spills of oil, fuel and hydraulic fluid from haul trucks may contaminate soils.	5	2	1	1	2.25	3	3	6	None	None	13.5
Air Quality	67	Wind erosion on exposed surfaces will generate dust.	5	1	1	1	2	3	2	5	Flora &	None	10

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
											Fauna (-ve)		
	68	Movements of machinery around the cleared sites will generate dust and exhaust fumes.	5	1	1	1	2	3	3	6	None	Health & Safety	12
Flora and Fauna	69	The clearance of vegetation leads to the loss of habitat and biodiversity.	5	2	1	1	2.25	4	4	8	Soils	Social Welfare	18
Surface water	70	Exposed surfaces are prone to erosion and may contaminate surface runoff. This may contaminate the Surface water.	5	1	1	1	2	3	3	6	None	Water Supply	12
	71	Leaks and spills of oil, fuel and hydraulic fluids from heavy equipment may contaminate soils.	5	2	1	1	2.25	3	3	6	None	Water Supply	13.5
Noise and Vibrations	72	Noise and vibrations are increased by the movements of construction vehicles.	5	1	1	1	2	4	3	7	Flora & Fauna	Health & Safety	14
Archaeology	73	Disturbance of archaeological or cultural site.	5	1	1	4	2.75	4	2	6	None	Culture	16.5
3. MINE COMPONENT: PROCESSING FACILITIES **3.2 ORE PREPARATION AREAS - OPERATIONAL PHASE**													
Soil	74	Inadequate storage, handling or transport of uranium ore may contaminate soils.	5	4	1	2	3	3	3	6	Surface Water	Health & Safety	18
	75	Spills of reagent solutions (acid) may contaminate soils.	5	3	1	2	2.75	4	3	7	Surface Water	Health & Safety	19.2 5
Air Quality	76	Dust emissions may occur due to emissions resulting from the ore handling.	5	3	1	2	2.75	4	3	7	None	Health & Safety	19.2 5
Surface water	77	Storm water may become contaminated in ore handling facilities such as the ROM pad and crushers.	5	3	1	2	2.75	2	3	5	None	Water Supply	13.7 5
	78	Equipment failures and spills may contaminate surface runoff and surface water.	5	4	1	2	3	4	3	7	Ground Water	Water Supply	21

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
Surface water	79	Wash water during maintenance may contaminate surface water.	5	4	1	2	3	3	3	6	Flora & Fauna	Water Supply	18
	80	Accidental spills from equipment, conveyors, reagent storage tanks, etc may contaminate water.	5	4	1	2	3	3	3	6	Soils	None	18
	81	Accidental spills of acid caused by inadequate storage handling or transport may contaminate water.	5	3	1	2	2.75	3	3	6	Soils	Health & Safety	16.5
Groundwater	82	Contamination of groundwater due to leaks from process water ponds.	5	3	1	2	2.75	2	3	5	Soils	None	13.75
Noise and Vibrations	83	Noise from ore preparation areas may affect localised noise levels.	5	1	1	2	2.25	3	2	5	Flora & Fauna	None	11.25
Health and Safety	84	Inadvertent access to the ore preparation facilities may pose a health and safety risk.	5	4	1	2	3	2	2	4	None	None	12
Radon	85	Radon will be released from the uranium ore that is being crushed.	5	4	1	3	3.25	4	3	7	None	Health and Safety	22.75
Radiation	86	Employees working in the ore preparation areas are all likely to be exposed to radiation.	5	4	1	3	3.25	4	3	7	None	Health and Safety	22.75
3. MINE COMPONENT: PROCESSING FACILITIES 3.3 ORE PREPARATION AREA - POST CLOSURE PHASE													
Soils	87	Exposed surfaces will be prone to erosion.	5	1	1	1	2	3	3	6	Flora & Fauna	None	12
Surface Water	88	Contaminated runoff from the ore preparation areas may contaminate the surface water.	5	3	1	3	3	3	2	5	Flora & Fauna	Water Supply	15
Air Quality	89	Exposed surfaces may be prone to erosion which may decrease downwind air quality.	5	1	1	3	2.5	3	3	6	Soils	None	18
Health and Safety	90	The safety and health of the public may be affected by inadequate decommissioning of the ore preparation areas.	5	3	1	3	3	3	2	5	None	None	15
Radon and Radiation	91	If left unmanaged the ore preparation area may be a long term source of radon or radiation to the surrounding environment.	5	4	1	3	3.25	2	3	6	Flora and Fauna	Health and Safety	19.5

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
3. MINE COMPONENT: PROCESSING FACILITIES													
3.4 HEAP LEACH PADS- OPERATIONAL PHASE													
Soil	92	Inadequate storage, handling or transport of uranium ore may contaminate soils.	5	4	1	2	3	3	3	6	Surface Water	Health & Safety	18
	93	Spills or leaks of process solutions (acid) from storage areas or the leach solution pipelines and ponds may contaminate soils.	5	3	1	2	2.75	4	2	6	Surface Water	Health & Safety	16. 5
	94	Leaks or spills of leach solution (PLS) from underneath the leach pads may contaminate underlying soils.	5	4	2	4	3.75	3	1	4	Groundwater	Health and Safety	15
Air Quality	95	Airborne dust may be generated from the leach heaps on the pad.	5	3	1	2	2.75	4	3	7	None	Health & Safety	19.2 5
Surface water	96	Storm water runoff on the pads may become contaminated with process solution through mixing.	5	3	1	2	2.75	2	3	5	None	Water Supply	13.7 5
	97	Equipment failures (liner) and spills may contaminate surface runoff and surface water.	5	4	1	2	3	4	3	7	Ground Water	Water Supply	21
	98	Leaks or spills of leach solution from the PLS ponds and the Emergency Containment Pond (ECP) may contaminate runoff and surface water.	5	4	1	2	3	4	3	7	Ground Water	Water Supply	21
	99	Accidental spills or leaks from leach solution pipelines or channels may contaminate surface water.	5	4	1	2	3	3	3	6	Soils	None	18
	100	Accidental spills of solutions (PLS), barren solution and contaminated runoff caused by inadequate storage, handling or transport may contaminate water.	5	3	1	2	2.75	3	3	6	Soils	Health & Safety	16.5
Groundwater	101	Contamination of groundwater due to leaks from the PLS pond, the intermediate pond and the barren solution pond.	5	3	1	2	2.75	2	3	5	Soils	None	13.7 5
Noise and Vibrations	102	Noise may be elevated through conveyors and stacker units placing crushed ore on the leach heaps.	5	1	1	2	2.25	3	2	5	Flora & Fauna	None	11.2 5

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
Health and Safety	103	Inadvertent access to the heap leach pads by the public will pose a safety risk.	5	4	1	2	3	2	2	4	None	None	12
Radon	104	Radon will be released from the heap leach pads during operations which may impact on health and safety.	5	4	1	3	3.25	4	3	7	Air Quality	Health and Safety	22.75
Radiation	105	Employees working on the heap leach pads are all likely to be exposed to increased levels of radiation.	5	4	1	3	3.25	4	3	7	Flora and Fauna	Health and Safety	22.75
3. MINE COMPONENT: HEAP LEACH PADS **3.5 HEAP LEACH PADS - POST CLOSURE PHASE**													
Soils	106	Exposed surfaces will be prone to erosion.	5	1	1	1	2	3	3	6	Flora & Fauna	None	12
Surface Water	107	Incomplete decommissioning of the heap leach pads may generate contaminated runoff that may flow into surface water.	5	4	1	3	3.25	3	2	5	Flora & Fauna	Water Supply	16.25
Groundwater	108	Long term contamination of groundwater may occur through seepage from the heap leach pads.	5	4	2	4	3.75	4	1	5	None	Water Supply	
Air Quality	109	Exposed surfaces may be prone to erosion which may decrease downwind air quality.	5	1	1	3	2.5	3	3	6	Soils	None	18
Health and Safety	110	The safety of the public may be affected by inadequate decommissioning of the leach pad area.	5	3	1	3	3	3	2	5	None	None	15
Radon	111	If left exposed and unmanaged the leach pad facility will be a long term source of radon into the surrounding environment.	5	4	1	3	3.25	3	3	6	Flora and Fauna	Health and Safety	19.5
Radiation	112	If left unmanaged the leached residue on the pads will be a source of radiation in the long term.	5	4	1	4	3.5	3	3	6	Flora and Fauna	Health and Safety	21
3. MINE COMPONENT: PROCESSING FACILITIES **3.6 URANIUM CONCENTRATION PLANT – OPERATIONAL PHASE**													
Air Quality	113	Dust emissions may result from concentrate handling.	5	1	1	3	2.5	3	3	6	Soils	Health and Safety	18

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
Surface Water	114	Surface water may be contaminated by wash water from plant maintenance, process plant spills, process solution spills, acid spills and spills of concentrate.	5	3	1	3	3	3	2	5	Flora & Fauna	Water Supply	15
Groundwater	115	Groundwater may be contaminated by leaks of leach solution and process spills.	5	3	1	2	2.75	2	3	5	Soils	None	13.75
Soils	116	Soils may be contaminated by leaks of solutions and chemicals.	5	3	1	2	2.75	4	3	7	Surface Water	Health & Safety	19.25
Accidental releases	117	Contamination of soil, water or air may occur from accidental spills or releases of process reagents or chemicals caused by inadequate handling, storage or transport thereof.	5	3	1	2	2.75	2	2	4	Surface Water Soil	Health & Safety	11
	118	Spillages of leach solution or barren solution from the plant pipeline to and from the leach pad may lead to contamination of the environment.	5	4	1	2	3	2	2	4	Soil Flora and Fauna	Health & Safety	12
	119	Spillages of loaded resin during transportation from the Dibwe leach pad to the Mutanga process plant later in the mine life may contaminate the environment.	5	4	1	2	3	3	1	4	Soil Surface Water Flora and Fauna	Health and Safety	12
Accidental releases	120	Soils and water may be contaminated by leaks and spills from process equipment; PLS pond, ion exchange columns, precipitators, clarifiers, burst pipelines and accidental releases from various locations in the plant.	5	4	1	2	2.75	3	1	4	Surface Water Soil	Health & Safety	11
	121	Spillages or accidental release of contaminated solutions, process solutions process effluent will lead to contamination of the environment with radioactive material and acid solutions.	5	4	2	2	3.25	3	1	4	SurfaceWater Soil Flora and Fauna	Health and Safety	13
Water consumption	122	There is potential for uncontrolled, excessive use of raw water in the processing facilities.	5	3	1	3	3	4	2	6	Groundwater	None	18
Radon and Radiation	123	There will be increased levels of radon and radiation produced through the decay of the concentrated uranium products.	5	4	1	2	3	4	2	6	None	Health and Safety	18

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
Public and Employee Safety	124	Inadvertent access by the public into the plant area my result in injury.	5	3	1	3	3	3	2	5	None	None	15
	125	Inadvertent access of the public or mine employees into the concentrate preparation and loading areas will result in higher radiation exposure.	5	4	1	2	3	1	1	2	None	None	6
3. MINE COMPONENT: PROCESSING FACILITIES **3.7 URANIUM CONCENTRATION PLANT – CLOSURE PHASE**													
Soil	126	Inadequate decommissioning and cleanup of the concentrator plant may lead to long term soil contamination.	5	4	1	2	3	2	2	4	Surface Water Groundwater	None	12
Surface Water	127	Contamination of surface water may occur due to dismantling activities during closure.	5	3	1	3	3	3	2	5	Flora & Fauna	Water Supply	15
Infrastructure	128	The land upon which the plant has been constructed will need to be returned to a sustainable use.	1	3	2	3	2.25	3	4	7	None	Public Safety	15.75
Waste	129	Inadequate disposal or management of waste may contaminate the environment.	5	3	1	2	2.75	2	2	4	Soil	None	11
Flora	130	After the plant has been demolished, the land will be bare and without flora	5	2	1	1	2.25	2	2	4	Soils	Social Welfare	9
Public Safety	131	Inadvertent access by the public into the plant area my result in injury.	5	3	1	3	3	3	2	5	None	None	15
4. MINE COMPONENT: RAW WATER PONDS (MUTANGA AND DIBWE) **4.1 RAW WATER PONDS - CONSTRUCTION PHASE**													
Land Use	132	Loss of agricultural land being used by the local populations.	5	2	1	3	2.75	4	4	8	None	Econ (L) Social Welfare	22
Soils	133	The erosion of soil will occur on exposed surfaces.	5	1	1	1	2	3	3	6	Flora & Fauna	None	12

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
			Environmental Impact Characterisation										
Color Code of Impact			Positive						Negative				
	134	Leaks and spills of oil, fuel and hydraulic fluid from heavy equipment may contaminate soils.	5	2	1	1	2.25	3	3	6	Surface Water	None	13.5
Air Quality	135	Dust erosion on exposed surfaces will affect air quality.	5	1	1	1	2	3	3	6	Flora & Fauna	None	12
	136	Airborne dust and exhaust fumes will be generated by heavy equipment.	5	1	1	1	2	3	3	6	Flora & Fauna	None	12
Flora & Fauna	137	The clearance of vegetation leads to the loss of habitat and biodiversity.	5	1	1	3	2.5	4	3	7	Soils	None	17.5
Archaeology	138	The loss of archaeological and cultural sites during construction.	5	1	1	4	2.75	2	2	4	None	Culture	11
4. MINE COMPONENT: RAW WATER POND **4.2 RAW WATER POND - OPERATIONAL PHASE**													
Air Quality	139	The exposed surfaces of the pond walls may generate airborne dust.	5	1	1	1	2	3	3	6	Soils	None	12
Surface Water	140	The discharged overflow from the raw water pond may affect the flows of surface streams and rivers.	5	2	2	3	3	3	2	5	Flora & Fauna	Water Supply	15
Groundwater	141	The water pumped from the dewatering wellfield into the RWPs will be re-injected into the aquifers and will affect local groundwater levels.	1	3	1	2	1.75	3	3	6	None	Water Supply	10.5
	142	The reinjected water from the dewatering activities may affect the local groundwater quality around the RWPs.	5	2	1	2	2.5	4	1	5	None	Water Supply	12.5
4. MINE COMPONENT: RAW WATER POND **4.3 RAW WATER POND - CLOSURE PHASE**													
Surface Water	143	The raw water ponds may provide a new water body in the local area.	1	2	1	4	2	4	3	7	Fauna	Water Users	14
Flora and Fauna	144	The raw water ponds may provide new aquatic habitat area and a water source for other terrestrial fauna.	1	2	1	4	2	4	3	7	None	None	14
5. MINE COMPONENT: OPERATIONS CAMP **5.1 OPERATIONS CAMP - CONSTRUCTION PHASE**													
Land Use	145	Loss of agricultural land being used by the local populations.	5	4	1	4	3.5	4	4	8	None	Econ (L)	28

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
												Social Welfare	
Aesthetics	146	The cleared area will be visible from the surrounding areas.	5	1	2	3	2.75	4	4	8	None	None	22
Soil	147	Soil erosion may occur on exposed areas during the construction phase.	5	1	1	1	2	3	3	6	Flora & Fauna	None	12
	148	The leaks and spills of oil, fuel and hydraulic fluid from heavy equipment may contaminate soils.	5	2	1	1	2.25	3	3	6	Surface Water	None	13.5
Air Quality	149	Airborne dust and exhaust fumes will be generated by heavy equipment.	5	1	1	1	2	3	3	6	Flora & Fauna	None	12
	150	Dust erosion on exposed surfaces will affect air quality.	5	1	1	1	2	3	3	6	Flora & Fauna	None	12
Noise and Vibrations	151	Construction equipment will increase the noise levels in active areas.	5	1	1	1	2	3	3	6	Flora & Fauna	Health & Safety	12
Surface Water	152	Soil erosion and run-off from erosion during site clearance.	5	1	1	1	2	3	3	6	Soils	Water Supply	12
	153	Leaks and spills of oil, fuel and hydraulic fluids from heavy equipment may contaminate water.	5	2	1	1	2.25	3	3	6	None	Water Supply	13.5
Flora and Fauna	154	The clearance of vegetation leads to the loss of habitat and biodiversity.	5	2	1	4	3	4	4	8	Soils	Social Welfare	24
Archaeology	155	The loss of archaeological and cultural sites during construction.	5	1	1	4	2.75	2	2	4	None	Culture	11
5. MINE COMPONENT: OPERATIONS CAMP **5.2 OPERATIONS CAMP - OPERATIONAL PHASE**													
Soils	156	Accumulations of domestic waste may contaminate soils.	5	2	1	1	2.25	2	3	5	Flora & Fauna	None	11.2 5

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
			Environmental Impact Characterisation										
Color Code of Impact			Positive						Negative				
Air Quality	157	Transport vehicles will generate airborne dust along transport routes on a daily basis.	5	1	1	1	2	3	3	6	Flora & Fauna	None	12
Noise and Vibrations	158	Mine camp activities will increase localized noise disturbances.	5	1	1	2	2.25	3	3	6	Flora & Fauna	None	13.5
Waste	159	Inadequate waste disposal may lead to contamination of the environment.	5	4	1	3	3.25	1	3	4	Soil Surface Water Groundwater	Health and Saftey	13
5. MINE COMPONENT: OPERATIONS CAMP **5.3 OPERATIONS CAMP – CLOSURE PHASE**													
General Public	160	The operations camp may provide an alternative housing area for the local communities.	1	4	2	3	2.5	4	4	8	None	Social Welfare	20
Waste	161	Inadequate decommissioning and closure of the waste disposal areas may lead to contamination of the environment.	5	4	1	3	3.25	3	3	6	Soils Surface Water Groundwater	Health and Safety	19.5
6. MINE COMPONENT: WORKSHOPS **6.1 WORKSHOPS - OPERATIONAL PHASE**													
Soil	162	Inadequate handling and storage of new/used oil, oil filters and used batteries may contaminate soil.	5	2	1	1	2.25	3	3	6	Surface Water	None	13.5
	163	Vehicles and equipment in the workshops awaiting service may contaminate soil from leaks of oils and fluids.	5	2	1	1	2.25	3	3	6	Surface Water	None	13.5
Noise and Vibrations	164	Activities in the workshops will increase localized noise disturbances.	5	1	1	2	2.25	3	3	6	Flora & Fauna	Health & Safety	13.5
Surface water	165	Contamination due to carry over of oil with storm water into site drainage system.	5	2	2	1	2.5	3	3	6	None	Water Supply	15

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
	166	Poor housekeeping, handling spills and inadequate storage of oils and used filters resulting in contaminated run-off.	5	2	2	1	2.5	3	3	6	None	Water Supply	15
Health and Safety	167	Employees in the workshop may mishandle and misuse oils that may cause fire hazards.	5	2	1	2	2.5	3	3	6	None	Health & Safety	15
Radiation	168	The pit vehicles in for maintenance may contaminate the workshop area with small amounts of radioactive dust.	5	3	1	2	2.75	3	1	4	Surface Water	Health and Safety	11
6. MINE COMPONENT: WORKSHOPS 6.2 WORKSHOPS - POST CLOSURE PHASE													
Soils	169	Stockpiled used filters, tyres and pumps etc. will contaminate soils after mine closure.	5	2	1	3	2.75	2	2	4	Surface Water	Health & Safety	11
	170	The used oil onsite after mine closure may contaminate the environment.	5	2	1	3	2.75	2	2	4	Surface Water	Health & Safety	11
	171	Soils that may have been contaminated with uranium from vehicle maintenance activities may contaminate the environment.	5	2	1	3	2.75	2	2	4	Surface Water	Health and Safety	11
Health and Safety	172	Waste that remains onsite after closure may be a health hazard to the local population.	5	2	1	3	2.75	2	2	4	Surface Water	Health & Safety	11
7 MINE COMPONENT: TRANSPORT INFRASTRUCTURE 7.1 TRANSPORT AND INFRASTRUCTURE - CONSTRUCTION AND OPERATIONAL PHASES													
Soils	173	Compaction during construction of roads may lead to loss of soil fertility.	5	1	1	3	2.5	2	2	4	Surface Water	None	10
Air Quality	174	Air pollution due to dust emissions from vehicles and trucks operating on dirt roads and in the plant area.	5	2	2	2	2.75	4	3	7	Flora & Fauna	Health & Safety	19.25
	175	Airborne dust generated from haul trucks from the open pits along access roads to the ore preparation areas may contain traces of radiation.	5	4	1	2	3	4	1	5	Flora	Health and Safety	15

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
Noise and Vibrations	176	Traffic around the project site and increased movement in the region will increase noise disturbances.	5	1	2	2	2.5	4	4	8	Flora & Fauna	Health & Safety	20
Surface Water	177	Accidental releases or spills of chemicals, acid, reagents, fuel, oil and uranium concentrate due to inadequate transport procedures may contaminate surface watercourses.	5	4	3	3	3.75	4	2	6	Soils Flora & Fauna	Health & Safety	22.5
	178	Releases caused by accidents due to defective or damaged infrastructure may contaminate water.	5	3	3	2	3.25	4	4	8	SoilsFlora & Fauna	Health & Safety	26
Flora and Fauna	179	The clearance of natural vegetation for the widening of existing roads and construction of new.	5	2	1	3	2.75	3	3	6	Soils	Social Welfare	16.5
Health and Safety	180	The increased traffic on dirt roads or national routes may affect the safety of the local populations.	5	3	3	2	3.25	4	3	7	None	None	22.75
Security	181	Safe and secure handling of the uranium concentrate from site to the buyer may be affected.	5	4	2	3	3.5	4	1	5	None	Public Safety	17.5
8 MINE COMPONENT: MATERIALS HANDLING AND STORAGE **8.1 WASTE MANAGEMENT - OPERATIONAL PHASE**													
Soil	182	Unnecessary accumulation of scrap metals and materials that can be sold reused or recycled.	5	2	1	2	2.5	2	2	4	Surface Water	None	10
	183	Inadequate handling, storage or disposal of hazardous waste may contaminate soils.	5	4	1	2	3	2	3	5	Surface Water	None	15
	184	Inadequate disposal of medical waste may contaminate soils.	5	4	1	2	3	2	3	5	Surface Water	None	15
	185	Inadequate handling and storage of reagent containers may contaminate soils.	5	4	1	2	3	3	3	6	Surface Water	None	18
	186	The inadequate disposal of domestic waste and effluent may contaminate soils.	5	2	1	2	2.5	2	3	5	Surface Water	None	12.5
Surface Water	187	Accumulations of scrap metals and recyclable materials may	5	2	2	2	2.75	3	3	6	Soils	Water	16.5

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
Color Code of Impact			Positive							Negative			
		contaminate surface water.										Supply	
	188	The inadequate disposal of domestic waste and effluent may contaminate water.	5	2	2	2	2.75	3	3	6	Soils	Water Supply	16.5
Radiation	189	General mine waste may be contaminated with radiation e.g. used PPE, contaminated scrap.	5	3	1	3	3.25	4	3	7	Environment	Public Safety	22.75
8. MINE COMPONENT: MATERIALS HANDLING & STORAGE 8.2 MINE STORES - OPERATIONAL PHASE													
Surface water	190	Fuel spills from fuel storage areas may contaminate water.	5	3	1	2	2.75	3	2	5	Surface Water	Water Supply	13.75
	191	Storm water runoff may become contaminated through pickup of spills from storage areas.	5	2	1	2	2.5	3	3	6	Surface Water	Water Supply	15
Health and Safety	192	The storage of incompatible chemicals and reagents may pose health and safety risks to employees.	5	3	1	2	2.75	2	2	4	None	None	11
	193	The lack of training of employees on appropriate handling and storage requirements may affect safety.	5	3	1	2	2.75	2	2	4	None	None	11
8. MINE COMPONENT: MATERIALS HANDLING & STORAGE 8.3 URANIUM CONCENTRATE STORES - OPERATIONAL PHASE													
Health and Safety	194	Increased levels of radiation may impact on employee health.	5	4	1	2	3	3	1	4	None	Health and Safety	12
	195	Increased levels of radiation may impact on public that have inadvertently accessed the concentrate storage areas.	5	4	1	2	3	2	1	4	None	Public Health	12
8 MINE COMPONENT: MATERIALS HANDLING & STORAGE 8.4 FUEL HANDLING & STORAGE - OPERATIONAL PHASE													
Soils	196	Leaks and spills of fuel from the mobile fuel tanker will contaminate soils.	5	2	1	2	2.5	3	2	5	Surface Water	None	12.5

Table 7.3 Environmental Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Duration.	Risk	Frequ. of Activity	Frequ. of Impact	Likelihood	Cum. Impact Environment	Cum. Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
Surface water	197	Handling spill or leak/rupture of fuel tanker may contaminate surface runoff.	5	4	1	2	3	2	2	4	Soils	Health & Safety	12
	198	Untreated run-off from fuel storage area entering site drainage system may contaminate the Surface water.	5	3	1	2	2.75	2	2	4	Soils	Health & Safety	11

Table 7.4 Socio-Economic Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Durat.	Risk	Frequ. of Activity	Frequ. of Impact	Likeli.	Cum. Impact Environment	Cumulative Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
1 MINE COMPONENT: SOCIO-ECONOMIC & CULTURAL IMPACTS **1.1 MAXIMISING LOCAL EMPLOYMENT AND ECONOMIC OPPORTUNITIES DURING MINING OPERATIONS**													
Local employment	1	The development of the project will generate job opportunities for Ivorian and the local population.	1	2	3	2	2	3	3	6	None	None	12
	2	The potential for employment will encourage the migration of job seekers to the area.	5	2	1	2	2.5	4	3	7	Land Use	Culture Water Supply	17.5
	3	The quality of labor and employee competency in the mining industry will improve through the implementation of training & development programs.	1	3	3	3	1.75	4	3	7	None	Social Welfare	12.25
	4	Generation of employment for the population which has been affected by relocation.	1	3	1	2	1.75	3	3	6	None	Econ (L) Social Welfare	10.5

Table 7.4 Socio-Economic Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Durat.	Risk	Frequ. of Activity	Frequ. of Impact	Likeli.	Cum. Impact Environment	Cumulative Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
	5	The employment of the local farming population in the area may impact on local agricultural activities.	5	2	2	3	3	3	2	5	Land Use	Econ (R) Culture	15
	6	Danison Mining Company will implement an equal opportunities method of employment where the position will be offered to the most suitable candidate available.	1	3	3	2	2.25	3	2	5	None	Social Welfare	11.25
	7	Danison Mining Company will promote the employment of women in the workplace.	1	3	3	2	2.25	3	2	5	None	Culture	11.25
Contractor employment	8	The contractors available in Zambia will be preferentially used where skills and quality are available.	1	4	3	2	2.5	4	3	7	None	Econ (R)	17.5
	9	The use of local contractors will increase their competency and managerial capacity.	1	3	3	3	1.75	4	2	6	None	Econ (R)	10.5
	10	The requirements for local contractors may encourage international contracting companies to develop in Zambia, resulting in sharing of skills and further job creation.	1	2	3	3	2.25	2	2	4	None	Econ (R) Culture	9
Employee retrenchment	11	Retrenchment packages to promote sustainable livelihoods. Counseling of employees prior to retrenchment.	1	2	2	2	1.75	2	2	4	None	Social Welfare	7
1 MINE COMPONENT:SOCIO-ECONOMIC & CULTURAL IMPACTS **1.2 LOCAL & REGIONAL ECONOMIC DEVELOPMENT**													
Local business enhancement	12	The project will improve local business multipliers and reduce unemployment through local procurement (where applicable).	1	3	2	2	2	3	3	6	None	Econ (L) Social Welfare	12
	13	The project will encourage the development of new businesses for the provision of services and supplies.	1	3	2	2	2	3	2	5	None	Econ (L)	10

Table 7.4 Socio-Economic Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation: Pos / Neg Impact	Intens.	Extent	Durat.	Risk	Frequ. of Activity	Frequ. of Impact	Likeli.	Cum. Impact Environment	Cumulative Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
	14	The project will assist with the development of new businesses and programs as part of its Sustainable Development Plan (SDP).	1	4	2	2	2.25	3	3	6	None	Econ (L) Social Welfare	13.5
Economic diversification	15	The requirement of services for the project will expand the opportunities for alternative economic activities to farming and mining in the Mutanga area.	1	3	2	3	2.25	3	3	6	Land Use	Social Welfare	13.5
	16	Danison Mining Company will develop a program as part of the SDP to assist and encourage economic diversification in the local area.	1	4	1	2	2	3	3	6	None	Econ (L) Social Welfare	12
	17	Danison Mining Company will assist in the empowerment of women through the SDP.	1	4	1	2	2	3	3	6	None	Culture Social Welfare	12
1 MINE COMPONENT: SOCIO-ECONOMIC & CULTURAL IMPACTS **1.3 PUBLIC RELATIONS WITH THE LOCAL POPULATION**													
Communication and Information Supply	18	Relations between the mine and the local communities may become strained due to high expectations.	5	3	1	3	3	3	3	6	None	Tolerance	18
	19	A Community Consulting Committee (CCC) will be developed to ensure regular meetings between Danison Mining Company and the local populations as well as identification of projects for the continual expansion of the SDP.	1	4	1	3	2.25	4	4	8	None	Econ (L) Social Welfare Tolerance	18
Public Consultation	20	The development of a relationship between Danison Mining Company and all stakeholders based on regular communication and transparency.	1	3	3	2	2.25	3	3	6	None	Tolerance	13.5
1 MINE COMPONENT: SOCIO-ECONOMIC & CULTURAL IMPACTS **1.4 LAND USE AND SETTLEMENT**													

Table 7.4 Socio-Economic Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Durat.	Risk	Frequ. of Activity	Frequ. of Impact	Likeli.	Cum. Impact Environment	Cumulative Impact Social	Total Impact
Color Code of Impact			Positive						Negative				
Agriculture	21	The loss of fields and crops will occur due to the mine development.	5	4	1	2	3	4	2	6	Land Use	Social Welfare	18
	22	Loss of the natural vegetation may remove species used for medicinal purposes by the local villagers.	5	2	1	2	2.5	2	2	4	Flora &Fauna	Health &Safety	10
	23	Fires started by the local population for clearing fields destroy the natural vegetation.	5	2	2	3	3	4	3	7	Flora & Fauna	None	21
Energy Resources	24	The felling of trees by the local population for firewood impacts on the local ecosystem.	5	2	2	3	3	4	3	7	Flora & Fauna	None	21
Forestry	25	The clearance of the large trees in the area during illegal timber practices.	5	2	2	3	3	4	3	7	Flora & Fauna	Health & Safety	21
Hunting Activities	26	Hunting activities conducted by the local populations' impacts on the birds and mammals in the project area.	5	2	2	3	3	4	3	7	Flora & Fauna	None	21
Settlements	27	There are 6 villages that will be affected by the project.	5	4	1	4	3.5	4	4	8	Land Use	Health & Safety	28
Resettlement	28	Six villages with population of 342 will be relocated to an area outside of project area to ensure the safety of the local population directly affected by mining activities.	1	2	1	4	2	4	4	8	Land Use	Tolerance Social Welfare	16
	29	Cultural tension and unease may occur among the relocated villagers	5	3	1	4	3.25	3	3	6	None	Health & Safety	19.5
1 MINE COMPONENT: SOCIO-ECONOMIC & CULTURAL IMPACTS **1.5 PUBLIC SAFETY**													
Access and Paths	30	Mining operations may impact on the natural access ways of the local populations.	5	1	1	3	2.5	3	3	6	None	Health and Safety	15
Access to Mine Operations	31	Inadvertent access by the public to the mine site and operational areas will case a risk to their safety.	5	3	1	3	3	3	3	6	None	None	18

Table 7.4 Socio-Economic Impact Characterization Table

Environmental Aspect/Issue	Item No.	Potential Environmental Impact	Environmental Impact Characterisation										
			Pos / Neg Impact	Intens.	Extent	Durat.	Risk	Frequ. of Activity	Frequ. of Impact	Likeli.	Cum. Impact Environment	Cumulative Impact Social	Total Impact
Color Code of Impact			Positive							Negative			
	32	Water pumped from the open pits, mine effluent streams and mine site run-off will pose a safety risk to the local communities if used for potable water or farming.	5	4	1	2	3	3	3	6	Flora and Fauna	None	18
1 MINE COMPONENT:SOCIO-ECONOMIC & CULTURAL IMPACTS **1.6 EDUCATION**													
Local Population in Mutanga	33	Denison will assist with the expansion of the local schools and infrastructure through the SDP.	1	3	1	2	1.75	4	3	7	None	Social Welfare	12.25
Regional Area	34	The potential for the assistance to schools and pupils in the regional area will be incorporated into the SDP.	1	3	2	2	2	3	3	6	None	Social Welfare (+ve)	12
1 MINE COMPONENT:SOCIO-ECONOMIC & CULTURAL IMPACTS **1.6 HEALTH PLAN**													
Healthcare for employees	35	Basic healthcare, sanitation and clean water will be provided to for all Danison Mining Company employees whilst on site.	1	3	1	2	1.75	4	4	8	None	None	14
	36	Basic healthcare will be provided to all employees and their immediate family dependents.	1	3	2	2	2	4	4	8	None	None	16
	37	Emergency healthcare will be provided to all employees in the case of accidents at the mine site.	1	3	1	2	1.75	4	4	8	None	None	14
Healthcare for the local communities	38	Danison Mining Company will assist with the provision of healthcare for the local communities through the SDP.	1	4	1	2	2	3	3	6	None	Social Welfare	12
HIV/AIDS	39	An HIV/AIDS awareness program will be implemented by Danison Mining Company for employees and their families.	1	3	1	2	1.75	4	3	7	None	Tolerance	12.25
Malaria	40	Reduce the incidence of Malaria amongst workers and their families and the community.	1	3	1	2	1.75	4	3	7	None	Econ (L)	12.25

7.3. Environmental Impacts

7.3.1. Land Use

The existing land uses in the project area are agricultural fields, widespread villages and free area considered as animal (cattle, goat) grazing land. and perennial plantations with some settlements for the field owners. Six villages, as well as 62 farmers, will be impacted on through the loss of this existing use.

Construction Phase

There will be considerable changes to the land use of the project area during construction. The existing land users and agricultural activities will be subjected to displacement and relocation. The significance of these impacts is very high.

The existing land use will change to industrial sites where the mine infrastructure will be developed. These sites will remain as industrial sites throughout the 10-15 year life of the project (10 years for operations). Permanent land use changes will occur at the open pits, waste rock dumps, the leach pads, raw water pond, the new field areas and Kashundi Village.

Operational Phase

The land use of areas where new development occurs during mining will be changed.

Exploration activities in the mine license for new deposits may lead to changes in land use through road development and land clearance. The development of roads may also encourage their use by the local population which could extend clearance activities for fields and plantations.

Closure Phase

The waste rock dumps can be re-profiled and re-vegetated with indigenous species. The soil fertility will also be amended to ensure that it can sustain alternative land uses.

The leach pads and WRDs will be capped and re-vegetated during decommissioning. The soil fertility will be amended using fertiliser and/or manure to ensure the success of re-vegetation.

7.3.2. Visual Aesthetics and Landscape

The site consists of steep hilly terrain for the locations of the open pits. The other infrastructructure lies on the plateaus or in the plains between the hills. There is no industry in the area and noise levels are low based on small rural populations. The villages overlie the proposed Mutanga open pit. There are fields in the valleys and on fertile areas on the plateaus. There is little clearance of the natural vegetation for charcoaling or timber so where it can thick vegetation dominates the sites.

Construction Phases

The characteristics of the landscape will be permanently altered when construction begins. Visual impacts of the construction activities will be high based on the locations of the pits.

Operational and Closure Phase

The mining of the Mutanga and Dibwe resources will lower the hills. The topography of the area is permanently altered. With appropriate closure and re-vegetation actions the new site will appear natural.

7.3.3. Geology and Rock Formations

The natural geology will be permanently and irreversibly modified permanently by the removal of U_3O_8 ore and waste rock. Waste rock will be deposited on the waste rock dumps. The geology of the site will be impacted on during the construction phase and will be continual throughout mining operations.

7.3.4. Soils

The soils impacted on directly by the project infrastructure are mostly sands and loamy sands with very little clay soils. These soils are highly erodible as there is little cementation material to bind them. Soil fertility is usually low but more fertile soils occur in stream channels or valley bottoms.

Construction Phase

Approximately 798.5ha (382ha for mine infrastructure and 416.5ha associated with relocation and compensation) of vegetation will be cleared from mine infrastructure which will expose soils to erosion and degradation actions. Soil fertility will decrease based on the loss of nutrients being recycled to the soil from the vegetation and leaf litter.

The soils on the infrastructure sites will all be modified during construction. Topsoil (0-15cm) will be removed affecting soil fertility. The topsoil will be stored for site rehabilitation and re-vegetation. Construction equipment will cause soil compaction and reduce soil permeability. This will then increase runoff and reduce soil moisture for micro-organisms.

The foundations of the process plant, WRDs and the leach pads will be built up using less permeable or impermeable ground layers to manage seepage. This will change the soil environment permanently.

Construction of the roads (main access and inter-mine) will lead to compaction of the soils to form a solid road surface. This will increase runoff eroded suspended solids.

Contamination from spillages and leaks from construction vehicles may occur.

Operational Phase

Soil may become contaminated from acid leaks under the leach pads, which will in turn effect groundwater quality. A leak detection system will be installed to prevent this.

Soil contamination from spillages of oils, hydraulic fluids, fuel, reagents, contaminated water, process solutions, seepage from accumulations of waste materials (metals, reagent containers, organic matter and sewage) etc may occur. These impacts can be managed on a daily basis and prevented or mitigated. Cleanup procedures will be followed during large spill incidents.

Soil may become contaminated with radioactive minerals during uranium mining, from dust blow or contaminated water. Appropriate management will prevent this from occurring. All contaminated soil will be fed through the leach pad or dumped on the waste rock dump (if contamination is negligible, as described in the Radioactive Waste Management Programme **(Appendix 6**).

Soil erosion and compaction in exploration activities will occur. Exploration management actions will be implemented to prevent this.

Erosion of soils and materials from the WRD, leach pads, around the project area and along access roads will lead to a reduction in soil agricultural capability. Measures shall be implemented to reduce areas where erosion can occur as well as actively seek to identify new areas during mining activities.

Closure Phase

The closure phase will lead to the removal of all site infrastructure and thus expose these compacted, infertile soils to the elements. This will lead to further erosion. The compaction of the soils will also drastically reduce the rate of recolonisation by vegetation.

All sites will be reprofiled to loosen the compacted soils to allow better aeration and permeability. The sites will be layered with the collected topsoil from the construction phase and the soil fertility will be assessed. Adjustment measures (fertiliser application, manure, compost) will be implemented if necessary. Profiling will ensure that slopes are reduced to discourage erosion actions.

There may be long term impacts on moisture and quality of soil that surrounds the WRD or leach pads due to runoff and eroded slope material.

7.3.5. Surface Water

There are no direct perennial drainage features from the Mutanga or Dibwe sites. Drainage from the Mutanga prospect flows in a northeast direction eventually flowing into the Lusitu River. Drainage from the Dibwe prospect flows in a southeast direction into the Nahunwe River, eventually into the Namatelo River which drains into Lake Kariba.

Construction

The modifications of the landscape due to construction activities will lead to contamination of surface runoff with eroded material. This runoff will impact on surface watercourses. Management measures will be implemented.

The changes to the landscape will directly impact on the direction of drainage and surface runoff on the project site. Infiltration rates will decrease due to compacted soils and runoff will increase on impermeable surfaces. The residence time of water in the environment prior to its arrival in the surface watercourse systems will be reduced (less in the soils and less for remaining vegetation). This will impact on annual flow patterns in these streams. Actions will be implemented to manage these long term impacts.

Contamination of surface runoff from spills (oil, fuel, hydraulic fluid) during movements of construction vehicles may eventually impact on surface watercourses. Management measures to prevent spills will be implemented.

The contouring of the surfaces around main infrastructure to collect all possibly contaminated drainage will reduce water volumes flowing into streams during the rainfall recharge. This has long term effects on the downstream water supply.

Operational Phase

The significance of the impacts on surface water quality during the operational phase are high.

The rainfall runoff and eventually surface waters will be contaminated by higher levels of solids and metals based on erosion activities in the project site. All areas of erosion will be managed in the EMP.

Breaches in the leach solution ponds or overflow from the leach pads during the wet season may contaminate surface runoff with highly acidic, metal-loaded leachate and impact on watercourses. The initial design of the ponds and pads will act to prevent the breaching.

The leachate would also contain concentrated levels of uranium, potassium and thorium and will definitely have a radiological impact on the watercourses. Water supplies may be lost. This is highly unlikely though. All contaminated water will be treated in the treatment plant.

The contamination of surface water may occur from spills and inadequate handling of oils, fuel, hydraulic fluids, reagents, process solutions etc. Management actions in the EMP will aim to prevent and reduce the occurrences of any spills.

Dewatering water from the open pits may contaminate surface water with suspended solids, radioactive minerals and possibly produce radon. Dewatering water from the wellfield will be stored in the RWP for mining activities and the rest will recharge the groundwater aquifers. The in-pit dewatering water will be pumped to the DWP for settlement and discharge to a reed bed.

Surface water may become contaminated from Acid Rock Drainage (ARD) developing within and under the WRDs or the leach pads. Initial acid base accounting (ABA) analysis indicates that waste rock samples analysed may be acid generating. Management measures have been described in **Sections 8 and 9** below.

Closure Phase

The surface water will be impacted on by the long term effects of the WRD, the open pits, waste (rubbish) dumps and the RWP. The other project infrastructure will be removed from site. A post-closure monitoring plan will be undertaken as part of the EMP.

7.3.6. Groundwater

Construction Phase

The contamination of groundwater could occur through contaminated seepage from spills, waste (rubbish) dump, collections of waste material, inappropriate waste storage or contaminated surface runoff. Measures to monitor and manage the contamination of groundwater are included in the EMP.

Operational Phase

Leachate containing materials that emit radiation may contaminate groundwater aquifers and affect water sources. Actions in the EMP will prevent this.

Dewatering activities in and around the open pits will lower local groundwater levels through the induction of flow. This could affect other groundwater users in the area. The inhabitants of the villages will be relocated roughly 4km from the project area and are not likely to lose their boreholes.

Seepage of runoff through the WRDs may generate acidic drainage which will drain from the base of the WRDs. Analytical results show that waste rock may be acid generating however there is a low sulphur content in the dumps. Further analysis of this is required on a larger number of samples. Management measures have been described in **Sections 8 and 9**.

Closure Phase

The groundwater will be allowed to stabilise at the end of mining operations in the open pits to approximately pre-mining levels. This may be affected by changes to the surface topography. It is possible that the open pits will become areas for alternative land use but radiological assessments will determine the mine post-closure land uses.

The long term impacts of seepage through the WRD may contaminate groundwater with metals. This impact will be assessed through the mine life. The areas will be capped with a less permeable layer and vegetation will be cultivated on their surfaces. The Mine Closure and Rehabilitation Plan will be updated prior to closure to ensure the accuracy of management measures.

The leach pads will be decommissioned during the closure of the mine. These pads are likely to generate acidic leachate if exposed to rainfall and seepage. Accumulated solution at the base of the pads may lead to stabilities. Closure activities of these pads will take these impacts into account.

7.3.7. Air Quality

The localised air quality in the project area is good with visibly low dust concentrations. Deteriorations will be caused by traffic, clearance of vegetation and seasonal fires. The main source of energy is wood and secondly charcoal. The air quality will be worst in the dry season (April to November). There are no industrial activities in the project area.

Construction Phase

The increased activities on site by vehicles and construction equipment will increase emissions to the atmosphere. The increased accessibility of the area may lead to increased transportation of the local people further increasing local traffic. Regular maintenance of mine vehicles will be conducted to reduce these emissions. Access to the mine site will be restricted.

The clearance of vegetation from construction sites and access roads will expose soils to wind erosion and dust generation from mobile vehicles. Dust suppression measures will be implemented.

Any crushing activities that may occur for aggregate material for construction will generate dust.

Operational Phase

There will be continued dust and vehicle emissions throughout the operational phase of the project. Water suppression methods will be implemented.

Ore handling by mine machinery in the open pit may generate airborne dust. This is being reduced by the mining method being decided on. There will not be any pit blasting.

The ore fed into the ROM hopper and the crushers will generate dust which will be reduced by wetting ore using sprayers and agglomeration of the pad feed. The crushed ore delivered on the mobile stacker units may release dust from the conveyor or ore transfer points. Hoods and mist sprayers will be utilised.

The leap pads may generate wind blown dust when they get drier in the dry season. Solution management will be conducted to prevent this.

Oxygen will be required for the process plant and a boiler will provide hot water for the process plant. Heat emissions will be monitored as well.

Dust blow may occur off the WRDs as well and so water bowsers will be deployed to spray the surfaces. Vegetating the dump walls will begin as early in operations as is feasible.

Closure Phase

Dust generation from exposed surfaces on the main infrastructure will impact on the long term air quality unless proper closure of the site is achieved. A Closure and Rehabilitation Plan will be implemented and the Ministry of Mines will sign off on the environmental liabilities of the site once there has been complete closure and favourable post-closure monitoring.

7.3.8. Radon

Radon is released as uranium decays and when it is exposed at the surface it is easy for the gas to accumulate.

Construction

Radon may be more concentrated around the undisturbed deposits. Inhalation can cause harm to the lungs. A monitoring program will be initiated through the EMP as soon as site activities occur.

Employees in the exploration program may be occupationally exposed to radon especially during corehouse activities.

Operations

Radon may be released from the waste rock dumps. It is unlikely as there will be low values of mineralisation but monitoring will be undertaken to identify the hazards first.

The radon will be released from the leaching and operational pads during operations. The number of employees working in the pad areas will be minimised.

Radon may also be generated along the process plant circuit. In-plant monitoring devices will be used to alert employees to gas alarm. The sealed unit process plant reduces employee exposure.

Closure

If left unmanaged the leach pad facility will be a long term source of radon into the surrounding environment. The closure management actions will profile and cover the pads to prevent the release of radon to the environment. A radon detection survey of the site prior to closure will identify areas that may require further management.

7.3.9. Radiation

Radiation is generated when an unstable nucleus releases excess energy through emittance of electrons or adsorption into the nucleus to form a new product.

Construction

Construction activities will expose soil and rock during these activities. Mineralisation of the soil and rock around Mutanga confirms there is the potential to slightly increase radiation levels that construction workers will be exposed to. PPE and dust suppression will be used.

Operations

Employees working in the open pits, truck and front-end loader operators, plant workers, security personnel, shipment drivers etc are all likely to be exposed to radiation levels. Methods for shielding, exposure reduction and PPE will be used to prevent unhealthy exposures occurring.

7.3.10. Flora and Fauna

It was identified during the baseline study that some habitats and species are considered to be vulnerable or protected due to the impact of development on areas where they are found. The forests located on the hills in the project area are considered to be habitats important for the maintenance of biodiversity.

Construction

The construction activities will lead to large scale clearance of vegetation on approximately 798.5ha of land. This will cause the loss of habitats for terrestrial animals as well as the loss of flora species. Habitat corridors will be maintained throughout the project to protect and enable movement of animals around the site.

Construction activities will generate noise and vibrations that may frighten animals and birds.

Flora and fauna may be impacted on by the project through consumption of contaminated water, or contamination to their environment.

Operational Phase

The progressive expansions of the open pits will cause ongoing clearance activities throughout the mine life. Management actions will be implemented to identify key habitat areas to protect and conserve.

The continuing loss of habitat will lead to an overall decline in biodiversity of the project area. The loss of specimens through road kill, drowning and electrification may also become important over the lifetime of the project. Ongoing monitoring will be conducted by the environmental department regarding animal sightings and deaths. Mitigation measures will be developed during activities to determine causes of deaths and prevention activities.

The continous long term degradation of the water quality of the aquatic environments will reduce aquatic biodiversity sensitive to these changes. Suspended solids and metals affect light penetration and toxicity of the habitats. Management measures will be implemented to reduce these impacts and long term monitoring of these habitats will be conducted to assess the impacts.

Hunting and fishing activities will increase with the influx of settlers to the area. These activities will be illegalised within the mine license area and any offenders will be reported to the appropriate ministries and protection services.

Closure

Site rehabilitation will occur during the closure phase. It will be determined after an assessment of the conditions on closure the best measures to implement for practical reasons and prevailing conditions. The aim of management actions in the closure phase will be to restore these areas to pre-mining land uses or alternative new ones. Flora and fauna biodiversity will be incorporated into that.

7.3.11. Noise and Vibrations

Increases in the local population and mining activities will impact on noise and vibration levels in the project area.

Construction Phase

The construction equipment, haul trucks, delivery trucks, mine vehicles and visitors to site will all increase traffic and noise generated in the area. All roads accessing the site will be affected as well as the major transport routes from Lusaka and Chirundu to site. The vibrations may impact on the safety of buildings and roads.

Increased levels of noise will impact on employee safety and exposure to high noise levels. An occupational health and safety plan (**Section 9.3**) will be developed to protect employees.

Operational Phase

The noise from operations will be generated by the crushers, the process plant, open pit mining equipment, haul trucks, mine vehicle movement around the site and various pumping facilities. Operators working in noisy areas will be the subject of occupational health and safety measures.

Vibration impacts from vehicle movement and mining may affect safety and integrity of surrounding buildings. An assessment of the ground vibrations and the impact on local buildings will be conducted during operations.

7.3.12. Archaeology

Construction and Operational Phases

New archaeological sites may be found or lost during clearance for construction of the mine and future infrastructure. Denison will undertake to ensure employees are aware of identifying new discoveries and to ensure that inspections are conducted for any reported finds.

Discovered sites will be managed with the aim to protect the historical archaeological assets found onsite.

7.4. Socio-Economic Impacts

7.4.1. Displacement and Compensation

The most important social impacts that will occur are the displacement of 6 villages and 62 farmers (RAP, 2009). These studies will need updating prior to the implementation of the project based on possible project design changes.

Construction Phase

The Mutanga Project will be constructed in an area which will require the relocation of 6 villages. The footprint will affect 62 fields owned by residents of the villages or those from the surrounding area. Prior to the commencement of construction activities the compensation and relocation of affected villages and farmers will need to be finalised. This has been described in the RAP.

A consultant will be engaged by Denison to manage the implementation of the RAP through design, construction, relocation, and resettlement of the communities (refer to the RAP Report). This will include engaging of architects, buildings and organisation of materials.

The construction of the housing in Kashundi Village shall begin with the development of access roads around the site for construction. The details of relocation will be finalised through the RC. The success of the relocation and compensation exercise will be determined throughout implementation of the program by the CCDC.

Operational Phase

The long term impacts of the displacement, relocation and agricultural loss will occur throughout the operational phase. Measures will be continued to monitor the state of the local population, assess their economic status pre- and post displacement and compensation and determine the future inputs from Denison to maintain the success of the program.

During design of Kashundi the RC will design the leadership of the village and it should consist of a panel of representatives from all of the villages to generate a fair and unanimous method of leadership. This aspect will be discussed with Chief Sinadambwe and district administration.Social tension may also arise over the improvements of living standards of the relocated communities and the surrounding communities.

The design and development of all relocation areas and infrastructure will be done with a sustainable approach to ensure that the community can continue to manage them without involvement from Denison. This will reduce the post closure reliance on the company. Denison will ensure monitoring and auditing of the progress of the local communities through the RAP(refer to the RAP Report)

7.4.2. Migration

Generally all new development leads to a massive influx of job seekers or service providers to rural areas with overstretched service facilities prior to their arrival. There are high levels of unemployment and socio-economic tensions may arise between local communities and immigrants.

Construction

A higher number of jobs will be available during the construction phase than normal operations which would encourage the influx of people. These immigrants would settle around the Mine or other surrounding villages and increase the demand on water, electricity and land supplies.

The increased influx of foreign immigrants may cause tension between the local populatons especially if foreigners are benefitting more due to better skills and experience.

The need for the employment of skilled or semi-skilled employees will require a training program to be initiated prior to construction activities being implemented. Denison will implement training as soon as the project is initiated to expand the skills of local people and identify existing skills within the communities.

Operational Phase

During activities the influx of people will lead to the reduction in available land for agriculture.

Squatters or job seekers may immigrant into the Project area. This will pose as a safety risk to the local communities and mine operations. Mine security officers will be required to manage these developments.

Closure

The closure of the mine will result in an increase in unemployment which may reverse the early trend of in-migration.

Socio-economic tensions between immigrants and the local populations will be amplified based on the difficult economic situation. Denison will ensure that adequate counselling and remuneration packages are available to all employees who will face unemployment at the end of the project or in economic difficulties. Retrenchment opportunities may be possible.

7.4.3. Employment and Training

The prospects of a new project and economic sector developing in will provide 384 jobs during operations. Uranium mining has not occurred in Zambia and the local resources of skilled employees is low. Foreign skilled workers will be employed as trainers and these personnel will be phased out over a 4 year period.

Semi-skilled employees such as builders, plumbers, carpenters and mechanics etc will all be employed from the Zambian population and trained by Denison adequately.

Construction Phase

The highest number of jobs will be available during the construction phase. The labour force will require skills in building, welding, carpentry, plumbing, electrical wiring. A database of locally available skills will be developed by Dension prior to the project and maintained throughout operations.

The installation of the process plant will require skilled personnel. The employment of foreigners should be managed with the RC and Community Consultation Committee (CCC) to ensure that communication of employment strategies are clear.

There are poor levels of literacy and numeracy in the Siavonga District. It may be that the skilled professionals required for training cannot communicate during training.. Training workshops on skills, culture, health and safety and environmental awareness will be provided by Denison and mandatory for all employees. This will improve educational and tolerance levels of foreigners with the local communities through better understanding.

Operational Phase

Different roles of employment will be necessary during the operational phase, mostly related to daily operations in all areas of the project with specific skill requirements.

The training initiated in the construction phase will continue through the operational phase. The focus of training through the operational phase will be the expansion of personal skills and experience to enable sustainable employment in the mining industry or elsewhere. This will assist with the concerns that may occur leading up to closure.

Closure

There will be unemployment generated through closure. Employees may be incorporated into other operations. Dension will strive to will provide active counselling and information assistance for other job opportunities through the training department. Redundancy and retrenchment packages will be provided to employees within reasonable timeframes.

7.4.4. Enhancements to Local Businesses and Projects

There will be the requirements for local and foreign service providers e.g. fuel suppliers, electricity suppliers, water rights, reagent suppliers, equipment suppliers, spares suppliers, vehicle suppliers, mechanics and maintenance suppliers, health and safety equipment suppliers, stationery and office materials suppliers, furniture suppliers etc. These service sectors will benefit from increased demand. Further economic growth and expansion will follow. There may be economic diversification in Siavonga where service providers may need to locate. The expansion of the Siavonga community may also encourage tourism.

7.4.5. Economic Expansion and Diversification

The mining activities will generate tax revenue payable to the Government and Ministries of Zambia. Mineral royalty taxes will be received as well as licensing fees for mineral rights and environmental, health and safety compliance. Value Added Tax (VAT) will also be charged on all services provided to and from the mine. The increased revenue will provide financial input to development projects and programs in the Southern Province. Denison will maintain a productive working relationship with Government authorities to monitor productive use of taxes to assist with social development in the project area.

The local economies in Kashundi, Siavonga, Chirundu, Kafue and Lusaka will all benefit from increased spending within the local populations and this will encourage economic growth. There will be diversification in economic service provision to the mine as well as other secondary industries. Denison will provide advice and encouragement to employees on investment issues related to salaries and pension plans, as well as financial planning.

Foreign revenue will be generated through the sale of the U_3O_8 on the international markets. Denison will provide a Product Marketing and Sales Plan to the Zambian Government during application for a mining license.

7.4.6. Public Accessibility, Health and Education

The local infrastructure such as roads, electricity supply, education services, health services and water supply are very sparse in the Mutanga area. There are no clinics in the immediate project area and limited primary education provision. Roads are in a state of disrepair and access is very limited during the rainy season.

Public transport is poor within the permit area and there are high expectations for this to be improved by Denison. The CCC will manage these expectations and instigate improvements on transport and accessibility with Government Ministries.

The public access to fields and villages around the mine may be affected. Denison will identify access routes with the local communities through the CCC.

Denison will instigate a development program with the Government of Zambia through a Sustainable Development Plan (SDP). The company will aim to work with local authorities with the implementation of projects in education, health, training, community empowerment, agriculture, livestock rearing, infrastructure development, equality and human rights. The progress and implementation of these projects will be documented and communicated through the CCC.

Health and safety impacts related to mining infrastructure such as the open pits, waste rock dumps, leach pads, access roads etc may affect operations. Concerns of dust, water quality, radiation, radon and uranium will be high amongst all of the communities in Zambia. Dension will implement an environmental management plan that will inform the public of the impacts of the project, the mitigation and management measures proposed for the Project and the development of a Community, Regulator and Stakeholder Educational Program. Aspects of the security management during the production of the concentrate and its storage and handling to prevent loss, theft or unlawful use will be discussed with the public to relay concerns over improper nuclear activities.

7.4.7. Information Exchange and Public Consultation

Active consultation and information exchange with the communities over future project plans will ensure positive project development with the local communities. This will also involve government regulators and interested stakeholders.

A public consultation program will be organised through the Environmental Department to improve the perception of Denison within the local communities, actively inform them of social investment, organise or contribute to community social events, sponsorship of sports teams etc. Denison will develop a Community Consultation Committee (CCC) which will inform the local communities of company activities, ongoing development projects, provide liaison opportunities for new projects and a grievance mechanism for community concerns. The Environment, Health and Safety Department of Denison will manage these activities.

A Relocation Committee (RC) will operate throughout the implementation of the RAP (refer to the Mutnga RAP Report, 2009) The monitoring and auditting of the relocation activities will be continuous throughout the mine operations and will be managed by Denison and an external review committee.

8. ENVIRONMENTAL AND SOCIAL IMPACT MITIGATION

The environmental and socio-economic impacts of the project were identified in Chapter 7. Chapter 8 describes mitigation measures that will be implemented during the project development to manage or prevent the environmental impacts. These mitigation actions have been ordered according to their phase of implementation to allow easier reference and prioritisation of actions. The mitigation actions are then related to each mine component. **Table 8.1** provides a summary of these impacts and mitigation actions in a format useful for future auditting of mine facilities.

The mitigation of socio-economic impacts have been described in detail in the Sustainable Development Plan (**Chapter 9**).

8.1. Construction/Pre-mining Phase

It is highly recommended that all construction activities be scheduled to maximise the dry season to reduce impacts on soils and surface water. It is also important to ensure the reduction of dust generation through the use of water bowsers especially in cleared areas and along access roads.

8.1.1. Displacement and Relocation

During the construction phase the displacement and relocation of the affected villages will be conducted in accordance with the RAP. The total cost of compensation activities are estimated at **US$2.5million**.

The RAP will be updated prior to the relocation exercise with the finalised decisions of the RC and communities on compensation, final village layout and housing designs, updated schedules and compensation estimates. The RAP together with the EIS will be submitted to the authorities for a review and upon approval of the update the development will begin.

Denison will involve a consultant to implement the RAP and the CCDC will monitor the performance of these activities. Daily progress meetings will be held with the CCDC, consultant and the mine manager to manage the schedule, identify issues and update schedules. The CCDC will meet regularly with the RC throughout the implementation of the RAP. All discussions will be documented and regular reporting as described in the RAP undertaken.

An external Monitoring Committee will convene on a quarterly basis to assess the progress of implementation of the RAP.

The Kashundi Village will be cleared. The wood will be made available to local communites or economic timber will be sold to the Forestry Department/timber merchant. An update of the baseline for this site will be required as it was not identified during the fieldwork assessment for the baseline studies.

Measures to manage air quality, water quality and erosion will all be addressed by the contractor employed. Impacts of construction will be reduced.

The housing will be constructed and approved prior to habitation by any of the relocated population. The local population can be hired/employed by the development contractors which will improve employment statistics prior to mine development. This will improve ownership and acceptance of the project by the local communities.

Table 8.1 Environmental Management Plans						
What needs to be managed?	**Why does it need to be managed**	**Item No.**	**How should it be managed?**	**Timing of management actions**		**Responsibility**
				Start	**End**	
1. MINE COMPONENT: MUTANGA AND DIBWE **1.1 OPEN PITS - CONSTRUCTION PHASE**						
Land Use	Some of the agricultural land being used by the local populations will be taken up by the open pits.	1	Displacement and relocation of the affected villages will be conducted in accordance with the Resettlement Action Plan	2010	2010	CCDC
Aesthetics	Most areas will be opened up due to clearance of vegetation from the hills where the resource is located.	2	Only vegetation in areas directly affected by mining activities will be cleared.	2010	2011	Director of Mines Safety Mine Manager
Soils	Cleared vegetation will expose soils to erosion processes.	3	Vegetation will only be cleared on earmarked mine sites and accesses.	2010	2011	Director of Mines Safety Mine Manager
	Leaks of oil, fuel and hydraulic fluid from the construction machinery may contaminate soils.	4	With the exception of breakdowns, the service, repair and maintenance of mining equipment will be restricted to dedicated areas specifically designed for the purpose.	2010	2011	Director of Mines Safety Mine Manager
Surface Water	Exposed surfaces are prone to erosion and solids removal by water. This may affect local watercourses.	5	Exposed surfaces will be compacted and run-off directed to sedimentation ponds. Only clear water will be released to water courses.	2010	2011	Director of Mines Safety Mine Manager
	Leaks of oil, fuel and hydraulic fluid from the construction machinery may contaminate local watercourses.	6	All drainage from dedicated areas specifically designed for service, repair and maintenance will pass through oil traps prior to release into the site drainage network which leads to local watercourses.	2010	2011	Director of Mines Safety Mine Manager
Groundwater	The lowering of the local water table in the vicinity of the open pits due to mine dewatering may affect the communities and biodiversity.	7	The depth of the water level in the boreholes sunk around the open pits and those located in the nearby communities will be monitored for any significant changes.	2010	2021	Director of Mines Safety Mine Manager
Air Quality	Movements of machinery around the cleared sites will generate dust and exhaust fumes.	8	Water will be routinely sprayed on all the haulage roads to suppress the dust.	2010	2011	Director of Mines Safety Mine Manager
		9	Vehicles should be in good working condition and be regularly services to reduce on the exhaust fumes	2010	2011	Director of Mines Safety Mine Manager

Table 8.1 Environmental Management Plans						
What needs to be managed?	**Why does it need to be managed**	**Item No.**	**How should it be managed?**	**Timing of management actions**		**Responsibility**
				Start	**End**	
Flora and Fauna	The clearance of vegetation will lead to the loss of habitat and biodiversity.	10	Only vegetation in areas directly affected by mining activities will be cleared.	2010	2011	Director of Mines Safety Mine Manager
Noise and Vibrations	Construction machinery during the pre-strips of the open pits will cause increased noise and vibrations.	11	Natural vegetation and topography will be maintained to prevent any unwanted noise from reaching the nearby communities. The mine will carry out noise sampling in the nearby communities when mining activities and mitigation measures formulated (if noise is not acceptable). No blasting will be conducted. Vibration assessments will be carried out to ensure that communities are not affected.	2010	2011	Director of Mines Safety Mine Manager
Archaeology	The loss of archaeological and cultural sites during site clearance.	12	Denison will undertake to ensure employees are aware of identifying new discoveries and to ensure that inspections are conducted for any reported finds. NHCC will be informed of the discovery.	2010	2011	Director of Mines Safety Mine Manager
Health and Safety	The construction workers will be required to work in hazardous situations during normal development activities.	13	• All areas of the plant where employees may come into contact with process solutions, reagents or acids will be provided with emergency showers and eye baths; • Access to reagent stores, sections of the process plant and the plant control room will be strictly controlled; • Fire suppression methods such as fire showers will be installed in all areas where heat is generated or areas where flammable materials are stored.	2010	2011	Director of Mines Safety Mine Manager
	Other mine employees and the local population may endanger themselves when entering development areas.	14	The public will be informed of the dangers of entering mine operational areas.	2010	2011	Director of Mines Safety Mine Manager
		15	Warning signposts will be erected around the dumps. Mine security will remove intruders from the mine site.	2010	2011	Director of Mines Safety Mine Manager
1. MINE COMPONENT: MUTANGA AND DIBWE OPEN PITS **1.2 OPEN PITS - OPERATIONAL PHASE**						
Soil	Soil may be contaminated from the onsite service,	16	With the exception of breakdowns, the service, repair and	2010	2021	Director of Mines

Table 8.1 Environmental Management Plans

What needs to be managed?	Why does it need to be managed	Item No.	How should it be managed?	Timing of management actions		Responsibility
				Start	End	
	repair or maintenance of open pit mining equipment.		maintenance of mining equipment will be restricted to dedicated areas specifically designed for the purpose.			Safety Mine Manager
	Erosion will occur on exposed soil surfaces.	17	Vegetation will only be cleared on earmarked mine sites and accesses. Loose soil will be compacted.	2010	2011	Director of Mines Safety
Air Quality	Air borne dust may be generated from haul trucks and other heavy equipment.	18	Water will be routinely sprayed on all the haulage roads to suppress the dust.	2010	2021	Mine Manager
	Exhaust fumes and smoke are produced by heavy equipment and haul trucks.	19	Only vehicles in good working order and regularly services will be used for mining operations	2010	2021	Director of Mines Safety Mine Manager
Noise & Vibration	Noise from mining activities could be a nuisance to the nearby communities.	20	Natural vegetation and topography will be maintained to prevent any unwanted noise from reaching the nearby communities. The mine will carry out noise sampling in the nearby communities and mitigation measures formulated (if noise is not acceptable). No mine blasting will be conducted.	2010	2021	Director of Mines Safety Mine Manager
Noise & Vibration	Vibrations may be generated from heavy equipment movements.	21	Vibration assessments will be carried out to ensure that nearby communities are not affected	2010	2011	Director of Mines Safety Mine Manager
Surface water	Local streams may be contaminated by the discharged dewatering water from the open pits.	22	The water from the pit will be discharged into a sedimentation pond were solids will be settled and clear water treated. Safe water will be pumped to the plant for use.	2010	2021	Director of Mines Safety Mine Manager
	Contamination of water from the accidental spills of hydraulic fluid, oil or fuel from heavy machinery.	23	The mine drainage system will have oil traps and treatment ponds to make effluent safe before discharge to the general environment.	2010	2021	Director of Mines Safety Mine Manager
	Contamination of water from inappropriate waste disposal practices.	24	Waste will be stored in secure areas. Any run-off from these areas will be treated in the site ponds before release to the general environment.	2010	2021	Director of Mines Safety Mine Manager
Groundwater	The lowering of the local water table in the vicinity of the open pits due to mine dewatering may affect the communities and biodiversity.	25	The depth of the water level in the boreholes sunk around the open pits and those located in the nearby communities will be monitored for any significant changes.	2010	2021	Director of Mines Safety Mine Manager

Table 8.1 Environmental Management Plans

What needs to be managed?	Why does it need to be managed	Item No.	How should it be managed?	Timing of management actions Start	End	Responsibility
Health and Safety	Operations in the open pits may affect the health and safety of mine employees.	26	Ensuring walls stability of the open pits. Erosion protection/control measures and storm water management infrastructure such as perimeter drainage channels, bund walls and perimeter slope profile will be monitored and maintained in order to minimize the inflow of water into the pit. Provision of necessary Safety attire to employees.	2010	2021	Director of Mines Safety Mine Manager
1. MINE COMPONENT: NORTH AND SOUTH OPEN PITS 1.3 OPEN PITS - POST CLOSURE PHASE						
Surface water	The natural flooding of the open pits by groundwater and rainfall will create a new lake resource.	27	Standing water in the open pit will be monitored for quality to ensure that it does not pose a health risk.	2021	2025	Director of Mines Safety Mine Manager
Groundwater	The groundwater rebound when dewatering is stopped may lead to destabilization of the pit walls.	28	Pit walls will be stabilized where possible prior to flooding of the pits, Monitoring of the pit wall stability will be conducted during closure flooding of the pit and post closure of the operations to prevent overtopping of the pits.	2021	2025	Director of Mines Safety Mine Manager
Health and Safety	Failures of the open pit wall may endanger the public.	29	Final pit walls will be designed with adequate factors of safety.	2021	2022	Director of Mines Safety Mine Manager
2. MINE COMPONENT: WASTE ROCK DUMP 2.1 WASTE ROCK DUMPS - CONSTRUCTION PHASE						
Land Use	Loss of agricultural land being used by the local populations.	30	Agricultural land will be compensated for in accordance with the Resettlement Action Plan	2010	2011	CCDC
Aesthetics	Visible impact of the cleared areas during construction activities.	31	Only vegetation in areas directly affected by mining activities will be cleared.	2010	2011	Director of Mines Safety Mine Manager
Soils	Cleared vegetation will expose soils to erosion processes.	32	Vegetation will only be cleared on earmarked mine sites and accesses. Land accidentally cleared will be re-vegetated.	2010	2011	Director of Mines Safety Mine Manager

Table 8.1 Environmental Management Plans						
What needs to be managed?	**Why does it need to be managed**	**Item No.**	**How should it be managed?**	**Timing of management actions**		**Responsibility**
				Start	**End**	
	Leaks and spills of oil, fuel and hydraulic fluids from heavy equipment may contaminate soils.	33	With the exception of breakdowns, the service, repair and maintenance of mining equipment will be restricted to dedicated areas specifically designed for the purpose. These areas will be equipped with impermeable surfaces and bundwalls. Contaminated soil will be collected for treatment.	2010	2011	Director of Mines Safety Mine Manager
Surface water	Exposed surfaces are prone to erosion and solids removal by water. This may affect the local streams	34	Exposed surfaces will be compacted and any run-off directed to sedimentation ponds. Only treated clear water will be released to water courses.	2010	2011	Director of Mines Safety Mine Manager
	Leaks of oil, fuel, and hydraulic fluids may contaminate surface runoff.	35	Drainage from dedicated areas specifically designed for service, repair and maintenance will pass through oil traps prior to release into the site drainage network which leads to local watercourses.	2010	2011	Director of Mines Safety Mine Manager
Flora & Fauna	The clearance of vegetation leads to the loss of habitat and biodiversity.	36	Only vegetation in areas directly affected by mining activities will be cleared.	2010	2011	Director of Mines Safety Mine Manager
Air Quality	Wind erosion on exposed surfaces will generate dust.	37	Water will be routinely sprayed on all the haulage roads to suppress the dust.	2010	2011	Director of Mines Safety Mine Manager
	Movements of machinery around the cleared sites may generate dust and exhaust fumes.	38	Only vehicles in good working order and regularly services will be used for mining operations	2010	2011	Director of Mines Safety Mine Manager
Noise and Vibrations	Noise and vibrations are increased by the movements of construction vehicles.	39	Natural vegetation and topography will be maintained to prevent any unwanted noise from reaching the nearby communities. The mine will carry out noise sampling in the nearby communities and mitigation measures formulated (if noise is not acceptable).	2010	2011	Director of Mines Safety Mine Manager

Table 8.1 Environmental Management Plans

What needs to be managed?	Why does it need to be managed	Item No.	How should it be managed?	Timing of management actions		Responsibility
				Start	End	
Archaeology	The loss of archaeological and cultural sites during site clearance.	40	Denison will undertake to ensure employees are aware of identifying new discoveries and to ensure that inspections are conducted for any reported finds. NHCC will be informed of the discovery.	2010	2011	Director of Mines Safety Mine Manager
2. MINE COMPONENT: MUTANGA AND DIBWE WASTE ROCK DUMPS **2.2 WASTE ROCK DUMPS - OPERATIONAL PHASE**						
Air	Airborne dust is generated from haul trucks and bulldozers working on the dumps.	41	Active areas of the waste rock dumps will be routinely sprayed with water in order to suppress dust when dumping the waste material.	2011	2021	Director of Mines Safety Mine Manager
	Exhaust fumes and smoke are produced by heavy equipment and haul trucks.	42	Only vehicles in good working order and regularly serviced will be used for mining operations	2011	2021	Director of Mines Safety Mine Manager
Noise & Vibration	When increased noise from haul trucks and bulldozers operating on the dumps becomes a nuisance.	43	The mine will maintain natural vegetation and topography around the waste rock dumps which will prevent any unwanted noise from reaching nearby communities. A noise complaint register will be kept on the mine and it will be open to the general public. If any serious noise complaint is received, the developer will carry out noise sampling and institute a mitigation measure.	2011	2021	Director of Mines Safety Mine Manager
	Vibrations from haul trucks and bulldozers.	44	Vibration assessments will be carried out to ensure that communities are not affected.	2011	2021	Director of Mines Safety Mine Manager
Soils	Exposed surfaces are prone to erosion.	45	Vegetation will only be cleared on earmarked mine sites and accesses. Loose soil will be compacted.	2011	2021	Director of Mines Safety Mine Manager
	Contaminated surface runoff may contaminate surrounding soils.	46	All silt traps and dump perimeter drains will be regularly monitored and maintained. Silt traps and drains will be cleared of solids before rain season and when necessary. Solids	2011	2021	Director of Mines Safety Mine Manager

Table 8.1 Environmental Management Plans

What needs to be managed?	Why does it need to be managed	Item No.	How should it be managed?	Timing of management actions: Start	Timing of management actions: End	Responsibility
			removed from the silt traps will be placed on the WRD.			
	Leaks and spills of oil, fuel and hydraulic fluid from haul trucks may contaminate soils.	47	With the exception of breakdowns, the service, repair and maintenance of mining equipment will be restricted to dedicated areas specifically designed for the purpose. These areas will be equipped with impermeable surfaces and bundwalls. Contaminated soil will be collected for treatment.	2011	2021	Director of Mines Safety Mine Manager
Surface water	Nearby Streams may be contaminated by run-off and erosion of dump walls.	48	The quality of dump wall runoff will be monitored. Run-off will be directed into one of three containment ponds and only safe water will be discharged to the general environment.	2011	2021	Director of Mines Safety Mine Manager
	Contamination of water due to inappropriate waste disposal practices.	49	Waste will be segregated and stored in secure areas. Any run-off from these areas will be treated in the site ponds before release to the general environment.	2011	2021	Director of Mines Safety Mine Manager
	Leaks of oil, fuel and hydraulic fluids from heavy equipment may contaminate surface water.	50	Equipment deployed on the dump will be thoroughly checked for any leaks. Any leaks from the equipment will be directed to the mine drainage and contaminants captured by traps or treatment ponds.	2011	2021	Director of Mines Safety Mine Manager
Aesthetics	Detraction from the natural beauty of the physical landscape.	51	Where possible, natural vegetation and topography will be maintained to shield mine infrastructure. All the facilities will be kept as low as possible relative to the immediate surroundings.	2011	2021	Director of Mines Safety Mine Manager
Health and Safety	Risks to the health and safety of other mine employees accessing the dump areas.	52	Employees operating on the WRD will be required to put on the required Personal Protective Equipment (PPE).	2011	2021	Director of Mines Safety Mine Manager
	Danger to the public from inadvertent access to operational areas.	53	The public will be informed of the dangers of entering mine operational areas. Warning signposts will be erected around the dumps. Mine security will remove intruders from the mine site.	2011	2021	Director of Mines Safety Mine Manager
2. MINE COMPONENT: MUTANGA AND DIBWE WASTE ROCK DUMPS **2.3 WASTE ROCK DUMPS – POST CLOSURE PHASE**						
Soils	Contaminated surface runoff from exposed dump walls may contaminate surrounding soils.	54	The quality of dump wall runoff and seepage (if any) will be monitored. A perimeter drain will be constructed around the WRDs to collect any run-off and direct it into a treatment pond.	2021	2025	Director of Mines Safety Mine Manager

Table 8.1 Environmental Management Plans

What needs to be managed?	Why does it need to be managed	Item No.	How should it be managed?	Timing of management actions		Responsibility
				Start	End	
Air Quality	Dust blow on exposed dump walls will reduce the local air quality.	55	The waste rock dumps will be re-vegetated and routinely sprayed with water until vegetation is adequate to trap dust.	2021	2025	Director of Mines Safety Mine Manager
Surface water	Contamination of local streams from run-off and erosion of exposed dump walls after mine closure.	56	The quality of dump wall runoff and groundwater around the dumps will be monitored.	2021	2025	Director of Mines Safety Mine Manager
Surface water	Contamination of local streams from run-off and erosion of exposed dump walls after mine closure.	57	The waste rock dumps will be profiled and capped during closure to prevent radon release, erosion and reduce infiltration of surface runoff. The dumps will be revegetated with indigenous drought resistant species.	2021	2025	Director of Mines Safety Mine Manager
Groundwater	Contamination of the groundwater underneath the dumps after mine closure.	58	The Developer will continue monitoring the quality of groundwater through boreholes around the WRD for a minimum of 3 years post closure. Any identified contamination will be reported to ECZ and MSD. Mitigation measures will be formulated and implemented.	2021	2025	Director of Mines Safety Mine Manager
Health and Safety	The safety of the public may be affected by inadvertent access to the dumps.	59	The public will be informed of the dangers of entering mine operational areas. Warning signposts will be erected around the dumps. Mine security personnel will remove intruders from the mine site.	2021	2025	Director of Mines Safety Mine Manager
3. MINE COMPONENT: PROCESSING FACILTY **3.1 PROCESSING FACILITY - CONSTRUCTION PHASE**						
Land Use	Loss of agricultural land being used by the local populations.	60	Agricultural land will be compensated for in accordance with the Resettlement Action Plan	2010	2011	CCDC
Aesthetics	Visible impact of the cleared slopes from the surrounding areas.	61	Only vegetation in areas directly affected by mining activities will be cleared. The plant will be constructed in such a way that it fits with the natural surroundings.	2010	2011	Director of Mines Safety Plant Manager
Soils	Cleared vegetation will expose soils to erosion processes.	62	Vegetation will only be cleared on the footprint of the processing facility. Land accidentally cleared will be re-vegetated.	2010	2011	Director of Mines Safety Plant Manager

Table 8.1 Environmental Management Plans

What needs to be managed?	Why does it need to be managed	Item No.	How should it be managed?	Timing of management actions		Responsibility
				Start	End	
	Leaks and spills of oil, fuel and hydraulic fluid from haul trucks may contaminate soils.	63	Only equipment in good condition will be used for construction. Any contaminated soil will be collected for treatment.	2010	2011	Director of Mines Safety Plant Manager
Air Quality	Wind erosion on exposed surfaces will generate dust.	64	Water will be routinely sprayed on all surfaces to suppress the dust.	2010	2011	Director of Mines Safety Plant Manager
	Movements of machinery around the cleared sites will generate dust and exhaust fumes.	65	Water will be routinely sprayed on haul roads to suppress the dust	2010	2011	Director of Mines Safety Plant Manager
Flora and Fauna	The clearance of vegetation leads to the loss of habitat and biodiversity.	66	Only vegetation in areas directly affected by mining activities will be cleared.	2010	2011	Director of Mines Safety Plant Manager
Surface water	Exposed surfaces are prone to erosion and may contaminate surface runoff. This may contaminate the local streams.	67	Exposed surfaces will be compacted and any run-off directed to sedimentation ponds. Only treated clear water will be released to water courses.	2010	2011	Director of Mines Safety Plant Manager
	Leaks and spills of oil, fuel and hydraulic fluids from heavy equipment may contaminate water.	68	Only equipment in good condition will be allowed to work on site. The mine drainage system will have oil traps and treatment ponds to make effluent safe before discharge to the general environment.	2010	2011	Director of Mines Safety Plant Manager
Noise and Vibrations	Noise and vibrations are increased by the movements of construction vehicles.	69	Natural vegetation and topography will be maintained to prevent any unwanted noise from reaching the nearby communities. The mine will carry out noise sampling in the nearby communities and mitigation measures formulated (if unacceptable noise is detected).	2010	2011	Director of Mines Safety Plant Manager
Archaeology	Disturbance of archaeological or cultural site.	70	Denison will undertake to ensure employees are aware of identifying new discoveries and to ensure that inspections are conducted for any reported finds. NHCC will be informed of the discovery.	2010	2011	Director of Mines Safety Plant Manager

Table 8.1 Environmental Management Plans						
What needs to be managed?	**Why does it need to be managed**	**Item No.**	**How should it be managed?**	**Timing of management actions**		**Responsibility**
				Start	**End**	
3. MINE COMPONENT: PROCESSING FACILITY 3.2 (a) ORE PREPARATION AREA - OPERATIONAL PHASE						
Air Quality	Generation of airborne dust from ore stockpiles, crushing circuit and ore transfer points.	71	- Water carts will operate on the ROM pad to suppress dust. - The ore stockpile size on the pad will be minimized through direct tipping of ore into the crusher hopper. - The residence time of the ore on the pad will be minimised and ore crushed from the stockpile prior to further dumping on the pad. - A front-end loader will transfer wetted ore from the pad into the crusher hopper.	2011	2021	Director of Mines Safety Plant Manager
		72	Sprinklers and a dust scrubber will be used in the crushing plant to suppress dust. Moisture in the form of leach solution will be added to material in the agglomerator.	2011	2021	Director of Mines Safety Plant Manager
Surface water	Water may be contamination by silt in the run-off from ROM pad and ore preparation areas.	73	Surface runoff from the ROM pad and crushing circuit will be directed to a containment pond and treated as contaminated water A.	2011	2021	Director of Mines Safety Plant Manager
Groundwater	The groundwater underneath the ROM Pad may become contaminated by seepage.	74	Runoff from the ROM pad will be channeled into containment ponds for reuse in the leaching circuit. The pad will be contoured to channel drainage to the pond and prevent surface ponding of water.	2011	2021	Director of Mines Safety Plant Manager
Noise & Vibration	Noise nuisance from the haul trucks, bulldozers and loaders.	75	Natural vegetation and topography will be maintained to prevent any unwanted noise from reaching the nearby communities. The mine will carry out noise sampling in the nearby communities and mitigation measures formulated (if unacceptable noise is detected).	2011	2021	Director of Mines Safety Plant Manager
3. MINE COMPONENT: PROCESSING FACILITIES 3.3 ORE PREPARATION AREA - POST CLOSURE PHASE						
Soils	Contaminated soils may be a source of long term contamination.	76	Plant area and the ROM pad area will be rehabilitated for future sustainable use.	2021	2022	Director of Mines Safety

Table 8.1 Environmental Management Plans

What needs to be managed?	Why does it need to be managed	Item No.	How should it be managed?	Timing of management actions Start	End	Responsibility
						Plant Manager
	Exposed surfaces will be prone to erosion.	77	The area will be re-vegetated.	2021	2022	Director of Mines Safety Plant Manager
Surface Water	Contaminated runoff from the plant area may contaminate the local streams.	78	The run-off will be directed to the treatment pond and then treated water will be released to the general environment.	2021	2022	Director of Mines Safety Plant Manager
Air Quality	Exposed surfaces may be prone to erosion which may decrease downwind air quality.	79	Water will be routinely sprayed on all surfaces to suppress dust until the area is fully re-vegetated.	2021	2022	Director of Mines Safety Plant Manager
Health and Safety	The safety of the public may be affected by inadequate decommissioning of the ROM Pad and process plant area.	80	Soil, water and air will be sampled for quality and final mitigation measures instituted to ensure that the area is made safe before decommissioning.	2021	2025	Director of Mines Safety Plant Manager
3. MINE COMPONENT: HEAP LEACH PADS **3.4 HEAP LEACH PADS - OPERATIONAL PHASE**						
Surface Water	Surface runoff on the walls of the heap leach residue may contaminate the Surface water.	81	All surface runoff from the leach pads will be channeled into the PLS ponds for storage. This water is considered as Contaminated Water Type B and the ponds will be lined with a double layer of HDPE. No water will be discharged and the water will be used for process water.	2010	2021	Director of Mines Safety Plant Manager
	Seepage of rain water through the leach pad may contaminate groundwater.	82	The leach pads will be lined with a double layer of non-woven geo-textile membrane to prevent seepage of leachate into the groundwater. A leak detection system will be incorporated into the lining.	2010	2021	Director of Mines Safety Plant Manager
		83	Boreholes will be sunk for groundwater monitoring. Any identified contamination will be reported to ECZ and MSD. Mitigation measures will be formulated and implemented.	2010	2021	Director of Mines Safety Plant Manager
Air Quality	Generation of airborne dust and radon from the leach pads.	84	The material on the heaps in the pad will be wetted with leach solution and capillary action will generate a crust on the surface of the heaps. Dust monitoring around the leach pads will be conducted and measures implemented to reduce dust if a	2010	2021	Director of Mines Safety Plant Manager

Table 8.1 Environmental Management Plans						
What needs to be managed?	**Why does it need to be managed**	**Item No.**	**How should it be managed?**	**Timing of management actions**		**Responsibility**
				Start	**End**	
			nuisance.			
Radon and Radiation	Exposures of employees to radon and radiation will be increased and may pose a threat to health.	85	Employees will not be operating in the leach lad over long periods of time, Respiratory PPE will be provided if necessary.	2010	2021	Director of Mines Safety Plant Manager
Aesthetics	Detraction from the natural beauty of the landscape.	86	Where possible, natural vegetation and topography will be maintained to shield mine infrastructure. All the facilities will be kept as low as possible relative to the immediate surroundings.	2010	2021	Director of Mines Safety Plant Manager
Groundwater	Seepage through the heap leach pad may contaminate groundwater through leaks and ruptures.	87	A two layer geo-synthetic non-woven membrane will be placed underneath the pads during construction. A leak detection system will be installed and regularly monitored by plant personnel.	2010	2021	Director of Mines Safety Plant Manager
Leachate Transportation	Leaks and spills of leachate from the PLS delivery and return pipelines (Mutanga) and tanker spills (Dibwe) may contaminate the environment.	88	The pipeline will be designed to minimise the flow rate requirements for pumping of the PLS to the process plant. The pipeline will be constructed in an HDPE lined drain with incorporated storage cells to collect spills.	2010	2021	Director of Mines Safety Plant Manager
		89	Further design work will be done prior to the development of the Dibwe leach pad for handling and transportation of the PLS.	2010	2011	General Manager
3. MINE COMPONENT: HEAP LEACH PADS 3.5 HEAP LEACH PADS - POST CLOSURE PHASE						
Surface water	Erosion of the heap leach residue may contaminate the Surface water.	90	The quality of the residue runoff will be monitored. Run-off will be directed into treatment pond and only safe water will be discharged to the natural streams.	2021	2025	Director of Mines Safety Plant Manager
Groundwater	Seepage of rain water through the base or toe of the dam may contaminate groundwater.	91	The Denison will continue monitoring the quality of groundwater through boreholes around the WRD for a minimum of 3 years post closure. Any identified contamination will be reported to ECZ and MSD. Mitigation measures will be formulated and implemented.	2021	2025	Director of Mines Safety Plant Manager
3. MINE COMPONENT: PROCESSING FACILITIES						

Table 8.1 Environmental Management Plans						
What needs to be managed?	**Why does it need to be managed**	**Item No.**	**How should it be managed?**	**Timing of management actions**		**Responsibility**
				Start	**End**	
3.6 URANIUM PROCESSING FACILITIES – OPERATIONAL PHASE						
Air Quality	To ensure that the dust concentration in air, complies with Zambian environmental regulations on dust and gas emissions.	92	Denison will regularly monitor dust and gases in and around the process plant area and downwind of the mine site as part of its ongoing environmental monitoring programme.	2010	2021	Director of Mines Safety Plant Manager
Surface Water	To prevent the contamination of water due to wash water from plant maintenance activities.	93	All wash water produced from the maintenance of storage tanks and process equipment washing will be collected and introduced into the process circuit.	2010	2021	Director of Mines Safety Plant Manager
	To prevent the contamination of water resulting from process plant spills.	94	All process plant spills will be collected in drainage sumps and returned to the process circuit.	2010	2021	Director of Mines Safety Plant Manager
Surface Water	To prevent the contamination of water resulting from the contact between process spills, acid spills, filter cake or leach residue and storm water i.e. to prevent carryover of spillages into plant site drainage system.	95	Storm water drains will be kept clear of debris to prevent overflow of drains into processing areas	2011	2021	Director of Mines Safety Plant Manager
		96	Plant spills of process solution will be collected in sumps and pumped back to the process.	2011	2021	Director of Mines Safety Plant Manager
Groundwater	To prevent the contamination of groundwater due to leaks from leach solution and process spills.	97	All process water pipes and storage areas will be regularly maintained to prevent leakage.	2011	2021	Director of Mines Safety Plant Manager
		98	Groundwater quality around the process plant will be monitored from boreholes.	2011	2021	Director of Mines Safety Plant Manager
Soils	To prevent the contamination of soil resulting from leaks.	99	The floors of the process plant will be fitted with impermeable surfacing and have containment to prevent seepage of any spill into underlying soils or surface water. Spills or leaks will be collected in sumps and returned to the process.	2011	2021	Director of Mines Safety Plant Manager
Accidental releases	To prevent contamination of soil and water due to spillage caused by equipment failure.	100	Process tanks, pipes, pumps and other equipment will be subject to a preventive maintenance programme aimed at reducing spill in the event of equipment failure.	2011	2021	Director of Mines Safety Plant Manager

Table 8.1 Environmental Management Plans

What needs to be managed?	Why does it need to be managed	Item No.	How should it be managed?	Timing of management actions Start	End	Responsibility
		101	Equipment and containment areas will regularly inspected. Inspection reports will be used to identify areas of concern and in need of repair.	2011	2021	Director of Mines Safety Plant Manager
	To prevent contamination of soil, water or air resulting from accidental spills or releases of process reagents or chemicals caused by inadequate handling, storage or transport thereof.	102	Handling and storage of reagents will be done according to the Denison materials handling procedures.	2011	2021	Director of Mines Safety Plant Manager
		103	Process reagents and chemicals will be moved around the site in accordance with the Denison materials handling procedures.	2011	2021	Director of Mines Safety Plant Manager
		104	In the event of a spill, spilled materials will be removed and the area cleaned up as soon as possible. If appropriate, soil and/or water samples will be taken to confirm effectiveness of the clean-up.	2011	2021	Director of Mines Safety Plant Manager
Accidental releases	To prevent contamination of soil, water or air resulting from accidental spills or releases of process reagents or chemicals caused by inadequate handling, storage or transport thereof.	105	An inventory control procedure will be implemented to track and document the flow of process chemicals and reagents through the process facility.	2011	2021	Director of Mines Safety Plant Manager
	To minimise the risk of spillage of waste during transfer by pipeline to the leach pad.	106	The pipe line transferring the barren solution to the Mutanga leach pad will be subject to preventative maintenance.	2011	2021	Director of Mines Safety Plant Manager
	To minimise the risk of spillage of waste during transfer by pipeline to the leach pad.	107	The return pipeline from the process plant to the Mutanga leach pad will be inspected daily for spilled material.	2011	2021	Director of Mines Safety Plant Manager
	To prevent contamination of water and soil due to leaks and spills from process equipment; leach solution ponds, ion exchange columns, precipitators, clarifiers, burst pipelines and accidental releases from various locations in the plant.	108	In the event of a spill, spilled materials will be removed and the area cleaned-up as soon as possible. If appropriate, soil and/or water samples will be taken to confirm effectiveness of the clean-up.	2011	2021	Director of Mines Safety Plant Manager
		109	Spill containment areas will be cleaned on a regular basis to ensure adequate storage capacity.	2011	2021	Director of Mines Safety Plant Manager

Table 8.1 Environmental Management Plans						
What needs to be managed?	**Why does it need to be managed**	**Item No.**	**How should it be managed?**	**Timing of management actions**		**Responsibility**
				Start	**End**	
Water consumption	To control, optimise and efficiently utilise raw water in the plant.	110	Water input and output in the process plant will be monitored and the data used to update the plant and site water balance.	2011	2021	Director of Mines Safety Plant Manager
Public Safety	To prevent inadvertent access by the public into the plant area.	111	Denison will erect a security fence around the process plant site and put warning signs. Access will be via a security gate.	2011	2021	Director of Mines Safety Plant Manager
3. MINE COMPONENT: PROCESSING FACILITIES **3.7 URANIUM PROCESSING FACILITIES – CLOSURE PHASE**						
Surface Water	To ensure that impacts to surface water are removed during post closure	112	All ore on the ROM Pad and transient ore stockpiles will be processed. The area will be re-profiled to establish the natural drainage pattern.	2021	2022	Director of Mines Safety Plant Manager
Infrastructure	To ensure that the area is returned to its natural condition and recover some value of the remaining facilities	113	The following plant and equipment dismantling and disposal practices will be applied to the crusher plant, mill, process plant and workshops, provided there are no demands on them from the local businesses or people. :- 1. Removal of all brick buildings; 2. Breaking out and removal of all concrete foundations; 3. Removal of steel frames; 4. Demolish reinforced concrete structures and dispose of on site; 5. Remove HDPE liners and backfill all ponds; 6. Remove electrical equipment, pumps, motors, and other fixed equipment; 7. Remove all above and subsurface ground fuel and chemical storage tanks; 8. Cut up and remove all steel tanks and vessels; 9. Remove all pipelines; 10. Dig up and remove all below ground electricity cables; 11. Remove conveyor belting and all ore transfer systems; 12. Remove all mechanical equipment;	2021	2022	Director of Mines Safety Plant Manager

Table 8.1 Environmental Management Plans						
What needs to be managed?	**Why does it need to be managed**	**Item No.**	**How should it be managed?**	**Timing of management actions**		**Responsibility**
				Start	**End**	
			13. Materials handling areas will be cleared of all raw materials; 14. General site clean up; 15. Site levelling and profiling to re-establish the natural drainage pattern across the site; and 16. Re-distribution of the stockpiled soils and re-vegetation of the site with indigenous grasses and trees. 17. Plant machinery, steel, HDPE liners, pipelines will be sold.			
		114	Concrete foundations will be retained for use as foundations for future buildings if required	2021	2022	Director of Mines Safety Plant Manager
Waste Disposal	To ensure that all waste is removed and re-used recycled, sold, or disposed of in a responsible manner.	115	Scrap metals and equipment will be sorted and sold to the local community, businesses and scrap metal dealers. The company will remove all equipment and non-hazardous materials that cannot be reused, recycled or sold and dump it at an approved non-hazardous disposal site.	2021	2022	Director of Mines Safety Plant Manager
		116	Septic tanks will be emptied and sludge dried treated before being disposed off.	2021	2022	Director of Mines Safety Plant Manager
Flora	To return the area to sustainable use.	117	A re-vegetation program will be implemented by Denison across the mine area. An experienced ecologist will be contracted to manage this process during operations and post closure phases.	2021	2022	Director of Mines Safety Plant Manager
Public Safety	To ensure the safety of the public during post closure activities	118	Access will be restricted to the mine until a time when it is certified safe by the Mines Safety Department and pronounced environmentally friendly by Environmental Council of Zambia	2021	2025	Director of Mines Safety Plant Manager
4. MINE COMPONENT: RAW WATER PONDS **4.1 RAW WATER PONDS - CONSTRUCTION PHASE**						

Table 8.1 Environmental Management Plans						
What needs to be managed?	**Why does it need to be managed**	**Item No.**	**How should it be managed?**	**Timing of management actions**		**Responsibility**
				Start	**End**	
Land Use	Loss of agricultural land being used by the local populations.	119	Agricultural land will be adequately compensated for in accordance with the Resettlement Action Plan	2010	2011	CCDC
Aesthetics	The clearance of the vegetation on the dam site will open up the area.	120	Only vegetation on the footprint of the pond will be cleared.	2010	2011	Director of Mines Safety Plant Manager
Soils	The erosion of soil will occur on exposed surfaces.	121	Vegetation will only be cleared on the footprint of the pond and access routes. Land accidentally cleared will be re-vegetated to prevent erosion.	2010	2011	Director of Mines Safety Plant Manager
	Leaks and spills of oil, fuel and hydraulic fluid from heavy equipment may contaminate soils.	122	Only equipment in good condition (with no leakages) will be used for construction. Any contaminated soil will be collected for treatment.	2010	2011	Director of Mines Safety Plant Manager
Air Quality	Dust erosion on exposed surfaces will affect air quality.	123	Water will be routinely sprayed on all surfaces to suppress the dust. The walls of the pond will be re-vegetated with grass.	2010	2011	Director of Mines Safety Plant Manager
Air Quality	Airborne dust and exhaust fumes will be generated by heavy equipment.	124	Only vehicles in good working order and regularly services will be used for construction.	2010	2011	Director of Mines Safety Plant Manager
Surface Water	Contamination of surface water resulting from soil erosion and run-off from exposed surfaces.	125	The run-off will be directed to the settlement pond for release to the natural environment.	2010	2011	Director of Mines Safety Plant Manager
Flora & Fauna	The clearance of vegetation leads to the loss of habitat and biodiversity.	126	Only vegetation in areas directly affected by mining activities will be cleared.	2010	2011	Director of Mines Safety Plant Manager
Archaeology	The loss of archaeological and cultural sites during construction.	127	Denison will undertake to ensure employees are aware of identifying new discoveries and to ensure that inspections are conducted for any reported finds. NHCC will be informed of the discovery.	2010	2011	Director of Mines Safety Plant Manager
4. MINE COMPONENT: RAW WATER PONDS **4.2 RAW WATER PONDS - OPERATIONAL PHASE**						
Air Quality	The exposed surfaces of the pond wall may generate airborne dust.	128	The pond wall will be made of consolidated material.The walls will be revegetated with grass to cover exposed surfaces.	2011	2012	Director of Mines Safety

Table 8.1 Environmental Management Plans

What needs to be managed?	Why does it need to be managed	Item No.	How should it be managed?	Timing of management actions Start	End	Responsibility
						Plant Manager
	The bare ground around the pond may generate dust.	129	Grass will be planted around the pond and sprayed with water to suppress any form of dust.	2011	2022	Director of Mines Safety Plant Manager
Surface Water	The raw water pond may affect the flows of the local stream on which it will be erected.	130	Water in the pond will be from boreholes and area run-off.	2011	2022	Director of Mines Safety Plant Manager
Groundwater	Contamination of the groundwater from dewatering water.	131	Dewatering water will be pumped from the wellfield directly to the RWP to prevent contamination and should exhibit its natural characteristics. The water will then recharge into the groundwater aquifers via the underlying seepage structures. Water quality of the RWp will be monitored.	2011	2022	Director of Mines Safety Plant Manager
5. MINE COMPONENT: OPERATIONS CAMP **5.1 OPERATIONS CAMP - CONSTRUCTION PHASE**						
Land Use	Loss of agricultural land being used by the local populations.	132	Agricultural land will be compensated for in accordance with the Resettlement Action Plan	2010	2011	Director of Mines Safety Camp Manager
Aesthetics	The cleared area on the top of the northwest hill will be visible from the surrounding areas.	133	Where possible, natural vegetation and topography will be maintained to shield mine infrastructure. All the facilities will be kept as low as possible relative to the immediate surroundings	2010	2011	Director of Mines Safety Camp Manager
Soil	Soil erosion may occur on exposed areas during the construction phase.	134	Vegetation will only be cleared on earmarked mine sites and accesses. Land	2010	2011	Director of Mines Safety Camp Manager
			accidentally cleared will be re-vegetated.			
	The leaks and spills of oil, fuel and hydraulic fluid from heavy equipment may contaminate soils.	135	With the exception of breakdowns, the service, repair and maintenance of mining equipment will be restricted to dedicated areas specifically designed for the purpose.	2010	2011	Director of Mines Safety Camp Manager
Air Quality	Airborne dust and exhaust fumes will be generated by heavy equipment.	136	Only vehicles in good working order and regularly services will be used for construction.	2010	2011	Director of Mines Safety

Table 8.1 Environmental Management Plans

What needs to be managed?	Why does it need to be managed	Item No.	How should it be managed?	Timing of management actions Start	End	Responsibility
						Camp Manager
	Dust erosion on exposed surfaces will affect air quality.	137	Vegetation will only be cleared on earmarked mine sites and accesses. Land accidentally cleared will be re-vegetated.	2010	2011	Director of Mines Safety Camp Manager
Noise and Vibrations	Construction equipment will increase the noise levels in active areas.	138	Natural vegetation and topography will be maintained to prevent any unwanted noise from reaching the nearby communities. The mine will carry out noise sampling in the nearby communities and mitigation measures formulated (if noise is not acceptable).	2010	2011	Director of Mines Safety Camp Manager
Surface Water	Soil erosion and run-off from erosion during site clearance.	139	The quality of surface run off will be monitored. Run-off will be directed into treatment pond and only safe water will be discharged to the natural streams.	2010	2011	Director of Mines Safety Camp Manager
	Leaks and spills of oil, fuel and hydraulic fluids from heavy equipment may contaminate water.	140	Equipment used during construction will be thoroughly checked for any leaks. Any leaks from the equipment will be directed to the mine drainage and contaminants captured by traps or treatment ponds.	2010	2011	Director of Mines Safety Camp Manager
Flora and Fauna	The clearance of vegetation leads to the loss of habitat and biodiversity.	141	Only vegetation in areas directly affected by mining activities will be cleared.	2010	2011	Director of Mines Safety Camp Manager
Archaeology	The loss of archaeological and cultural sites during construction.	142	Denison Mining Company will undertake to ensure employees are aware of identifying new discoveries and to ensure that inspections are conducted for any reported finds. NHCC will be informed of the discovery.	2010	2011	Director of Mines Safety Camp Manager
5. MINE COMPONENT: OPERATIONS CAMP **5.2 OPERATIONS CAMP - OPERATIONAL PHASE**						
Soils	Accumulations of domestic waste may contaminate soils.	143	Waste bins will be provided for the mine camp. Once every two days, waste from the bins will be collected and dumped at the domestic waste dump site that will be created.	2011	2022	Director of Mines Safety Camp Manager
Air Quality	Transport vehicles will generate airborne dust along transport routes on a daily basis.	144	Active areas of the waste rock dumps will be routinely sprayed with water in order to suppress dust when dumping the waste material.	2011	2022	Director of Mines Safety Camp Manager

Table 8.1 Environmental Management Plans						
What needs to be managed?	**Why does it need to be managed**	**Item No.**	**How should it be managed?**	**Timing of management actions**		**Responsibility**
				Start	**End**	
Noise and Vibrations	Mine camp activities will increase localized noise disturbances.	145	Natural vegetation and topography will be maintained to prevent any unwanted noise from reaching the nearby communities. The mine will carry out noise sampling in the nearby communities and mitigation measures formulated (if noise is not acceptable).	2011	2022	Director of Mines Safety Camp Manager
6. MINE COMPONENT: WORKSHOPS **6.1 WORKSHOPS - OPERATIONAL PHASE**						
Soil	Inadequate handling and storage of new and used oil may contaminate soil.	146	Oil handling and storage areas will be subject to regular inspection. Inspection results will determine service, maintenance and repair requirements.	2011	2021	Director of Mines Safety Plant Manager
	Vehicles and equipment in the stockyard waiting to be maintained may contaminate soil from leaks of oils and fluids.	147	All new and used oil will be stored in a designated area equipped with; impermeable surfaces, 110% containment capacity and protection against rain.	2011	2021	Director of Mines Safety Plant Manager
	Inadequate handling, storage and disposal of used filters, tyres, pumps etc may contaminate soils.	148	All the items will be handled and stored in designated areas. Storage areas will be equipped with impermeable surfaces and adequate containment capacity, fire protection feature and protection against sun and rain.	2011	2021	Director of Mines Safety Plant Manager
	Inadequate handling and storage of batteries may contaminate soils.	149	Used batteries will be stored in a dedicated area awaiting collection by a supplier for re-cycling. Good second-hand batteries will be sold/given to employees.	2011	2021	Director of Mines Safety Plant Manager
Noise and Vibrations	Activities in the workshops will increase localized noise disturbances.	150	Natural vegetation and topography will be maintained to prevent any unwanted noise from reaching the nearby communities. All activities will be done in an enclosure. However, a complaints register will be kept at the mine.	2011	2021	Director of Mines Safety Plant Manager
Surface water	Contamination due to carry over of oil with storm water into site drainage system.	151	All drainage from workshop will pass through oil traps prior to release into the site drainage network.	2011	2021	Director of Mines Safety Plant Manager

Table 8.1 Environmental Management Plans						
What needs to be managed?	**Why does it need to be managed**	**Item No.**	**How should it be managed?**	**Timing of management actions**		**Responsibility**
				Start	**End**	
	Poor housekeeping, handling spills and inadequate storage of oils, used filters, tyres etc. resulting in contaminated run-off.	152	Regular inspections of the workshop areas will be conducted as part of a preventive maintenance programme to monitor potential sources of contamination.	2011	2021	Director of Mines Safety Plant Manager
Health and Safety	Employees in the workshop may mishandle and misuse oils that may cause fire hazards.	153	Workshop mechanics and operators will receive training on oil handling and disposal. The programme will focus on environmental awareness, safe handling procedures, spill reporting and spill response/action.	2011	2021	Director of Mines Safety Plant Manager
6. MINE COMPONENT: WORKSHOPS **6.2 WORKSHOPS - POST CLOSURE PHASE**						
Soils	Stockpiled used filters, tyres and pumps etc. will contaminate soils after mine closure.	154	Stockpile of used material will be sorted and sold to the local community, businesses and scrap metal merchants. The company will dump all equipment and materials that cannot be reused, recycled or sold, on an approved non-hazardous disposal site.	2021	2022	Director of Mines Safety Plant Manager
	The used oil onsite after mine closure may lead to soil and water contamination.	155	Used oil will be removed from site and sold to ECZ- approved used oil dealers. All areas will be subjected to a soil monitoring program to identify potentially contaminated areas. These areas will be cleaned up and the area re-profiled to establish the natural drainage pattern.	2021	2022	Director of Mines Safety Plant Manager
Health and Safety	Waste that remains onsite after closure may be a health hazard to the local population.	156	All waste will be removed from site. Access will be restricted to the mine until certified safe by the Mines Safety Department and Environmental Council of Zambia.	2021	2022	Director of Mines Safety Plant Manager
7 MINE COMPONENT: TRANSPORT INFRASTRUCTURE **7.1 TRANSPORT AND INFRASTRUCTURE - CONSTRUCTION AND OPERATIONAL PHASES**						
Air Quality	Air pollution due to dust from vehicles and trucks plying the dirt roads.	157	Water spraying will be done on all mine dirt roads.	2010	2022	Director of Mines Safety General Manager

Table 8.1 Environmental Management Plans

What needs to be managed?	Why does it need to be managed	Item No.	How should it be managed?	Timing of management actions		Responsibility
				Start	End	
Noise and Vibrations	Traffic around the project site and increased movement in the region will increase noise disturbances.	158	Natural vegetation and topography will be maintained to lower the noise reaching villages which straddle the roads to be used by mine vehicles. A complaints register will be kept at the mine.	2010	2022	Director of Mines Safety General Manager
Surface Water	Accidental releases or spills of chemicals, acid, reagents, fuel or oil due to inadequate transport procedures may contaminate water.	159	The transport of hazardous materials to, from, in and around the mine site will be done in accordance with laid down procedure. Requirements will include: documentation and inventory control through chain-of-custody; emergency response training for all drivers (contractors and mine employees); tracking and notification of shipment location and condition; carrying of onboard emergency equipment; vehicle pre-checks and preventative maintenance programme; and random unannounced en route safety checks/inspections. All outside contractors will adopt the above procedures which will be integrated into contract agreements.	2010	2022	Director of Mines Safety General Manager
Surface Water	Releases caused by accidents due to defective or damaged infrastructure may contaminate water.	160	A preventive maintenance programme will be implemented on all mine roads, bridges, and culverts to ensure that they are kept in good condition. This will minimise the occurrence of accidents caused by defective or damaged infrastructure.	2010	2022	Director of Mines Safety General Manager
Flora and Fauna	The clearance of natural vegetation for the widening of existing roads and construction of new.	161	Developer will ensure that as much vegetation and habitat along the route is maintained. Only vegetation in the way leave will be cleared. Accidentally cleared areas will be re-vegetated.	2010	2022	Director of Mines Safety General Manager
Health and Safety	The increased traffic on dirt roads or national routes may affect the safety of the local populations.	162	Transport routes will be approved by the mine safety department and inspections/checks will be conducted regularly.	2010	2022	Director of Mines Safety General Manager
		163	Speed retarding mechanisms will be implemented on the mine roads. Traffic signs will also be displayed on mine roads.	2010	2022	Director of Mines Safety General Manager
Health and Safety	The increased traffic on dirt roads or national routes may affect the safety of the local populations.	164	The contractor's vehicles will be examined for road worthiness and drivers examined for safe driving practices.	2010	2022	Director of Mines Safety General Manager

Table 8.1 Environmental Management Plans

What needs to be managed?	Why does it need to be managed	Item No.	How should it be managed?	Timing of management actions Start	End	Responsibility
8 MINE COMPONENT: MATERIALS HANDLING AND STORAGE 8.1 WASTE MANAGEMENT - OPERATIONAL PHASE						
Soil	Accumulation of scrap metals and materials that can be sold or reused.	165	Scrap metal and general material will be reused, recycled or sold to the general public. Material will not be allowed to accumulate to unprecedented levels.	2010	2022	Director of Mines Safety Mining Manager Plant Manager Camp Manager
	Inadequate disposal of medical waste may contaminate soils.	166	Medical waste will be sent to a nearby approved medical waste incinerator.	2010	2022	Director of Mines Safety Mining Manager Plant Manager Camp Manager
	The inadequate disposal of domestic waste and effluent may contaminate soils.	167	Waste will be sorted and stored in a secure area. Waste will be dumped on the approved dump sites.	2010	2022	Director of Mines Safety Mining Manager Plant Manager Camp Manager
Surface Water	Accumulations of scrap metals and recyclable materials may contaminate surface water.	168	Materials will be stored in secure areas. The storage area will be covered from rain, have an impermeable surface and a containment mechanism not to allow any effluent to flow from the area.	2010	2022	Director of Mines Safety Mining Manager Plant Manager Camp Manager
	The inadequate disposal of domestic waste and effluent may contaminate water.	169	Materials will be stored in secure areas. The storage area will be covered from rain, have an impermeable surface and a containment mechanism not to allow any effluent to flow from the area.	2010	2022	Director of Mines Safety Mining Manager Plant Manager Camp Manager
8 MINE COMPONENT: MATERIALS HANDLING & STORAGE 8.2 MINE STORES - OPERATIONAL PHASE						

Table 8.1 Environmental Management Plans						
What needs to be managed?	**Why does it need to be managed**	**Item No.**	**How should it be managed?**	**Timing of management actions**		**Responsibility**
				Start	**End**	
Soil	Leaks or rupture of fuel storage tanks (above and below ground) will contaminate soils.	170	Fuel delivery and usage records will be kept by mine stores in order to determine fuel losses/leaks. A fuel tank leak detection programme will be implemented.	2011	2021	Director of Mines Safety Plant Manager
	Spills of greases, oils, chemicals and reagents during handling and storage may contaminate soils.	171	Spills of oils, grease or chemicals will be immediately cleaned-up in accordance with the mine's Spills Prevention, Control and Clean-up Plan.	2011	2021	Director of Mines Safety Plant Manager
Surface water	Fuel spills from fuel storage areas may contaminate water.	172	Statutory containment (110% of storage capacity) and impermeable surfaces will be provided to all fuel storage tanks.	2011	2011	Director of Mines Safety Plant Manager
	Storm water runoff may become contaminated through pickup of spills from storage areas.	173	Drainage from storage areas will be isolated from the mine site drainage system and passed through an oil trap before release to general environment.	2011	2012	Director of Mines Safety Plant Manager
Health and Safety	The storage of incompatible chemicals and reagents may pose health and safety risks to employees.	174	Non-compatible hazardous wastes will be stored on separate sites.	2011	2021	Director of Mines Safety Plant Manager
Health and Safety	The lack of training of employees on appropriate handling and storage requirements may affect safety.	175	Operators handling or using chemicals and reagents will receive training. Training will focus on potential risks, hazards, safe handling procedures, safety precautions, first aid, emergency response and appropriate disposal procedures.	2011	2021	Director of Mines Safety Plant Manager
8 MINE COMPONENT: MATERIALS HANDLING & STORAGE **8.3 URANIUM CONCENTRATE STORE - OPERATIONAL PHASE**						
Health and Safety	Increased levels of radiation may impact on employee health.	176	The concentrate packing, loading and storage areas will be sealed restricted access areas where only trained personnel operating with appropriate PPE will be allowed to operate.	2011	2021	Director of Mine Safety Plant Manager Concentrate Foreman
	Increased levels of radiation may impact on public that have inadvertently accessed the concentrate storage areas.	177	Acces of the public to the concentrate packing, loading and storage areas will not be allowed.	2011	2021	Director of Mine Safety Plant Manager Concentrate Foreman
8 MINE COMPONENT: MATERIALS HANDLING & STORAGE **8.4 FUEL HANDLING & STORAGE - OPERATIONAL PHASE**						

Table 8.1 Environmental Management Plans

What needs to be managed?	Why does it need to be managed	Item No.	How should it be managed?	Timing of management actions		Responsibility
				Start	End	
Soils	Leaks and spills of fuel from the mobile fuel tanker will contaminate soils.	178	Spills of fuel will be immediately cleaned-up in accordance with the mine's Spills Prevention, Control and Clean-up Plan. Contaminated soil will be collected for treatment.	2011	2021	Director of Mines Safety Plant Manager
Surface water	Handling spill or leak/rupture of fuel tanker may contaminate surface runoff.	179	In the event of a leak/rupture, procedures outlined in the Spill Response Plan will be followed. The procedures include: clean-up action	2011	2021	Director of Mines Safety Plant Manager
			; clean-up materials; and disposal of contaminated soil and clean-up materials.			
	Untreated run-off from fuel storage area entering site drainage system may contaminate the Streams.	180	Run-off will be directed to treatment ponds before release to the general environment.	2011	2021	Director of Mines Safety Plant Manager
9 MINE COMPONENT: RADIATION MANAGEMENT **9.1 RADIATION MANAGEMENT - OPERATIONAL PHASE**						
Radiation during all mining activities	Radiation will be generated in all stages during the mining of the uranium and will pose different levels of risk that may impact on employee safety.	181	The activities will be conducted to be compliant with the Zambian Mines and Minerals Development Act and all subsidiary legislation.	2010	2025	General Manager Director of Mine Safety Radiation Protection Officer
		182	A detailed Radiation Operational Management Plan will be developed and finalized prior to construction of the Project. The plan will be annually reviewed and updated when required.	2010	2021	General Manager Director of Mine Safety Radiation Protection Officer
		183	A detailed plan on Selection, Use and Maintenance of Personal Protective Equipment will be developed and finalized prior to construction of the Project.	2010	2021	General Manager Director of Mine Safety Radiation Protection Officer
		184	A detailed Worker Training Manual will be developed and finalized prior to the construction of the Project.	2010	2021	General Manager Director of Mine Safety Radiation Protection Officer

Table 8.1 Environmental Management Plans

What needs to be managed?	Why does it need to be managed	Item No.	How should it be managed?	Timing of management actions		Responsibility
				Start	End	
	Radioactive material may contaminate scrap, soils or other waste products which may contaminate the environment.	185	A detailed Radioactive Waste Management Plan will be developed and finalized prior to construction of the Project.	2010	2021	General Manager Director of Mine Safety Radiation Protection Officer
Radiation during all mining activities	High levels of radiation generated from the uranium oxide concentrate will impact on employee or public health and safety.	186	A Storage of Radioactive Material Procedure will be developed and finalized prior to construction of the Project.	2010	2021	General Manager Director of Mine Safety Radiation Protection Officer
		186	A Procedure for the Off-site Transport of Radioactive Materials will be developed and finalized prior to the construction of the Project.	2010	2021	General Manager Director of Mine Safety Radiation Protection Officer
		187	A Environment, Health and Safety Education Program for the Public will be developed and finalized prior to the construction of the Project	2010	2021	General Manager Director of Mine Safety Radiation Protection Officer

The CCDC and relocation management consultant will liaise with the RC and affected communities about leaving and arriving ceremonies to be conducted during the relocation. Denison will assist with any ceremonies if these are required.

Denison will follow the guidelines in the RAP during the implementation of the relocation.

All compensation activities will be agreed and finalised prior to movement of communities from their villages or clearance of fields and households. This will be conducted by Denison and the RC.

8.1.2. Contractors Operations

Prior to the construction phase some project work will be contracted out to experienced, licensed contractors. Wherever possible, these contractors will be hired from Zambia provided they have adequate experience.

Contractors agreements will be developed regarding the supply of services and the compliance with company policies on health, safety, environment, as well as Zambian labour laws. Within these agreements Denison will encourage the use of local employees as well as the possibility of foreign contractors assistance in training the local workforce.

A contractors camp area will be developed at the operations camp to accommodate the contractors required for construction. This camp will consist of temporary housing structures usually with a mess and ablutions. Denison shall oversee management of the contractors camp through Mine Management.

Contractor's Traffic

There will be increased levels of traffic and possibly accidents involving contractor traffic. Approved transport routes will be developed in order to minimise accidents. The Environmental Department will be responsible for monitoring compliance with the contractor agreement, road-worthiness, safe driving practises and driving tests/licenses.

Soil, Vegetation and Surface Water

The clearance of vegetation at site will be minimised and large trees will be maintained where possible. Site drains will be installed with soil traps and sediment ponds leading into soak aways.

Poor storage practices may lead to contamination of water and/or soil. Hazardous waste will be incorporated into the Waste Management Plan. Any use of temporary storage areas e.g. transport containers will require prior approval from the Environmental Department.

Surface water from construction sites will be directed into the mine site storm water system for treatment prior to discharge to the environment.

Water use will be monitored by the Environmental Department to improve efficiency and consumption.

Erosion will be limited in construction areas by using slope limitation methods, rip rap, silt fences and lining methods (concrete). Re-vegetation of exposed surfaces with turf as soon as construction areas have been finished will reduce overall long term soil erosion.

Noise and Vibrations

General noise levels from traffic and an increased population in the Operations Camp area will be managed to ensure that there is minimal night time disturbance especially to the local communities.

Radiation and Radon

The monitoring and management of the exposures of contractors to radiation will be conducted as described in the Radiation Management Plan in **Section 9.5**.

General Environment

The contractor will implement good housekeeping practices and will be monitored by the SHE Officer.

All waste generated in the camp or from contractor activities will be incorporated into the Waste Management Plan. Waste separation will be conducted into glass, wood, plastic, rubber and toxic/hazardous waste. The contractor will be responsible for implementing waste separation methods and be responsible for placement of waste in designated storage areas. The Environmental Department will monitor contractor waste management activities on a weekly basis.

Security

The contractors camp will be patrolled by mine security to ensure the safety of all equipment and housing. All storage areas will be secured.

8.1.3. Transport and Electricity Infrastructure

An accreditted contractor in road construction with proof of previous experience will be used to construct all roads. The design of the roads will include a central road sloping into the road shoulder to allow drainage to flow off the road. Drainage off the road will be channelled into runoff trenches and soak aways. Erosion minimisation through shallow gradients, maintenance of roadside vegetation and slope stabilisation on steep hill faces.

The construction of bridges and culverts will be carefully planned into the design where streams and general drainage crosses over planned roads. There will be no obstruction to natural drainage.

All drainage channels and ditches will be designed for the 1:100 year storm to prevent contamination of watercourses. Soakaways will be designed with appropriate storage capacity.

Landuse

Transport and electricity infrastructure is important in the construction phase. Roads will be developed initially as outlined in **Figure A in Appendix 8**. A final electricity powerline route will be developed and an EIS lodged for development approval.

All routes for new roads will be surveyed by the Environmental Department for landusers and vegetation to provide compensation if necessary.

Flora and Fauna

All construction sites will be incorporated into the activities of the Progressive Revegetation Plan.

The vegetation will be cleared using axes, chainsaws and bulldozers. The wood material will be made available to the local communities for their use or sold to the forestry department/timber merchant. Clearance activities will not be conducted in the rain for safety reasons as well as prevention of erosion.

DMZL will liaise with relevant Zambian Government Authorities to ensure that fauna is conserved during the construction of Transport and Electricity Facilities.

Soils, Surface Water and Air Quality

The road soil surface will be compacted by construction machinery and a layer of gravel laid down. Laterite will be laid over the gravel to provide the road surface.

Soil compaction will be restricted to the road itself and mimimal disturbance along the periphery of the road will be allowed. This will be communicated to the contractors and monitored by the Environmental Department.

Increased runoff will occur from the exposed compacted surfaces which will contain sand and soil. Muddy runoff will be directed to soak aways to prevent solids from contaminating natural water ecosystems through sediment loading.

All exposed soil surfaces during road development will be wetted on a daily basis with water from a mine bowser to reduce dust emissions.

Accidental Spills/Releases

The contamination of soil, air and/or water resulting from spills or accidents involving vehicles transporting reagents, acids, chemicals, oils, fuel and other materials will be minimised through the implementation of transportation procedures for hazardous materials to, from, in and around the mine site. These procedures include but are not limited to:-

- Documentation and inventory control through a chain of custody;
- Radiation assessment procedures for all transport vehicles leaving site to prevent contamination;
- Emergency response training for all Denison and contractor employees;
- Tracking and notification of shipment location and condition;
- Carrying of onboard emergency equipment in transport vehicles;
- Use of designated transport routes only;
- Vehicle road worthiness checks and implementation of a preventative maintenance programme; and
- Random and unannounced en route safety inspections.

All outside contractors will adopt these procedures, which will be incorporated into all contract agreements. The Procurement Department will be responsible for contract agreements in conjunction with mine management and the Environmental Department.

Tarpaulins will cover open top bulk transport trucks in order to prevent spills resulting from the exposure of cargo to rain and/or wind.

Contracts with haulage contractors will include clauses from relevant Zambian and international standards on the transport of hazardous materials.

Mine transport infrastructure including roads, bridges, culverts and traffic signs will be subject to a preventative maintenance programme to ensure that they are kept in a good condition. This will reduce the number of road accidents, which could potentially result in soil or water contamination.

Noise and Vibrations

Construction activities will increase the noise levels during road development which will be monitored as described in the Environmental Monitoring Plan. Measures will be implemented to prevent disturbance to surrounding villages.

Vibrations along roads may affect local housing. Vibration assessments will be conducted as described in the Environmental Monitoring Plan to prevent damage or loss.

Mine and Public Safety

Signposting, barrier tapes and traffic cones will be used to alert mine and other vehicles of construction road works to prevent accidents. A mine speed limit will be imposed if necessary.

The progress of activities will be regularly communicated to the local populations and provisions will be made if accessibility is inconvenienced

8.1.4. Open Pits (Mutanga and Dibwe)

The open pit areas will undergo an initial pre-strip during construction of the process plant. The vegetation will be cleared, topsoil stored near site for use in re-vegetation and a bund wall created around the edge of the pits which will expand with the developing pits. Thick vegetation will be cleared within a 5m radius of the pit walls to allow visibility of the pit edges.

A road will be created around the boundary of each open pit to provide easier access for pit inspections.

Vegetation and Landuse

The open pits are included in the Progressive Revegetation Plan activities. All compensation activities for land loss in these areas will be completed prior to site disturbance. Approximately 87.3ha of vegetation will be cleared off the location of the open pits during the pre-strip phase. Clearance will be done using dozers and chain saws where necessary. Progressive clearance will reduce long term impacts on soil and surface water.

Surface Water and Soils

Drainage control systems will be designed during construction of the pits. The edges of the pits will be contoured away from the rim, layered with laterite and a perimeter drain will channel surface runoff downslope and away from the pits. The drains will feed into sedimentation ponds where uncontaminated runoff will be allowed to soak away.

Sediment traps will be installed in the perimeter drains. All stormwater runoff channels and ditches will be designed for the 1:100 year storm.

The topsoils (0-15cm) will be removed during clearance as described in the Progressive Revegation Program. Exposure of soils to the elements will be minimised to reduce erosion. Slopes will be graded to reduce the erodibility of runoff.

Groundwater

The dewatering of the open pit area will commence during the construction phase of the Project. The lowering of the local groundwater levels by the wellfield may affect groundwater users in the areas around the mine. Mitigation measures will include monitoring of the boreholes or wells in Kashundi and the surrounding villages for quality and water levels as well as the provision of alternative water sources if necessary. Monitoring of the groundwater levels will be conducted as described in the Environmental Monitoring Plan to assess the zone of influence of the dewatering activities. The groundwater levels will be monitored throughout the mine operation to prevent loss of boreholes or contamination of groundwater through the mining activities. The shallow depth of the open pits and the short mine life are unlikely to have long term impacts on the groundwater level.

Dewatering water will be pumped to the raw water ponds (RWP). Raw water will be used for mining activities and the excess will seep into the groundwater system. These ponds will be located on fractures and will be unlined. It is anticipated that dewatering water will not impact the groundwater as there will be no contamination between dewatering and re-injection in the RWP. Dewatering water quality will be monitored as described in the **Section 9.4**. Detailed site water management is discussed in **Section 9.6**.

In-pit dewatering will be conducted through horizontal drainage holes and this water will discharge into a dirty water pond (DWP). This pond will consist of a series of sedimentation ponds and a final discharge into a reed bed. Water quality will be monitored as described in **Section 9.4**.

Air Quality

The generation of dust through vehicle movements and clearance equipment will be reduced by spraying of water with bowsers, especially in the dry season.

Air quality monitoring sites will be identified for dust and particulates in accordance with the Environmental Monitoring Plan.

Flora and Fauna

Areas of specific vegetation types (forest and fallows) will be protected around the site to allow corridors of habitat to maintain flora and fauna diversity in the area (Environmental Monitoring Plan). Specific areas will be identified through specialist consultation during the construction phase.

Noise and Vibration

Noise and vibration assessments will be conducted as described in the Environmental Monitoring Plan. Management measures have been described in the Environmental Monitoring Plan.

Archaeological Sites

Denison will provide training to all employees about systems of identification and alert when possible new sites of archaeological importance are identified.

Public Safety

Signposts, barrier tape and traffic cones will alert the local population to activities at the pits.

8.1.5. Ore Crushing Area and Leach Pads

The leach pad areas will be developed according to finalised mine design submitted for the application of the processing license. The pad areas will cover approximately 125ha. They will be cleared and a layer of clay laid down once site profiling has been conducted. A two layer geotextile non-woven membrane will be installed with an internal leak detection system. This design will be finalised prior to the application of the processing license.

Vegetation and Landuse

The site is incorporated into the Progressive Revegetation Plan. Progressive clearance will be conducted.

Surface Water and Soils

Drainage control measures will be developed during construction to separate uncontaminated surface runoff (stormwater) from contaminated water (runoff around pads, water around ore preparation area). All stormwater will be diverted from the construction areas into a sedimentation pond and discharged to the environment. Contaminated water will be captured and stored in the barren water pond at the leach pads.

The immediate areas around the ore preparation area and leach pads will be profiled to control drainage in these facilities to ensure that any contaminated drainage is captured and can be treated. No contaminated drainage will be released to the environment.

All stormwater drains and ditches will be designed for the 1:100 year storm.

Groundwater

Groundwater seepage of leachate will be prevented by the installed impermeable geo-textile membrane. A leak detection system will identify any leaks or spills which will be managed as described in **Section 9.7**.

Air Quality

Air quality monitoring sites will be installed as described in the Environmental Monitoring Plan. Dust emissions will be reduced by spraying of water on exposed surfaces using a water bowser.

Flora and Fauna

Areas of forest and fallow vegetation with higher species diversity will be protected to maintain flora and fauna in the area (Environmental Monitoring Plan). Specific areas will be identified through specialist consultation during the construction phase.

Security

The leach pad and ore preparation area will be enclosed in a security area to control access by mine security.

Public Safety

Signposts, barriers tapes and traffic cones will be used to warn miners and the public of construction activities.

8.1.6. Process Plant Area

All compensation activities for fields and relocation requirements will be completed prior to site disturbance.

The process plant area (27ha) will be cleared of vegetation and the topsoil stored nearby. The general facilities (offices, clinic, workshops, stores etc) will be laid with standard building foundations in accordance with designs made by MDM. All required infrastructure will be installed such as pipes, septic tanks, roads and drains. Security fences will be erected.

The foundations of the ROM Pad and crushing/milling plant will be developed in accordance with specifications by MDM. This will include ground compaction and reinforcement.

Vegetation and Landuse

The site is incorporated into the Progressive Revegetation Plan. Progressive clearance will be conducted.

Surface Water and Soils

Drainage control measures will be developed during construction of the process plant to separate uncontaminated surface runoff (stormwater) from contaminated water (process water, workshop water, stores water). All stormwater will be diverted from the construction areas into a sedimentation pond and soakaway. All contaminated water will feed into the process water pond for reuse during mining activities or treatment by the water treatment plant which will affect layout of drains.

All stormwater drains and ditches will be designed for the 1:100 year storm (248mm in 24hrs). Contaminated runoff will be treated prior to release to the environment.

Air Quality

Air quality monitoring sites will be installed as described in the Environmental Monitoring Plan. Dust emissions will be reduced by spraying of water on exposed surfaces using a water bowser.

Flora and Fauna

Areas of forest and fallow vegetation with higher species diversity will be protected to maintain flora and fauna in the area (Environmental Monitoring Plan). Specific areas will be identified through specialist consultation during the construction phase.

Security

The process plant area will be fenced during early construction and mine security will control access.

Public Safety

Signposts, barriers tapes and traffic cones will be used to warn miners and the public of construction activities.

8.1.7. Process Plant – Mine Stores

The mine stores will be developed in the process plant area. A major amount of spares and materials will be required during construction. The construction of a good mine store area with a detailed database with user friendly stock assessment will prevent construction delays. This will be the responsibility of the Procurement Department or the mine development contractor. A financial aspect to the database will allow the determination of stock values for the finance department. Reporting is described in further detail in **Chapter 9**.

The Procurement Department will also keep a record of chemical and reagent movement through delivery, storage facilities and use. Procedures are outlined in the Emergency Response Plan for any spills of reagents during transport.

The Environmental Department should ensure that all chemicals, solutions, powders or solid material with Material Safety Data Sheets (MSDSs) that may affect mine workers or the environment are obtained through the Procurement Department during purchasing.

The mine stores will be designed with safety and organisation as a priority. All liquids will be stored in designated bunded areas to contain spills. Sawdust will be available in buckets to clean up spills. Contaminated sawdust will be handled in compliance with the Waste Management Plan.

Oils will be stored in drums until use that will be stored in a bunded area with impermeable flooring. Used oil will be stored in drums and be compliant with guidelines in the Waste Management Plan.

Flocculant and lime will be stored in a separate plant chemicals store equipped with impermeable flooring. Water and other liquids will not be stored in this store to prevent contamination incidents. Spilled solids will be contained within bunded areas within the store and swept up for use in the plant.

A copy of the MSDSs for all chemicals will be held in the Procurement Department. Copies of these sheets will be provided to the Environmental Department as well as the respective store areas. A copy of the MSDSs for chemicals used in the laboratory for routine analysis will be maintained by the Director of the laboratory.

8.1.8. Process Plant – U_3O_8 Concentrate Store

This store will be constructed in a separate sealed facility with high levels of security and restricted access. The store will be located away from the process plant to prevent uncontrollable accidents that may arise from emergencies at either facility.

The facility will be a steel shelter with a roof and vacuum sealed entrances similar to the plant concentrate exit facility.

The concentrate will be stored in accordance with guidelines provided from the WNTI and as described in the Procedure for Storage of Uranium Concentrate **(Appendix 4).**

8.1.9. Process Plant – Fuel Storage

Fuel storage facilities will be developed early in the construction phase. The provision of fuel to the mining operation will be provided by a fuel dealer/contractor who will be responsible for the design, development and maintenance of all the on site fuel storage facilities.

Surface Water, Groundwater and Soils

The fuel storage facilities are to be equipped with a containment bund wall with a storage capacity of at least 110% of the storage volume. The bund wall will be equipped with an impermeabe floor. A decant system with a fuel trap should be installed to separate rainwater from spilled fuel. Sand or sawdust can be used to wipe up spilled fuel which will be incorporated into the Waste Management Plan.

A mobile fuel bowser will be available for construction vehicles. This bowser will be regularly maintained to prevent fuel leaks. All spills will be cleaned up and contaminated material will be incorporated into the Waste Management Plan.

No other means of fuel storage will be used around the project site in order to prevent uncontrollable spills or leaks.

Health and Safety

The fuel storage facilities will be equipped with fire extinguishers, sand and warning signs. Access to the storage facilties will be restricted by the Procurement Department.

Procedures will be developed to handle all accidents as described in the Emergency Response Plan (**Chapter 9**).

8.1.10. Process Plant – Medical Facility

The medical facility will be constructed and utilised for injured and sick employees and contractors during the construction phase.

All medical waste will be incorporated into and managed as described in the Waste Management Plan.

8.1.11. Process Plant - Laboratory

Construction of the laboratory will occur early in the construction phase in order for sampling of material to be conducted during the pre-strip and development of material for the leach pads.

All laboratory waste will be incorporated into and managed as described in the Waste Management Plan.

8.1.12. Waste Rock Dumps and Raw Water Pond

All compensation activities will be completed prior to the disturbance of these areas. This will include relocation and field compensation.

The locations identified for the WRDs and the RWP will be cleared of vegetation using a bulldozer and chainsaws where necessary. The topsoil will be stored nearby for future revegetation activities.

Overburden material from the open pits will be hauled to these sites for ground preparation of less permeable surfaces to protect groundwater from contamination.

The timber will be provided to the local communities or sold to the forestry department/timber merchant.

An access road will be created around the boundary of each facility to provide easier access for inspections. Progress inspections will be conducted on a daily basis to ensure compliance with the recommended facility design features.

All stormwater drains and ditches developed on site will be designed for the 1:100 year storm (248mm in 24hrs).

Visual Aesthetics

The RWP is located in a drainage depression to maximise water conservation. The visual impact will be reduced by maintaining surrounding trees and bushes where feasible.

The WRDs are located around the proposed open pits and will form new hills in the area. The slopes of these dumps will be vegetated during construction and operations to minimise the visual impacts.

Vegetation and Landuse

All compensation activities for land loss in these areas will be completed prior to site disturbance. Approximately 85ha and 45ha of vegetation will be cleared off the WRD and RWD respectively.

Progressive clearance will occur during construction to reduce long term impacts on soil and surface water. These facilities are included in the Progressive Revegetation Plan.

Soils

Contaminated soils from spills of oil and fuel will be removed and stored in dedicated areas in compliance with the Waste Management Plan.

Erosion management measures will include the vegetating of exposed surfaces and the reduction of slope gradients.

Surface Water

The edges of the RWP will be contoured to retain flow into the facility. A drain will be installed around the RWP to divert surface runoff away from the facility and protect the pond walls. The RWP will be designed by best industrial practices and will be installed with failure prevention and wall safety mechanisms.

An overflow channel with drains will be installed in the side of the pond to manage water storage capacity at the Mutanga and Dibwe RWPs.

Drainage control systems will be designed during construction of the WRDs to divert uncontaminated runoff away from the facilities. A stormwater cutoff drain will be developed upstream of the WRDs and divert runoff into sedimentation ponds for the removal of suspended solids.

Footslope drains will be developed for the WRDs to collect runoff from slope walls and manage slope stability. These drains will incorporate sediment traps. At least one sedimentation pond is recommended for each facility. The water quality will be monitored at the WRD sedimentation pond to prevent and monitor contamination that may occur off the dumps (uranium, sediments, dissolved metals).

Surface water monitoring sites will be placed to monitor sedimentation ponds and any downstream watercourses. There will be no discharge of contaminated water from either facility.

Groundwater

Monitoring wells will be constructed around the WRDs as described in the Environmental Monitoring Plan. Guidance from the facility designers will be important in their final location. At least three wells are important in the determination of impacts on the groundwater.

Air Quality

The generation of dust through vehicle movements and clearance equipment will be reduced by spraying of water with bowsers, especially in the dry season.

Air quality monitoring sites will be identified in accordance with the Environmental Monitoring Plan. These will incorporate general environmental air as well as radon.

Noise and Vibrations

Noise and vibrations will be assessed as described in the Environmental Monitoring Plan and appropriate measures will be implemented to prevent disturbances.

Flora and Fauna

Vegetation areas (fallows) that can be protected will be maintained to provide habitat areas Environmental Monitoring Plan). Specific areas will be identified through specialist consultation during the construction phase. Revegetation will be conducted in fallows where feasible.

8.1.13. Operations Camp

The clearance of vegetation and removal of topsoil will cover approximately 13.5ha. Foundations and pipework will be laid for the housing, ablutions and entertainment facilities of the camp.

All stormwater drains and ditches will be designed for the 1:100 year storm (248mm in 24hrs). The stormwater will be monitored as indicated in the Environmental Monitoring Plan.

Flora and Fauna

All large trees within and vegetation around the operations camp will be maintained with as little disturbance as necessary. It will also shelter the camp visually and reduce noise impacts affecting the surrounding environment.

Specialist advice is recommended for the identification of the areas that can be maintained for development into conservation areas around the camp that may provide the employees and local communities with recreational areas.

Fauna species found in the area will be relocated to safe areas within the District or elsewhere with the help of relevant Government Authorities.

Soils and Surface Water

Staged clearance will be implemented during the construction of the camp to minimise soil exposure and erosion.

Perimeter drains around the camp, with internal drains, will collect surface runoff and discharge it through a sedimentation pond or soakaway downslope of the camp prior to release to the environment.

Groundwater

Engineered designs will be put in place to ensure ground water pollution wastewater and other potential contaminants is minimised.

Security

Access to the mine camp will be restricted by a perimeter fence and monitored by security officers.

Waste Generation

All waste generated in the mine camp will be incorporated into the Waste Management Plan.

8.2. Operational Phase (2011-2020)

8.2.1. Transport and Infrastructure

Contract Agreements

A contractor may be hired to maintain the roads which will need to comply with company Environment, Health, Safety and Social policies.

A contractor will be used to deliver all inputs and spares to the mine site. This contractor will sign a contract agreement with specific statements on means of transport, levels of protection for different cargo and emergency response procedures.

Access roads along the powerlines will be cleared and maintained in collaboration with Zesco (or power supplier).

Health and Safety

Denison will not permit drinking prior to or on the job for safety reasons. Speed control and alcohol testing will be implemented based on observations, accidents and concerns from the local communities.

Denison will manage and maintain the access roads to the mine site throughout the operational phase. Regular inspections will be conducted by the Environmental Department to identify areas of maintenance and safety concern (villages, blind corners, bridges and culverts).

When explosives are required an escort vehicle will accompany explosives delivery trucks and all vehicles will be flagged.

Employee's health will be one of the priority issues for DMZL. The health of employees will be checked prior to their employement and continuously during employment in line with the requirements of the Mines Safety Department. On – site Medical services will also be made available.

Air Emissions

The generation of dust by heavy equipment and vehicles will be prevented by frequent water spraying on all mine roads.

8.2.2. Open Pits (Mutanga and Dibwe)

Soils, Surface Water and Groundwater

There is seasonal drainage from these area and monitoring points will be indentified on construction has been completed that will monitor water quality as well as described in the Environmental Monitoring Plan.

Dewatering water from the pit perimeter dewatering wellfield will be pumped to the RWP for storage prior to discharge to the aquifer or to local water courses.

Storm water run-off from around the open pits will be collected in the perimeter drains that connect to the mine site drainage system and settled in sedimentation ponds prior to soaking away. The management of water has been described in **Section 9.6**.

There will be no workshops located in the open pits. An impervious wash bay may be installed at the entrance to the pits to remove mud off wheels. Spray may also be released into the beds of the haul trucks to wet ore and reduce dust. The trucks may be hosed down in the wash bay to remove surface radioactive contamination. The effluent from the wash bay will pass through an oil and sediment trap and will be pumped to a water treatment facility at the leach pads. The water will be treated for the removal of solids and metals. The oil and sediment traps will be inspected weekly during the wet season and regularly cleaned. The oil supernatant will be managed in accordance with the Waste Management Plan.

A radiation screen will be installed to determine if there are losses off the truck and prevent release during transit to the ore preparation area and the crusher.

All open pit equipment using hydraulic fluid, oil, fuel or any other substance that has the potential to contaminate surface water, groundwater or soil will be subject to a preventative maintenance programme.

Emergency response procedures for spills will be developed in the Emergency Response Plan (ERP).

Pit dewatering will be handled as described in **Section 8.1.4** above open pit construction phase.

Soil contamination will be minimised by ensuring that the service, maintenance and repair of vehicles and equipment is only carried out in areas designed for such activity i.e. mine workshops. The movement of any in-pit mobile fuel tankers will adhere to specified delivery and storage procedures to prevent the contamination of soils from accidents involving oil and fuel.

The continuous miners used for the operations in the pit will be subject to cleaning and decontamination activities in the same way as all other open pit mine equipment.

Flora and Fauna

Clearance activities will restrict damage to the surrounding vegetation. Sightings of animals and birds will be recorded as described in the Environmental Monitoring Plan.

Air Emissions, Radiation, Noise and Vibration

Routine spraying of haul roads to suppress the dust generated by the movement of haul trucks and other heavy equipment will be conducted by water bowsers.

Mining methods will be investigated to reduce the generation and emission of dust. The continuous miners are a result of these investigations. Spraying on areas to be mined will be conducted provided that it does not affect the final mining design method.

Visual assessments of dust generation will be conducted. Air quality monitoring will be conducted as described in the Environmental Monitoring Plan. Based on the results of the monitoring plan management measures will be implemented to reduce or prevent dust generation.

There is not likely to be any blasting activities in the pits and therefore dust emissions will from the pits to the surrounding area will be very low. However, air quality monitoring will be conducted as described in the Environmental Monitoring Plan. A complaints register will be located at Mutanga Mine for feedback from the local communities. This will be managed by the CCDC.

The heavy equipment operating in and around the open pits will be fitted with sealed air conditioned cabs to reduce their exposures to dust. All operators in the open pits, ore spotters for the selective mining and other personnel will be supplied with radiation badges. The measures implemented by Denison to reduce employee exposure will consist of shielding sources, managing exposure times in radioactive areas and supply of protective equipment. The workers in the pits will be rotated regularly.

Mining equipment such as compressors, haul trucks, loaders and dozers will increase the mine site noise levels. The current average daytime noise levels in the open pit areas are low and reflect the rural setting and the lack of existing industry. Mine equipment operation is expected to generate noise up to 2km away. There are no settlements within that zone and so noise is not likely to affect the communities. Noise assessment and monitoring is described in the Environmental Monitoring Plan.

The open pits are not likely to be affected by vibrations from mining equipment. There are no building in the area and blasting will not occur. Vibration assessments will be conducted as described in the Environmental Monitoring Plan.

No public buildings will remain within 1,000m of the open pits and process plant area. These buildings are all included in the RAP, 2009.

Pit Stability

The pit designs will include measures for the management of storm water to promote stability. A series of diversion channels will direct storm water away from the pit perimeters.

In pit dewatering will be conducted using the pit sump and an external (perimeter) wellfield will lower the surrounding groundwater levels to reduce in pit dewatering requirements.

Ongoing review of the pit slope design will be conducted throughout operations by the mining engineers.

Waste Generation

Waste generated from the repair, maintenance or servicing of open pit equipment will be handled, stored and disposed of according to the Waste Management Plan.

Public Safety

The public will be informed of the dangers of entering into areas of mining operations. Public accessibility to site will be restricted. Mine security will regularly patrol the mine site to remove trespassers. Denison will erect warning signposts around the open pits to alert mine employees and workers of open pit dangers.

8.2.3. Ore Preparation Area, Transfer Facilities and Leach Pads

The Environmental Department will inspect the ROM Hopper and Crushers on a weekly basis to monitor environmental performance with respect to noise and air quality. Department assessments will be conducted on a daily basis.

Ore will be delivered to the ore preparation area in Haul Trucks and dumped into the ROM Hopper to feed into the Cone Crusher. The Crusher Plants will be enclosed in a building to reduce the loss of contaminated dust. The buildings will be provided with a ventilation system to remove dust from the air to reduce impacts on employees.

The crusher plant will be controlled from a remote access point. The number of employees operating in the crusher or exposed to transfer routes for long periods of time will be minimised and regular shift changes will reduce personnel exposures.

Daily inspections will be conducted by the Mining Department to monitor the stability of the Leach Pads and integrity of the liners and assessment for leak alerts. The Environmental Department will consult with the Mining Department on concerns they may have from groundwater monitoring programs.

A weekly report will be completed discussing inspecton findings, groundwater contamination and proposed mitigation measures. A monthly report will be compiled by the Mining Department to incorporate monitoring results into the analysis of site findings.

Soils

The crusher plant will be provided with impervious flooring and ore delivery will be directly into the ROM hopper in this facility. A small ROM pad will be developed to manage a stockpile of ore during maintenance activities on the crushers. Contaminated soils will be disposed into the crushing plant as part of the ore feed. All runoff from this area will be captured in the ECP as barren solution.

The leach pad will be a lined facility and no contamination of soils will occur. The lining mechanism of the pad will be monitored for leaks and remedial measures implemented.

All reagents for the leaching process will be stored in sealed units and spills of acids will be contained within bunded area. Spillages will be cleaned up using lime and contaminated soil will be treated in the ore preparation area.

Air Emissions, Noise and Vibration

Dust will be emitted at the ROM hopper and dust suppression through fine mists will be conducted in the hopper. The release of airborne dust around the hopper will be reduced by regular spraying using the water bowser. Water cannons or a Water Cart or Water Bowsers will be used to disperse a fine spray onto stockpiles as well as any dust raised during transportation of ore as required.

Dust generation will be highest at the cone crusher, the pebble crusher plant and ore transfer sites. Water will be sprayed to reduce dust emissions at all of the conveyor transfer points. Hoods or other modes of dust capture will be incorporated into the plant design. Water sprays will operate on conveyor belts especially those delivering agglomerated material to the leach pads on the mobile stackers.

Air quality monitoring at the Crusher Plant and Mobile Stacker Units have been described in the Environmental Monitoring Plan. All workers in the area will be supplied with respirators and time limits on activities will be implemented.

The noise generated will exceed recommended occupational noise levels. A noise monitoring program has been described in the Environmental Monitoring Plan. All employees working in this area will be equipped with Dust Masks, Protective Glasses and Hearing Protection.

Surface Water

Drains to collect the contaminated run-off from around the crusher area will channel this water to the water storage facility which will supply water to the leaching process.

Rainwater on the leach pad will be directed to the barren solution pond (also used as the emergency containment pond)

The stormwater runoff around the crusher and leach pad facilities will be directed away from areas of possible contamination. The solids in the pond will be removed prior to the wet season and inspected regularly during the wet season to prevent build up in the pond. The solids will be disposed of in a dedicated area in the waste rock dumps.

Groundwater

The groundwater around the crusher plants and pad facilities will be monitored as described in the Environmental Monitoring Plan (**Section 9.4**).

Radiation

The ore is being concentrated at this facility to provide a concentrated feed for leaching on the pads. The levels of radiation may be higher at the ore preparation area and the stacker units. These areas will be subject to a radiation assessment survey in which they will be classified with levels of high radiation hazard. All employees working in these areas will be provided with PPE and trained on the potential hazards in these areas.

Public/Employee Safety

Public access to the ore preparation area will be restricted by the perimeter fence around the leach pad area which will be patrolled mine security. Warning signs will be erected indicating hazard and the requirement for safety equipment (hearing) as well as respiration Personnel Protective Equipment (PPE).

8.2.4. Process Plant – Processing of PLS

The Environmental Department will inspect the process plant facilities on a daily basis to monitor environmental performance with respect to contamination events, noise and air quality.

Surface Water, Groundwater and Soils

Contamination of surface water, groundwater and/or soils may occur from contact between process spills, acid spills, reagent spills, wash water and storm water which result in the carry over of spills into the site drainage system.

The measures to protect surface water quality will include: -

- All process plant spills will be collected in sumps and returned to the process;
- The wash water from hosing down and maintenance activities will be introduced to the process circuit or treated prior to discharge into the process water pond. This water will be kept separate from storm water run-off;
- All pipes and storage facilities in the process plant will be subject to a preventative maintenance program. Regular inspections for leaks and spills will be conducted by the plant personnel;

- Procedures will be developed in the Emergency Response Plan to describe the chain of events to occur in the case of spillages, fires and accidents;

- Storm water drains around the perimeter of the plant will be kept clean and clear of debris and sediment to prevent overflow of the drains into processing areas;

- Reagents will be stored in make-up tanks to prevent contamination of runoff. Standing water in acid storage containment areas will be collected and neutralised before being released into the site drainage system; and

- Spilled materials will be removed and the area cleaned up as soon as possible. The Emergency Response Plan will discuss accidental releases and emergency procedures.

The measures to protect soil and groundwater quality will include:-

- All surfaces in the process plant area will be impermeable and acid resistant where appropriate;

- Oil traps will be installed in areas around machinery in the mill to capture spills. The oil traps will be regularly serviced and cleaned. Oily residues will be incorporated into the Waste Management Plan;

- Acid and hydrogen peroxide off-loading bays will be equipped with an impervious floor surface and containment to recover spillages and prevent ingress into the site drainage system;

- Reagent (lime, caustic soda) offloading areas will be equipped with an impervious floor and containment. Ideally the reagents will be offloaded inside the reagents store and all spills will be contained within the store bunding. The reagent store will be covered and provide protection from water and direct sunlight. All spilled reagents will be swept up and used;

- All containment areas will be regularly cleaned and drained to maintain storage capacity;

- Process water and other process solution ponds will be lined with impermeable HDPE liners to prevent leaks. Monitoring boreholes will be installed adjacent to the ponds to provide early warning of leaks and possible groundwater contamination; and

- Monitoring boreholes will be located around the process plant to monitor the groundwater quality in the area and quickly identify any contamination events.

A preventative maintenance program will be implemented for all plant equipment, process infrastructure, drains and containment areas. This will involve regular inspection of all equipment to prevent spillage due to equipment failures.

The process plant and administration facilities will not release any effluent into the environment. All effluent will be managed in accordance with the Water Management Plan.

Water Consumption

A mine water balance will be finalised during initial mining. Flow monitors will be installed on all major water transfer pipes (raw water pond, dewatering pipelines, process water pond, plant raw water pond, process plant, leach pads) to accurately quantify water volumes. This will be used to identify areas where water recycling and conservation may be maximised. This will be conducted as described in the Water Management Plan. The plant and site water balances will be continually updated.

All pipelines will be subject to a preventative maintenance program to reduce water loss through leaks and spills.

Air Emissions

Radon will be emitted during treatment activities of the uranium ore. These will be monitored in accordance with the Radiation Management Plan. All emissions from the process plant will be prevented through ventilation systems with cleaning and scrubbing units for removal of airborne radioactive dust.

Other air quality parameters will be measured in accordance with the Environmental Monitoring Plan.

General Releases

All reagents and chemicals being transported to site will be covered with tarpaulins to protect them from the elements, which could result in contamination of water and soil or air pollution.

Public Safety

Access to the process plant area will be restricted by an internal security fence and warning signs. An external security gate will provide access to the plant. Training will be provided for all employees and the public on the hazards of the site. Day visitors will be accompanied at all times to restricted areas and be provided with identification tags.

8.2.5. Process Plant – Mine Workshops

The workshop will be inspected on a daily basis by the workshop foreman/manager to manage housekeeping issues and practise good waste management.

The Environmental Department will inspect the workshop areas on a weekly basis to monitor workshop environmental performance.

The Environmental Department will provide training to all employees on good housekeeping practises with specific focus on their departments.

Surface Water and Groundwater

The washing of mobile equipment and machine parts will be carried out in wash bays equipped with impervious flooring and spillage containment. The wash bay drainage will pass through oil traps and then be released to the site drainage system. The oil traps will be inspected weekly to monitor condition and performance. Oil residue and sludge will be incorporated into the Waste Management Plan.

Oil traps will be installed in drains at all oil handling and storage areas in order to capture all oily residues. This will prevent the carry over of oil by storm water into the mine site drainage system.

Oil collectors will be used to capture leaks of vehicles awaiting maintenance in the vehicle yard to prevent contamination of stormwater.

All vehicle maintenance will be conducted in the workshop which will be provided with impervious concrete floors, bund walls for collection of contaminated runoff or water and adequate lighting. The workshop will be equipped with a maintenance pit and tools necessary for all on site maintenance activities.

Handling spills and poor housekeeping etc will be minimised and prevented by regular inspections of the workshop area. This will form part of a preventative maintenance program to monitor potential sources of contamination.

All workshop employees will be trained on the importance of good housekeeping practises in the prevention and minimisation of environmental contamination from oils and fuel.

Soils

Inadequate handling and storage of new and/or used oil may result in soil contamination. New and used oils will be handled in accordance with the Handling and Storage Plan (**Chapter 9**).

Oil will only be stored and handled in designated areas and the workshop drains will be equipped with oil traps.

Waste oil will be incorporated into the Waste Management Plan (**Section 9.8**).

Inadequate handling and storage of new and/or used batteries may contaminate soils. New batteries will be incorporated into the Handling and Storage Plan. Old batteries will be incorporated into the Waste Management Plan.

Accidental Releases/Spills

Procedures will be developed in the Emergency Response Plan (**Chapter 9.9**) to handle accidental spills or releases of battery acid or oils.

Waste Generation

Waste generated at the mine workshops include old filters, old batteries, used oil, used parts, used hydraulic fluids and greases, scrap metal and broken glass. These materials will be incorporated into the Waste Management Plan.

8.2.6. Process Plant – Fuel Storage Facilities

Surfacewater, Groundwater and Soils

All spills/accidents will be managed as described in the Emergency Response Plan (**Section 9.9**). All contamination will be considered as hazardous waste and incorporated into the Waste Management Plan.

Weekly inspections will be conducted by the Environmental Department to monitor environmental performance.

8.2.7. Waste Rock Dumps

Surface Water, Groundwater and Soils

Stormwater will be directed away from the WRDs and water will be settled in sedimentation ponds and allowed to soak away. Monitoring of these ponds will be conducted as discussed in the Environmental Monitoring Plan. The ponds will be cleaned out regularly and the solids dumped on the WRDs.

Perimeter drains around the foot of the WRDs will divert contaminated run-off to a series of sedimentation ponds. All drains will be lined with HDPE and sediment traps will be kept clear of debris and sediment. The sediment will be removed from the ponds regularly and dumped on the WRD. Settled water will be directed to the contaminated water storage pond at eahc heap leach pad and used in crushing operations. There will be no discharge of contaminated water to the environment. The sedimentation pond discharge will be monitored as described in the Environmental Monitoring Plan to monitor long term changes in water chemistry of drainage from the dumps.

Inappropriate dumping of non-hazardous waste on the dump will not be allowed. Waste will not be stored on the WRDs and will be managed in accordance with the Waste Management Plan. All radioactive contaminated waste will be identified and managed in accordance with Radioactive Waste Management Plan (**Appendix 6**).

An investigation into backfilling of the open pits to reduce the movement and storage of overburden material to the waste rock dumps will be conducted during the completion of final pit designs. The reduction in material stored at surface will reduce the scale of impacts on soils and water.

Dump Stability

Denison will adopt the following procedures during the expansion and construction of the dumps:-

- The dumps will be constructed in 10m lifts with 10m wide berms and inter-berm slope angles of 18º;
- Overall slope angles will range from 16 º-17º;
- The average height of the waste rock dumps will range from 30m to correspond with surrounding topography;
- A strategy of dumping weathered waste rock in central dump areas and using more competent waste rock for construction of the outer walls will be implemented. The more competent waste will also be used to dress dump slopes. This will maintain the long term stability of these facilities;
- The dump will be of terrace construction with no end-tipping and regular inspection will be conducted by a mining engineer to ensure construction is occurring as per design;

- Daily inspections will be conducted by the Mining Department to monitor the stability of the WRDs to take into consideration changes in the geotechnical properties of the overburden material. The Environmental Department will consult with the Mining Department on concerns they may have from groundwater monitoring programs; and

- A weekly report will be completed discussing issues of stability and failure risks, groundwater contamination, areas of erosion and proposed mitigation measures, progress of revegetation programs and any other concerns.

A schedule will be developed based on finalisation of the mining schedule to plan progressive revegetation of the WRDs. The Progressive Re-vegetation Plan describes activities to be conducted for the rehabilitation of all mine facilities.

Air Emissions, Noise and Vibration

The generation of airborne dust from the movement of trucks and other heavy equipment will be suppressed by routine spraying of haul roads with water.

It is unlikely that noise and vibration generated from the operation and movement of heavy equipment will be a nuisance to local communities. However, a complaints register will be set up in Kashundi Village. Noise monitoring will be conducted as described in the Environmental Monitoring Plan.

Public Safety

The public will be informed of the dangers of entering mine operational areas. Warning signposts will be erected around the dumps. Mine security will remove intruders from the mine site.

8.2.8. Raw Water Ponds

Surface Water

The surface water flow paths will be altered by the development of the RWP. Natural drainage patterns will be maintained or reconstructed if damaged whereever feasible.

Raw water may be extracted from the RWP to top up process plant water requirements. A raw water pump will supply the plant raw water pond to feed the process water pond.

A pond overflow will be designed on the wall of the RWP to manage water containment and prevent overtopping of the walls.

Aquatic Habitats

During the construction phase of the project regular monitoring of surface flows will be conducted as described in the Environmental Monitoring Plan (**Section 9.4**). Water will be released from the RWP in accordance with natural runoff and drainage fluctuations.

The water body created by the RWP can be developed into a habitat area for aquatic organisms. This will only be conducted as advised by the designers of the raw water pond for stability issues and prevention of impacts to the delivery lines.

Pond Stability

The pond will be inspected on a daily basis. The pond wall will be inspected for cracks and leaks and the integrity of the pond overflow channel. Inspection results will be included in the weekly inspection reports.

Public Safety

Denison will erect warning signs alerting the public to the dangers of drowning. Mine security will patrol the RWP and remove all trespassers. Emergency safety floats or rings will be provided in case of accidents.

There are no settlements in the immediate downslope side of the RWP. Emergency measures will be developed in the Emergency Response Plan (**Section 9.9**) for dam failure.

8.2.9. Mine Camp

Surfacewater, Groundwater and Soils

All forms of waste generated at the mine camp will be incorporated into the Waste Management Plan.

Environmental monitoring of stormwater will continue during operations.

Safety

Access to the mine camp will be controlled by mine security throughout operations.

8.2.10. Public Safety

Protection measures for the implementation of pulic radiation safety measures have been described in the Radiation Managment Plan.

Security measures will reduce accessibility of the local communities to the plant area and infrastructure where exposure levels to airborne radioactive dust or radiation are higher than normal for the Mutanga site.

8.2.11. Infrastructure

Airbourne dust reduction measures such as road sealing (polymers to prevent dust releases) will be implemented along all mine roads that will remain untarred.

8.2.12. Closure Phase

During the mine closure phase all operations will cease at the open pits, stockpiled ore will be processed through the process plant, the WRDs, heap leach pad and process plant will be decommissioned and the site area will be cleared.

The preliminary draft of the Mine Decommissioning and Closure Plan (**Chapter 10**) will cover all activities related to the closure phase of operations.

9. ENVIRONMENTAL AND SOCIAL MANAGEMENT PLANS

The Environmental and Social Management Plans (ESMP) for Denison's Mutanga Project are structured as follows:-

- Project Management;
- Resettlement Action Plan;
- Occupational Health and Safety;
- Environmental Monitoring Plan;
- Radiation Management Plan;
- Water Management Plan;
- Handling and Storage Plan;
- Waste Managment Plan;
- Emergency Response Plan;
- Conservation and Vegetation Plan;
- Preliminary Progressive Revegation and Rehabilitation Plan; and
- Sustainable Development Plan.

The Environmental Management System (EMS) will be implemented through the project management, which has been described as part of the ESMP. Within the ESMP, a series of policies have been developed to target key aspects requiring specific management actions, such as the Radiation Management Plan, Waste Management Plan, Resettlement Action Plan, Progressive Revegetation and Rehabilitation Plan, Handling and Storage Plan and an Emergency Response Plan amongst others. These policies will be implemented through the EMS by Denison. At present these management plans are in a preliminary form and will be updated prior to the application of a processing license, construction phase, operational phase and mine closure phase in accordance with the timeline identified in Chapter 3.

9.1. Project Management

9.1.1. Management Structure

The implementation of the mining project will be conducted through the management hierarchy as indicated in **Figure 9.1** below. The project will be managed by the Vice President for Operations (VP Ops). The General Manager (GM) will oversee the daily operations of all departments of the mine project. There will be 5 departments responsible for the following:-

- Mining;
- Processing;
- Mine Security;
- Community Communications and Development Coordinator; and

- Human Resources/Administration.

Mining Department

The management of the mining operations in the open pits will be the responsibility of hte Mining Department. This department will consist of 21 Denison staff and 123 mining contractor personnel. All activities associated with mining in the pits will be managed by the mining department. The mining department will be responsible for management of the WRDs activities.

Processing

The Plant Manager will oversee all plant operations which would include management of operations at the ore preparation area and leach pads; the process plant; the workshops; the process water balance and all facilities incorporated into the Water Management Plan.

Security

All mine security issues will be managed through the security department. Daily security will be provided by a contractor or mine security provided through the Ministry of Mines and Minerals Development. The security department will handle all safety incidents related to the project activities in conjuction with the Environment, Health and Safety Department. The security officer will also be responsible for updating the Project Management on regional security issues. The security department will have a leading role in the management of the mine uranium oxide concentrate products.

Community Communications and Development Coordinator

The CCDC will be responsible for liaison with the communities and public in general on project aspects as well as potential community development projects. The CCDC will oversee implementation of the RAP, liaise with the Relocation Committee (RC) and the activities of the Communitiy Consultation Committee (CCC).

Human Resources/Administration

Administrative issues with respect to mine approvals, licensing, correspondence, mine visits and inspections will be dealt with through this department. The finance department will be responsible for the mine accounting system, salary payments and compliance with the tax requirements. The finance department will be responsible for the preparation of annual financial schedules and reports and budgets. The Camp management will involve all activities related to miners and contractors at the camps, which will include managment of supplies and the accommodation schedules.

Safety, Health and Environment

The Safety, Health and Environment department will manage all SHE activities in relation to the entire project and will monitor and enforce departmental management actions through the Director of Mines Safety. The Director will oversee the department and be assisted by four SHE officers (SHEOs).

The Radiation Protection Department will be part of the SHE Department. The Radiation Protection Officer will manage the department and report directly to the Gnereal Manager. There will be three Radiation Monitors working in the processing faicilities.

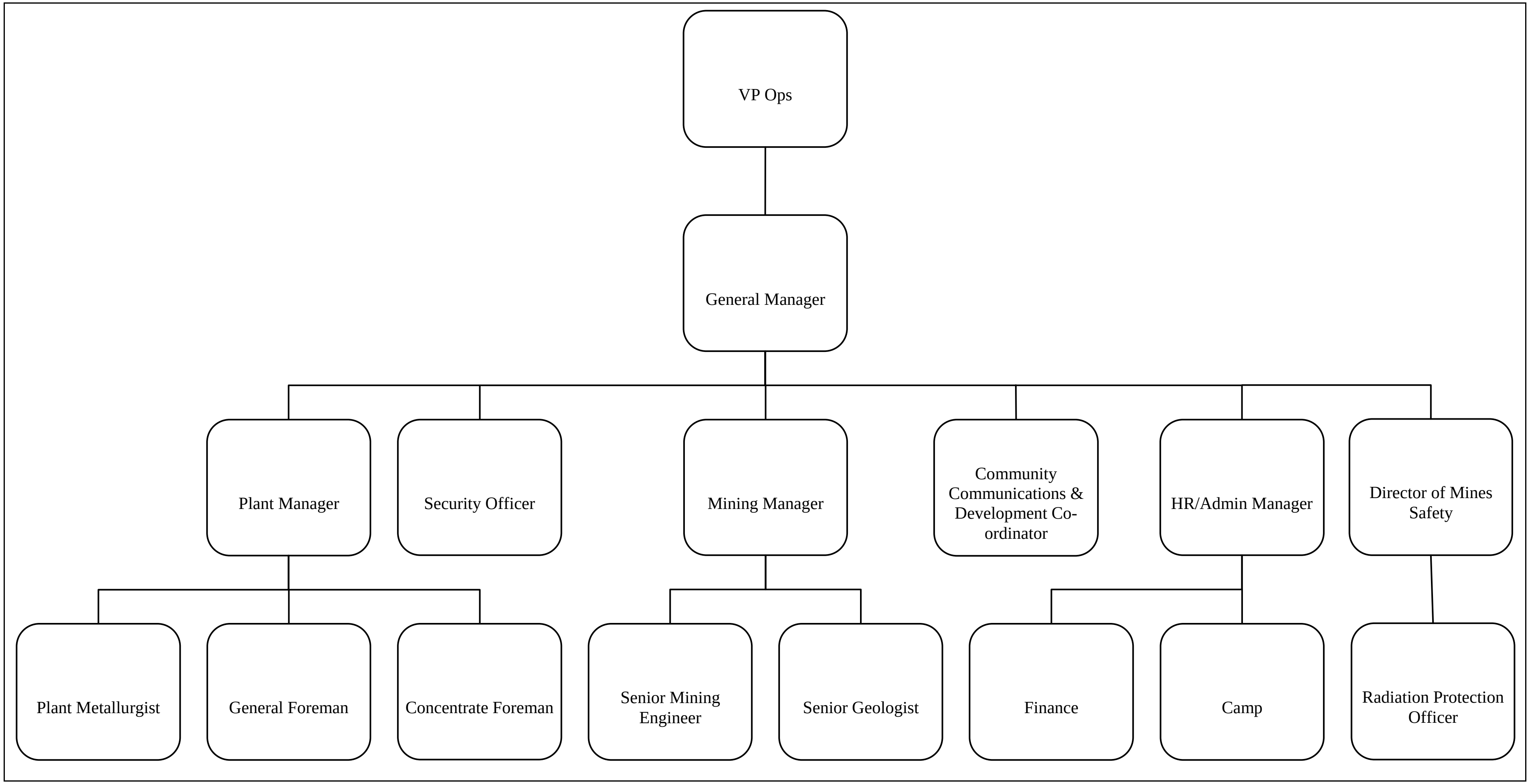


Figure 9.1 Project Management Stucture of the Mutanga Project
(Source: MDM, 2009)

The SHEOs will be responsible for the implementation of mine related environmental and safety issues. Through the SHEOs all departments will be advised on the requirements of the ESMP and their roles through increased environmental awareness. The implementation of the departmental management actions will also be the responsibility of each department.

Radiation Protection Officers (RPOs) will implement the requirements of the management plans for all radioactive aspects of the Mutanga Project.

Implementation of internal auditing will be conducted by the SHE Department. Safety and health aspects related to personal protective equipment, safety training, accident prevention and employee general health will be managed by the SHEO and the Radiation Department.

9.1.2. Internal Monitoring and Reporting

The management of operations should be conducted using internationally accepted procedures, which have been described in detail in ISO 14000 for accreditation. Recommendations for the mine management of Mutanga Mine consist of the following:-

- Regular management meetings ususally on a daily basis to inform the mine manager or operational vice president of daily operations, accidents, issues of concern etc that are documented with minutes for future company reference;

- The generation of weekly and monthly reports by each department for the VP describing all activities, which will be submitted to and finalised by the General Manager;

- Design and implementation of a record management system which will include a worker exposure, an emissions inventory database, a complaints register, meterological measurements, modelling results (dispersion analysis), environmental monitoring and a compilation of reports; and

- The generation of incident reports for all accidents and emergencies by each department in conjunction with the SHE Department.

9.1.3. External Reporting

External reporting to the Ministries of Mines and Minerals Development (MMMD), the ECZ, and the Radiation Protection Authority (RPA) will be conducted in accordance with Zambian legislation.

Once a Minerals Processing License has been approved the project will be subject to contributions for the Environmental Protection Fund (EPF) over the initial 5 years of the project. Annual audit reports will be produced outlining all mine activities for each year, production and sales statistics, the progress of the environmental and social management plan, accidents or incidents, status of compensation and relocation activities and any other information. These reports will be submitted to the Ministry of Mines and Minerals Development.

Quarterly reporting will be required from Denison by the Ministries of Mines and Minerals Development, Environmental Council of Zambia, Radiation Protection Authority, Zambia Revenue Authority etc.

An annual review of the implementation and success of the RAP will be conducted through meetings of the Relocation Committee, Denison and a team of independent reviewers. These reports will be provided to the Mines Safety Department (MSD), ECZ and the RPA.

Audits of the ESMP will be conducted by an independant competent consultant every 2 years during operations. The first audit will be conducted within the first 18 months since project construction was initiated. More frequent monitoring may be required by the MMMD, ECZ or RPA.

All incidents where non-compliance of operations occurs with various environmental standards related to the project will be reported to the MSD, RPA and ECZ as soon as possible. All occupational accidents/incidents will be reported to MSD and RPA.

MSD shall be informed of all proposed changes to the project from its original design through official correspondence for approval and advice. Regular updating of the EIS will be necessary based on the update in project activities.

9.1.4. Budget for Implementation of the Environmental Management Plan

The budget estimated during the feasibility study for environmental and labour costs is described in **Table 9.1** below. The labour costs cover mostly health and safety equipment such as personal protective equipment and training.

Table 9.1 Environmental, Health and Safety Budget for the Mine Life of the Project

Item	Budget
Safety and HR Training and Audits	930,000
Environmental Applications and Licenses	250,000
Environmental Monitoring and Social Development	750,000
Total	**1,930,000**

9.2. Resettlement

The RAP has been developed and contains a record of the commitments, procedures, and actions to be undertaken to resettle and compensate the people, households and communities impacted by the Project, consistent with the World Bank Group policy on Involuntary Resettlement (Operational Policy 4.12 of 2004), the International Finance Corporation (IFC) Performance Standard 5 and in compliance with the laws of the Republic of Zambia.

The current estimate of the compensation for the relocation and compensation activities is approximately US$2.5million (equal to K14.3 Billion Zambian Kwacha). Currently relocation of the communities into Kashundi Village is anticipated for the end of 2010.

9.3. Occupational Health and Safety Plan

Denison will implement internationally accepted occupational health and safety standards and procedures throughout its operations as part of an Occupational Health and Safety (OHS) Plan. They will be in compliance with guidelines for mining operations from the IFC (General Environment, Health and Safety Guidelines and guidance specific to the mining sector). This will create a safe workplace thereby protecting its employees from accidents and sickness.

The implementation of the OHS Plan will be managed by the Environment, Health and Safety Department through the SHEO. Each department will be incorporated into the OHS with specific requirements and will assist with the implementation of their departmental OHS. The OHS will be aimed at:-

- Hazard elimination;
- Hazard control;
- Hazard minimisation; and
- Provision of personal protective equipment.

The SHEO and the manager of each department will develop a job hazard analysis for all employees to identify management strategies for each hazard. A hazard coding system will be developed for mine facilities and activities (electrical, acid, water etc). This will be conducted for all phases of the project and will incorporate contractor activities.

9.3.1. Training

All Denison mine employees (management, supervisors, workers, visitors) shall be provided with basic OHS training. This training will be provided by the SHE Department or through a private contractor. The Worker Training Manual is included in **Appendix 1.**

Specific training will be provided to workers with specific hazards (e.g. open pit personnel, process plant). The training will include:-

- Training on the use of equipment, materials and tools for their tasks;
- Hazards identified in their operational areas and management measures installed (signposting, emergency equipment procedures, MSDSs, PPE);
- Potential health risks which will include those related to ionising radiation;
- Exposure prevention measures and hygiene requirements;
- Wearing and use of protective equipment and clothing; and
- Responses to operation extremes, incident and accident reporting.

Employees will also receive training regarding safety, health and environmental matters including accident prevention, safe lifting practices, safe chemical handling practices, and proper control and maintenance of equipment and facilities. This will aid in the prevention of accidents or chemical spills.

Training on emergency response systems and procedures including the location and proper use of emergency equipment, use of personal protective equipment, procedures for raising the alarm and notifying emergency response teams, and the proper response actions for each foreseeable emergency situation will be conducted.

SHE training will be provided to new employees related to their specific tasks. This training will inform them of Denison workplace policies and employee requirements. The training will focus on hazard awareness, site-specific hazard identification, safe working practices, accident prevention and all site emergency procedures.
The SHEO will develop a hazard identification colour system for different levels of hazard which were identified through the job hazard analysis activities. All employees will be informed of this colour code system.

Visitors to the mine site that will enter operational areas will undergo a visitor orientation seminar aimed at informing them of health and safety issues, hazards, protective equipment required etc. The Visitor Training Manual provides details of the training activities a visitor will experience during a site induction. All visitors will be escorted around the process plant area and will require security passes for access to all mine facilities.

All new employees or contractors will be provided with OHS training courses in conjunction with their activities as described in the Worker Training Manual.

Employees volunteering for rescue services of those requiring first aid training will receive specific training to prevent exacerbation of the incident, accident situations involving their co-workers or increased danger to themselves. The first aid training will include guidance on the protection of their health during the use of their first aid knowledge.

Contract agreements with Denison will ensure that all contractors, sub-contractors and service providers are adequately trained prior to initiation of activities.

9.3.2. Communication

Hazards and procedures will be communicated to all personnel through adequate signage and in accordance with international safety standards. Hazardous areas (electrical rooms, reagent storage areas, ionising radiation, loud noise) will be clearly signposted outside the buildings. Protection measures and requirements will be signposted in appropriate areas (radiation PPE, hearing protection at the crusher plant, no smoking signs at fuel storage areas). All emergency exits, equipment and procedures will be signposted in areas where they will be seen.

All mine personnel will be trained through the basic OHS program on the meaning of signs used throughout the mine site. Signposting will be designed to accommodate the capacities of all employees so will be in English and Tonga languages as well as pictorial where relevant.

Through the hazard coding system all equipment will be labelled with appropriate coding to indicate materials and potential hazard e.g. acid storage tanks and pipes, hot and cold pipes, process solutions). Hazards related to chemical, toxicity, temperature, pressure and contamination will be identified. Piping systems will be labelled with contents and flow direction and colour coded.

The hazard coding system will be signposted on all notice boards throughout the mine site. Specific hazards in the respective facility will be posted on notice boards to remind employees and inform visitors/emergency services. The volunteer mine rescue team will receive specific training on the hazard coding system.

Denison will manage inventories and checklists of chemicals onsite in their respective storage areas to be able to assist emergency services when needed. These inventories will be managed through the Procurement Department and the Process Plant. The SHEO will ensure these files are kept and regularly updated.

Emergency service providers will be identified and incorporated into the Emergency Response Plan. These service providers will be offered an annual visit to the Mutanga Project to familiarise them with operations and possible incidents to ensure effective assistance when required.

9.3.3. Workplace Integrity

All of the surfaces, buildings and storage areas will be easy to clean and regularly maintained to prevent the accumulation of hazardous materials and accidents. All flooring will be even, level and non-skid. Adequate access to all buildings and passageways will be incorporated into the building designs.

The facilities on the mine will be provided with adequate lighting, air conditioning or ventilation and appropriate noise levels for all personnel. High Efficiency Particulate Air (HEPA) air filters will be incorporated into the crushing and process plant facilities. Fire and noise insulation will be utilised in the ceilings and walls of noisy areas (e.g. crusher plant) and the process plant.

Dedicated buildings have been designed for the crushing plant to prevent the emission of radioactive dust. These facilities shall be enclosed as required and noise insulation provided for the walls and ceilings.

9.3.4. Workspace and Emergency Exits

The working space for each employee and in general shall be large enough to allow for safe implementation of all activities. This is specifically important in the process plant and workshop areas.

All office, dining and accommodation space will be sufficient enough to prevent overcrowding and hazardous accident scenarios. The design of space will incorporate disabled accessibility such as wider corridors and access ramps.

All buildings will be designed with well marked, safe emergency exits in the case of fires, spills, ruptured tanks etc. All exits will be lit through a dedicated power source. Each building will have at least 2 emergency exits each of which will allow efficient orderly exit of the highest number of persons in each respective building. Important areas with accumulations of personnel will be dining facilities, accommodation and mine offices. At least four exits will be provided to the mine offices. Emergency check points will be located at safe distances from all buildings.

9.3.5. Workplace Safety

A medical centre will be constructed at the mine site to provide medical services to all Denison employees and their immediate families. These facilities will be equipped with a pharmacy, a reception and 6 beds. The facility will be equipped with gloves, gowns and masks for medical staff to prevent contact with blood and body fluids.

A qualified first aider (site nurse, doctor or emergency medic) will be permanently provided by Denison to ensure appropriate health measures are implemented during accidents. First aid stations or equipment will be provided at the open pits, crushers and leach pads, in the process plant buildings, the Operations Camp, the workshops, the mine offices and the medical centre. Mobile first aid kits will be provided in mine vehicles.

The site medical officer will develop written procedures for all cases of trauma that may be expected on site, from minor trauma to major sicknesses, which will occur as part of the job hazard assessment by the SHEO. Procedures will be included in an update to the Emergency Response Plan.

The Radiation Protection Officer (RPO) in conjunction with Radiation Monitors (RMs) will manage ionising radiation levels for all facilities especially the open pits, ore preparation areas, leach pads and ponds, process plant and ponds and contaminated equipment storage areas.

All areas of the plant where employees may come into contact with process solutions, reagents or acids will be provided with emergency showers and eye baths.

Access to reagent stores, the process plant refinery and concentrate packing areas, the plant control room will be strictly controlled.

All workplaces shall be protected against fire outbreaks. All buildings will be equipped with fire detectors and alarms. The alarm system shall be site specific and shall be visible and audible i.e. noisy environments may suppress audible alarm systems.

Fire suppression methods such as fire showers will be installed in all areas where heat is generated or areas where flammable materials are stored. Fire extinguishers will be provided in all buildings specifically targetted for electrical, chemical or other flammable sources. Fire blankets can be provided in accommodation and dining areas.

Fire fighting equipment will be located in easily accessible areas during emergencies and will be clearing signposted. All employees will be trained on the use of equipment on a regular basis.

Emergency Fire and Rescue Services

The Mutanga Project will be located 39km from Siavonga Town and it is likely that emergency services would need to travel approximately 79km (access to mine site along the Zyiba Meenda Road) in order to access the facilities. Denison will equip the Mutanga Mine with water bowser equipped with detachable water canons to assist with fire fighting or other emergency activities. A mine rescue team, based on volunteer employees, will be trained up in first aid, emergency rescue procedures and techniques. Training refreshment courses will be conducted on a monthly basis.

9.3.6. Workplace Environment

A water treatment plant will be installed at site to provide potable water to the mine project. This water will supply ablution systems, the mess halls and drinking fountains in all buildings.

All buildings will be provided with segregated showers and toilets in dedicated ablution blocks with appropriate ‘occupied’ signage. Hot and cold water will be provided in showering areas with all cleaning and washing supplies provided to promote employee cleanliness. Dedicated showers will be provided in the process plant and workshop areas. All workers will shower at the start and end of every shift.

Workplace lighting will be natural wherever possible and artificial lighting provided in enclosed areas. Emergency lighting will be supplied to all facilities in the mine site through backup generators. Dedicated moveable light sources may be required during maintenance activities.

All buildings will be well ventilated, either naturally by design or mechanically with fans. Workers will not be exposed to draughts in their workplace. An air distribution system has been designed for the process plant buildings that will minimise employee exposure to hazardous gases.

Extractor fans equipped with dust filters will be installed as required in the crushing plant and process plant areas. A warning system for air contamination as well as malfunctioning air supply equipment will be installed. These will be monitored daily by each department and regularly by the SHE Department.

Mine offices, some accommodation and mess hall areas will be equipped with air conditioning units. These systems will be monitored, cleaned and maintained on a monthly basis to prevent the growth and spread of pathogens.

Workplace temperatures will be regulated through the ventilation system. Cooling will be provided in hot, confined work areas. Internal temperatures of the workplace, medical centres, mess halls and entertainment facilities will be maintained at appropriate levels dependant on activities being conducted.

Safe and easy access will be provided to all buildings and infrastructure on site. Covered walkways will be developed for pedestrian access around the mine especially the offices. Pedestrians will be segregated from vehicle movements for safety concerns. Inspection sites will have easily accessible and unobstructed access. These areas include septic tanks, pipelines, flow meters, and storage facilities.

Safety rails (hand, knee and foot) will be developed for ramps, stairs, ladders, raised platforms and loading bays. This is specific to the process plant, workshops, mine offices, dining and accommodation areas.

Any below-ground valves around the project site will be accessible via manholes. These openings will be sealed with metal plates or chained gates.

9.3.7. Working in Confined Spaces

Entering into confined spaces such as tanks, vessels, sumps and excavations to carry out inspection, repair and/or maintenance can expose workers to the danger of toxic, flammable or explosive gases, or lack of oxygen.

These spaces will be tested for the presence of gases or lack of oxygen prior to entry. Adequate ventilation will be provided before and during occupancy. Employees working in confined spaces will wear appropriate air-supplied respirators. Suitably equipped safety watch observers will be stationed outside of confined spaces to provide emergency assistance if required.

9.3.8. Lone or Isolated Work

A lone worker is out of verbal and visual contact from supervisors or other mine workers for continuous periods exceeding an hour making them very vulnerable during accidents.

Lone working will not be permitted by Denison.

9.3.9. Physical Hazards

Rotating and Moving Equipment

Equipment with exposed moving parts will be provided with guard meshes or screens. All hazardous moving equipment will be equipped with two switches to enable operation and will have an emergency stop device. These devices will be clearly marked. The machines will be desiged to enable cleaning and lubrication activities without removing safety guards and grids.

Turn off, disconnection or de-energizing techniques will be designed into all moving or rotating equipment as per CSA, ISO or ANSI Lockout guidelines.

Workplace Noise

All plant equipment (belonging to the mine and contractor) will undergo routine maintenance to ensure it's in good working order and to minimise noise levels. The collected debris and followup mine

All noisy equipment will be isolated where feasible. Sound proofing insulation will be installed in the ceilings and walls of noisy buildings (enclosed crusher plant).

Noise will be monitored as described in the Environmental Monitoring Plan. Employees will wear appropriate hearing protection in workplaces where noise levels exceed 85dB(A) or a peak sound level pressure (instantaneous) greater than 140dB(C). Protection devices will reduce noise to the ear to a minimum of 85dB(A). The ESO will monitor the use of protective equipment to ensure appropriate and correct use.

Exposure of workers to noisy environments can be reduced using 'for every 3dB(A) increase in sound levels, the exposure period is reduced by 50%'. This will only occur where hearing protection equipment is not feasible.

Quarterly medical hearing assessments will be conducted on all employees exposed to loud noise in their workplace. This will be monitored by the SHEO and the onsite Medical Centre.

Workplace Vibration

The exposure of workers to whole body or hand-arm vibrations shall be managed to internationally accepted standards (**ACGIH, 2006**) to prevent worker injury.

Exposure levels can be calculated based on equipment supplier information and daily exposure time.

A workplace vibration survey will be conducted by the ESO during the construction/operation phases to determine hazardous areas. Measures to reduce vibrations include equipment choice, vibration dampeners and exposure reduction.

Workplace Electricity

All energised electrical wires will be marked or signposted. All overhead electrical wires will be fastened to prevent capture on traffic and at adequate height. Electrical cables will be buried where possible with adequate signposting and depth information. Locking out and tagging out equipment from active use during maintenance activities will be implemented.

All electrical equipment will be maintained in good working order and regularly serviced or repaired. Adequate earthing/grounding/insulation will be provided on all lines/equipment that are likely to become wet/damp.

Access and entry to equipment service areas of high voltage equipment will be restricted and all service rooms will be clearly marked with hazard signs in accordance with the hazard coding system. 'No approach' zones for high voltage power lines will be established around all applicable electrical facilities (refer to **Table 9.2**). It is likely that powerline feeds for Zones 1-3 will exist around the mine site.

Table 9.2 No Approach Zones for High Voltage Power Lines (IFC, 2007)

Zone	Nominal Phase-to-Phase Voltage Rating	Minimum Distance (m)
1	750 ≥ 150,000volts	3

2	150,000 ≥ 250,000volts	4.5
3	>250,000volts	6

Worker Eyesight

Machine guards or splash screens will be installed in all areas where workers are susceptible to eye hazards. Eye protection (goggles, safety glasses with side shields, full face shield) will be provided to workers in these areas (process plant, wet moving equipment, workshops). Workers wearing prescription glasses will be provided with specific eye protection.

All welders will be provided with a full set of welding PPE for eye protection and protection from inhalation of toxic fumes. Welding work will be conducted at a designated workstation with screening from other workers.

Industrial Driving and Site Traffic

All Denison drivers will be specifically trained for their respective duties (forklift operator, heavy equipment operators, staff drivers). Drivers will be subjected to regular site health checks.

All drivers will be provided with safety training specific to radiation exposure.

All heavy equipment and mine vehicles will be equipped with reverse alarms as well as emergency fire extinguishers.

The mine transport network will have clear signposting for all roads showing rights of way and any speed limits. Private or delivery vehicles will be restricted to the external security area around mine administration area. No access will be allowed into the inner security of the process plant area. One way routes will be installed around the process plant area where feasible.

Workplace Temperature

The use of PPE can lead to increased occurrence of heat-related illnesses and so ventilation will be provided in all enclosed buildings. Temporary shelters against the sun will be provided in areas where long term outdoor activities will be conducted. Easy access to water or refreshments will be provided.

Thermometers will be installed in areas where high heat and humidity occur to ensure there are no detrimental effects on employees. Employees working in areas of high temperature and humidity will be allowed regular breaks.

Manual Handling and Repetitive Motion

Lifting will be assisted with mechanical equipment where possible. All tools used will consider force requirements and should improve posture.

All workers will be allowed to take regular breaks from activities. OHS training will discuss safe lifting practises.

Workplace Height

All areas where workers are required to work at a height exceeding 2m above ground surface will be equipped with guardrails, midrails and toe boards. Only trained workers will use ladders and scaffolding and fall preventing devices will be used (lanyard, safety belt).

Workplace Illumination

The IFC guidance for minimum illumination requirements for various work environments are indicated in **Table 9.3** and will be used to assist with design of all facilities. Energy efficient lighting will be used where feasible.

Table 9.3 Minimum Workplace Requirements for Light Intensity (IFC, 2007)

Location/Activity	Light Intensity (lux)
Emergency light	10
Outdoor non-working areas	20
Simple orientation, temporary visits	50
Workspace with occassional visual tasks	100
Medium precision work (welding, machine work)	200
Precision work (reading, offices)	500
High precision work (difficult assembly)	1,000-3,000

Unexploded Ordinance's (UXO's)

DMZL in conjuction with ZMAC will ensure that all work areas are cleared off of UXO's.

9.3.10. Chemical Hazards

The occurrence of chemical hazards will be minimised by Denison through the procurement of less hazardous chemicals and reagents wherever feasible. Measures will be implemented to reduce spills and contamination as well as the number of workers exposed. Enough ventilation will be provided and chemicals storage areas bunded. Material Safety Data Sheets (MSDSs) displayed for all chemicals and reagents on site and available to all workers. All chemicals will be labelled, stored in highly secured places with adequate fire fighting equipment. Empty Containers after use of chemicals will be disposed in line with the Zambian legislation requirements.

Workplace Air

The monitoring of occupational radon and ionising radiation has been described in the Radiation Operation Management Protection Plan (ROMP) in **Appendix 14**. Handling of dry powdered reagents will be minimised to prevent dust release. All exhaust generation points will be equipped with ventilation.

Fires and Explosions

All storage areas for flammable materials and chemicals will be equipped with spark-proof fixtures. All chemicals with the potential to ignite during spills and mixing will be stored separately in the reagent stores.

Fuel storage tanks will be located at a distance from mine buildings or adjacent buildings will be constructed with flame impinging materials. The fuel storage areas will not directly face access points or emergency exit routes. Emergency fire fighting equipment will be installed at these facilities.

Corrosive, Oxidising and Reactive Chemicals

All corrosive, oxidising or reactive chemicals will be stored away from flammable material/liquids or incompatible classes (acids and bases, oxidizers and reducers) in areas surrounded by a bund wall.

No handling of these chemicals will be undertaken unless PPE is worn by trained employees worker.

First aid stations, eye washes and emergency showers will be provided in areas where these chemicals are stored or used (leach pads, process plant, reagent stores).

9.3.11. Biological Hazards

A biological hazard plan will be developed to classify any hazards experienced on site. All biological hazards will be grouped as described in **Table 9.4**.

Table 9.4 Biological Hazard Classification Scheme

Classification	Description of Biological Agents
Group 1	Unlikely to cause human disease with control measures similar to hazardous or reactive chemical substances
Group 2	Can cause human disease and are thereby likely to require additional controls, but are unlikely to spread to the community
Group 3	Can cause severe human disease and affect workers with a risk of outbreak to the community which has effective prophylaxis or treatment available and require extensive additional controls
Group 4	Can cause severe human disease and seriously affect workers with a high risk of spreading to the community with which there is usually no effective prophylaxis or treatment available and require very extensive additional controls.

Emergency response procedures for biological hazards that may occur on the mine site will be developed by the emergency medic in conjunction with local health authorities.

Malaria is a common occurrence and precautionary prophylactics shall be provided for volunteer employees by the mine medical centre. Employees will be advised on malaria prevention measures and may be provided with mosquito nets. All mine accommodation will be equipped with mosquito nets and repellent spray.

The main mine building will be incorporated into a regular spraying program to eradicate the incidence of malaria and reduce lost time.

Training on health and cleanliness issues will be provided through the SHE Department.

Any measures/activities encouraging the growth of mosquitoes and flies will be reduced e.g ponds, stagnant runoff.

Waste disposal as part of the Waste Management Plan will prevent the accumulation of biodegradable waste that may attract rats or other vermin.

9.3.12. Employee Health - General

Denison will provide an onsite medical centre to deal with mining emergencies. The medical facility will be equipped with medical material, medicines and vaccines.

Pre-employment and regular medical examinations will be carried out on all mine employees. As a minimum, the annual baseline medical examination would include the following:-

- A short medical history of the employee and his family history;
- Full occupational history of the employee;
- Signature of the employee to state that the above information is accurate and correct;
- Examination of:-
  - Weight
  - Height
  - Blood pressure
  - Pulse
  - Urine test
  - Eye Test (Snellen Chart)
  - Chest X-ray (large 35 cm x 43 cm) indicating date and name of employee on X-ray plate
  - Audiometry test - physical and visual inspection of both ears
  - Lung function
  - Cardio-respiratory examination (general physical examination)

This examination will probably be performed at a medical facility in Siavonga. Denison would facilitate these examinations if no facility was available in Siavonga.

Urinalysis surveys would be conducted to monitor the employees that have been exposed to ionising radiation through maintenance activities e.g. the U_3O_8 concentrate packing house; or have been routinely exposed to airborne uranium ore dust. Shows the frequency analysis of employees exposed to varying levels of radiation.

Table 9.5 Frequency of Urinalysis for Different Employee Groups

Employee Groups	Frequency of Urinalysis
Ore Preparation Area	As required in the regulatory standards
Highly radioactive areas E.g. concentrator, uranium oxide concentrate handling and packaging, crushing, leach pads, sample plant and scale laboratory	Every 2 weeks during production
Other facilities	Every month
None production phase where exposures exceed 25% of the DAC value	Every 2 weeks
Non-routine work e.g. Radiation Work Permits	Non-routine analysis
Individual exposure, exposed to airborne uranium or ore dust concentrations that exceed the 25% of the DAC level.	Non-routine analysis

The procedures for urinalysis are discussed in the ROMP in **Table 9.5** above.

Well-equipped sanitary facilities will be provided to employees. Workers will be encouraged to wash or shower frequently, particularly those employees exposed to dust, chemicals or pathogens.
Employees will be informed and counselled with regard to HIV/AIDS to reduce the further spread of the disease.

The emergency medic will maintain a record of employee medical examinations, specific surveillance records and medical history at the mine medical centre.

9.3.13. Monitoring

Regular monitoring of the success of OHS procedures will be conducted through:-

- Safety inspection, testing and calibration exercises;
- Working environment surveillance records;
- Surveillance of workers health; and
- Monitoring of training events and exercises.

A system of reporting occupational accidents and diseases will be developed. This will be the responsibility of the SHEO and the medical centre. Reporting of all occupational accidents, diseases and dangerous occurrences will be done to the department supervisor, medical centre or the SHE Department immediately. An investigation will be conducted and an incident report filed.

Environmental monitoring records and templates will be developed by the SHEO. These templates will be used to record samples collected, sampler, sampling time, field parameter records and details on the pre-treatment of samples. Sampling photos will be taken during each sampling event as they are an important visual record of the changes that occur at sampling sites over time.

The ESO will maintain records of all significant environmental and safety matters, including but not limited to accidents, monitoring data, spills, fires and other emergencies. This data will be used to evaluate and improve the efficiency and effectiveness of the Safety, Operation and Environment Health (SHE department) environmental health and safety programme.

Health and safety statistics will be reported on at Management Meetings and included in monthly and annual mine environmental reports.

9.4. Environmental Monitoring Plan

Denison will implement an Environmental Monitoring Plan in and around the mine site in accordance with the requirements of the environmental and mining legislation of Zambia. The environmental monitoring will include the following:-

- Surface Water;
- Groundwater;
- Air Emissions;
- Radon;
- Radiation;
- Noise;
- Vibration;
- Workplace Environment;
- Erosion and Soil Fertility; and
- Habitat Management.

Monitoring programs dealing with ionising radiation and radon are described in the Radiaton Operation Managment Plan (ROMP) as part of the Radiation Management Plan.

All environmental monitoring will be conducted by suitably trained and experienced personnel in the SHE Department. The environmental monitoring program will enable the impact of mining operations to be quantified and environmental performance evaluated.

Monitoring data records will be kept by the SHEO and easily accessible during inspection and auditting exercises. A database of monitoring sites will be maintained, with GPS coordinates, regular photographs of site conditions and field record sheets will be developed by the SHE department. This database will be useful during reporting purposes.

9.4.1. Surface Water Monitoring

There will be various types of water on site which have been described in more detail in the Mine Water Management Plan (**Appendix 7**) and **Section 9.6**.

The location of surface water monitoring sites will be chosen with respect to:-

- Understanding background levels and seasonal fluctuations;
- Monitoring mine effluent and process water streams with respect to effluent standards;
- Ensuring the ‘no discharge’ status of the mine operations and all facilities; and
- Prevention of contamination of the natural aquatic environment by mining activities.

9.4.1.1. Water Quality Standards

Denison will adopt monitoring in compliance with standards from Zambia, WHO and the IFC. **Table 9.6** and **Table 9.7** display the Zambian effluent and wastewater discharge parameters for the aquatic environment and the Zambian drinking water standards. Denison will strive to achieve these background levels.

Table 9.6 Zambian Effluent and Wastewater Parameters

	PARAMETER	EFFLUENT AND WASTE WATER INTO AQUATIC ENVIRONMENT
A. Physical		
1	Temperature (Thermometer)	40 °C at point of entry
2	Colour (Hazen Units)	20 Hazen units
3	Odour and Taste (Threshold odour number)	Must not cause any deterioration in taste or odour as compared with natural state
4	Turbidity (NTU scale)	15 Nephelometer turbidity units
5	Total suspended solids (Gravimetric method)	100 mg/l must not cause formation of sludge or scum in receiving water
6	Settleable matter sedimentation in 2 hours (Imhoff funnel)	0.5 mg/l in two hours. Must not cause formation of sludge in receiving water
7	Total Dissolved Solids (Evaporation @ 105 C and Gravimetric method)	3000 mg/l The TDS of wastewater must not adversely affect surface water
8	Conductivity (Electrometric method)	4300 *m*S/cm
B. Bacteriological		
9	Total Coliform/100 ml (Membrane Filtration method)	2500°
10	Faecal Coliform/100ml (Membrane Filtration method)	5000°
11	Algae /100 ml (Colony counter)	1000 cells
C. Chemical		
12	pH (0-14 scale) (Electro-metric method)	6.0 - 9.0
13	Dissolved oxygen mg Oxygen / Litre (Modified	5 mg/l after complete mixing extreme

	PARAMETER	EFFLUENT AND WASTE WATER
14	Chemical Oxygen Demand (COD) (Dichromat method)	COD based on the limiting values for organic carbon 90 mg /l average for 24 hours
15	Biochemical Oxygen Demand (BOD) (Modified Winkler method and Membrane Electrode method)	50 mg /l (mean value over 24 hours period) According to circumstances in relation to the self-cleaning capacity of waters
16	Nitrates (NO3 as nitrogen) (Spectrophotometric method and electrometric method)	The nitrates burden must be reduced as far as possible according to circumstances: watercourse 50 mg/L; Lakes 20 mg/l
17	Nitrite (NO2 as nitrogen/L pectrophotometric	2.0 mg NO2 as N/l
	sulphanilamide)	
18.	Organic Nitrogen (Spectro-photometric method NKjeldal)	5.0 mg/L Mean* (* the % of nutrient elements for degradation of BOD should be 0,4 - 1 % for phosphorous (different for processes using algae)
19	Ammonia and Ammonium (Total) (NH3 as N/L) (Nesslerization method and Electrometric method)	The burden of ammonium salts must be reduced to 10 mg/l (depending upon temperature, pH and salinity)
20	Cyanides (Spectrophoto-metric method)	0.2 mg/l
21	Phosphorous (Total) (PO4 as P/L) (Colori-metric method)	Treatment installation located in the catchment area of lakes: 1.0 mg/l; located outside the catchment area: reduce the load of P as low as possible (PO^4 = 6 mg/l
22	Sulphates (Turbidimetric method)	The Sulphate burden must be reduced to 1500 mg/l
23	Sulfite (Iodometric method)	0.1 mg/l (presence of Oxygen changes SO^3 to SO^4)
24	Sulphide (Iodometric and electrometric method)	0.1 mg/l (depending on temperature, pH and dissolved O^2)
25	Chlorides CI/L (Silver nitrate and Mercuric nitrate) waters	Chloride levels must be 800 mg/l
26	Active chloride Cl2/L (Iodometric method)	0.5 mg/l
27	Active Bromine (Br2/L)	0.1 mg/l
28	Fluorides F/L (Electro-metric method and Colori-.metric method with distillation)	2.0 mg/l
29	Aluminium compounds (Atomic Absorption method)	2.5 mg/l
30	Antimony (Atomic absorption method)	0.5 mg/l
31	Arsenic compounds (Atomic Absorption method)	0.5 mg/l
32	Barium compounds (water soluble concentration) (Atomic Absorption method)	0.5 mg/l
33	Beryllium salts and compounds (Atomic Absorption method)	0.5 mg/l
34	Boron compounds (Spectro photometric method-curcumin method)	0.5 mg/l
35	Cadmium compounds (Atomic Absorption method)	0.5 mg/l
36	Chromium Hexavelant,Trivalent (Atomic absorption method)	0.1 mg/l
37	Cobalt compounds (Atomic Absorption method)	0.1 mg/l
38	Copper compounds (Atomic Absorption method)	1.5 mg/l
39	Iron Compounds (Atomic Absorption method)	2.0 mg/l
40	Lead compounds (Atomic Absorption	0.5 mg/l

	PARAMETER	EFFLUENT AND WASTE WATER
	method)	
41	Magnesium (Atomic Absorption method and flame photometric method)	500 mg/l
42	Manganese (Atomic Absorption method)	1.0 mg/l
43	Mercury (Atomic Absorption method)	0.002 mg/l
44	Molybdenum (Atomic Absorption method)	5.0 mg/l
45	Nickel (Atomic Absorption method)	0.5 mg/l
46	Selenium (Atomic Absorption method)	0.02 mg/l
47	Silver (Atomic Absorption method)	0.1 mg/l
48	Thallium (Atomic Absorption method)	0.5 mg/l
49	Tin compounds (Atomic Absorption method)	2.0 mg/l
50	Vanadium compounds (Atomic Absorption method)	1.0 mg/l
51	Zinc compounds (Atomic Absorption method)	10 mg/l
D. Organics		
52	Total hydrocarbons (Chromatographic method)	10.0 mg/l
53	Oils (Mineral and Crude) (Chromatographic method and Gravimetric method)	5.0 mg/l
54	Phenols (steam distillable)	0.2 mg/l
	(Colorimetric method) (Non-steam distilled)	0.05 mg/l
55	Fats and saponifiable oils (Gravimetric method and chromatographic method)	20 mg/l
56	Detergents (Atomic) (Atomic Absorption Spectrophometric)	2.0 mg/l (Detergents should contain at least biodegradable compounds)
57	Pesticides and PCB's (Total) Chromatographic method)	0.5 mg/l
58	Trihaloforms (Chromatographic)	0.5 mg/l
E. Radioactive Materials		
59	Radioactive materials specified by International accepted Atomic Energy Agency	No discharge accepted. Not permitted

The Zambian environmental regulations shown above do not allow radioactive material to be discharged off site. Zambian drinking water standards are attached below in **Table 8.7**

Table 9.8 and **Table 9.9** describe guideline standards for all water used as a drinking water source (surface water or groundwater) from the IFC and WHO respectively. **Table 9.10** describes the IFC indicative values of treated sanitary sewerage discharges. These may act as useful guidelines for discharge from the sewerage treatment facility.

Table 9.7 Zambian Drinking Water Standards

Parameter	Concentration
Asbestos	7 million fibres/l
Alkalinity (CaCO3)	500mg/l
ammonia	0.5mg/l
Aluminium	0.05-0.2mg/l
Arsenic	0.05mg/l
Bacteria faecal coliform count	0/100ml (NIL)
Barium	1mg/l
Boron	5mg/l
Cadmium	0.005mg/l
Calcium	200mg/l
Caesium	50Bq/l
Chloride	250mg/l
Chromium	0.05mg/l
Colour	15TCU
Copper	1mg/l
Cyanide	0.2mg/l
Conductivity	1500□S/cm
Chlorine	50mg/l
Cobalt	1mg/l
Carbon Dioxide	N/A
Carbon Monoxide	1mg/l
Dissolved Oxygen	10-12mg/l
Fluoride (Fluorine)	1.5mg/l
Hardness (CaCO3)	120mg/l
Iodine	10Bq/l
Iron	0.3-1mg/l
Lead	0.05mg/l
Magnesium	150mg/l
Manganese	0.05mg/l
Mercury	1□g/l
Nitrate	10/mg/l
Nitrite	1mg/l
Oil and Grease	ND
pH	6.5-8.5
Phenol	0.02mg/l
Phosphates	0.4-5mg/l
Alpha-Radiation	0.02Bq/l
Beta-Radiation	0.19Bq/l
Selenium	0.01mg/l
Silver	0.05mg/l
Sodium	270mg/l
Strontium	10mg/l
Silica	N/A
Sulphate	500mg/l
Sulphide (H2S)	0.05mg/l
Total Dissolved Solids	500mg/l

Table 9.8 World Health Organisation Guidelines for Drinking Water Quality (WHO, 2006)

Parameter	WHO Criteria[1] mg/L	Parameter	WHO Criteria[1] mg/l
Ag	NA	Mo	0.07
Al**	0.2	Na**	200
As	0.01	Ni	0.07
Ba	0.7	Nitrate	50
Boron	0.5	Nitrite	0.2
Ca**	300	Pb	0.01
Cd	0.003	pH**	6.5 to 9.5
Chlorine	5	S	NA
Chloride**	250	Sb	0.02
Co	NA	Se	0.01
Cr	0.05	Sn**	NA
Cr6+	NA	SO_4^{2-}**	250
Cu	2	Total Cyanide	0.07
Fe**	0.3	Total Dissolved Solids**	1200
Free Cyanide	NA	Hardness**	200
H_2SO_4	NA	Total Fluorides	1.5
Hg	0.006	Uranium	0.015
Mg	NA	Zn**	3
Mn**	0.4	Total and Faecal Coliforms	0

[1] WHO Guidelines for Drinking-water Quality, 1st Addendum to 3rd Edition, 2006. ** Indicates aesthetic (non-health) parameters under the WHO Guidelines 2006. NA = Not applicable (no WHO value provided).

Table 9.9 World Health Organisation Guidelines for Drinking Water Guidelines (WHO, 2006)

Parameter	WHO Criteria[1] mg/L	Parameter	WHO Criteria[1] mg/l
Ag	NA	Mo	0.07
Al**	0.2	Na**	200
As	0.01	Ni	0.07
Ba	0.7	Nitrate	50
Boron	0.5	Nitrite	0.2
Ca**	300	Pb	0.01
Cd	0.003	pH**	6.5 to 9.5
Chlorine	5	S	NA
Chloride**	250	Sb	0.02
Co	NA	Se	0.01
Cr	0.05	Sn**	NA
Cr6+	NA	SO_4^{2-}**	250
Cu	2	Total Cyanide	0.07
Fe**	0.3	Total Dissolved Solids**	1200
Free Cyanide	NA	Hardness**	200

Parameter	WHO Criteria[1] mg/L	Parameter	WHO Criteria[1] mg/l
H_2SO_4	NA	Total Fluorides	1.5
Hg	0.006	Uranium	0.015
Mg	NA	Zn**	3
Mn**	0.4	Total and Faecal Coliforms	0

[1] WHO Guidelines for Drinking-water Quality, 1st Addendum to 3rd Edition, 2006. ** Indicates aesthetic (non-health) parameters under the WHO Guidelines 2006. NA = Not applicable (no WHO value provided).

Table 9.10 Indicative Values for Treated Sanitary Sewage Discharge (IFC, 2008)

Pollutant	Guideline Value
pH	6 – 9 S.U
COD	150mg/l
BOD_5	125mg/l
Oil and Grease	10mg/l
Total Nitrogen	10mg/l
Total Phosphorus	2mg/l
Total Suspended Solids	50mg/l
Total Coliform Bacteria	400 MPN/100ml

9.4.1.2. Surface Water/Effluent Discharge Monitoring Sites

Construction Phase

The implementation of water monitoring as early as possible in the construction phase is of high importance as this phase is when the highest level of site disturbance occurs. A regular sampling program in this initial phase will provide more information on the background levels and seasonal chemistry and flow changes.

The location of these sites is quite difficult as drainage over the project site is seasonal and will be highly modified during construction activities. The natural uncomtaminated runoff channels are likely to be diverted around facilities like Dibwe pit, the WRDs, the leach pads and the process plant. These diversions will be done by profiling drainage away from the site.

Long term monitoring sites on the Machinga, Nahunwe and Namatelo Rivers will be monitored for background variations or patterns.

Sedimentation ponds will be constructed to collect the uncontaminated surface runoff diverted away from major facilities. The water will be settled prior to its runoff into the environment.

Contaminated water will be collected in periphery drains and stored in the Emergency Containment Pond (ECP). This water will be used for the process plant.

Denison will monitor the quality of surface water and effluent streams at 12 initial locations across the mine site. Sampling will be conducted according to internationally accepted standards (refer to Appendix 11). The location of the monitoring sites is described in **Table 9.11**. These sites should be located in areas that will not be disturbed during construction activities.

Table 9.11 Description of Surface Water and Effluent Monitoring Sites at Mutanga (Construction)

Monitoring Site	Location of Monitoring Sites
SW 1	Nahunwe River, upstream of all Dibwe operations (natural)
SW 2	Machinga River, north of Mutanga (natural)
SW 3	Namatelo River, downstream of all Dibwe operations (natural)
SW 4	Combined borehole groundwater at RWP
SW 5	Run-off from the workshops, wash bays and fuel storage areas – mine drains.
SW 6	Run-off from the ROM Pad, transient stockpile and leach pads – mine drains to Emergency Containment Pond (ECP) Mutanga.
SW 7	Run-off from the ROM Pad, transient stockpile and leach pads – mine drains to Emergency Containment Pond (ECP) Dibwe.
SW 8	Runoff (sedimentation pond) from around WRDs - Mutanga
SW 9	Runoff (sedimentation ponds) from around WRDs – Dibwe
SW 10	Dewatering Dibwe open pit – DWP
SW 11	Dewatering Dibwe open pit – DWP
SW 12	Runoff from catchment pond – process plant
SW 13	Runoff from around Operations Camp (mine drain)- sedimentation pond overflow.

Long term monitoring of environmental changes to aquatic environments could be conducted by incorporating sites further downstream of SW 1 to SW 3.

The location and appropriateness of the surface water and effluent monitoring sites will be reviewed after the first 6 months of the construction phase. The sites will be updated or changed if required.

Surface runoff from the Operations Camp will be drained to one facility equipped with an oil trap. Natural soakaway of the runoff will be encouraged.

Operational Phase

Some of the main site activities will only begin during operations and process plant start-up. Therefore some water sampling sites may need to be chosen during operations.

Ongoing exploration activities may mean that new sources of water may be affected by temporary exploration camps. All new surface water sites will be incorporated into the monitoring program which will increase the baseline database and identify contamination.

9.4.1.3. Monitoring Frequency and Analytical Parameters

The collection of samples and the monitoring of SW 1, SW 2 and SW 3 will occur as start early to increase the database of baseline information. Sedimentation ponds and drainage systems will be developed after the initial site clearance activities. Therefore all sampling sites will have been commissioned and active within the first three months of site clearance. The proposed monitoring frequency and sample analyses at each site are shown in **Table 9.12**.

Table 9.12 Monitoring Sites and Frequency

Monitoring Site	Monitoring Frequency	Comment
SW 1	Six times per year	Monthly for 6 months
SW 2	Six times per year	Monthly for 6 months
SW 3	Six times per year	Monthly for 6 months
SW 4	Quarterly	Monthly for 6 months
SW 5	Monthly	Monthly for 6 months
SW 6	Monthly	Monthly for 6 months
SW 7	Monthly	Monthly for 6 months
SW 8	Monthly	Monthly for 6 months
SW 9	Monthly	Monthly for 6 months
SW 10	Monthly	Monthly for 6 months
SW 11	Monthly	Monthly for 6 months
SW 12	Monthly	Monthly for 6 months
SW 13	Monthly	Monthly for 6 months

Full suite analytical assessments are recommended for the first 6 months.

9.4.1.4. Monitoring Equipment and Procedures

Denison will endeavour to obtain equipment to conduct field measurements. A wide range of field and portable equipment exist. Some reliable manufacturers are Horiba and Hanna. A portable multi-parameter (pH, EC, temperature, dissolved oxygen etc) probe will be important for assessing field conditions at the time of sampling. Other portable instruments that may be used include turbidity, salinity and BOD_5 meters. The mine site is fairly remote so on-site coliform analysis of water samples is recommended (Colilert System).

Field measurements will be done for pH, EC and temperature as a minimum. Field measurements of EC and pH will be conducted at site SW 05 up to SW 13.

Safety gloves, waders and safety boots will be provided for all sampling activities. A safety briefing will be conducted prior to all site excursions being undertaken.

Sampling will be conducted by the SHEO in accordance with international standards. Sampling equipment will be calibrated in accordance with manufacturers guidelines and standard solutions.

9.4.1.5. Quality Assurance/Quality Control (QA/QC) Analyses

The mine laboratory will be equipped for and be proficient in the analysis of the parameters for a full suite assessment. The above analyses will be subject to quality assurance/quality control (QA/QC) procedure which will be to perform duplicate analyses on 5% of the samples and to carry out additional checks using standard reference materials and spiked samples. QA/QC sample analysis will be performed through an independent accredited laboratory on a quarterly basis.

9.4.1.6. Flow Rate Measurement

The discharge of effluent or flow of water from SW 5 to SW 13 can be measured using installed flow meters

The surface streams will require the continuation of flow monitoring using waders and in flow channel measurements.

9.4.1.7. Stream Sediment

Samples of stream sediment will be collected twice a year (dry and wet seasons) from the sampling sites. At the sampling points located where effluent discharges into the stream the sample will be collected 5m downstream. At least 1kg of sample will be collected in a plastic bag or jar and submitted for analysis. The water will be drained out of the bag as much as possible.

A full suite analysis of total metals and abundant minerals will be conducted by the mine lab or an independant accredited lab if the facilities are not available. Substrate analysis to determine particle size distribution will also be conducted.

Table 9.13 Sediment Sampling Points

Sampling Site	Location	Sampling Frequency
SS 1	Same site as SW 1	2 times per year
SS 2	Same site as SW 2	2 times per year
SS 3	Same site as SW 2	2 times per year

9.4.2. Groundwater Monitoring

9.4.2.1. Groundwater Quality

Groundwater contamination will most likely occur as a result of seepage and infiltration of process spills and leaks from the process plant, and seepage through the base of the leach pads and WRDs.

There are no groundwater standards or guidelines related to groundwater quality. Denison proposes to use baseline data and an intensive phase of data collection during the construction phase as an indication of baseline groundwater conditions.

Groundwater monitoring will be conducted to identify contamination from waste storage facilities, processing facilities and landfills.

9.4.2.2. Groundwater Monitoring Boreholes

Groundwater monitoring boreholes will be located in areas that will be monitored continuously throughout the mine life. Denison will install 13 monitoring boreholes across the mine site to monitor groundwater quality as described in **Table 9.14**.

Table 9.14 Location of Groundwater Monitoring Sites

Monitoring Site	Location
GW 1	4 boreholes for Dibwe leach pad area; east, west, north and south
GW 2	
GW 3	
GW 4	
GW 5	2 boreholes for Dibwe WRDs
GW 6	
GW 7	4 boreholes for Mutanga leach pad area
GW 8	
GW 9	
GW 10	
GW 11	2 boreholes for Mutanga WRD

Monitoring Site	Location
GW 12	
GW 13	4 boreholes around the process plant to monitor leaks
GW 14	
GW 15	
GW 16	
GW 17	Kashundi Village borehole

The installation and location of the borehole will be conducted by an experienced hydrogeologist. The borehole will be cased to prevent failure or collapsing and slotted casing will be located at the optimum zone of groundwater flow, if feasible. The boreholes will be equipped with an outer casing at surface that will have a lockable lid. This will prevent use of the boreholes by the local populations as well as loss of the holes due to obstructions.

In addition peizometer monitoring stations will be installed in the starter wall of the RWP.

There will be no underground fuel storage or waste storage facilities. Two monitoring sites will be installed around the process water pond to identify leaks in the lining.

9.4.2.3. Monitoring Frequency

The boreholes will be monitored on a monthly basis from the start of construction and will undergo full analytical testwork for at least 6 months. The sample collection can then be turned to quarterly sampling.

Collection of groundwater samples will be done using a bailer or lowering a small gland pump into the borehole and extracting a water sample. Similar measures to those used for contamination prevention when sampling for surface water will be applicable for groundwater samples.

It is anticipated that further groundwater boreholes will be added during mine operations. These boreholes may be used for further monitoring or water use for the local communities. These sites will be incorporated into

9.4.2.4. Groundwater Levels

Borehole water levels will be measured and recorded during monitoring events. Denison will obtain a portable dipmeter for these measurements or equip the boreholes with continuous monitoring devices. Changes in groundwater levels can indicate increased flows and data will be regularly reviewed. The water models of the site are being updated continuously throughout the project.

9.4.2.5. Quality Assurance/Quality Control (QA/QC) Analyses

QA/QC analyses for groundwater samples are the same as those proposed for surface water and effluent streams.

9.4.3. Air Monitoring

An air monitoring program attempts ways of preventing, mitigating or reducing impacts of air emissions to human health, safety and the environment. The monitoring program will be started as early as possible prior to site clearance and construction activities.

As part of the monitoring program the following are considered:-

- Regulatory requirements;
- Significance of the source;
- Location of emittance and location of other sources;
- Location of sensitive receptors;
- Existing ambient air quality and potential for degradation; and
- Feasibility and cost of implementing available technology for prevention or control of emissions.

Sensitive receptors are considered to be nearby settlements which would be the relocated Kashundi Village.

All aspects of air monitoring in conjunction with radon and radioactive dust measurement will be covered in the Radiation Management Plan in **Section 9.4**.

9.4.3.1. Air Quality Standards

The ambient air quality standards for Zambia are shown in **Table 9.15**. The industry specific guidelines which may be applicable to the project are shown in **Table 9.16** recommended by the IFC, 2005 (**Table 9.17**) provide guideline levels for sulphur, nitrogen and ozone gases in the atmosphere. Particulate matter (dust) guidelines for material less than 10 or 2.5μm in diameter are provided.

Table 9.15 Air Contaminant Standards of Ambient Air

Parameter	Reference Time		Guideline Limit ($\mu g/m^3$)
Sulphur Dioxide (SO_2)	10 mins		500
	1 hour		350
Sulphur Dioxide (SO_2) in conjunction with Total Suspended Particles (TSP) and PM_{10}	SO_2	24 hours	125
		6 months	50
	TSP	24 hours	120
		6 months	50
	PM_{10}	24 hours	70
Respirable Particulate Matter PM_{10}	PM_{10}	24 hours	70
Ambient Lead	3 months		1.5

Source: Air Pollution Control (Licensing and Emissions Standards) Regulations, 1996

Table 9.16 Industry Specific Air Emission Standards

Combustion Units	Parameter	Standard
Coal Fired <10MW	Dust	150mg/Nm3
	SO	2,000mg/Nm3
Coal Fired	Dust	50mg/Nm3
	SO_2	1,000mg/Nm3
	CO	175mg/Nm3

Source: Air Pollution Control (Licensing and Emissions Standards) Regulations, 1996

Table 9.17 Ambient Air Quality Guidelines (IFC, 2005)

Emissions	Averaging Period	Guideline ($\mu g/m_3$)
Sulphur Dioxide (SO_2)	24 hour 10 min	20 (guideline) 500 (guideline)
Nitrogen Dioxide (NO_2)	1 year 1 hour	40 (guideline) 200 (guideline)

Emissions	Averaging Period	Guideline (µg/m$_3$)
PM_{10}	1 year 24 hours	20 (guideline) 50 (guideline)
$PM_{2.5}$	1 year 24 hour	10 (guideline) 25 (guideline)
Ozone	8 hour daily max	100 (guideline)

Denison will implement an air monitoring program to ensure compliance with the ambient air quality standards. Denison will submit applications to MSD and ECZ for permits to release gasesous emissions into the atmosphere.

Careful management of the process environment can minimise the generation of these gases. Detectors will be installed in all areas of the plant where these gases are generated respectively to alert operators of buildups and instigate evacuation procedures. Vents will be installed in the electrowinning circuit and ammonia scrubbed from emissions.

The dust generated from open pit mining activities is not expected to be very high external to the open pits based on the lack of blasting activities. Regular visual assessment of dust emissions will be conducted to ensure that the anticipated negligible impact of dust from these areas is accurate. If this is no longer the case a monitoring site will be installed and appropriate reduction measures implemented.

9.4.3.2. Monitoring Sites and Frequency

Three forms of air emissions will be measured during the monitoring program (gaseous emissions, dust particulate emissions and nuisance dust). Sites monitoring particulate dust are generally associated with employee occupational exposure. Nuisance dust is generally of larger sizes and contamination is visible. Gaseous emissions will be monitored throughout the site to monitor occupational conditions. The monitoring sites identified in the air quality monitoring program are described in **Table 9.18**.

Table 9.18 Air Monitoring Sites

Monitoring Site	Location
Particulate Dust	
PD 1	Excavator Operator – open pits
PD 2	Haul Truck Operator – open pits
PD 3	Plant Control Room
PD 4	ROM Pad sizing screens
PD 5	Mine Offices
PD 6	Operational Camp
PD 7	Leach Pad
Nuisance Dust	
ND 1	Upwind of the Mutanga WRD
ND 2	Downwind of the Dibwe WRD
ND 3	Downwind of Mutanga open pit
ND 4	Downwind of Dibwe open pit
ND 5	Kashundi Village
Gaseous Emissions (NOx, COx and SOx)	
GE 1	Process plant combustion facilities
GE 2	Boundaries of process plant

Occupational air quality and environmental (receptors) air quality will be monitored.

9.4.3.3. Monitoring Frequency and Parameters

Air quality monitoring will be conducted as described in **Table 9.19**.

Table 9.19 Air Quality Monitoring Frequency

Monitoring Site	Frequency	Parameters
PD 1	Quarterly	PM_{10}, Total Dust
PD 2	Quarterly	PM_{10}, Total Dust
PD 3	Quarterly	PM_{10}, Total Dust
PD 4	Quarterly	PM_{10}, Total Dust
PD 5	Quarterly	PM_{10}, Total Dust
PD 6	Quarterly	PM_{10}, Total Dust
PD 7	Quarterly	PM_{10}, Total Dust
ND 1	Quarterly	Total Dust
ND 2	Quarterly	Total Dust
ND 3	Quarterly	Total Dust
ND 4	Quarterly	Total Dust
ND 5	Quarterly	Total Dust
GE 1	6 times a year	SO_2, CO_2 and NO_2
GE 2	6 times a year	SO_2, CO_2 and NO_2

PD and ND sites will be monitored in January, April, July and October. GE sites will start monitoring and continue to be undertaken every other month.

For the development of accurate air quality models the frequency of monitoring would have to increase for all parameters (PD – monthly, ND – monthly, GE – fortnightly). Air modelling will be conducted for radioactive dust as described in the Radiation Management Plan.

The monitoring program will include new receptor sites where necessary.

9.4.3.4. Procedures and Equipment

All air monitoring should be conducted by trained and/or experienced personnel to ensure accuracy of the data.

Nuisance Dust

Dust buckets are located at monitoring sites in open areas to enable collection of dust fallout. The buckets are filled with water and copper sulphate or other chemical to prevent bacterial/algal growth. The dust buckets are deployed for a month and then the solids are filtered and weighed after drying. Dust equipment can be obtained from several suppliers.

Particulate Dust

Volunteer employees in the departments where monitoring is required will be incorporated into the quarterly monitoring program. The same person will be monitored every quarter. High volume portable pumps to measure occupational exposures (8 hour shitfs) are available from a wide number of sources. The pump sucks in air and any particulates absorbed will deposit onto a filter which is weighed and analysed in the laboratory.

Gaseous Emissions

Gas absorbant cartridges can be deployed to the atmosphere at the site for a period of two weeks. They are sheltered from the rain and direct sunlight. The cartidges are analysed for the total amount of gas absorbed. Samples have to be refrigerated and are usually only analysed by the supplier of the system. Portable gas monitoring devices can also be used in similar ways to the particulate dust measurement.

9.4.3.5. Quality Assurance/Quality Control (QA/QC) Analyses

The analysis of all samples collected will either be conducted in the mine laboratory or an identified independant accredited laboratory.

9.4.4. Noise Monitoring

A noise monitoring program will be implemented by Denison which will aim at identifying all sources of noise, classification of the hazard of these sources and the design of mitigation measures.

9.4.4.1. Noise Standards

Noise level guidelines are provided by IFC (IFC, 2007) for the sound levels created by various activities. Environmental and occupational noise guidelines are displayed in **Table 9.20**.

Table 9.20 Noise Limits for Various Working Environments (IFC, 2007)

Occupational Noise		
Location/Activity	**Equivalent Level LA_{eq}/8 hours**	**Maximum Level LA_{max}, fast**
Heavy Industry (no need for oral communication)	85 dB(A)	110 dB(A)
Light Industry (decresed demand for oral communication)	50-65dB(A)	110dB(A)
Open Offices, Control Rooms, Service Counters	45-50dB(A)	-
Individual Offices (no disturbing noise)	40-45dB(A)	-
Classrooms, Lecture Halls	35-40dB(A)	-
Hospitals	30-35dB(A)	40dB(A)
Environmental Noise		
Receptor	**Daytime 07:00-22:00 (1 hour LAeq (dBA))**	**Nighttime 22:00-07:00 (1 hour LAeq (dBA))**
Residential, Institutional, Educational	55	45
Industrial, Commercial	70	70
Receptors off-site	>3dB(A) increase from background	

During the construction phase noise surveys involving continuous 24 or 48hr continuous monitoring events will be conducted by experienced and trained personnel to provide a more representative averge noise level. All loud instantaneous noise will be removed during data analysis. All potential receptors (villages up to 3km around the mine project) will be monitored. Noise impacts will be measured

During the operational phase areas around the mine site will be monitored for occupational exposures.

9.4.4.2. Noise Hazards

The initial survey of the mine site will focus on all mine departments and assess all activities generating noise. This survey will be used to conduct the job hazard analysis for all employees around the site. A system of zone classifications will be developed for different noise brackets. An example of the noise zones is shown in **Table 9.21** below. Colour coding of these zones or respective signposting will be used in sites which fall within each bandwidth. Each zone will have its own mitigation and protection requirements. All employees will be trained on noise hazard identification and protection measures.

Table 9.21 Zone Classification of Generated Highest Noise

Zone Colour Code	Equivalent Noise Levels (8 hours)	Protection Measures
1 Blue	<45dB(A)	No protection measures required.
2 Green	85dB(A) ≥ 45dB(A)	Hearing protection required if remaining around noise generating equipment.
3 Red	>85dB(A)	Full hearing protection with noise reduction technology.

9.4.4.3. Noise Monitoring Sites and Frequency

After all of the mine activities have been classified a management plan can be developed for facilities in Zones 2 and 3. **Table 9.22** indicates some proposed noise monitoring locations.

Table 9.22 Location of Noise Monitoring Sites and Monitoring Frequency

Monitoring Site	Location	Frequency
NS 1	Loader operator	Quarterly
NS 2	Open Pit Employee	Quarterly
NS 3	Ore Preparation Area	Quarterly
NS 4	Generators	Quarterly
NS 5	Workshops	Quarterly
NS 6	Haul Truck Operator	Quarterly
NS 7	Offices (Secretary)	Quarterly
NS 8	Kashundi Village	Quarterly

As conducted in the monitoring of particulate dust volunteer employees will be monitored over a shift (or corrected for shift exposure).

The measurement of all receptor sites within a 3km radius of the mine project area will be conducted in the construction phase.

9.4.5. Vibration Monitoring

Ground vibration assessments will be conducted during the pre-construction phase to determine vibrational impacts on surface infrastructure and facilities. These measurements will be conducted by a skilled professional with experience in the assessment of ground movements and their potential impacts on surrounding infrastructure (mine and private).
Occupational vibrations can affect employee health and this shall be monitored. A wide variety of measurement devices for various equipment are commercially available. New equipment may specify vibration levels produced. There are currently no standards for

occupational vibration exposure. Denison will ensure that exposure reduction methods are implemented.

9.4.6. Workplace Environment

The occupational environment of all mine employees will be monitored in terms of the installed management measures. This monitoring will provide a part of the preventative maintenance program for mine equipment.

The monitoring of the following will be conducted:-

- Workplace ventilation – extractor fans, air conditions, exhaust vents etc;
- Workplace temperatures – thermometers installed will be monitored and readings recorded;
- Workplace drinking water supply – all facilities will be inspected and maintained on a monthly basis; and
- Workplace air quality – all emergency alarm devices will be checked.

The monitoring of the workplace environment will also include on-site climate/weather conditions. A continous monitoring weather station may be provided to measure rainfall, rainfall event intensities, max and min temperatures, wind direction and speed and evaporation. This information will aid with the prediction of extreme weather and emergency situations.

9.4.7. Habitat Monitoring

This monitoring program will cover activities described in the Conservation and Vegetation Plan (CVP) (**Section 9.8**). The aim of habitat monitoring over the project life is to determine any impacts that the project might have on the frequency of sightings over the project life.

A system for monitoring and recording sightings of species in designated conservation areas, along powerlines and in fallow/grassland areas of the project site will be developed by a specialist. The monitoring will record visual sightings and will be conducted by the SHEO.

Invasive species brought in through increased movement of persons and private planting activities will be monitored by the SHEO. Those existing on the site during project construction can be identified by a specialist. The monitoring will be conducted on a monthly basis.

9.5. Radiation Management Plan

The Radiation Management Plan has been developed in-line with the principles of radiation protection which were developed by the International Atomic Energy Agency (IAEA). The RMP was also developed in compliance with Zambian legislation, such as Act 85 of 2008 and Act No. 16 of 2005.

Act No. 85 of 2008 requires the development of the following plans:-

- “Employee Training Program” focusing on health, safety, education and environmental awareness **(Appendix 1**);
- “Radiation Safety Worker Training Program” **(Appendix 1**);
- “Storage and Transportation of Radioactive Material” Plan **(Appendix 4** and **(Appendix 5**);
- “Radioactive Waste Management Plan” **(Appendix 6**);
- “Mine Water Management Plan” **(Appendix 7**).

- "Radiation Operation Management Protection Plan" **(Appendix 14**);
- "Selection, Use and Maintenance of Personal Protective Equipment" plan for protective equipment for employees (**Appendix 15**);
- "Accidental Release of Radioactive Substances Management Program" incorporating mine employees, the public and government authorities**(Appendix 16**);
- "Environment, Health and Safety Education Program" for all persons living in the area adjacent to the Mutanga Project or working for DMZL (**APPENDIX 17**7); and
- "Quantitative Radiological Hazard and Safety Assessment" **(Appendix 17**).

9.6. Mine Water Management Plan

A Mine Water Management Plan (MWMP) has been developed to outline the strategies that Denison will adopt during the Mutanga Project.

A mine water balance has been developed for the mine site. The water balance includes all water sources (groundwater from dewatering boreholes, open pit runoff) and estimated volumes of water required. An initial assessment is described in the Mine Water Management Plan **(Appendix 7**).

The sustainable use of water sources will be considered e.g. to prevent depletion of underground aquifers and the mitigation of impacts on surrounding water users. Estimates of sustainable yield from the site aquifers were indicated to be in the region of 10l/s. Two aquifers were identified onsite all located in the vicinity of the Mutanga and Dibwe pit areas (natural hilly areas). A detailed hydrogeological survey has been conducted as part of the FS to describe required dewatering volumes and a schedule of implementation of the dewatering activities. The dewatering activities will occur during the construction phase.

All water users in the area adjacent to the mine site will inhabit Kashundi Village (6km). A monitoring borehole will be stationed at Kashundi to identify impacts on groundwater quality, height and volumes from the mine.

The water sources, uses and expected consumptions have been described in more detail in the MWMP. A preliminary mine water balance has been included in this plan.

Where feasible, clean water consumption will be reduced through the re-cycling of contaminated water and reduction of effluent volume. The methods of recycling and reusing water are discussed in the MWMP.

There will be no discharges to the environment of any contaminated water from the mine site with prior treatment. All highly contaminated water and process water will be recycled to the process plant and leaching facilities.

Contaminated water will be screened for levels of radiation through a water classification system. This will dictate the management methods incorporated into the management of the water on the Project site. These are all described in the MWMP.

9.7. Handling and Storage Plan (HSP)

9.7.1. Mine Stores

All chemicals and supplies for the project activities will be stored in the mine or reagents stores. Deliveries will be received at the mine stores and trucks will be offloaded within the covered areas.

Only trained personnel will deal with procurement, handling and storage of project supplies. These personnel will have access to MSDSs for all of the supplies stored on the mine site. Access to the mine stores will be restricted to authorised personnel to control stocks and prevent theft.

Incompatible materials will not be stored together. Liquids in storage will be stored in areas equipped with impermeable surfaces and bund walls with a capacity of 110% of the largest container.

All materials in the mine stores will be marked (colour coded) with their hazard ratings.

All spills and leaks will be immediately cleaned up to prevent mixing of compounds and hazardous working environments (slippery floors). These will be cleaned up by trained personnel and the material will be incorporated in the Waste Management Plan.

9.7.2. Reagent Stores

All lime and caustic soda will be stored in the reagents store located near the process plant. These reagents are considered to be highly hazardous and will be stored away from all liquids and flammable materials.

The reagents store will be an enclosed building equipped with impervious flooring and segregated bund walls. All spills will be contained within the reagent stores.

Handling of reagents during re-stocking of made-up reagent supplies (reagent storage tanks at process plant) will only be conducted by appropriately trained employees who will be equipped with gloves, safety boots, eye protection, overalls and dust masks.

All spills at the reagents stores will immediately be cleared up to prevent the spread of any contamination. The spilled reagents in the reagent stores will be mixed into the reagents make-up tank at the process plant.

9.7.3. Fuel Handling and Storage

The supply of fuel and its storage facilities will be contracted out. Contract agreements will provide for the internationally approved storage facilities with appropriate impermeable surfaces and at least 110% storage capacity (bund wall) of the largest fuel tank. Water in the containment area will be periodically removed and discharged through a fuel/oil water separator before being discharged.

Fuel/oil separators will be regularly monitored and cleaned and drains will be kept clear. All contaminated materials from the separator will be mixed with sand and incorporated into the Hazardous Waste Management Plan.

The facilities will be overseen by the mine stores manager. Access will be restricted to fuel storage areas and a fence will be erected as an enclosure with a gate and fuel pump. The mine stores manager will conduct all re-fueling activities.
Vehicle re-fueling areas will be equipped with impermeable surfaces to restrict soil contamination with spilled fuel. Drainage controls measures will direct run-off from the re-fueling bay to the facility fuel separator. Contaminated sludge and fuels will be treated as hazardous waste.

No other materials will be stored in the fuel storage area to minimize fire hazard.

The facility will be equipped with safety stop valves on the fuel pumps, emergency alarm buttons and emergency equipment such as fire extinguishers. There will be no smoking allowed around the fuel storage facilities. Any offenders will be punished.

An inventory of fuel delivery, volumes and consumption rates will be maintained by the mine stores. The inventory will be up-to-date to allow this supply of information to any emergency services.

There will be no underground fuel storage facilities on site.

Regular inspections of surface fuel storage tanks will be conducted by the SHEO to check the integrity of safety equipment, contamination prevention measures (fuel separator). This will minimise the risk of the contamination of soils and water through handling or leak/rupture of a fuel tank.

9.7.4. Mine Workshops

The following oil and battery handling and storage procedures will be implemented by Denison:-

- Oil handling and storage areas at the mine workshops will be equipped with impervious surfacing; containment, impact and fire protection and protection against the sun and rain;

- The workshop personnel (management, engineers, mechanics and operators) will receive training on oil handling and disposal. The programme will focus on environmental awareness, safe-handling procedures, spill reporting and spillage response/action;

- The oil handling and storage areas will undergo regular inspections by workshop management and the SHEO, which will determine service, maintenance and repair requirements;

- Batteries will only be stored and handled in designated areas; and

- The used oil and batteries will be incorporated into the Waste Management Plan;

- Battery storage areas will be equipped with impervious flooring, containment, impact and fire protection and protection against the sun and rain.

9.7.5. Spills, Leaks and Contamination Events

Spills may occur during delivery, truck offloading, site storage, handling, secondary storage facilities or transport activities. The SHE Department will develop product specific spillage handling procedures based on recommendations from MSDSs.

Spills of oils, greases and chemicals during handling and storage will be immediately cleaned up. The spilled materials will be neutralised as described in their respective MSDSs. The waste will be swept or wiped up and stored in a dedicated hazardous storage container. Oil, fuel and reagent contaminated substances are considered as hazardous materials for dedicated storage as part of the Waste Management Plan.

All accidental spills and leaks will be reported in weekly operational reports. All incidents will be immediately brought to the attention of the department supervisor and the SHEO.

All spills and leaks will be contained as soon as they have been identified to prevent the further spread of the spilled materials. Responsible personnel will be alerted as soon as possible and the procedures for the approriate spilled chemical implemented.

The spills of PLS, barren leachate, process solutions will all be treated as hazardous material containing ionising radiation.

Training will be given to employees handling oils, reagents and chemicals that will focus on potential risks, safe handling procedures, safety precautions, first aid, emergency response and appropriate disposal practices.

9.7.6. Materials Contaminated with Radiation

The management practises for handling accidental spills of radioactive substances are detailed in **Appendix 16**.

9.8. Waste Managment Plan (WMP)

Denison will implement a Waste Management Plan (WMP) for all mine waste generated throughout the project. This plan shall be implemented during the Construction Phase of the Project.

The WMP will be managed through the SHE Department and the

as soon as site clearance and construction activities begin. The plan will be managed through the Environment, Health and Safety Department with individual departments cooperating and implementing procedures identified for waste they have generated.

The classification of waste will determine the means by which it will be managed on site. All radioactive waste screening and management has been described in the Radioactive Waste Management Plan in **Appendix 6**.

The implementation of the waste management plan will be based on a waste management strategies to prevent, reduce, reuse, recover, recycle, remove and finally dispose of waste materials. All waste generated will be classified into types and assigned a management strategy e.g. old tyres can be recovered to mark road boundaries. Waste generation will be prevented as much as possible.

It is anticipated that Denison will require the development of a landfill to dispose of hazardous and non-hazardous waste. Denison will apply to Sodemi and ANDE for permits to create and dispose of waste in a landfill. The selection of the landfill site, lining requirements and disposal procedures should be designed by a suitable qualified person to prevent contamination of soils, surface water and groundwater resources. IFC guidelines for Waste Management Facilities will be applicable.

9.8.1. Waste Sources

During the early stages of the project construction phase the WMP will be updated by the Environment, Safety and Health Department, based on all of the reagents, chemicals, liquids and building materials that will be used at site.

These materials will be classified into types and will be incorporated into the general management actions described below. Waste specific management actions may be incorporated into the WMP based on information provided in the MSDS.

The sources of waste will be incorporated into the job hazard assessment in Section 9.2 above and be classified in the hazard coding system. All areas of storage of each waste material will be colour coded according to this system.

9.8.2. Waste Management Planning

The waste management planning for each waste product will be identified. These will include storage areas, waste generation volumes, removal logistics, incineration or disposal methods based on waste type. The SHEO will identify all waste streams on the mine site and determine volumes, storage requirements and treatment requirements. This will be done with all of the mine departments.

The SHE Department will be notified of all new products used on site through the Procurement Department and be provided with MSDS information. These products will then be included in the WMP.

9.8.2.1. Waste Prevention

The following procedures will be implemented by Denison to prevent waste generation:-

- The use of raw materials and inputs will be monitored by the respective department managers and research conducted on product substitutions that will produce less waste or hazardous and toxic materials. The Procurement Department will be responsible for all potential product identification and research;
- The Procurement Department and Mine Stores will generate an inventory of all stocked products on site. The inventory will include purchase dates, expiry dates, storage capacity information, stocks, use information and manufacturer information. The inventory will have a self-regulating nature and will alert Mine Stores or Procurement of low stocks and products nearing expiry date;
- The Mine Stores will be responsible for ensuring that products are used prior to their expiry date and update Procurement on stocks to prevent over-ordering;
- Supplies who require or accept reusable containers will be sought in preference to site disposal; and
- Waste segregation (bunding, separate rooms, container storage) in storage areas to prevent increased hazardous waste volumes.

9.8.2.2. Waste Recycling and Storage

The following procedures will be implemented by Denison:-

- Each department in conjunction with the SHEO will evaluate waste production processes and identify potentially recyclable materials;
- Wherever feasible products that be be reintroduced into processing activities will be conducted (e.g. reuse of activated carbon);
- Denison will investigate and identify external markets for recycling by other industrial processing operations (e.g. waste exchange) to produce cleaner waste (returning waste oil to supplier for reprocessing);
- The SHE department will develop recycling objectives for the mine site and formalise tracking of waste generation and recycling rates; and
- Provide training and incentives to employees in order to meet objectives, in the form of an awards or benefits scheme.

9.8.2.3. Waste Disposal and Treatment

Denison will implement the following procedures:-

- All disposal and treatment of waste will avoid contamination impacts to human health and the environment;
- The SHE Department will design on-site biological, chemical or physical treatment of each specific waste to render it non-hazardous for disposal (e.g. incineration of oil contaminated cloths to allow landfill disposal of ash, use of waste oil to power these high temperature incinerators);
- The SHE will conduct research into the licensed facilities available around the project area for the treatment and/or disposal of waste (properly designed, permitted and operated landfills or incinerators designed for the respective type of waste); and
- The SHE will research bioremediation for some of the wastes that may be conducted on-site.

9.8.3. Waste Separation

Denison will implement a waste separation management system in order to maximise recycling and reuse opportunities and minimise volumes of waste generated.

At all waste generation sites non-hazardous and hazardous wastes will be separated. Non-hazardous wastes will be further classified into glass; plastics; biodegradeable; scrap metal, wood and rubber. A series of coded bins (old fuel or oil barrels) will be provided in areas like the mine stores, reagent stores, workshops, mine camp and reagent mixing areas. The waste separation system will be described to all employees during OHS training.

A means of waste collection and transfer to storage or disposal sites will be developed by Denison and the persons responsible identified. The SHE Department will regularly monitor all waste management practises.

9.8.4. Types of Waste

There will be the following forms of waste on the Mutanga mine site:-

- General Non-Hazardous Waste; and
- Hazardous Waste.

General Non-Hazardous Waste

A waste material is described by the IFC as any solid, liquid or gas that will be disposed of through disposal, recycling, burning or incineration. Wastes may be a byproduct of a manufacturing process or an obsolete commercial product which is no longer useable and requires disposal.

Solid non-hazardous waste generally includes any refuse or garbage waste. Examples are domestic trash and garbage; inert construction / demolition materials; refuse (metal scrap, empty containers); and residual waste from industrial operations (boiler slag, clinker, fly ash). All containers of waste or products considered hazardous or packaging of these products are treated as hazardous waste.

Hazardous Waste

According to the IFC, hazardous waste consists of hazardous materials (Hazmats) such as explosives; compressed gases; flammable liquids; flammable solids; oxidising substances; toxic materials; radioactive materials and corrosive substances. Hazmats pose a risk to human health, property and the environment based on their physical or chemical characteristics.

9.8.5. Waste Geochemical Characterisation

A geochemical characterisation of waste produced from the mining facilties (sludge from the water treatment plant, waste rock, leached ore) is used to classify these materials.

These materials will all be classified during the final design of the Project.

Ongoing geochemical characterisation of any new wastes, during operations, generated at site will be conducted to identify the type of waste. Waste sludge generated from the water treatment plant will be assessed once in operation.

9.8.6. General Non-Hazardous Waste

The waste will be stored in secure areas. Significant quantities of scrap metal and empty containers will be generated. These should be sold or recycled to minimise the amount stored at the mine. All the industrial waste (building materials, scrap concrete etc) will be disposed of through identified options for each waste (road aggregate).

Scrap metal dealers will be located to purchase scrap metal from the mine. Used equipment dealers will be encouraged to remove waste materials.

Reusable materials such as empty drums and timber will be reused by the mine, sold or given away. Used tyres will be painted by the mine and used to mark the edges of roads, bends, operational areas and accident black spots.

Non-hazardous biodegradeable waste will be composted on-site at the mine nursery for use in re-vegetation programs.

9.8.7. Hazardous Waste

All hazardous (reactive, radioactive, corrosive and toxic) materials or substances will be stored in dedicated storage areas and in clearly labelled containers or vessels where applicable. Fire protection systems and secondary containment will be provided to the storage area to prevent fires or the release of hazardous materials to the environment. All disposal methods and sites for hazardous waste disposal will be finalized with the ECZ.

The contracts of contractors hired to treat and remove hazardous waste will require proof of their capacity to do so and ensure the contractor is compliant with international best practices for each waste.

The handling, storage, transport and treatment of hazardous waste will be done in compliance with the legislation of Zambia and applicable international standards and guidelines.

Hazardous waste is frequently generated in small quantities by many projects through a variety of activities such as equipment and building maintenance activities (e.g. spent solvents, oily rags, empty paint cans, chemical containers, used lubricating oil, used batteries, lamps or lamp ballasts. Solid and liquid waste from the mine laboratory will be considered to be hazardous material.

Sanitary wastewater from ablution facilities is considered as potentially hazardous. This waste will be treated in septic tanks.
Medical waste will be classified as hazardous waste due to its toxic and potentially dangerous natures. This waste will be incinerated either on-site or off-site.

9.8.7.1. Waste Storage

The following procedures will be implemented:-

- Management and handling of hazardous wastes will be conducted by trained employees. Access to storage areas will be restricted to these employees;
- All employees will be allowed access to information on compatibility (MSDSs), health and safety information and informed of waste labelling systems;
- A map of all waste stored in the hazardous storage building will be developed;
- The waste will be colour coded through the job hazard identification program and clearly marked in the storage area;
- There will be no underground storage tanks or piping of hazardous waste;
- No commingling of incompatible wastes will be allowed. Secondary storage areas will be provided with bunding (110% of largest storage container) and impermeable surfaces;
- Options for return of used lubricating oil to suppliers will be investigated otherwise other alternatives will need to be developed such as onsite recycling methods;
- Containers will be stored in a manner that allows the containers to be easily inspected for leaks and spills (access). All storage areas will be fitted with impermeable surfaceing and bund walls to contain spills;
- All hazardous materials will be stored in closed containers out of direct sunlight, wind and rain;
- Volatile waste will be stored in a well ventilated area;
- No smoking, eating or drinking will be allowed in the hazardous storage facility and all employees in these will shower before and after work;
- A dedicated waste storage area will be developed for radioactive contaminated materials which will be in a secure fenced area, covered if possible with access control to the facility. Signs will be erected around the facility alerting personnel to the hazards of radiation.

9.8.7.2. Transport

It is anticipated that waste will all be stored at the mine facility. Radioactive materials may require transport to other facilities.

The following will be implemented:-

- A set of procedures for the hazardous waste being transported will be developed by Denison in compliance with legislation of Zambia and applicable international standards;
- The procedures will include preparation of a shipping manifest, labelling (waste description and quantity), correct delivery address, chain of custody;
- Appropriate packaging and containers will be used for the packaging of the waste dependant on transport method used;
- Only trained employees or experienced contractors will be involved in transportation of hazardous chemicals. Contractors will be required to provide proof of their capabilities, training of their employees, a history of accident/incident reports;
- Transport vehicles will be in a good condition with adequate external marking for the waste transport;
- Dedicated transport routes will be established and all potential hazards on these routes identified and mitigated against e.g. local communities, private traffic;
- Emergency response procedures will provide for 24 hour emergency cover;

- Management and monitoring of transportation arrangements will be conducted through the SHE Department. Unexpected inspections, emergency drills and frequent audits of procedures will be conducted; and
- All incidents will be managed as described by the emergency response plan and incident reports filed with appropriate disciplinary measures, if necessary.

All training will advise employees on preventative measures and emergency response procedures.

9.9. Emergency Response Plan

The Emergency Response Plan (ERP) is developed to outline procedures that will be implemented in the event of any emergency that may occur on the mine site. The IFC defines an emergency as an unplanned event in which the operation could or does lose control of a situation in where human health, property or the environment are put at risk. This may occur within the mine license area or in the local community.

A detailed ERP will be developed by the SHE Department in the early construction phase. The ERP will outline procedures for:-

- Administration (policy, purpose, distribution, definitions, etc);
- Organization of emergency areas (command centers, medical stations, etc);
- Roles and responsibilities;
- Communication systems;
- Emergency response procedures;
- Emergency resources;
- Training and updating;
- Checklists (role and action list and equipment checklist); and
- Business Continuity and Contingency.

Some preliminary procedures have been outlined below. An emergency analysis will be conducted on all forms of emergency that may occur at site. The activities that will be implemented and the persons responsible will be identified.

9.9.1. Emergency Resources

Denison will implement the following:-

- A budget will be prepared for the highest of emergencies and be set aside annually for the management of all accident situations. The finance department in conjunction with the General Manager and Vice President will prepare this budget;

- The mine will be equipped with fire suppression methods, safety equipment and a trained fire fighting team. The capacity for the involvement of the fire and emergency services in Siavonga is very low. Other services will be investigated during construction;

- Medical equipment supplied to the medical centre will include a portable life support machine, portable oxygen supplies and an ambulance. Other equipment required for the medical centre will be sought by the emergency medic. An annual operating budget shall include projections for extra equipment;

- A list of available resources will be developed by the emergency medic for use in emergency situations. The list will include personnel with specialised training and expertise, as well as their availability and contact details;

- A team of emergency personnel who have specific responsibilities in emergency situations will be developed. The team manager will be responsible for tracking emergency costs. A list of these emergency personnel will be displayed in all mine buildings, held by the SHEO and the medic;

- Onsite services and facilities to cope with emergency situations will have been developed after consideration of regional fire and emergency services capability, response times and quantity. The cost for implementing onsite services will be reviewed by mine management, the SHE Department and the medical centre; and

- Mutual aid agreements with organisations in the area requiring similar emergency services shall be investigated and implemented. Local businesses or industry related operations will be involved in the emergency response team.

9.9.2. Communication and Notification Systems

The development of useful, fast and diverse forms of emergency notification to all employees is very important in determining response and evacuation times.

Denison will implement the following communication procedures:-

- Alarm bells with activation switches or buttons will be installed in all buildings around the process plant site;

- Visual alarms with switches will be installed in areas of high background noise;

- All emergency warning systems will be linked to an emergency control room from where all site activities will be monitored (security office);

- The communication of emergencies will firstly be done to the department supervisor or manager and then the Emergency Response Team (ERT);

- An external radio connection will be installed to communicate with external emergency services in Siavonga, Chirundu and Kafue in the event that normal communication links are inoperable;

- All fire, smoke, gaseous etc warning systems will be tested on a minimum of an annual period;

- The community will be notified of all emergencies at the project site through audible sirens, telephone call lists, mobile loudspeakers etc. The CCDC will be informed and requested to assist with informing the rest of the community;

- A procedure will be developed by Denison to alert the government service, the public and the local community through the CCDC and Public Liaison Office of the Administration Department when incidents occur for radiactive material;

- The community will be provided with incident information, protection measures or options (evacuation, quarantine) and couselling advice for the population; and

- The CCDC, in conjunction with mine management, will be responsible for contacting the media and will provide relevant details for the accident. Secure relations will be maintained with the local media to ensure accurate relay of information.

9.9.3. Training and Updating

Denison will implement the following procedures:-

- Regular updating and maintenance of emergency procedures will be conducted by emergency team. Regular testing and practice programs will improve emergency preparedness (fire drills, evacuation exercises, first aid scenarios). Regular inspection of emergency equipment (e.g. fire extinguishers, life support systems) will be conducted by the medic and the ESO;

- Specific training with respect to the requirements of the personnel on the emergency team will be provided through the EHS training department on a regular basis. This will include updating first aider certificates;

- The SHEO will develop a training schedule for fire fighting, spill response, evacuation, open pit emergencies, traffic accidents (on-site or off-site). This schedule will include bi-annual fire fighting training and quarterly training on spill response, evacuation, traffic accidents etc;

- Upon the completion of training the emergency team will conduct a de-briefing exercise to determine the success of the procedures, highlight areas for improvement and amend the procedures and contact lists, if out-of-date; and

- A report will be developed for all training exercises and kept in the mine records.

9.9.4. Business Continuity

Denison will implement the following:-

- Identification and arrangement for alternative supply services (electricity and fuel) will be conducted through mine management. Dual supply services will be sought to prevent business stoppages after emergency events;

- All mine records will be backed up and stored in an area off-site to prevent their loss during fire emergencies on-site.

9.9.5. Emergency Procedures

Specific emergency procedures are required for the following and others:-

- Open Pits;
- WRDs;
- ROM Pad and Ore Preparation Areas;
- Process Plant;
- Mine Camp;
- Waste Storage – general and hazardous waste;
- Traffic and Transport Systems – mine site traffic, regional transport routes, local community;
- Fires and Explosions; and
- Security Events and Evacuation.

The ERP procedures for all of these locations will be drafted by the management personnel for each area in collaboration with the SHE Department. A system of ranking emergency events and coding them will be developed based on number of personnel affected (actual or possible), cost of emergency (property loss, emergency response implementation, medical costs, evacuation), zones of impact, impacts to the local community (health, safety, property loss, evacuation). Mine management will approve and finalise these procedures.

These procedures will define the possible emergency scenarios that may occur in each area of operation of mining activities. Zones of impact should be investigated, such as TSF failure and spill zonesEmergency response procedures for each scenario will be developed.

Emergency personnel for each of the above facilities will be identified and listed as a member of the Emergency Response Team (ERT).

Details of the average number of personnel working in these areas on a daily basis shall be defined to assist with emergency rescue services. A system of daily records identifying sites of work for all employees will be instigated in all departments. Interactive methods of informing emergency services on occupancy numbers for buildings and activity sites should be displayed on notice boards (i.e. personnel in mine offices, open pit personnel).

Emergency Assembly Points will be located for all departments and a role call system developed to check for missing personnel.

The SHE department will be responsible for the development of specific procedures related to spills (large scale incidents resulting from leaks, burst storage units or pipelines), waste management and fires and explosions.

The development of emergency procedures for traffic and transport systems will be the responsibility of the departments of Procurement, Security and Administration. This should cover mine traffic (haul trucks and mine vehicle movements), contractor traffic (delivery trucks) and private vehicles. Security practises for the movement of concentrate will also be important.

9.9.6. Reporting and Inspection

During and after all emergency incidents a detailed investigation will be led by the EHS Department. An incident report describing details of the emergency, the stages of emergency response activities undertaken, the final or current situation of events and provide an evaluation of the success of the ERP for that emergency. Recommendations for changes or updates to the ERP will be made. The incident report will be drafted and provided to all departments for review in management meetings and then finalised by the SHE Department.

All reports will be maintained at the mine site and in the record backup facility.

Routine inspections and external audits will be conducted by external organisations either contracted by the mine or regulatory bodies. It is important that all documentation (incidents reports, ERP) is available for their review. This documentation will be stored at the SHE Department.

9.10. Conservation and Vegetation Plan

The implementation of the project activities will impact on the natural environment. Measures to manage and conserve the natural habitats have been described in the Conservation and Vegetation Plan (CVP).

9.10.1. Land Use and Biodiversity

Changes in land use result from the development of mine projects, which include loss of agricultural land, relocation of settlements in the vicinity of the mine, the development of industrial land use in areas where often it did not originally exist and the expansion and development of existing or new settlements.

The following measures will be implemented by Denison to manage landuse changes:-

- Conduct an active consultation program to understand the land and animal requirements of the local communities. During the social baseline study, the local communities and Denison formed the Consultation Committee (CC) to act as the forum for all consultation between both parties. The CCDC and another company official will represent Denison in this forum;

- Implement programs to provide alternative economic options for the local communities such as reforestation/revegetation of areas within the mine license. These programs can be designed or investigated by the CCDC;

- Discourage the development of shanty areas around the mine site with squatters selling goods or job seekers. Agreements will be made with the community through the CC, regarding these issues in order to discourage in-migration;

- Conflicting land use will arise between the mine and local farmers as agricultural activities in the project area are the most dominant land use. Denison will ensure that all fields are surveyed accurately and in accordance with the guidelines of the Valuation Department for compensating agricultural land use. All farmers will be consulted on the compensation they will receive and be allowed to indicate grievances. Compensation records will be kept where, once compensation values have been agreed, the affected farmers will sign a compensation certificate;

- Conflicting land use will arise with 6 existing settlements in the project area, and these will require compensation. The RAPhas been developed for the affected farmers and fields.

9.10.2. Biodiversity

The changes to habitats through site clearance and changing land uses greatly affects biodiversity.

Habitat alteration will occur throughout the project phases (exploration, construction, operation, mine closure) and may be short term, long term or permanent.

Denison will implement the following:-

- The consultation through the CCDC will also include awareness training of the local communities in the importance of their natural resources. Increased accessibility to new vegetated areas can lead to drastic habitat changes through hunting and charcoaling activities;

- There were no conservation areas within the mine project area but the majority of the Mutanga area is considered to be sensitive habitat for the dwindling wildlife in the lower Zambezi area northwest of Siavonga. Denison will implement policies to promote biodiversity and habitats management. Some of these actions will be to designate management and conservation sites (habitats and species); and

- The research and review of partnerships with internationally recognised institutions undertaking biological/ecological research to assist in conducting biodiversity assessments and manage biodiversity programs. Alternatively local recognised institutions in Zambia may be approached.

9.10.2.1. Terrestrial Habitats

Denison will endeavour to minimise the habitat alteration (temporary or permanent) on and around the site through the following:-

- The final design of access routes and facilities will consider the results of the Environmental Baseline Study (**Chapter 5**). Forest areas are considered to be areas of high biodiversity and recommended for protection;

- Clearance activities will be restricted to infrastructure sites where possible and large trees and bushes will be utilised as visual environment improvements and wind breaks;

- Barriers to migratory wildlife affect population movements and habits.Habitat corridors will be maintained through guidance by a specialist during the construction of the project infrastructure;

- Buffer zones between the forest areas and project activities will be developed. These will consist of grassy areas with a few trees to allow movements of animals within the project area. This will also minimise the loss of animals on roads.

9.10.2.2. Aquatic Habitats

Mine operations may alter surface water and groundwater regimes through modification to catchment areas, which will indirectly impact on fish and aquatic biodiversity. The mobilisation of sediment which may enter watercourses will impact on water quality and flow rates.

Denison will implement the following to minimise the alteration of aquatic habitats:-

- The development of many or new access corridors around the mine site or during exploration activities will be prohibitted;

- Old access routes will be decommissioned (compacted road surface is disturbed, a soil layer placed) and re-vegetated with indigenous grasses, shrubs and trees. If these routes are to remain open access barricades will be placed to prevent vehicle movements;
- Natural drainage routes/paths will be maintained where possible or recorded prior to disturbance inorder to be re-established during decommissioning and closure activities;

- The water catchment areas for the natural site streams will be maintained where possible;

- There will be no development in streams or on stream banks unless it is related to road access. Care will be taken not to disturb the stream sediment and affect water quality (runoff during the construction of bridges will be diverted from the stream for settlement). The bridges and culverts will be designed to manage peak stream/river flows which will be monitored through a vigorous monitoring campaign during pre-construction phase;

- Where bridges and culverts are no longer required they will be removed with as little disturbance to stream channels as possible. The banks will be re-profiled to pre-construction profiles and the slope will be re-vegetated to prevent mass wasting into the stream; and

- Water storage facilities (RWD) will be designed to collect and cope with the 100yr/24hr storm events. Sedimentation ponds, raw water pond (process plant) and the management of the mine site water balance will be used to regulate surface runoff drom high rainfall events.

9.10.3. Erosion and Soil Fertility

Clearance activies, excavations and stockpiling (ores, wastes) during mine activities affect original soil properties and thus their ability to support vegetation.

Denison will implement the following to reduce changes to soils:-

- Soil conservation measures will be undertaken. Cleared clean topsoil will be stockpiled where it has been cleared from for re-vegetating slopes and exposed surfaces during construction, operations and closure. A small soil or aggregate bund wall will be constructed around the stockpiled soils to prevent its loss in runoff. The spreading of rapid colonising hardy grass species that can exist on unstable materials will be used to vegetate the top surface of the stockpiled soils, if the topsoil is not likely to be used in the near future;

- Soils that have been removed during the pre-strip activities will be stored near the mine nursery in a bunded area, for potting soil or in soil addition methods on cleared sites;

- Key areas where slopes exist onsite will be identified and will undergo visual assessment and monitoring of the progress of erosion, as part of habitat monitoring (**Section 9.3**);

- It is likely that any topsoil removed from areas on the mine site will require pre-treatment (compost addition, fertiliser) before it can be used for re-vegetating purposes; and

- Vegetation growth along access roads and on permanent above-ground facilities will be managed. This will involve planting of indigenous species to replace those cleared during road development and the removal of invasive species in the area. Only biological, physical or thermal methods of vegetation control will be employed. Pest identification and management will also be conducted.

9.11. Preliminary Progressive Re-Vegetation and Rehabilitation Plan

The Progressive Re-Vegetation and Rehabilitation Plan (PRVRP) for the Mutanga Project will aim to return areas cleared through mining activities to pre-clearance vegetation states.

This will be done throughout mine construction and operational phases and does not include procedures for mine closure.

Sites that will be incorporated into this program are:-

- Construction sites/areas where activities have been completed;
- Maintenance sites where activities have been completed;
- Old access routes around the mine or the exploration program; and
- Sites around the project area that have experienced deforestation due to increased accessibility of the local communities as a result of mining activities.

Denison will adopt the procedures described below to reduce overall impacts on soils, surface water, groundwater, air and habitat areas from the mining development. Specific guidance procedures will be included in updates of the PRVRP.

9.11.1. Inspection of Proposed Construction Sites

Between the development of the EIS and the final construction there are likely to have been a few changes in the exact locations of infrastructure. Therefore it is recommended that prior to construction an inspection of the exact construction sites is conducted by a botanist, a terrestrial ecologist and an aquatic ecologist to identify the site specific species. It is recommended that seasonal variation is incorporated into the final surveys. Partnerships may be made with local or international research institutions to conduct biodiversity assessments and biodiversity programs.

The specialist will develop species lists. Advice will be provided on the species that are most useful for re-vegetation. The specialists will provide information on any endangered species on the sites.

Some of the facilities that will be constructed onsite and where it is recommended to conduct inspections are:-

- Open Pits (Mutanga and Dibwe);
- WRDs (Mutanga and Dibwe);
- ROM pads and leach pads (Mutanga and Dibwe);
- RWPs;
- Process Plant (Mutanga);
- Operations Camp;
- Kashundi Village;
- Water Treatment Plant; and
- Access Roads (new or widened).

A report of the findings of the inspections should be provided to Denison for future reference when re-vegetation and closure occurs.

9.11.2. Relocation of Endangered Species

Endangered species as described in **Section 5.17** were identified during the site survey. These mostly consisted of birds, and mammal species in the area were not considered threatened.

If there are endangered species located in any of the final areas of construction Denison will undertake the following procedures:-

- Assess the feasibility of modifying the site layout to avoid disturbance of the habitat area;
- Assess the feasibility of the relocation of the terrestrial species to the protected forest habitat near the mine camp; and
- Assess the feasibility of the relocation of the aquatic species to an area of similar habitat to be designated as a conservation area.

The specialists will provide a description of activities to be conducted in the event that relocation is decided on. Relocation of the endangered species is not recommended and will only occur if modifications can not be conducted in the final layout.

9.11.3. Mine Protected Areas

The mine will designate some areas around its license area as protected sites. These may be socially protected or habitat protected. Some of these will be:-

- The woodland areas around the Project site; and
- Any other site recommended after the pre-construction inspections.

The location of these sites and the reasons for their establishment will be communicated to all mine employees in the SHE training events. The local communities will be informed through the CCDC of these sites and be provided with an opportunity to visit them. Their importance will be communicated to the communities. The local community will be requested to join in active conservation of these areas, possibly through labour supply (relocation, mine nursery) or patrolling (game rangers) the conserved sites.

9.11.4. Re-Vegetation and Rehabilitation of Cleared Areas

During the mine operations, previously cleared areas will be re-vegetated when construction or maintenance activities have been finished. These activities will require specimens of the indigenous species for planting as well as guidelines on the preparation of the site prior to re-vegetation.

9.11.4.1. Mine Nursery

A mine nursery will be located on the mine site (possibly east of the process plant on a 1ha facility). The mine nursery will generate seedlings for re-vegetation as well as store topsoil removed from pre-stripping activities.

The species lists developed by the botanist will be used to identify indigenous species for the project site as well as site specific facilities. The botanist can provide information on plants best for proliferation in the nursery, methods of reproduction (seeds, cuttings, sideshoots, runners) and advice on ground preparation (fertilisers, mulches, composting) and pests eradication methods

Seeds can be planted in seed trays (bought from local agricultural suppliers) or designed using wood and ground plastic sheeting. Plastic pots can be used to grow cuttings or transfer seedlings from seedtrays. Alternatively seeds and cuttings can be planted directly into seedbeds in the nursery. This can reduce costs in the nursery.

Equipment needed would consist of safety equipment for nursery attendants, agricultural equipment (spades, shovels, forks, hoes, planting spades), seeds, fertilisers and chemicals (not recommended).

9.11.4.2. Site Remediation and Preparation

Initially some soil samples will be collected and analysed for evidence of metals or chemical contamination. Appropriate measures to remediate the site will be conducted prior to any preparation or re-vegetation activities are conducted.

The site will be ploughed and contoured to reflect pre-disturbance conditions and the pre-existing natural drainage flows will be developed. A layer of modified topsoil (5-10cm) will be laid out over the site and watered down.

The modified topsoil will contain some compost (generated from biodegraded non-toxic organic mine waste), fertiliser or mulching adjustments. Indigenous grass seeds can be included to the topsoil before spreading. Turf grass can also be used to facilitate faster grass stabilisation and drainage control.

9.11.4.3. Re-vegetation

If the site will be re-vegetated with other species besides grass then the original site species lists will be referred to for guidance on species types and composition over the initial site. Based on this a determination will be made on the species used for planting and the different numbers planted over the vegetation site.

The planting of seedlings into the prepared topsoil layers will be conducted once the soil has been well watered in. Holes will be dug dependant on the seedling sizes and watered regularly to ensure successful establishment of the plants.

9.11.4.4. Monitoring and Reporting

Annual targets will be established for the re-vegetation of the mine site. The progress and status of all re-vegetation projects will be inspected by the ESH Department on a regular basis. The reporting of this will be included in weekly reports, annual environmental reports or summary reports for the status of the PRVRP.

9.12. Sustainable Development Plan

The management of identified social impacts for the project will be implemented through the Sustainable Social Development Plan (SDP). The CCDC will be responsible for the management and implementation of the SSDP.

The main objectives of the SDP will be:-

- To, wherever possible and economically feasible, maximise the use of local and provincial employment and business opportunities;
- To encourage the development of a diverse range of local businesses and reduce reliance on the agricultural sector;
- To undertake the conduct of compensation and relocation activities in a fair and transparent manner through active consultation with the local communities and affected populations;
- To implement a consultative relationship with the local communities and administrative authorities through regular meetings, information events and media interactions;

- To, wherever possible and economically feasible, assist in projects that improve the living conditions, accessibility and well being of the local populations; and

- To explain Denison policies on environmental and social issues to the community and wider public, via public consultation processes during mining operations.

An annual budget will be allocated by Denison for the implementation of this plan. Financial arrangements for this budget will be finalised during the Development Agreement (DA) for the project.

The project will have conflicts with landusers and settlements. All land users and settlements likely to be affected by mining activities were identified during the Social Baseline Study (**Chapter 6**). An RAP has been developed to describe:-

- the affected population and land users;
- evaluate the compensation for fields and the construction of a relocated settlement area;
- identify the possible location for the development of a relocated settlement, Kashundi Village;
- provide preliminary designs for the housing in Kashundi; and
- outline a relocation and compensation schedule for implementation of the RAP.

9.12.1. Local Employment

Denison will implement a strategy to employ local people during all phases of the mining project from the Southern Province and Zambia. All employment related issues will be managed by the Human Resources Department. The company is an 'equal opportunity' employer and in practice, the best applicant for the position will be offered employment. Local people will be given priority in employment subject to their experience and qualifications. Denison will employ 382 employees of various skill levels.

Uranium mining in Zambia is very young and it has been recognised that skilled staff in Zambia may be difficult to employ. Therefore Denison plans to initially hire international professionals with high levels of experience into management levels to provide training and support to Zambian employees identified as potential candidates for these jobs in the future. Denison will then implement a program of Zambianisation within the first 3 years of operations (Year 4 of mining) through the Human Resources Department. This program will phase out the number of international professionals employed at the Project and ensure the employment of Ivorians instead.

The HR Department will inform the local communities of all job opportunities and request application data from appropriately skilled persons. A survey of the availability of skilled individuals will be conducted to develop a skills database. This database may be directly used during future job availabilities.

Employees will be offered salaries and conditions of service commensurate with other mining companies operating in Zambia and in compliance with local laws on employment, minimum wages and casualisation.

9.12.2. Local and Regional Economic Growth

Denison will implement a local procurement strategy through the Procurement Department. The Procurement Department will distribute information material to explain the procedures for doing business with Denison for supplies and contracts. This will improve local business multipliers and reduce regional unemployment. Regional local entrepreneurial business will be encouraged to expand.

Denison will implement a contractor engagement strategy that ensures local contractors are employed in preference to foreign contractors, subject to their ability to carry out the work in compliance with international best practices. This action will improve contractor competency and the managerial capacity of local contractors.

The Procurement Department and Human Resources will formulate templates for service specific contract documents that will be finalised through mine management. Contracted supplies to the mine will be issued for fuel, transport providers, spares suppliers etc. Denison will outline the safety standards and conditions that employees and contractors will have to comply with so as to promote a safer working environment. These conditions will include an HIV/AIDS awareness and prevention campaign.

9.12.3. National Economic Growth

The remittance of local taxes and fees can be used for district development projects. Mining taxes, surface ownership fees, application fees and operational license fees paid to Government will be used to develop the mining and environmental sectors. This income for the Government of Zambia will encourage and progress national growth in all economic sectors.

9.12.4. Occupational and Skills Training

Denison will provide active ongoing occupational training through all phases of the Mutanga Project (construction, operations and closure). The training program will be managed through the SHE Department.

The training programs are essential for the safe operations of all mine-related activities. This training will provide all employees with transferable skills and experience that can be used elsewhere after mine closure.

General occupational skills and safety procedures training will be provided to all workers. Employees operating in hazardous areas; conducting dangerous activities; handling hazardous chemicals or waste; exposed to dangerous environments; and responsible for the safety of others will be provided with tack specific training.

Emergency rescue training will be provided to volunteer employees who will form an Emergency Response Team (ERT). This training will provide first aider qualifications to all those trained in first aid practices.

Other skills that can be acquired through the Denison training program are the opportunities to improve adult literacy and expand communication with English and Tonga lessons.

A retrenchment-training program will be designed to assist employees who undergo retrenchment. The program will be ongoing and will offer a counselling service through the medical centre if required. The program will focus on the identification of a workers' transferable skills achieved through work in Denison and assist them with seeking alternative jobs, either in the mining sector or an alternative economic sector. This will aim at promoting sustainable livelihoods.

9.12.5. Land Use and Settlement

The mine site boundaries will be clearly demarcated and Denison will not allow the presence of any unauthorised persons on the mine site for safety reasons. Denison will clearly communicate this to the local communities and stakeholders. The boundaries will be marked on-site with beacons and the use of signposts. They will be shown on all mine plans. The encroachment of local population housing on to the mine site areas will not be permitted and persons will be legally requested to vacate the mine area. The local communities will be discouraged from using the mine site for settlement or their livelihoods.

Denison will engage in natural resource management at the local community level. This will involve the management and conservation of trees, assistance with re-vegetation projects and management of conservation areas.

Denison will promote awareness of the water quality in its effluent streams and the risks of its consumption as drinking water. Signs in local languages/symbols will be erected alerting the public of drowning, sickness etc. The aim will be to discourage the use of mine surface water by local communities.

9.12.6. Health

Mining projects generally have large and positive economic impacts on the immediate communities which may affect pre-existing health conditions of the community. The occurrence of infectious diseases, e.g. malaria, respiratory and gastrointestinal infections may decrease with a corresponding increase in non-communicable diseases, e.g. hypertension, diabetes, obesity and cardiovascular disorders. This generally occurs due to increased spending capacities of employees and an improvement in lifestyle. Denison will provide counselling and awareness training for all its employees about changing lifestyles and habits and their effects on health. Employees will be advised to invest money and plan for the future and their families and provided with assistance and contacts through the counselling programs.

The impact of mine projects on employee and local community health can be very high. The effects on health during the entire project can be caused by:-

- Communicable diseases – are usually caused by poor sanitation, cramped living conditions, sexual transmission and vector-borne infections. Of the highest concern is transmission of HIV/AIDS during construction due to increased population mobilities; and
- Vector-borne Diseases – malaria (mosquitos).

9.12.6.1. Communicable Diseases

Denison will have a policy to actively discourage the spread of HIV/AIDS throughout the mine project. The highest movements of population occur during construction and decommissioning phases. There is no pre-project information for the Mutanga area related to the prevalence of communicable diseases due to the poor local health services. Denison will work with local action groups and NGOs to:-

- Provide surveillance, confidential screening and treatment (ARVs, immunisation programs) options;
- Implement good safe waste management and removal practices to prevent vector generation and contamination of water and food sources;
- Provide workers with enough living space to prevent over-crowding and the transmission of communicable respirable diseases; and

- Only qualified (hazard analysis critical control point – HACCP) and registered catering facilities/services will be used to feed the mine workforce in order to prvent the spread of food related illnesses.
- Monitoring of prevalence will be conducted through various established data sources;
- Training local community health workers in disease treatments; and
- Provision of health care facilities and treatments.

The spread of HIV/AIDS leads to long term pain and suffering in communities as well as affecting staff turnover, productivity and increases costs. The following procedures will be implemented:-

- Develop personal counselling services identifying specific personal behaviour patterns that may increase contraction of HIV. The promotion of methods of personal protection (condoms) will be conducted;
- A workplace plan to increase awareness, prevent new infections and provide support and councelling for infected and affected families;
- Develop community outreach activities in combination with NGO's and other action groups

9.12.6.2. Vector-borne diseases

Denison will work closely with sponsor organisations and community health authorities to implement some of the following:-

- Develop and implement integrated vector-control through the prevention of habitat locations for reproduction by these vectors;
- Reviewing all engineering designs in order to reduce the occurrence of exposed standing water;
- Collaboration and exchange of similar services with other control programs in the project area (distribution of bed nets for malaria prevention);
- All workers will be counselled on malaria and other diseases, prevent the contraction of the disease (provision of nets, mosquito repellant), be provided with chemoprophylaxis (non-immune personnel) and provide facilities for diagnosis and treatment (microscope, medication);
- Utilise selected indoor sprays recommened by Ivorian health officials and chosen to prevent environmental degradation;

9.12.6.3. Social Disorders

There are other social disorders that may occur within local communities that will affect the overall health; drug abuse, alcohol abuse, sexually transmitted infections, gender violence and other psychological effects of rapid influx of labour. The prevalence of these disorders within the workforce as well as the local communities will be investigated throughout the mine project.

Awareness campaigns targetted at informing the local populations of the health risks associated with various lifestyles will aim to improve the overall health of the local communities.

9.12.7. Public Access Routes

There is no regular transport system within or surrounding the mine project area and no many people walk or use bicycles between settlements and villages. These routes do not always follow roads. The restriction of access of the local populations through the mine project area may cause great disturbance to travelling regimes of the local populations.

The CCDC will liaise with the local communities directly and through the CCC to identify these routes based on the final design of the project. Some of these pathways may then be allowed for use by Denison but persons not on the pathway will be considered as trespassers.
Pathways leading to dangerous/hazardous areas will be restricted in agreement with the local communities otherwise detour arrangements will need to be designed.

9.12.8. Public Consultation

Denison will implement a several pathways for public consultation and communication of the public with the Company.

A CCDC will be actively involved in social projects managed by Denison and will interact with the local people in great detail. Contact will be possible directly through him.

Denison has developed the Community Consultation Committee (CCC) which will have a board populated with key representative from the local community and two members of Denison personnel. All meetings of the committee will be documented as well as external correpsondence. Meetings will be conducted on a monthly basis.

The RC in Kashundi will provide a forum for consultation and information exchange on the progress of resettlement.

A method of registering formal complaints against the mine, its personnel or activities will be done through a register in Kashundi Village. This register will be the responsibility of the CCDC. All complaints lodged will be recorded and a series of documentation developed to monitor progress on solutions and agreements with the community.

Monitoring and auditting of the public consultation will be conducted to identify breakdowns in communication or community preferred/suggested methods of discussion.

9.12.9. Development Projects

The general development categories of the social improvements anticipated from the project are:-

- Compensation of Fields and Houses;
- Employment;
- Training and Skills Acquisition;
- Agriculture;
- Health;
- Education;
- Water Supply;
- Infrastructure; and
- Recreational Facilities.

Other projects that may be of interest to the local communities are:-

- Involvement in conservation management programs; and
- Involvement in re-vegetation and habitat improvement schemes.

The category of greatest importance is compensation. The compensation values were evaluated by independant qualified persons. Denison will implement the relocation of villagers to Kashundi and compensation for field loss during construction.

The next important categories include health, education and water supply projects. Benefits of employment and training will be initiated as soon as the project construction begins or even months before. Training requirements included alternative skills such as carpentry, sewing, blacksmithing etc.
The CCDC will be responsible for the management of these programs. Independant organisations (NGOs, government organisations, research institutes) can be sponsored to implement the activities for these programs.

9.12.10. Monitoring and Reporting

All activities in the SDP will be reported on in weekly, monthly and dedicated annual reports. Records for all projects will be maintained and readily accessible and available during inspections and audits.

10. MINE DECOMMISSIONING AND CLOSURE PLAN

10.1. Introduction

The mine closure and post-closure activities of a project are very important when considering the environmental and socio-economic impacts. Project developers or sponsors should be able to guarantee the funding required to appropriately close-down operations, such that the environment and the socio-economic impacts have been mitigated.

According to the IFC, the mine closure plan should:-

- Ensure that future public health and safety is not compromised;
- The after-use of the site is beneficial and sustainable to the affected communities in the long term; and
- Adverse socio-economic impacts are minimized and benefits are maximized.

Two years prior to the closure of Mutanga Mine activities will be conducted to update the Mine Decommissioning and Closure Plan (MDCP). Denison will conduct a series of discreet multi-stakeholder consultation sessions (local and regional Government, Kashundi Village and surrounding communities, traditional land users, neighbouring leaseholders) to identify aspects to be involved in the updating of the Mine Decommissioning and Closure Plan. Some of the key aspects will be:-

- Future land use of the project site;
- A mine radiation survey to identify all areas of contamination and to identify management measures;
- Identification of postclosure monitoring sites for air, surfacewater, groundwater, air quality and parameters of particular interest;
- Security management for the facilities during post closure monitoring;
- Updating the managment issues for each facility based on current activities;
- Public concerns over closure of the facilities.

An independent specialist assessment of the mine closure requirements and rehabilitation methods will be undertaken to develop an updated Mine Rehabilitation and Closure plan on behalf of Denison. Denison will liaise with government departments during the development of this update.

As part of the updating of the MDCP, DMZL will conduct a Quantitative Radiology Hazard Analysis (QRHA) as required by Regulation 11(2) of the MMMD’s Act No. 7 of 2008. This assessment will be done by independent specialists.

Denison will conduct a public consultation meeting the local and regional government addministration, the RC, the CCC, the local communities and other interested stakeholders

It is likely that the mine offices and the housing in the operations camp will be made available to the local communities. These facilities would not be decommissioned.

Security and access to areas around the mine site which will need be prevented throughout post closure monitoring. This is especially important in areas such as the WRDs, the leach pads, the open pits and the process plant. A Post Closure Security Plan will be incorporated into the Mine Rehabilitation and Closure Plan.

The Mine Rehabilitation and Closure Plan (MRCP) will be updated on an annual basis by Denison to reflect current economic prices and the current state of mine activities. The update of the MRCP will also consider changes in environmental and social conditions. In compliance with the PRVRP (**Section 9.9**), there will be progressive re-vegetation and rehabilitation activities conducted throughout the mining project. Detailed progress reports and final reports of all revegetation and rehabilitation exercises will be maintained by the EHS Department as evidence of these activities. All these annual activities will be incorporated into the mine closure cost assessment.

A Post-Closure Plan has been developed to describe monitoring activities during a minimum of 10 years after the closure of the mine site.

A financial guarantee for the full cost of mine closure and rehabilitation will be developed with the Ministry of Mines and Minerals Development (MMMD) and a well-reputed financial institution prior to any construction activities occurring on site. Denison will develop agreements with MMMD for initiation of payments into the Environmental Protection Fund as described in SI No. 102 of 1998. Contributions to the EPF are made on an annual basis for 5 years and contributions are related to total cost of environmental rehabilitation and the environmental performance of the project during operations. The EPF can be used to refund government departments who have had to conduct rehabilitation or remediation activities on behalf of the mining company. The financial guarantee and contributions to the EPF will be annually updated in accordance with mine closure requirements.

10.2. Care and Maintenance Plan

Economic influences can lead to a mining project requiring a state of care and maintenance to be declared. These are usually considered to be emergency closure requirements. These influences are generally well out of the control of individual companies and are governed by global economic patterns.

A drop in the economy and value of the mined products can lead to the cutback of operations until a more favourable economic climate has evolved. This generally means that a proportion of the workforce are laid-off, the mining activities on site are shutdown and minimal site personnel are available.

10.2.1. Procedures during Care and Maintenance

The following procedures will be implemented by Denison during care and maintenance (C&M):-

- Government and administrative departments will be alerted by DMZL to its requirements to declare C&M;
- DMZL will ensure compliance with all mineral and environmental licensing during the C&M period;
- DMZL will continue environmental and social monitoring activities to investigate and identify site problems;
- DMZL will ensure that any employees experiencing redundancy will receive all benefits owed to them, in compliance with Zambian employment regulations; and
- DMZL will conduct public consultation with the local communities to inform them of the status of the operations and consider the future of the operations.

The mine operations monitoring plan will be continued with a lower frequency of sampling events (quarterly).

Ongoing assessment and feedback of the C&M status will be conducted and the government and administrative authorities will be regularly updated.

10.3. Preliminary Mine Rehabilitation and Closure Plan

The following sections outline activities that will be conducted for all of the individual facilities. These may be changed or updated during the Project based on changed operations or conditions.

Once these activities have been completed for each facility a radiation and radon assessment survey will be implemented over the site. This survey will identify the baseline information to be used for post closure monitoring activities. Water quality (groundwater and surface) as well as final soil qualities will be determined.

The objectives of the Mine Decommissioning and Closure Plan will be to:-

- Achieve long term radiation protection by reducing the effective equivalent dose to the individual in the critical group to below 0.1mSv/year;
- Achieving background water quality in the long term by controlling groundwater contamination;
- Reducing the residual concentration of radioactive elements through soil clean-up operations;
- Reducing the radon flux over leach pads to 20pCi/m^2;
- Rehabilitating leach pads for a stability period of two hundred years;
- Mininise hazards to the public and the environment;
- Preventing inadvertent human intrusion and dispersion of contaminated materials;
- Compliance with environmental and safety regulations and standards of Zambia and international guidance from IAEA;
- Successful decontamination and disposal of waste and equipment in sustainable manner.

The QRHA will identify the amounts of airborne radiation at the particular sites of the WRDs, the open pits, the milling facilities, the workshop infrastructure, the office infrastructure. The survey will be conducted over the whole mine site including the Operations Camp and exploration camp areas.

The QRHA will include radiation assessments of the following:-

- All water ponds generated through mining activities;
- Contaminated equipment and waste materials generated from the proposed closure activities;
- Amount of contamination of seepage from WRDs and the leach pads.

The QRHA will be done in conjunction with the mines Radioactive Waste Management Plan to classify degrees of contamination and management activities.

The QRHA will include:-

- Modelling for the dispersion of dust from the WRDs, leach pads and open pits existing prior to mine closure to determine contaminant plumes and movements;
- Modelling results for possible contaminated seepage of groundwater from the WRDs and leach pad areas;
- A geotechical study of the stability of the existing WRDs, the leach pads and the open pits with results of the study and recommendations for inclusion in the MRCP closure plan of activities for each facility.

The results of the QRHA will determine the activities required to close down the facilities described below. Some preliminary activities have been identified.

10.3.1. Open Pits

The open pits will cover an area of 87.3ha (33ha Mutanga and 54.3ha Dibwe) with maximum depths at closure of 70m and 120m for Mutanga and Dibwe respectively.

The pit walls will be assessed for stability and any remediation measures conducted to prevent slope failure once mine dewatering stops.

Mine dewatering will stop and the pits will flood to the pre-mining ground water levels. The water quality will be monitored and compared with baseline water quality results as described in Chapter 5. Ongoing groundwater monitoring during mine operations will be conducted and used to predict mine closure conditions. The flooded pits should not impact on adjacent watercourses.

Final pit slopes will be designed for long-term stability.

The slopes around the open pit areas will be vegetated if necessary and signs will be erected or maintained for the post closure phase.

10.3.2. Waste Rock Dumps (WRDs)

The final WRDs will cover an area of 85ha and will attain heights ranging from 30-60m so that they correspond with the surrounding topography.

The WRDs will be progressively re-vegetated during the mining operations in conjunction with the Preliminary Progressive Re-Vegetation and Rehabilitation Plan (**Section 9.9**). The dumps will be profiled with overall slope angles of 16º-18º, to prevent erosion. The berms will be flattened and the dumps capped with a clay liner to prevent seepage of rainfall into the dumps. The slopes will be re-vegetated with indigenous species analogous to those that existed in the area prior to site clearance during construction (**Section 9.9**).

During dump development the dump walls will be fortified by placing more competent waste materials close to the walls and less competent waste materials at the centre of the dump. The profiled slope angles will allow the dumps to merge with the surrounding topography with minimal obtrusiveness.

If ARD assessments and groundwater monitoring during the mine operations have indicated any adverse impact of the dumps on the groundwater quality, an independant specialist should be consulted on alternative remedial measures to cleanup, prevent and control ARD or leached metals.

10.3.3. Ore Preparation Area, Process Plant and Workshops

These areas will be considered together for the present but key actions for each area will be identified in annual updates of the closure plan once design and implementation activities have occurred.

All contaminated process water or runoff water will be treated remove all contaminants in the water. Analysis prior to treatment activities will assist with undertaking the water treatment. Treatment will include removal methods for reagents, acid neutralisation methods, water demineralisation, hydrocarbon removal and removal of uranium or radioactivity in the water.

Evaporation methods may be necessary if treatment becomes difficult. The solids from water treatment will be disposed of onto the heap leach pads prior to decommissioning in the designated pad area.

All ore will be processed and no stockpiles will develop at the ore preparation areas during operations as direct tipping would occur into the hopper. All pregnant leach solution will be processed from the PLS ponds and the processing plant.

A radiation survey of the facilities will determine radiation areas. These areas would be decontaminated prior to decommissioning activities where feasible. The contaminated materials would be disposed of based on assessments of the levels of contamination. Disposal will follow the procedures outlined in the Radioactive Waste Management Program (**Appendix 6**).

The ore preparation equipment and the processing plant will be demolished and the materials will be treated as contaminated waste. The level of contamination will outline the management practices for the material in accordance with the RWMP (**Appendix 6**).

Once all buildings have been removed then the area will be re-profiled to establish the natural drainage pattern (**Section 9.9**).

Through stakeholder consultation prior to mine closure uncontaminated materials from decommissioning activities will be sold off to local merchants.

Dismantling and disposal practices will be applied to the crusher plant, process plant andworkshops:-

1) Removal of all brick buildings;
2) Breaking out and removal of all concrete foundations;
3) Removal of steel frames;
4) Demolishment of reinforced concrete structures and disposal in the WRDs or landfill;
5) Removal of HDPE liners and backfilling of all process ponds;
6) Removal of electrical equipment, pumps, motors, and other fixed equipment;
7) Removal of all above and below ground fuel storage tanks;
8) Cutting up and removal of all steel tanks and vessels;
9) Removal of all pipelines;
10) Digging up and removal of all below ground electricity cables;
11) Removal of all conveyor belting;
12) Removal of all mechanical equipment;
13) Clearing of raw materials from all materials handling areas;
14) General site clean up;
15) Site levelling and profiling to re-establish the natural drainage pattern across the site; and
16) Re-distribution of the stockpiled soils and re-vegetation of the site with indigenous grasses and trees (**Section 9.9**).

All concrete foundations will be broken out to a depth of 500mm below existing ground level and disposed of in the WRDs or landfill along with bricks, mortar and concrete debris from the demolition of plant buildings in compliance with the RWMP.

Scrap metals, non-hazardous containers and equipment will be sorted and sold to the local community, businesses and scrap metal merchants. Denison will remove all equipment and materials that cannot be reused, recycled or sold, to an approved non-hazardous disposal site or the mine landfill (if developed).

The dismantling and removal from site of all buildings, sewage systems, workshops, fuel storage facilities, electrical and mechanical equipment and materials will be carried out, unless they can be put towards a sustainable use. The mine drainage sedimentation ponds, contaminated water ponds, process water ponds and clean water ponds will be cleaned (if necessary), any HDPE lining removed and backfilled.

A soil survey will be conducted at closure to identify any areas of inorganic and/or organic and metal contamination. The soil survey will involve a programme of test pitting to a depth of 500mm, soil sampling and analysis. A radiation survey will be conducted alongside the soil survey to assist with identification of uranium contamination. The number and location of test pits will be based on a site walkover/inspection at closure to identify potentially contaminated soils. These sites will include chemical and reagent storage areas and their vicinities, waste storage areas, WRDs, process plant and soils under process water ponds. A deeper soil inspection may be necessary (pollution sources) depending on the findings of the near surface soil survey.

Soil contamination (metals, sulphate, acids) will be treated on-site through reduction or stabilisation methods. Acid contaminated soils will be removed and treated using liming methods. Lime may be used to stabilise the soil pH between 5.3 and 6.5 (or suitable pH for re-vegetating species).

Localised organic soil contamination resulting from the accidental spill of diesel and oil will either be treated by the removal from site to an approved hazardous disposal site or processing of contaminated soil on site to reduce extractable concentrations to an acceptable level (< 300mg/kg), and/or by capping with waste rock. Bioremediation methods can be used to remove the organic contaminants.

Soil contaminated with chemicals, reagents or sulphuric acid will be removed to an approved hazardous waste disposal site or in a defined, lined cell in the landfill. This disposal will require approval by ECZ and the MMMD.

The removal of any remaining ore, process plant dismantling, removal from site of all equipment and materials, treatment or removal of contaminated soil (if any) will occur.

Profiling activities in the areas where mine infrastructure was removed will be conducted to encourage natural drainage patterns and will be re-vegetated.

A soil improvement program will be carried out using stockpiled organic matter and topsoil, prepared organic mulches and fertilizer. Indigenous plants, shrubs and trees will be transplanted from the mine nursery (**Section 9.9**).

10.3.4. Heap Leach Pads

All the equipment at the heap leach pads will be removed and identified for contamination in accordance with the RWMP. These include the mobile stacker units and all support equipment.

The leach pads will be decommissioned and allowed to dry out. This will be conducted through the dry season. The drying out of the pads will be monitored through the drainage system underneath. Once the pads have stopped producing leachate then the closure activities will begin.

These will include:-

- Closure of drains and storage ponds for the facility;

- Profiling the heaps with overall slopes of 18º and interberm slope angles of 20º;
- Laying a membrane liner on the surface; and
- Placing a soil layer on the surface which will allow revegetation of the pads.

The aim of the closure activities will be to cover over the leach pads to prevent release of radon or other materials into the environment. Levels of uranium will be low but radiation may still be high. Therefore lining through several layers is important.

The closure of the heap leach will be investigated through a series of trials based on different methods of liner and soils etc, that will be conducted during the early operational phase of the project. These trials will be used to update the Mine Decommissioning and Closure Plan.

The leach pads are likely to produce effluent for some years after active use (all dependent on operational rates of leaching and results of detailed design work) so dewatering measures may need to be conducted.

The PLS ponds and the barren pond will be emptied and the contaminated material treated in accordance with the RWMP. The liner of the ponds will be removed and the ponds will be filled and profiled.

The heap leach pads will act as the final dumping area for the waste. The remediation measures in the final Mine Rehabilitation and Closure Plan will aim at designing final closure methods to reduce the radon flux from the facility to 20pCi/m^2. This will be achieved by sealing and capping the facility. All possible remediation methods will be described in the final MRCP, which will be approved by ECZ, MSD and RPA.

Re-vegetation (**Section 9.9**) using grasses and small shrubs will ensure that the stability of the closed leach facility is not compromised.

Groundwater monitoring will continue in the area for at least 20 years to assess groundwater quality and determine any further requirements.

10.3.5. Raw Water Pond

The RWP will remain in-situ during the closure activities and will provide an alternative water source in the area. The habitat of the RWP will be adjusted to encourage the development of fish communities. This will reduce the growth and development of larval communities of disease vestors (mosquitoes).

10.3.6. Operations Camp

The operations camp is likely to remain as an accommodation area and will not be decommissioned. Agreements can be made with the Zambian government and local stakeholders on its use. Some housing will be maintained for an onsite presence for post closure monitoring personnel.

10.3.7. Infrastructure (Roads and Powerline)

All mine roads will be decommissioned and closed except for main access to general facilities for post-closure monitoring. The closure of mine roads will prevent uncontrollable future deforestation activities and will reduce accessibility to the old mine facilities by the local population. The level of decommissiong will be decided during the pre-closure public consultation on land use.

It is likely that the main powerline supply will remain and substation facilities (or transformers) will further rural electrification schemes. All on-site electrical delivery lines will be removed, dependant on the agreed closure land use.

10.3.8. Conservation Areas

Those areas conserved and designated by DMZL as conservation or habitat management areas will be converted to official sites during mining operations in conjunction with Zambian Authorities. ZAWA and other institutions will be consulted with on the allocation of responsibility for the management of these sites.

DMZL will involve the local community in training to help appreciate thebenefits of conserving natural resources during mining operations. With the involvement of government departments during mine closure the local community can be involved in sustainable management of these areas. These areas can be used to promote local tourism and assist with educational programs.

10.3.9. Socio-Economic Environment

There are a number of negative socio-economic impacts that will occur during mine closure, some of which are:-

- Loss of employment;
- Loss in standard and quality of services infrastructure (health, education, water supply);
- Increased prevalence of disease through decreased living standards; and
- Increased social disorders (theft, vandalism, alcoholism, physical abuse) through loss of income.

DMZL will allocate a budget for counselling and assistance to mine workers during any mine closure event. Guidance on obtaining skills and alternative incomes will be provided.

DMZL will continue with stakeholder consultation to identify main areas of concern from the local communities. Meetings with the CCC will be conducted on a monthly to quarterly basis.

DMZL will collaborate with government departments to try to minimise the impacts of mine closure on the socio-economic conditions of the Siavonga District.

The monitoring of the prevalence of social conditions will be continued through any of the health and educational facilities developed during the mining project.

The measures implemented during the Sustainable Development Plan will continue through mine closure. The mine will conduct social monitoring to assess the success of any sustainable projects that were implemented during the mine project. This assessment can be done through mine personnel or other NGO or local social programs that worked in collaboration with DMZL during mining operations.

The amplitude of HIV/AIDS awareness training campaigns will be increased due to the expected increase of labour movement during mine closure (similar to construction).

10.3.10. Mine Closure Reporting

The updated Mine Rehabilitation and Closure Plan will include for each mine component the following, as a minimum:-

- Description of the closure activities required and implemented for each component;
- Description of soil assessments, results and remediation measures;
- Updated Radioactive Waste Management Plan;
- Updated Programme to Manage Accidental Releases of Radioactive Substances;
- Description of quality results and remediation measures to be conducted on the process water; and
- The results of a detailed Mine Radiation Survey;
- Description of socio-economic assessment of projects and evaluation of present and future status/management of all mine initiated projects;
- Mine closure schedules for rehabilitation activities and completion dates for all facilities.

It is anticipated that mine closure activities could take up to 5 years dependant on closure activities of areas such as the heap leach facility.

An updated Mine Rehabilitation and Closure Plan will be developed by an independant consultant during the year prior to the implementation of mine closure activities. The report will be submitted to ECZ, MSD and RPA for approval and further recommendations. The results of public consultation of the requested land uses and other feedback will be included in this report.

10.4. Post Closure Plan

DMZL will employ an independent consulting company to conduct a post closure monitoring program over a minimum period of 5 years. The post closure plan will be conducted to manage the mine site into a state of equilibrium. The consultant will develop a program of post-closure environmental inspection and monitoring to assess the success of mine reclamation.

The program will be developed prior to completion of closure activities and will include some of the following activities:-

- Development of an inspection program for site facilities during the post closure phase;
- Monitoring will include assessments of radon, water and soil quality monitoring;
- Regular radiation assessment surveys;
- Assessment of revegetation progress;
- Description of reporting to ECZ, MMMD, RPA and other institutions of post closure activities.

This plan will be submitted to the ECZ, MMMD, RPA and other institutions for review and approval prior to closure and initiation of post closure program.

The mine inspections will verify that the components of the closed mine are not adversely impacting on the environment and do not pose a potential health risk and/or danger to the public. An independent consultant will conduct the site inspection and environmental monitoring.

The monitoring of post-closure conditions will occur for a period of at least 5 years. The monitoring of the leach pads, open pits and WRD areas is expected to continue for up to 30 years. Agreements will need to be developed with the Zambian government departments on the handling and final ownership of facilities once stabilised conditions have occurred.

10.4.1. Post Closure Environmental Inspections

These inspections will focus on:-

- Any instability issues around the mine site;
- Erosion occurring around the mine site;
- Success of re-vegetated sites with indigenous vegetation;
- Assessment of radiation from the leach pad area, the WRDs, the open pits;
- Any activity by the general public or persons unknown that may adversely affect the stability of disused mine structures, pose a danger to the community or possibly result in environmental degradation;
- The condition of site access roads, bridges and culverts.
- Collection of water (surface and ground), soil, radon and ARD samples to monitor environmental performance of closed facilities.

Consultations will be held with local community leaders to record any issues of concern pertaining to the closed mine site. Information on accidents, injuries or other events will be obtained from the local people.

Consultations will be conducted with local community services and other interested parties to determine post closure progress and any problems they may be experiencing.

10.4.1.1. Open Pits

Post-closure monitoring of pit slopes will be carried out to ensure that the pit high walls are stable and that there is no significant risk of failure.

The water quality of the flooded pits will be assessed for metal leaching or evidence of ARD. Groundwater samples will also be collected from sites maintained adjacent to the open pits. The water quality will determine future land uses.

Provided water quality monitoring results are favourable the open pit water may have other uses and could provide sources of water. General post mining land uses of pits, such as recreational facilities are generally not acceptable due to the nature of the mine (uranium).

10.4.1.2. Waste Rock Dumps

The WRDs will be inspected for the success of re-vegetation of the re-profiled dumps. Recommendations will be made for adjustments or further activity during each inspection.

Visual assessments for erosion occurring on the WRD sidewalls and upper surfaces will be conducted and measures recommended to halt and reverse these actions.

Groundwater and surface water samples will be collected in the vicinity of the WRDs (using original mine sampling sites or post-closure sites if the originals were disturbed) to determine any impacts on the water quality. The results will indicate the need for further remediation measures or ARD follow-up sampling.

Radon assessments will be continued for at least five years post closure to monitor the environmental releases (if any) from the closed facility.

Radiation assessments will be conducted over the facilities and in the surrounding areas to monitor contamination from the dumps or possible exposures that may exist.

10.4.1.3. Ore Preparation Area, Process Plant, Workshops

The inspections will evaluate the success of remediation and re-vegetation activities during mine closure. Improvement measures will be recommended.

The collection of water samples (surface and ground) and soil will be conducted. The results will indicate the need for further remediation measures.

10.4.1.4. Leach Pads

The monitoring and assessment of erosion around the leach pads will be conducted during inspections. Recommendations for further remediation measures will be made during the inspection reporting. Assessments of the effects that this may have on stability will also be conducted.

The collection of surface water and groundwater samples in monitoring boreholes will be continued. The results of the analysis will indicate the need for further remediation measures.

Radiation assessments will be conducted over the facility and surrounding area to monitor changes since closure activities were completed. Management measures will be developed for changed conditions.

The integrity of the liners on the leach pads will be monitored through groundwater and surface water quality monitoring.

10.4.1.5. Other Inspection Sites

The monitoring of surface water quality in the Namatelo, Nahunwe and Machinga Streams will be continued through the post closure period.

10.4.2. Frequency of Post-Closure Inspections

Post closure environmental inspection and monitoring will be done on a quarterly basis for the first 2 years to establish seasonal variations. Quarterly site visits will be made in January (rainy season), April (end of rains), July (dry season) and October (end of dry season). Monitoring may occur on a bi-annual basis for years 3 to 5 based on the results of the initial period.

Inspection and monitoring activities will continue up to 5 years after mine closure and may be required for a much longer period especially in the vicinity of the leach pads. The findings of this inspection will determine whether or not any further post closure site inspection is necessary.

10.4.3. Environmental Monitoring

Post closure monitoring activities will be conducted by an independent consultant. The consultant will be responsible for the collection of samples and delivery to approved analytical institutions.

Surface water samples will be submitted to an independent accredited laboratory and analysed for the key parameters pH, EC, TSS, TDS, SO_4, radioactivity, uranium as well as changes in total metal concentrations. Results of historical mine monitoring will be used to identify key parameters to monitor. Full suite analyses are recommended for the first 2 years of quarterly assessments to determine seasonal changes while the site reverts to an environmental equilibrium after mine closure. This may be required for up to 5 years for selected areas such as the WRDs, the leach pads and the open pits. Most surface water sites will be dry during the dry season so sites will be chosen that will facilitate effective monitoring.

Groundwater samples will be collected from the monitoring boreholes identified in the Mine Rehabilitation and Closure Plan. The samples will be submitted to an independent accreditted laboratory and analysed as described in the updated Mine Rehabilitation and Closure Plan. Full suite analyses are recommended for the first 2 years of quarterly assessments to determine seasonal changes while the site reverts to environmental equilibrium after mine closure.

Soil samples will be collected from areas where soil remediation activities are required (process plant, leach pad areas, WRDs, reagents store, fuel storage areas etc). A series of soil samples will be collected (based on the size of the remediated area) and submitted to an independant accredited laboratory for total metal analyses.

Radon monitoring will be conducted through samplers which can be used over a period of 3 months (quarterly). A series of monitors will be placed at the rehabilitated WRDs, leach pads and at the open pits to identify ambient conditions. If excessive levels are recorded then measures to identify emission areas and outline further remedial measures will be developed.

Radiation assessments will be conducted on an annual basis throughout the post closure phase of activities on the WRD, the leach pad areas and around the open pits to determine significant changes from the closure baseline levels. The results will be used to identify possible areas where contamination or erosion of closed facilities is affecting radiation levels.

The post-closure environmental monitoring program will be continuously evaluated during its implementation.

10.4.4. Post-Closure Environmental and Social Reporting

The independent consultant will produce an annual post-closure environmental monitoring report at the end of years 1 to 4 and a final post closure environmental report at the end of year 5. This final report will identify any impacts still occurring and discuss the requirements for future monitoring or remediation, if necessary. Further monitoring and data collection will be required for the leach pads and possibly the WRDs for up to 30 years.

The findings of all socio-economic consultations will be included in the annual post-closure reports.

These post closure annual environmental and social reports will be submitted to the EZC, MSD and RPA. The reports will also be made available to all stakeholders. The reports will present the findings of the mine site inspections/walkovers and the results of the environmental monitoring programme.

Where reclamation activities have not obtained the desired result, the consultant will make recommendations on what additional reclamation work is required to achieve full reclamation. Any areas of concern will be highlighted. The reports will include a post closure photographic record of mine reclamation.

No significant post closure environmental issues are anticipated. Environmental inspections and monitoring should cease in year 5.

11. MINE CLOSURE COSTS

Mine decommissioning and closure activities will be conducted on the open pits, waste rock dumps, leach pads, ore preparation areas, process plant, workshops and the operations camp.

11.1. Mine Decommissioning and Rehabilitation Costs

Denison will conduct mine decommissioning and closure activities for all mine facilities. The facilities created during the mining operation are described in **Table 11.1** below. It is unlikely that any of these areas will be made available to the local communities during closure planning and implementation. The Raw Water Pond (RWP) and the Mine Camp may be sold or handed over to the local communities and therefore have not been included in the cost breakdown.

Table 11.1 Mine Facilities to Undergo Closure Activities

Mine Facility	Surface Area (ha)
Mutanga Open Pit	33.0
Dibwe Open Pit	54.3
Process Plant	7.5
Ore Preparation Areas	2
Waste Rock Dumps	85.0
Heap Leach Pads	125
Operations Camp	13.5
Raw Water Dam (RWP)	4
Total	**324.3**

11.1.1. Cost of Mine Site Reclamation Tasks

A detailed costing study undertaken at Zambia Consolidated Copper Mines Limited (ZCCM) Copperbelt mines in Zambia by SRK Consultants and AMC in 1997 was used to determine the cost of decommissioning of the process plant, ROM Pad and workshop areas.

The study involved a survey of each mine plant site to identify the dismantling tasks. The labour and plant equipment requirements were determined and unit rates for each task were used to determine cost per hectare based on building densities and activities to be carried out. The costs calculated are considered to be indicative of reality because the approach was thorough and methodical.

Table 11.2 shows the unit plant site dismantling and disposal rates (US$/ha) for the Nkana, Chambishi, Nchanga, Konkola, Mufulira and Luanshya copper mines (1997 EIS).

The newer plants that have open spaces between buildings and plant (e.g. Chambishi) have lower unit costs than higher density buildings on older sites (e.g. Nkana).

DMZL will be a new mine site with low density of buildings and closure would be similar to Chambishi Mine with extra consideration for cleanup of contamination. It is estimated that with changes in economy and inflation the current closure cost for Mutanga processing facilities would be approximately US$45,000/ha.

Closure costs for profiling and infilling were used from this study and represent current estimates.

Table 11.2 ZCCM - Plant Site Dismantling & Disposal Cost, 1997 EIS

Mine Plant Site	Dismantling and Disposal Unit Cost (US$/ha)
Nkana Mine *	$103,571
Nchanga Mine	$59,895
Mufulira Mine	$57,333
Luanshya Mine	$55,266
Konkola Mine	$50,844
Chambishi Mine **	$39,482

* Relatively old mine with high density of plant/buildings across the mine site
** Relatively new mine with low density of plant/buildings across the mine site

11.1.1.1. Open Pits

The cost of decommissioning and closure of the Mutanga and Dibwe open pits are described in **Table 11.3**. The total estimated cost is **US$96,000**.

Table 11.3 Closure and Decommissioning Costs for the Open Pits

Activitiy/Task	Unit Cost US$	Unit (pits)	Cost US$
Removal of floating platform and dewatering pumps	8,000	2	16,000
Removal of dewatering pipeline	7,500	2	15,000
Removal of electrical equipment and cables	5,000	2	10,000
Removal of scrap materials	4,500	2	9,000
Blocking of pit ramp to prevent unauthorised access	8,000	2	16,000
Backfilling and profiling of sedimentation ponds	6,000	3	18,000
Signposting and bunding around open pits	6,000	2	12,000
Total Estimated Open Pit Decommissioning Costs			**96,000**

11.1.1.2. Processing Facilities, Offices, Workshop and Fuel Storage

The estimated dismantling and disposal costs have been evaluated on the basis that the mine will be a new site with a low density of mine buildings. On this basis the dismantling and disposal costs for the ore preparation areas and process plant facilities will be approximately US$45,000/ha. The breakdown of the **Table 11.4** is the breakdown of the decommissioning and closure costs for the processing facilities. The total estimated cost is **US$698,500**.

Table 11.4 Decommissioning and Closure Costs for the Processing Facilities

Activitiy/Task	Unit Cost US$	Unit	Cost US$
Disposal and Dismantling	45,000	9.5	427,000
Removal of HDPE liners on contaminated water ponds	10,000	1	10,000
Soil contamination survey	5,000	30 samples	150,000
Backfilling of sedimentation ponds	3,500	2 ponds	7,000
Grading and re-profiling	6,000	9.5	57,000
Re-vegetating	5,000	9.5	47,500
Total Decommissioning and Closure Cost			**698,500**

These costs do not include any revenue generated from the sale of scrap metal, mine equipment or vehicles, which may offset some decommissioning costs.

A soil contamination survey will be carried out after the process plant has been dismantled and disposed of. This will be used to assess and cleanup any contaminated soils present (if any). This cost includes assessment of collected samples and minor treatment of contaminated soils.

The estimated unit rate for grading and re-profiling the plant site to re-establish natural drainage is US$6,000/ha. The re-profiling will be done to a depth of 300mm.

The re-vegetating of the process plant and other facilities will be US$5,000/ha, which will include the costs to generate/buy seedlings, fertiliser and irrigation. The re-vegetation will be conducted using local plant species.

11.1.1.3. Operations Camp

The Operations Camp will cover an area of 13.5ha. It will be decommissioned assuming costs lower than the processing facilities based on less steelwork dismantling. The housing and building densities will be higher at the operations camp area. The total cost of the dismantling of the Operations Camp will be **US$557,700** and is described in **Table 11.5**.

Table 11.5 Decommissioning and Closure Costs for the Operations Camp

Activitiy/Task	Unit Cost US$	Unit	Cost US$
Dismantling and Disposal, Removal of pipelines	30,000	13.5	405,000
Backfilling of sedimentation ponds	3,500	1 pond	3,500
Grading and re-profiling	6,000	13.5	81,000
Re-vegetating	5,000	13.5	67,500
Total Decommissioning and Closure Cost			**557,000**

11.1.1.4. Raw Water Ponds

The raw water ponds may not be decommissioned during closure based on the potential for future public use. The ponds will drain themselves otherwise dewatering of the raw water will need to be conducted. However, a decommissioning cost has been prepared based on the assumption that the ponds will be decommissioned and revegetated. The decommissioning and closure costs for the raw water ponds are **US$50,500** which are shown in **Table 11.6**.

Table 11.6 Closure and Decommissioning Costs for the Raw Water Ponds

Activitiy/Task	Unit Cost US$	Unit (ponds)	Cost US$
Removal of floating platform and pumps	8,000	2	16,000
Removal of raw water pipeline	7,500	1	7,500
Removal of electrical equipment and cables	5,000	1	5,000
Backfilling and profiling of ponds	6,000	2	12,000
Re-vegetation of the ponds	5,000	2	10,000
Total Decommissioning and Closure Costs			**50,500**

11.1.1.5. Waste Rock Dumps

The decommissioning and closure cost for the WRDs is described in **Table 11.7** below.

Mine solid waste (plastics, filters, wood etc.) will be incinerated or dumped in a dedicated landfill site within the project area.

The waste rock dumps may contain a low amount of uranium and radioactivity. The requirement of lining or capping the WRDs will be determined during mine life. The estimated total closure cost is **US$952,000**.

Table 11.7 Decommissioning and Closure Costs for the Waste Rock Dumps

Activitiy/Task	Unit Cost US$	Unit	Cost US$
Backfilling and re-profiling sedimentation ponds	3,500	3 ponds	10,500
Signposting of low grade stockpile hazards	3,500	1 stockpile	3,500
Backfilling and re-profiling perimeter drains	3,000	1 series of drains	3,000
Grading and Re-profiling of WRDs	6,000	85	510,000
Re-vegetating	5,000	85	425,000
Total Decommissioning and Closure Cost			**952,000**

11.1.1.6. Heap Leach Pads

The heap leach pads will be decommissioned at mine closure. The pads may contain acidic leached material and will be rehabilitated in-situ.

At closure, the pads will be decommissioned as described in the Mine Decommissioning Plan above. The pads will be decommissioned in the dry season. The pads will be profiled and covered with an impermeable cap liner. Soil will cover the liner to allow for re-vegetation to be conducted. The estimated total closure cost is **US$7,771,500**.

The decommissioning and closure cost for the pads is described in **Table 11.8** below.

Table 11.8 Decommissioning and Closure Costs for the Heap Leach Pads

Activitiy/Task	Unit Cost US$/ha	Surface Area Ha	Cost US$
Neutralisation and analysis of leachate	1,000	125ha	125,000
Backfilling and re-profiling ponds	3,500	3	10,500
Signposting of hazardous area	3,500	1 series of signposts	3,500
Backfilling and re-profiling perimeter drains	3,000	1 set of drains	3,000
Grading and re-profiling of leach pads	6,000	125ha	750,000
Impermeable lining of leach pads	50,000	125ha	6,250,000
Re-vegetating	5,000	125ha	625,000
Total Decommissioning and Closure Cost			**7,767,000**

11.1.2. Total Mine Decommissioning and Rehabilitation Cost Estimate

The total decommissioning and rehabilitation costs are described in **Table 11.9** below.

Table 11.9 Total Closure and Decommissioning Costs for the Mutanga Project

Item no.	Activity/Task	Cost US$
1	Decommissioning and Closure of the Open Pits	96,000
2	Decommissioning of the Processing Facilities	698,500
3	Decommissioning of the Operations Camp	557,000
4	Decommissioning of the Raw Water Ponds	50,500
5	Decommissioning and Closure of the WRDs	952,000
6	Decommissioning Heap Leach Pads	7,767,000
	Sub Total	**10,121,000**
	10% Contingency	**1,012,100**
	Total Decommissioning and Rehabilitation Costs	**11,133,100**

The total Mutanga Mine decommissioning and rehabilitation cost is estimated at **US$11,133,100**.

APPENDIX 1 DMZL POLICIES AND PROCEDURES

DENISON MINES

ENVIRONMENT, HEALTH AND SAFETY POLICY

Denison is committed to the operation of its facilities in a manner that puts the safety of its workers, its community and the environment above all else. Whenever issues of safety conflict with other corporate objectives, safety shall be the first consideration. Accordingly, Denison is committed to the following principles:

- it will build and operate its facilities in compliance with all applicable laws and regulations of the jurisdictions in which it operates;
- it will adopt and adhere to standards that are protective of both human health and the environment at all of its facilities; and
- it will keep radiation health and safety hazards and environmental risks as low as reasonably achievable.

In support of these principles, Denison will:

- establish and maintain clearly defined safety and environmental management programs to guide its operations in accordance with the foregoing principles;
- ensure that it has adequate resources and appropriate staffing in order to implement its safety and environmental programs;
- ensure that its employees are properly trained in the implementation of its safety and environmental programs and in compliance with applicable laws and regulations;
- institute regular monitoring programs to identify risks to its workers, the public or the environment and to ensure compliance with regulatory requirements;
- set objectives and targets in an effort to continually improve its health, safety and environmental management and performance;
- identify and reduce the potential for accidents and emergency situations, and implement emergency response plans that will protect the health and safety of its workers, the public and the environment;
- conduct regular audits to assess and ensure compliance with this policy;
- develop processes for preventing non-conformance with this policy and adopting corrective actions; and
- require regular reporting to its Board of Directors regarding compliance with this policy.

This policy has been adopted by and its implementation is the responsibility of the Board of Directors of Denison. The Board of Directors holds all levels of management and all employees responsible for compliance with this policy within their areas of responsibility.

E. Peter Farmer	Ron Hochstein
Chief Executive Officer	President and Chief Operating Officer

APPENDIX 2 SECURITY DURING THE TRANSPORTATION OF URANIUM CONCENTRATES

APPENDIX 3 MATERIAL SAFETY DATA SHEETS

APPENDIX 4 PROCEDURE FOR THE STORAGE OF URANIUM CONCENTRATES

APPENDIX 5 PROCEDURE FOR THE OFF-SITE TRANSPORT OF RADIOACTIVE MATERIALS

APPENDIX 6 RADIOACTIVE WASTE MANAGEMENT PROGRAMME

APPENDIX 7 MINE WATER MANAGEMENT PLAN

APPENDIX 8 DRAWINGS AND MAPS

APPENDIX 9 TERMS OF REFERENCE

APPENDIX 10 SOIL SAMPLING DATA

APPENDIX 11 WATER SAMPLING DATA

APPENDIX 12 FAUNA SURVEY RESULTS

APPENDIX 13 PUBLIC CONSULTATION

APPENDIX 14 RADIATION OPERATION MANAGEMENT PROTECTION PLAN (ROMP)

APPENDIX 15 SELECTION OF PERSONAL PROTECTIVE EQUIPMENT

APPENDIX 16 PROGRAM TO MANAGE ACCIDENTAL RELEASE OF RADIOACTIVE SUBSTANCES

APPENDIX 17 QUANTITATIVE RADIOLOGICAL HAZARD AND SAFETY ASSESSMENT