NI 43-101 TECHNICAL REPORT ON A PRELIMINARY ECONOMIC ASSESSMENT OF THE MUTANGA URANIUM PROJECT IN ZAMBIA

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Prepared For

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EXECUTIVE SUMMARY (ITEM 1)

1 EXECUTIVE SUMMARY INTRODUCTION (ITEM 1)

SRK Consulting (UK) Limited ("SRK") has been requested by GoviEx Uranium Inc ("GoviEx"), hereinafter also referred to as the "Company" or the "Client") to prepare a Technical Report evaluating the potential economic and technical viability of the Mutanga Uranium Project ("Mutanga Project" or "the Project") in the Southern Province of the Republic of Zambia ("Zambia") near the town of Siavonga. GoviEx holds several contiguous mining and prospecting licences acquired from Denison Mines Corp ("Denison") and African Energy Resources ("AFR") that are now grouped as the Mutanga Project.

1.1 Geology

The Project area is situated within the Karoo Supergroup, a thick terrestrial sedimentary strata, widespread across much of southern Africa and deposited during late Carboniferous to late Triassic. Sediments were deposited in an extensive foreland basin where rifting is thought to be associated with the breakup of Gondwanaland during the Permian Period, followed by opening of the proto-Indian Ocean in the Jurassic and finally development of the East African Rift system in late Cretaceous and early Tertiary. During the Cenozoic, the East African Rift System propagated across the continent and led to reactivation of the Karoo rift basins and formation of new fault depressions, such as the south-eastern extension of the mid-Zambezi and Luangwa rift systems.

The Karoo Supergroup consists of the three Formations within the Lower Karoo and four Formations within the Upper Karoo. There are at least six regional depositional sequences that broadly reflect synchronous episodes of basin subsidence and climate change. These vary considerably in detail from one sub-basin to another. Karoo strata typically overlie Precambrian crystalline basement rocks. Many of the Karoo rift basins contain sandstone-hosted uranium mineral deposits typically within the Upper Karoo. At Mutanga, all of the known uranium mineralisation occurs within the Escarpment Grit, a 400 m thick series of continental arenaceous silici-clastic sediments with interbedded mudstones and fine grained sandstones as well as grits and conglomerates. The Escarpment Grit consists of two informal members thought to represent a change in fluvial style; a lower "Braided Facies" member is interpreted as braided stream deposits and the overlying "Meandering Facies" is much more extensive and thought to represent point-bar and flood plain deposits. The Escarpment Grit unconformably overlies the Madumabisa Mudstone that appears to have acted as an impermeable barrier controlling the base of the mineralisation. Mineralisation appears to have been introduced after sedimentation, weathered from surrounding Proterozoic gneisses and plutonic basement rocks, transported in solution then precipitated in siltstones and sandstones. Mineralisation appears to be later than at least some of the normal faults that cut the Escarpment Grit Formation. This is evident from the good correlation of the radiometric logging data between adjacent holes within the Mutanga mineral deposit separated by interpreted faulting. Within the Mutanga uranium deposit, the Escarpment Grit Formation comprises at least 120 m of sandstone and conglomerates with occasional mudstones and silts. It overlies the Madumabisa Mudstone Formation, comprising of silty mudstone, with a dark red hematised layer, two to three meters below the contact, representing either oxidising groundwater or a sub-aerial surface. Dibwe East occurs predominantly within the Escarpment Grit Formation and specifically, the uraniferous mineralisation is hosted by the relatively un-faulted meandering facies. Generally, uranium mineralisation occurs in a number of different associations: (i) as disseminated mineralisation where grades vary considerably; (ii) associated with mudstones and siltstones; (iii) fracture hosted uranium mineralisation and (iv) mineralisation associated with pyrite.

The geology at Gwabe and Njame consists entirely of Escarpment Grit, ranging from thick coarse conglomerate beds to thinly bedded or cross-bedded fine to medium grained sandstones. Thin bands of shale and mudstone are intercalated in the sequence. Below the Grits are well-developed calcareous shale and siltstone layers, possibly representing the upper part of the underlying Madumabisa Mudstone. Uranium mineralisation occurs at the interface between siltstones and sandstones at redox boundaries.

1.2 Resource

The Mutanga Project contains a Measured and Indicated Mineral Resource of 21.6 million tonnes at an average grade of 318 ppm U_3O_8, containing 15 million pounds of U_3O_8, and an Inferred Mineral Resource of 74.6 million tonnes at an average grade of 273 ppm U_3O_8, containing 45 million pounds of U_3O_8 in six deposits (Mutanga, Dibwe East, Dibwe, Gwabe, Njame, and Njame South), located over 65 km strike. The Mineral Resource estimate determined by SRK, based on information provided in previous studies, is shown in Table ES-1 and the location of the deposits in Figure ES-1. No Mineral Reserve has yet been determined for this Project.

Table ES-1: Mineral Resource Estimate[1], Mutanga Uranium Project, Zambia, SRK Consulting (UK) Ltd, November 20, 2017

Deposit	Category	Tonnes (Mt)	U_3O_8 Grade (ppm)	U_3O_8 Mlb
Mutanga[2]	Measured	1.9	481	2.0
	Indicated	8.4	314	5.8
	Inferred	7.2	206	3.3
Dibwe[2]	Inferred	17.0	239	9.0
Dibwe East[2]	Inferred	43.1	304	28.9
Gwabe[3]	Measured	1.3	237	0.7
	Indicated	3.6	313	2.5
	Inferred	0.7	178	0.3
Njame[3]	Measured	2.7	350	2.1
	Indicated	3.7	252	2.1
	Inferred	2.1	225	1.1
Njame South[3]	Inferred	4.4	250	2.4
Sub-total Measured		5.9	366	4.8
Sub-total Indicated		15.7	299	10.4
Measured and Indicated		21.6	317.5	15.1
Inferred		74.6	273.0	44.9

[1] Mineral Resources have not been constrained by pit shells, however, almost all of the mineralisation occurs within 125 m of surface with uranium grades which are, in general, considered to have reasonable prospects for eventual economic extraction by open pit mining.

[2] The cut-off grade used for reporting the Mineral Resource is 100 ppm U_3O_8, which is applied directly to block model cells.

[3] No U_3O_8 ppm cut-off is applied to block model cells for reporting the Mineral Resource. However, the outer limits block model was constrained within a 100 ppm U_3O_8 wireframe used for geological modelling.

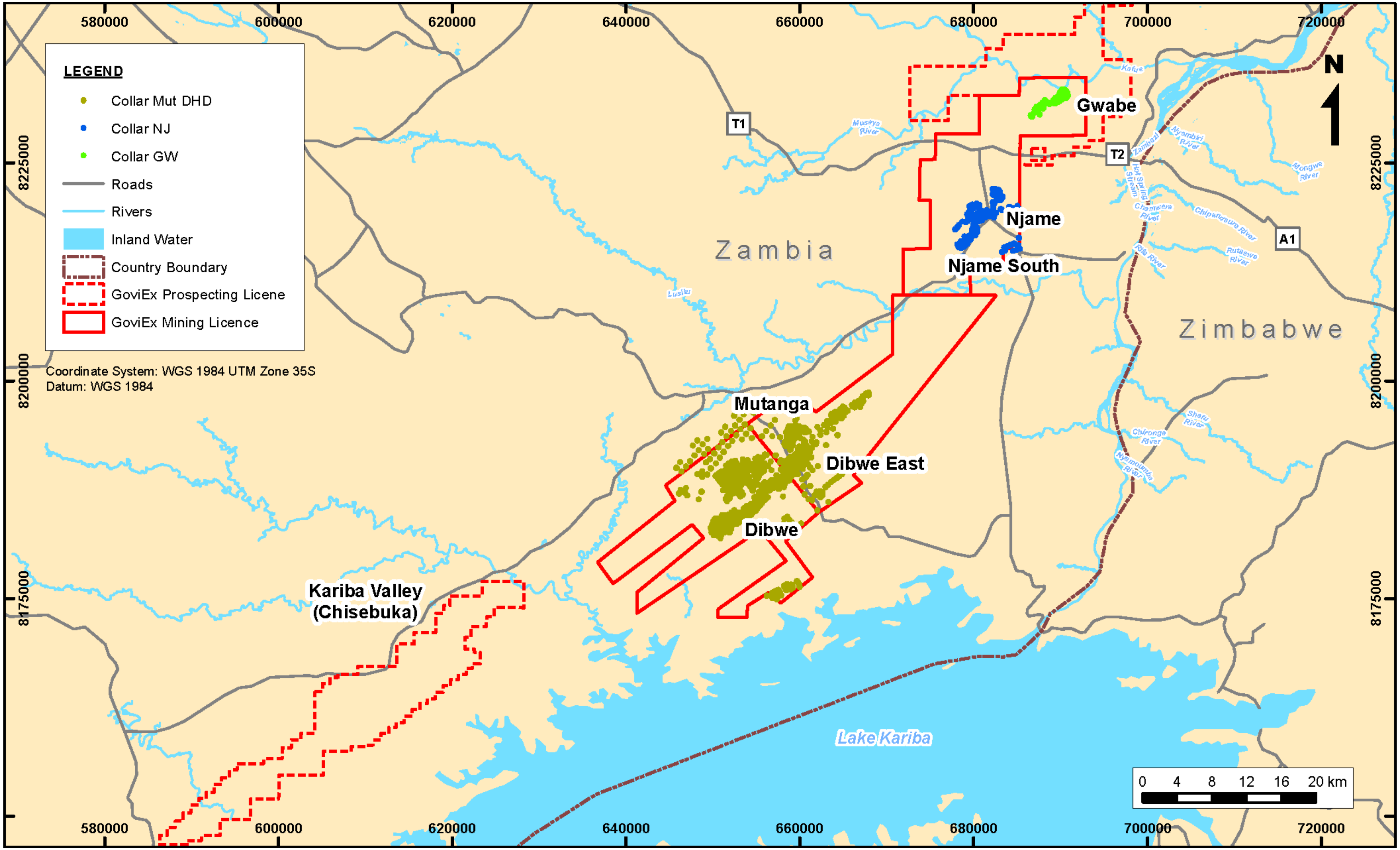

Figure ES-1: Location of Named Prospects in the GoviEx Mutanga Project

1.3 Mining

The deposits are amenable to conventional, shallow open cast mining methods utilising excavators and trucks with relatively low stripping ratios. Ore and waste is in a cemented sandstone that will require blasting. Pit optimisations were run for considered deposits to determine pit limits and pushback development. Production schedules have been prepared for all deposits using a cut-off grade of 129 ppm U_3O_8 and a plant feed rate of 4.0 Mt per annum (“Mtpa”).

A number of economic and technical parameters used for this study are based on assumptions and historical studies. These parameters will be further interrogated and updated in future studies. A base case metal price of 50USD/lb U_3O_8 was used for the pit optimisation results in a Run of Mine (“RoM") inventory to cover 11 years of production from the six considered deposits.

Mining losses and dilution were applied as 10% and 10% global values. Diluting grade used was 0.0 ppm U_3O_8. The total pit inventory for mineralized material is 40.8 Mt at 333 ppm U_3O_8. The overall strip ratio for the Project is 3.4 (t:t), but varies from 1.4 to 6.0 (t:t) depending on the deposit.

At the time of writing, the pit design is preliminary and SRK only developed wireframes with appropriate sensitivity analysis. The mining production schedule has been developed at a feed rate of 2.0 Mtpa in Year 1 and 4.0 Mtpa thereafter.

The conceptual waste and RoM mining fleet estimates are based on 5.0 m^3 excavators and 45 t articulated trucks, the assumption was made that waste, and RoM materials will be drilled, blasted and mined on 10 m benches.

1.4 Processing

Two process options have been investigated: alkaline leach and acid leach. Acid heap leaching was selected on the basis of giving slightly better overall recovery and leaching rate for all six deposits and it has lower operating and capital costs. Test work has indicated that heap permeability would be good and that acid consumption would be relatively low in a range of 3-9 kg/t for all deposits except Gwabe that requires 18 kg/t. The process is robust, simple and has a low environmental profile. The nature of the operation will support greater participation by the local labour force. Work has been completed including bottle roll and column testwork, mineralogy and metal recovery and precipitation.

The acid consumption and uranium recovery for each deposit is shown in Table ES-2.

Table ES-2: Summary of Metallurgical Data

Deposit	Average U recovery, %	Acid consumption kg/t
Mutanga	85.4	3.86
Dibwe East	93.3	6.37
Dibwe	74.6	9.34
Njame	85.1	2.61
Gwabe	75.4	18.49

Three separate ore preparation and leach areas will be developed adjacent to the deposits. The main facilities for recovery of uranium oxide will be located close to the Mutanga and Dibwe East pits. Ore will be trucked from the pits and dumped directly into a crushing and agglomeration circuit. The crushed ore will be transported by conveyor to the adjacent leach pad and stacked in 4 m lifts in a continuous operation. Each lift will be irrigated using a drip system with an acidic solution to dissolve the uranium; in addition, ferric sulfate may be used at Gwabe to improve extraction of uranium from slow leaching silicates. The leach solution will percolate through the heap into drains located above the top pad liner and drain into an intermediate preganant leach solution ("PLS") pond. It will then be pumped back on to the heap. Once the solution has sufficient uranium (approximately 30 g/L), this will be directed by open ditches to the pregnant leach solution pond and pumped to the process plant. Pads will be built, operated and closed out in one to two year increments. Once the maximum three lifts are leached, then closure activities will commence. Pads, ditches and ponds will be double lined. Pads and ponds will have leach detection systems as well as piezometers to monitor local ground water quality.

At the Central Process Facility ("CPF"), uranium will be stripped from the leach solution and loaded onto a resin. The process is reliable and has been proven at other locations. The barren leach solution will be returned to the barren pond to be used for leach solution make up. The CPF will produce uranium oxide in the form of a dry powder that will be loaded directly into drums and immediately sealed. The drums will be washed, transported to an adjacent storage area and then loaded into 6.3-m sea containers for transport to port. The plant has the capacity to produce sufficient uranium to fill two or three barrels a day, each drum weighing about 1,000 kg. Uranium production is expected to average approximately 2.4 Mlb U_3O_8 per annum of uranium contained in uranium oxide.

For Mutanga-Dibwe East leach pad, PLS will be pumped to the adjacent CPF for stripping and concentrating uranium. For the other deposits, PLS will be pumped to an adsorption plant to be stripped of uranium and loaded onto resin shipped to the CPF. Approximately 24,000 L per day of resin will be transported by truck to the CPF for concentrating; barren resin will be trucked back to satellite operations.

1.5 Hydrogeology and Hydrology

At Mutanga and Dibwe, the aquifers are heterogeneous, semi-confined exhibiting both structural and matrix porosity which contributes to overall yield and storativity. The aquifers in both the Njame and Gwabe prospects are thought to be comprised of a poorly developed weathered, unconsolidated aquifer and a deeper, consolidated fractured aquifer. Groundwater is thought to flow relatively easily across the Project area due to fault zones and lateral interconnections between aquifers. Near Mutanga and Dibwe there is a relatively poor correlation between surface topography and static water level elevation, but close to Njame and Gwabe a correlation is more apparent, overall static groundwater levels appear to vary significantly across the project site.

Local communities rely almost solely on groundwater from handpumps, especially during the dry season. Where settlements do occur, water is in high demand by people and animals; however, overall, the region is relatively sparsely populated, so current aquifer utilisation is low.

An investigation of flood hydrology revealed that the area to the south of the proposed Mutanga Pit lies within the flood inundation area and the Dibwe open pit is located on the natural water course and will be affected by any 1:50 and 1:100 year floods unless water course-diversions are put in place. At Dibwe and Gwabe, nominal grading and ditches should be adequate to maintain a well-drained site.

Aquifer testing at Mutanga and Dibwe has reported an average blow-yield of 3.6 L/s and average hydraulic conductivity (K) values of 0.63 m/day for Mutanga and 0.31 m/day for Dibwe. Average sustainable yield was calculated at 4.51 L/s and 2.67 L/s for Mutanga and Dibwe respectively assuming no recharge and 6.93 L/s and 3.5 L/s respectively assuming a recharge of 3.2 % of the mean annual precipitation of 529 mm.

Aquifer testing at Njame and Gwabe has been limited, but preliminary tests have revealed yield values that are significantly variable. Relatively high yields for this geological environment (approximately 2 L/s) were encountered in areas which are deeper weathered and in an inferred fault zone. Very low yields (<0.1 L/s) were observed in boreholes drilled on the rocky ridges with very shallow weathering.

A series of pit perimeter wells and internal horizontally drilled boreholes will be required for dewatering at Mutanga and Dibwe. A dewatering rate of 172 L/s will be needed to keep the Mutanga pit free of hydrostatic pressure for the first six years, after which an additional 177 L/s will be abstracted from the Dibwe Pit area. For the limited time when both dewatering systems are operational, a combined 349 L/s will therefore be abstracted from the aquifers on site. The proposed dewatering rate is expected to keep the water level approximately 20 m below the depth of the open pits at all times during mining and related activities.

Dewatering and runoff from areas disturbed by the project will provide sufficient water to meet the needs of operations. Surplus water from the dewatering programme will be released to environment after treatment for removal of solids. Aquifer water quality is very high with minimum uranium contamination.

Numerical modelling has shown that groundwater quantity is expected to decrease due to dewatering; however, throughout the Life of Mine (“LoM”), the cone of depression is not expected to extend out of the concession area and groundwater is expected to fully recover after 65 years in the Mutanga Pit and 82 years in the Dibwe Pit. During the LoM, any potential contaminant plumes will be drawn towards the open pits due to the dewatering process, these are expected to migrate further from the source once dewatering is decommissioned.

Dewatering is likely to be required at Dibwe and Gwabe during the rainy season in which 600 mm of rain falls. Only preliminary studies have been conducted to date but initial results indicate that a pumping rate of 65 L/s is required to reach a sufficient drawdown after one year of pumping and around 6 to 10 suitably sited dewatering boreholes should be sufficient to achieve this. Limited aquifer testing has revealed highly variable borehole yields across the study area and low yields may be an issue for dewatering because underlying lithologies may be able to store significant volumes of groundwater, but low transmissivity may limit flow in the dewatering boreholes.

1.6 Environment

GoviEx currently holds Zambia Environmental Management Agency (“ZEMA”) licences for management, generating and storing of hazardous waste plus an emissions licence. Environmental Impact Assessments (“EIA”) were prepared for the Njame and Gwabe operations in 2008 and for the Mutanga and Dibwe operations in 2009. Environmental Management Plans (“EMP”) were generated for both EIA and a Resettlement Action Plan

("RAP") was also prepared for Mutanga. All licences required have been approved and are currently valid.

The Project area is characterised by a combination of Mopane or Miombo woodland, bare rock outcrops, small agricultural fields and degraded grassland. Soils are gleysols and sandy loams which are nutrient deficient with poor water retention capacity. There is a distinct wet and dry climate; land adjacent to watercourses is cultivated during the wet season then abandoned in the dry season. Insects in the Project area are diverse and abundant and a wide variety of bird species has been witnessed at surveys conducted near Mutanga and Dibwe. Mammal species are relatively low in abundance and diversity; those identified on the IUCN Red List are classified as "Least Concern". Site clearance and the removal of vegetative cover during the Project pre-construction phase will affect indigenous woodland areas and part of the farming land for the local community; however, it is expected to have little impact on species number or diversity. GoviEx will only conduct clearance where necessary and will implement a revegetation program as part of its environmental management plans. GoviEx will work with local NGOs and government departments on sustainable projects to promote the regeneration of fauna and flora in the Project area and ensure the protection of sensitive areas in and around the Project that may provide conservation areas for existing fauna and flora. GoviEx will ensure that maintenance areas are fully equipped with impermeable surfaces and containment facilities to prevent any land contamination through accidental spillage or poor waste management.

A policy of zero discharge is planned for all contaminated water and process water as although there will be no direct impacts to hydrology as a result of the Project, surface waters will be indirectly affected through discharge of effluents from the Project to the surrounding environment. All water contaminated by uranium or process residues will be recycled. Rain water runoff from potentially contaminated areas will be designated as contaminated and contained. Suspended solids from otherwise clean water will be settled prior to discharge to local water courses or use as process makeup water. Tests on mine wastes indicate that there is minimal potential for acid rock drainage. Runoff from dumps will be tested to confirm quality prior to release.

When Mutanga and Dibwe are both operational, dewatering will be necessary at a combined rate of 349 L/s (equivalent to approximately 30,000 m^3/d). This could impact on groundwater users in the area. Wells in neighbouring villages will be regularly monitored to assess impacts on water levels. An impermeable HDPE liner in the process water, rafinate, and PLS ponds will be used to prevent impacts to groundwater. Inspection pits or monitoring boreholes will also be constructed adjacent to the ponds to provide an early warning of leaks.

Closure of heap leach pads will begin as soon as leaching of three lifts is complete. Activities include water flushing the heaps to reduce pH, sealing with an impermeable membrane, capping with 300 mm of soil and re-vegetating. Side slopes will be graded to approximately 18°. Commencement of closure activities early will minimize the catchment area for contaminated runoff that will have to be captured in the barren solution pond.

Temporal deterioration has been observed in air quality in the Project region, although no formal air quality data is available. The haze is most apparent in the cooler months and occurs as a result of grassland and forest fires, charcoal burning, and shifting cultivation practices. There is currently very limited traffic in the region therefore exhaust emissions are localised and dispersed rapidly; however, the Project will significantly increase the volume of traffic in the site vicinity. The main threat to air quality is the dispersion of uranium-bearing dust which could occur during the construction and operational phases. Road dust will be controlled by regular sprinkling with water. Areas that generate dust such as crushers and screens in the ore preparation area, will be enclosed and exhaust air will be filtered. Material handling transfer points will use water sprays to minimize dust. GoviEx will conduct regular monitoring and comparison to appropriate international and Zambian statutory dust emission limits. Monthly radon concentration returns will also be submitted to the ECZ as per the Radiation Management Plan.

Current noise levels in the Project area are very low owing to the remote location and the absence of active industry. The Project will have some noise impacts on the environment, but it is unlikely that they will significantly impact local villages as the open pits are situated several kilometers away and blasting will be conducted infrequently over a short duration.

Although there are known archaeological and palaeontological sites in the region, studies conducted to date have not revealed any archaeological sites or artefacts within the Project vicinity. Two sacred cultural sites have been identified, but they will not be affected by the Project activities. Three burial grounds were also identified near Njame; however, these are not ancient and fall outside of heritage legislation. It is possible that there may still be negative impacts to archaeological heritage, and if there are cases where destruction of an archaeological resources is inevitable rescue/salvage operation will be carried out to mitigate the impact.

The main social impact will be the relocation of 1300 people from nineteen small villages, which will be managed through the RAP. A number of additional environmental management plans will be developed and implemented to reduce health and safety impacts to the environment and public. To manage local public expectations of the Project, GoviEx will ensure effective community liaison through consultation programs.

1.7 Infrastructure

The Project will consist of five open pits at Mutanga, Dibwe, Dibwe East, Gwabe, and Njame. There will also be three heap leach pads at Dibwe East/ Mutanga, Dibwe and Gwabe/Njame and a CPF between Dibwe East and Mutanga. Other Project infrastructure includes waste rock dumps, RoM ore stockpiles, mine workshops, mine stores, mine camp, power supply, pollution control dam, sewage treatment plant, raw water tank, administration building, assay laboratory, and other facilities. The camp will be constructed with living and normal recreational facilities. Onsite facilities for storage of fuel and reagents will have a live capacity equivalent to approximately 30 days' usage. Storage for uranium oxide and plant reagents will include a concrete floor slab and block work dwarf wall to contain any spillage. A new site access road will be constructed using the existing right of way occupied by the current Zyiba Meenda road. The road will be re-routed to avoid villages, rebuilt and sealed for a total length of 26 km. Power will be provided by a new 66 kV power line from Chirundu to site, the right of way following the access road.

1.8 Human Relations

The mine will operate year round and 24 hours a day on three 8 hour shifts. A total of approximately 384 persons will be employed single status on a turnaround basis.

The Project will be developed and operated based on the principle of maximizing opportunities for participation by Zambian nationals. Skills training will begin during the construction phase and continue during operations. Opportunities will be sought to build the capacity of Zambian companies with the potential for ongoing opportunities during operations.

1.9 Health, Safety and Security

Zambia upgraded its mining legislation to take into account uranium, following detailed consultation with the IAEA. It started issuing uranium mining licenses late in 2008. It is signatory to the Non Proliferation Treaty and has been a member of the IAEA since 1969.

A safety and health management programme ("SHMP") will be developed based on the principles of the GoviEx Health and Safety Policy. Procedures, guidelines and work instructions from other GoviEx operations will be used as starting points for development of site specific documents for Mutanga.

A programme to manage the identification, mitigation and avoiding hazards such as radiation and radon will be in place prior to the start of operation. This programme will be part of the overall SHMP and will include community awareness, worker training, personal protective equipment, preventive measures, monitoring and emergency response.

Onsite facilities for emergency response will include a medical facility, ambulance, fire truck and fire fighting equipment. A trained medic will be on site at all times as will a trained volunteer emergency response team.

The site access road will remain a public road. Open pits, leach pads, ore preparation areas, process plant areas and camps will all be fenced to restrict access which will be controlled by a trained security team. The security team will work closely with local communities.

1.10 Transport and Logistics

Imported cargo will be either sourced in South Africa or imported through either Durban, South Africa, Walvis Bay, Namibia and/or Dar-es-Salaam, Tanzania, then transported to site by road. Barrels of uranium oxide will be loaded into standard 6.3 m sea containers and trucked to Walvis Bay sea port, Namibia; one truck load per week is expected.

1.11 Capital Cost and Operating Cost

Total capital expenditure for the life of the operation is presented in Table ES-3. A two-year construction period ahead of production is envisaged. The LoM costs are shown in Table ES-4. The operation is intended to be contractor mined.

Table ES-3: Capital Expenditure

Parameter	Units	Total Amount
Project Capital		
Mine Mobilisation Fee	(USDm)	0.4
Plant	(USDm)	82.6
Camp	(USDm)	3.2
Infrastructure	(USDm)	7.5
G&A	(USDm)	2.1
EPCM	(USDm)	12.0
Contingency	(USDm)	10.7
Community	(USDm)	5.0
Total Project Capital	**(USDm)**	**123.4**
Deferred / Sustaining capital		
Plant	(USDm)	27.2
Camp	(USDm)	1.6
Infrastructure	(USDm)	4.4
G&A	(USDm)	1.6
EPCM	(USDm)	4.6
Contingency	(USDm)	3.9
Closure Cost	(USDm)	11.1
Community	(USDm)	5.0
Total Deferred / Sustaining Capital	**(USDm)**	**59.5**
Total Capital Expenditure	**(USDm)**	**182.9**

Table ES-4: LoM Operating Costs (excluding royalty)

Operating Cost Item	Total Amount (USDm)	Unit Cost (USD/t ore)	Unit Cost (USD/lb U_3O_8)
Mining	452.5	11.1	17.1
Ore Transport	20.4	0.5	0.8
Processing	288.9	7.1	10.9
G&A	39.7	1.0	1.5
Transport U_3O_8	3.0	0.1	0.1
Environmental	18.0	0.4	0.7
Subtotal Operating Costs	**822.5**	**20.2**	**31.1**

1.12 Implementation

Table ES-5 shows provisional major milestones, subject to financing.

Table ES-5: Summary of Project Milestones

Milestone	Date
Submit mining license application	awarded
Begin detailed feasibility study	2019
Begin design, procurement and construction	2020-2021
Begin commissioning	2022
Full production	2022 / 2023

1.13 Marketing

The world's operating nuclear power reactors currently require an average of approximately 180 Mlb of U_3O_8 per year. As nuclear power capacity increases, the world's uranium fuel requirement also increases and is estimated to rise to approximately 235 Mlb U_3O_8 by 2030.

1.14 Project Statistics

The study has produced the results shown in Table ES-6.

Table ES-6: Technical Economic Model Summary and Results

Parameter	Units	Base Case
Mining	(USD/t ore)	11.1
	(USD/t mined)	2.5
Ore Transport	(USD/t ore)	0.5
Processing	(USD/t ore)	7.1
G&A	(USD/t ore)	1.0
Transport U_3O_8	(USD/t U_3O_8)	250.0
Environmental	(USD/t ore)	0.4
Subtotal operating costs	**(USD/t ore)**	20.2
	(USD/lb U_3O_8)	31.1
Royalty	(USD/t ore)	3.4
Total Operating Costs	**(USD/t ore)**	23.5
	(USD/lb U_3O_8)	36.4
Operating Profit - EBITDA	**(USDm)**	**571**
Corporate Profit Tax	**(USDm)**	**(119)**
Capital Expenditure		
Project Capital		
Mine Mob Fee	(USDm)	0.4
Plant	(USDm)	82.6
Camp	(USDm)	3.2
Infrastructure	(USDm)	7.5
G&A	(USDm)	2.1
EPCM	(USDm)	12.0
Contingency	(USDm)	10.7
Community	(USDm)	5.0
Project Capital Expenditure	**(USDm)**	**123.4**
Deferred/Sustaining capital		
Plant	(USDm)	27.2
Camp	(USDm)	1.6
Infrastructure	(USDm)	4.4
G&A	(USDm)	1.6
EPCM	(USDm)	4.6
Contingency	(USDm)	3.9
Closure Cost	(USDm)	11.1
Community	(USDm)	5.0
Sustaining Capital Expenditure	**(USDm)**	**59.5**
Total Capital Expenditure	**(USDm)**	**182.9**
Net Free Cash	**(USDm)**	**269**
NPV @ 8.00%	**(USDm)**	**112**
IRR	(%)	25

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NI 43-101 TECHNICAL REPORT ON A PRELIMINARY ECONOMIC ASSESSMENT OF THE MUTANGA URANIUM PROJECT IN ZAMBIA

2 INTRODUCTION (ITEM 2)

SRK Consulting (UK) Limited ("SRK") is an associate company of the international group holding company, SRK Consulting (Global) Limited (the "SRK Group"). SRK has been requested by GoviEx Uranium Inc ("GoviEx"), hereinafter also referred to as the "Company" or the "Client") to prepare a Technical Report evaluating the potential economic and technical viability of the Mutanga Uranium Project ("Mutanga Project" or "the Project") in the Southern Province of the Republic of Zambia ("Zambia") near the town of Siavonga.

The Project reflects the consolidation of contiguous licences previously held by Denison Mines Corp ("Denison") and African Energy Resources ("AFR"). The Technical Report is based on work previously completed up to bankable feasibility study, in order to secure the mining licenses, and has been updated as appropriate to provide a reassessment of the project and the resources.

The report is prepared in accordance with the disclosure and reporting requirements set forth in the Toronto Stock Exchange Manual, National Instrument 43-101 (2011) - Standards of Disclosure for Mineral Projects ("NI 43-101"), Companion Policy 43-101CP to NI 43-101, and Form 43-101F1 of NI 43-101.

SRK (including its directors and employees) does not have nor hold:

- any vested interests in any concessions held by GoviEx, or any adjacent concessions;
- any rights to subscribe to any interests in any of the concessions held by GoviEx either now or in the future; or
- any right to subscribe to any interests or concessions adjacent to those held by GoviEx either now or in the future.

SRK's only financial interest is the right to charge professional fees at normal commercial rates, plus normal overhead costs, for work carried out in connection with the investigations reported here. Payment of professional fees is not dependent either on project success or project financing.

The authors have relied upon the work of others to describe some aspects of the project including data collection on site and published work for the primary data used by SRK in the re-reporting of resources in this report. The information contained in these sections was obtained from GoviEx.

This report includes technical information which requires subsequent calculations to derive subtotals, totals, and weighted averages. Such calculations inherently involve a degree of rounding and consequently can introduce a margin of error. Where these rounding errors occur, SRK does not consider them material.

The results of this Technical Report are not dependent upon any prior agreements concerning the conclusions to be reached, nor are there any undisclosed understandings concerning any future business dealings between GoviEx, SRK, and the authors.

The report has an effective date of November 30, 2017 and its conclusions and recommendations could alter over time depending on exploration results, commodity prices and other relevant market factors.

This report is written to comply with the requirements of the national instrument 43-101 “standards of disclosure for Mineral properties”. It has been prepared under the supervision of and by Dr Robert Bowell. The Mineral Resource estimation has been undertaken by My Guy Dishaw and the mine design and schedule has been prepared by Mr Filip Orzechowski. The report has been reviewed by Mr Martin Pittuck.

Dr Bowell and Mr Dishaw are Qualified Persons (“QP”) as defined by the CIM Definition Standards and Section 5.1 of National Instrument 43-101 – Standards of Disclosure for Mineral Projects, Form 43-101F1 and Companion Policy 43-101CP) for the purposes of this Technical Report.

2.1 Qualifications of Consultants

Robert J. Bowell, BSc PhD C.Chem. C.Geol FGS, E.Geol.FIMMM

Robert Bowell is a Principal Geochemist with SRK, with 21 years experience in applied geochemistry, data analysis and qualification, exploration, exploration management, and mining project evaluation. He has had four years’ direct experience with uranium exploration, geochemical analysis, mineralogy and evaluation of uranium deposits for project development. He is a registered professional geologist with the Geological Society of London and with the European Geological Association. He is a Qualified Person for this report and in particular is responsible for the discussion on Recovery Methods (Section 17) and Mineral Processing and Metallurgical Testing (Section 13). In addition, he is also responsible for Sections, 1 – 6, 8 and 18 – 27 and is QP for the overall report.

Guy Dishaw P.Geo

Guy Dishaw is a Principal Mining Geology Consultant with SRK, with 18years’ of international experience in mining operations, mineral exploration, and Mineral Resource evaluation. Guy is skilled in 3D geological modelling and interpretation, geostatistical analysis and Mineral Resource estimation in accordance with International Reporting Codes. He is experienced in developing Mineral Resource models and estimates to support detailed mine design and planning studies and in the management of geological teams. Guy has over nine years of operational experience in production and exploration at Unconformity-Related-Uranium and polymetallic VMS projects in Canada, which included leading successful brown-fields exploration programs. Additionally, he has several years of advanced pre-feasibility study experience in exploration and mineral resource modelling at an IOCGU project in Australia. For SRK, Guy undertakes all aspects of Mineral Resource estimation and evaluation on a variety of commodity and deposit types, but specializes in base metal, precious metal, and uranium projects. He is the Qualified Person for the Mineral Resource estimate given in this report and in particular is responsible for the discussions on exploration, geology, drilling, sample preparation and resource estimation. (Sections 7-11, 14).

Filip Orzechowski MSc MIMMM CEng

Filip Orzechowski is a Chartered Mining Engineer with around 11 years experience in the mining industry. Filip has worked on various mine planning studies with a significant focus on selective mining and deposit balance. Before joining SRK, Filip managed two limestone quarries in Central France. His key role was to ensure production targets were met, to prepare and maintain annual budgets with respect to the mine plan, supervision of mining personnel, planning and supervising blasting activities and maintenance, and dealing with client requests. Filip currently specialises in consulting for open pit mining and quarrying operations, feasibility and scoping studies, cost modelling and application of mining software packages. Since joining SRK, Filip has mainly been involved in undertaking open pit studies and acting as Competent Person for industrial minerals, bauxite, metals and oil shale in Europe Western Africa, and Indonesia. He is a Qualified Person for this report and in particular is responsible for Section 16 Mining Methods.

Martin Pittuck CEng, FGS, MIMMM

Martin Pittuck is Mining Geology Corporate Consultant with SRK, with 20 years of international experience in the industry, specialising in mineral resource estimation, mining geology, mine project evaluation and reporting of Mineral Resources and Ore Reserves according to international reporting codes. He has signed-off technical reports and public disclosure of Mineral Resource estimates for a wide variety of commodities and mineralisation styles.

2.2 Qualified Persons and Site Visits

The work reported here has been accumulated by previous site owners within the last ten years. This has been subject to desk review by SRK and deemed suitable for use. SRK has then undertaken a new estimation of resources and a preliminary economic analysis.

In addition, Dr Bowell visited the Chirundu project from 3 to 7 May 2011 as part of a due diligence for a third party. During the visit, he observed drilling, core and drill chip library, sample preparation, and data collection. He can confirm that the description of mineralization, exploration methods, storage and sample information in reports by AFR as well as their consultants is a fair reflection of observations made in the field. In addition, the observations made at Chirundu are consistent with the extensions reported on the Denison licences.

3 RELIANCE ON OTHER EXPERTS (ITEM 3)

The Qualified Persons for this technical report, Robert Bowell, Guy Dishaw and Filip Orzechowski, have examined the historical and current data for the Mutanga Project provided by GoviEx with respect to resources, metallurgical test work, and other project information, and have relied upon that basic data to support the statements and opinions presented in this Technical Report. A full list of documents reviewed is included in Section 27. In the opinion of the authors, the project data is presented in sufficient detail to provide an accurate representation of the Mutanga Uranium Project.

It is the opinion of the QPs that there are no material gaps in the information for the Project. Sufficient information is available to prepare this report, and any statements in this report related to deficiency of information are directed at information, which in the opinion of the authors, should be sought as the project progresses. The QPs take responsibility for the content of this Technical Report; however, the QPs are not responsible for, nor have they undertaken any due diligence regarding the non-technical aspects of this report, which include legal matters marketing information and transport network.

The authors have relied upon the work of others to describe project and data collection on site and have had to rely on the published work for the primary data used by SRK in the re-reporting of resources in this report. The information contained in these sections was obtained from the GoviEx source information.

This report includes technical information which requires subsequent calculations to derive subtotals, totals, and weighted averages. Such calculations inherently involve a degree of rounding and consequently can introduce a margin of error. Where these rounding errors occur, SRK does not consider them material.

The results of this Technical Report are not dependent upon any prior agreements concerning the conclusions to be reached, nor are there any undisclosed understandings concerning any future business dealings between GoviEx, SRK, and the authors.

The report has an effective date of November 30, 2017 and its conclusions and recommendations could alter over time depending on exploration results, commodity prices and other relevant market factors.

CIBC Global Mining Group, Analyst Consensus Commodity Price Forecasts were used in the prediction of uranium price in section 19 (CIBC 2017).

4 PROPERTY DESCRIPTION AND LOCATION (ITEM 4)

The Mutanga Uranium Project comprises three mining licences and two prospecting licences. (Figure 4-2).

Licences for Gwabe, Njame, Njame South and Kariba Valley (Chisebuka) were acquired from African Energy Resources Ltd, on 31 October 2017. Licences for Mutanga, Dibwe and Dibwe East were acquired from Denison Mines Corp, on 13 June 2016.

4.1 Location of Property

The Mutanga Project area is located in the southeast region of Zambia in the Siavonga District. The northern extent of the Project, where the Gwabe, Njame, and Njame South deposits are situated, is located close to the town of Chirundu, near to the Zimbabwe border. The prospect areas extend south towards Siavonga and along the northern edge of Lake Kariba to Kariba Valley, the southernmost extent (Figure 4-1). The northern most deposits of Njame and Gwabe are located approximately 100 km southeast of the Zambian capital, Lusaka and Chisebuka, further south, is approximately 180 km southeast of Lusaka.

There are four local chiefs within the Project area, namely Chiefs Sinadambwe, Chipepo, Sikoongo and Simamba. Proximity to Chirundu and Siavonga means that the area is relatively well serviced with sealed roads and numerous gravel tracks, which lead to farms and villages.

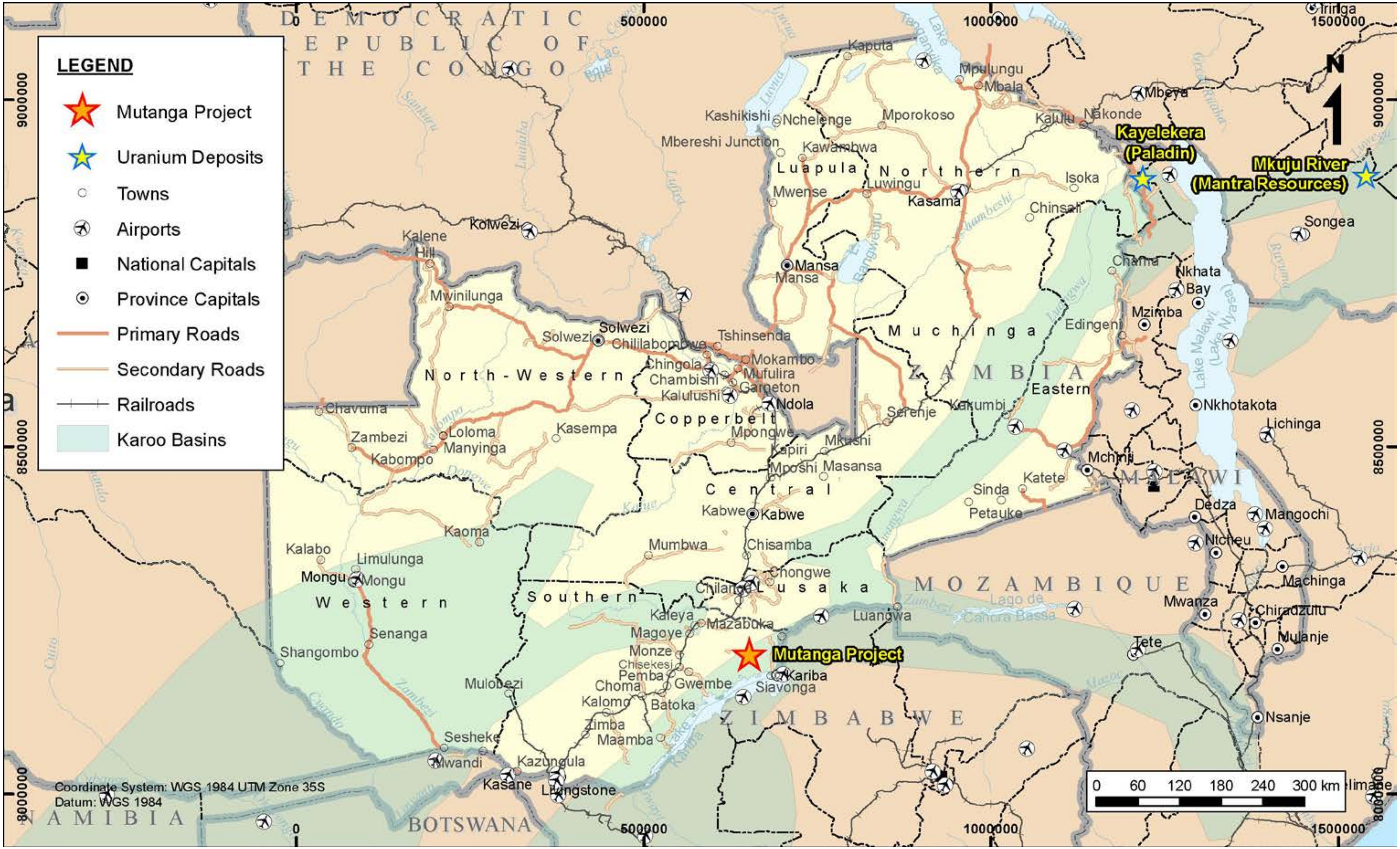


Figure 4-1: Project Location Map

4.2 Mineral Tenure

In 2008, the Zambian Government introduced the Mines and Minerals Development Act of 2008 to which all tenements are required to conform. According to the Act, Prospecting Licences can have a maximum size of 1000 km^2 and licence corners must conform to a six arc-second graticular grid; each Company is allowed a total holding area of 5000 km^2.

GoviEx currently holds three mining licences (Table 4-1 and Figure 4-2) for Mutanga, Dibwe and Chirundu ML (Gwabe and Njame). Two additional prospecting licences for Chirundu PL and Kariba Valley are pending renewal.

Table 4-1: Current Tenements

Permit Name	Permit Number	Area (km^2)	Date First Granted	Date Expiry	Commodity Group	Current Status
Mutanga	13880-HQ-LML	234.3	26 March 2010	25 April 2035.	Uranium, Coal, Sand, Clay, Gravel and Limestone	GRANTED
Dibwe	13881-HQ-LML	238.2	26 March 2010	25 April 2035.	Uranium, Coal, Sand, Clay, Gravel and Limestone	GRANTED
Chirundu ML	12634-HQ-LML	248	09-Oct-09	08-Oct-34	Uranium	GRANTED
Chirundu PL	22075-HQ-LEL	230	17-Dec-09 Renewed, 18/7/17	Renewal Submitted	Uranium	New Application
Kariba Valley	19800-HQ-LPL	251	23-Feb-15	Renewal Submitted	Uranium	Renewal Submitted

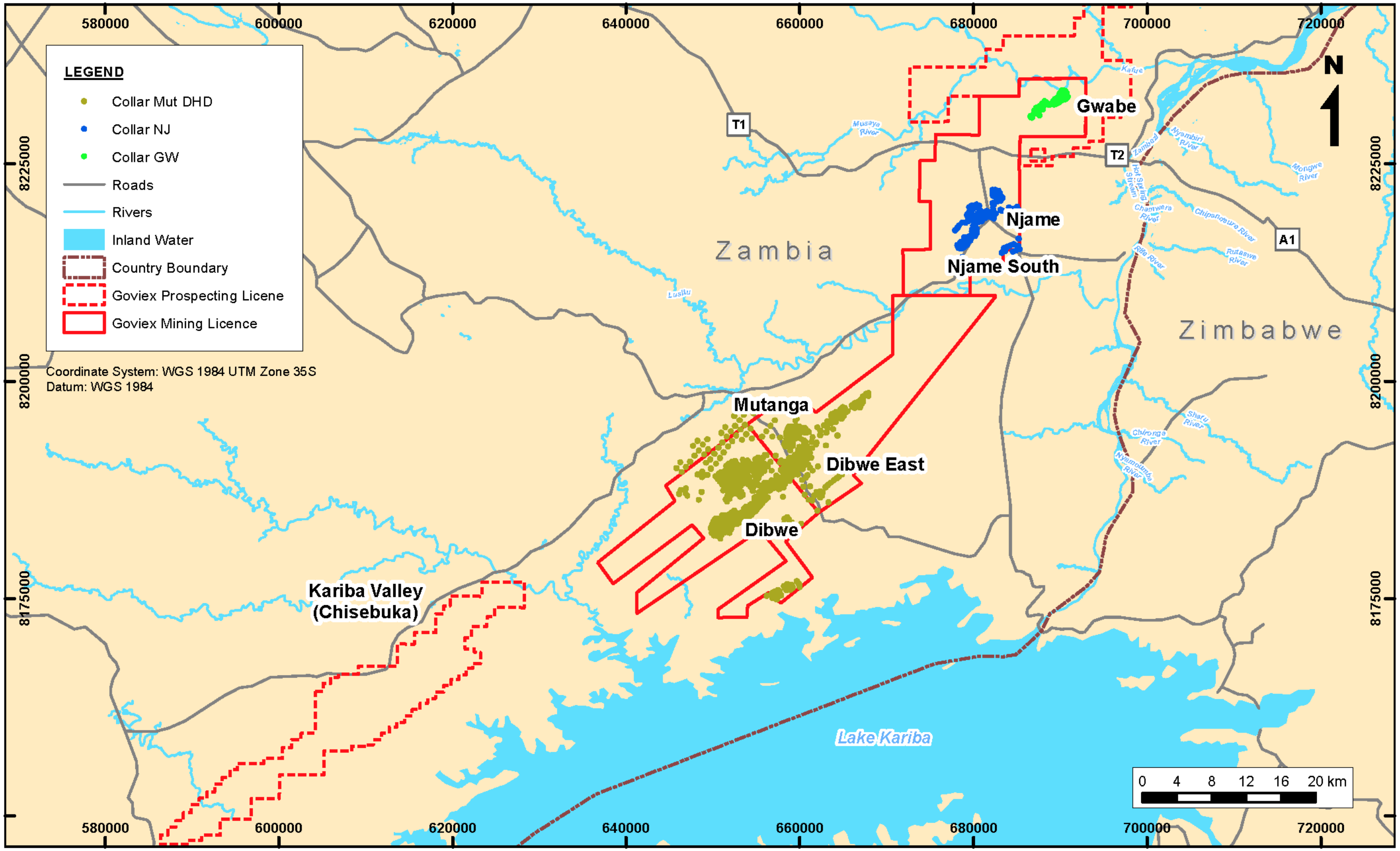


Figure 4-2: Mutanga Project Site and Licence Boundaries

4.3 Environmental Liabilities

The Project is not considered an advance property and has no known environmental liabilities as it has not been subject to any mechanised mining activities. GoviEx currently holds Zambia Environmental Management Agency ("ZEMA") licences for management, generating and storing of hazardous waste, as well as an emissions licence, details of which are included in Table 4-2.

Table 4-2: Summary of GoviEx ZEMA Licences

Permit	Date Awarded	Duration	Expiry Date
Hazardous waste management licence	16 September 2015	3 years	15 September 2018
Licence to generate hazardous waste	16 September 2015	3 years	15 September 2018
Licence to store hazardous waste	16 September 2015	3 years	15 September 2018
Emission licence	16 September 2015	3 years	15 September 2018

5 ACCESSIBILITY, CLIMATE, LOCAL RESOURCES, INFRASTRUCTURE AND PHYSIOGRAPHY (ITEM 5)

5.1 Topography, Elevation and Vegetation

The Mutanga Project area is located within the Zambezi Rift System in southern Zambia. The Zambezi River flows to the east of the area, following the border between Zambia, Zimbabwe and Mozambique.

Surface runoff is predominantly contour controlled but occasionally fault controlled. Lake Kariba is situated at 485 m above mean sea level and the Project region varies between 500 m and 960 m above sea level.

Vegetation typically consists of forest which is predominantly Miombo mixed with Munga and Mopane, there are also small areas of agricultural fields and degraded grassland. The dominant vegetation is as follows:

- Commiphora – Kirkia thicket on lower Karoo sands. Frequently occurs as lake basin chipya, semi-evergreen thicket or termite moulds.
- Colophospermum mopane woodland on heavy clay soils. Dominant vegetation type that is frequently pure or almost pure in mopane woodlands, mopane munga and mopane miombo. Also occurs on munga and mopane termitaria in deciduous thicket.
- Southern Isoberlinia – Brachystegia woodland on escarpment soils. Highly favoured for fuelwood production, especially charcoal.
- Acacia woodland on clay soils. Vegetation that favours dry areas; it is important for soil improvement, livestock and game, gum exudation, timber and traditional medicine.

The wild bush land experiences only minor disturbance including dry season fires, human cutting for building materials or fuel and human clearing for agriculture, grazing or settlements. Approximately 10% of the land is used for agriculture (Section 5.3).

5.1 Access to Property

Access to the Project is by the sealed main road running between Chirundu and Lusaka and the sealed road to Siavonga, then turning onto the newly constructed sealed road. The main roads are in a fairly good condition, but the actual Project area is located east of the main roads and accessed via poorly maintained gravel roads that require a four-wheel drive vehicle (“4WD”).

The Zyiba Meenda road will be developed for access to the project site, running east from the Dibwe East site and meeting the sealed Siavonga road approximately 1 km south of the Lusitu River and village. The existing right of way will be maintained but the road will be re-routed to avoid villages and development will include rebuilding and sealing for a total length of 26 km. Once the new road is complete the total distance from Lusaka to site will be 174 km, all on sealed roads

5.2 Climate

The Mutanga Project has a climate described as tropical wet and dry, with very distinct wet and dry seasons. Meteorological information is obtained from the nearest station at Lusita, approximately 40 km north-east of Mutanga with a similar elevation and climate. The meteorological station operated from 1995 to 2005 and since 2005 weather data has been measured at site, but is not considered to be sufficiently reliable. Annual rainfall is recorded as between 600 and 720 mm and the wet season occurs in the hottest summer months between November and March. Highest rainfall generally occurs in January/February. Maximum temperatures range from 22°C to 46°C and minimum temperatures range from 20°C to 38°C during the hottest months; highest temperatures typically occur just prior to the onset of the rains in October. Wind speeds are greatest during this period and can range from approximately 2.5 ms^{-1} to approximately 3.6 ms^{-1}, typically from an east-southeast direction. Lightning storms can be common during the hottest months and occasionally hailstones are experienced, associated with thunderstorms. During the wettest months of October to February, average daily sunshine hours can range from only 4.6 hours (February) to 8.8 hours (October).

During the cooler months of April to October, rainfall varies significantly spatially and temporally. Maximum temperatures range from 23°C to 40°C and minimum temperatures range from 6°C to 28°C, with lowest temperatures occurring in June and July. Winds are typically much calmer during the colder, dry months, particularly between April and August. On average, at least nine hours of daily sunshine is generally received during the drier months of May to September.

The highest maximum temperature recorded at the Project site was 46°C and the lowest minimum temperature that has been recorded is 6°C. Evaporation typically exceeds precipitation for most of the year. Monthly relative humidity generally ranges from a minimum of 46% in September to a maximum of 79% in December.

Weather data taken from Lusaka airport and corrected for the altitude difference at the Project site mean station level barometric pressure for Mutanga is 951 hPa (corrected for the altitude difference with respect to Lusaka airport).

5.3 Local Resources

There are many small villages located around the Project area and approximately 10% of land is used for small-scale agriculture including millet and maize, sorghum, bananas, cotton and minimal animal husbandary. There are currently no industrial activities within the Project area.

According to the United States Department of Agriculture (“USDA”), the regional land classification indicates medium to low potential for sustainable development based upon extremely weathered and iron rich soils. The soils are typically nutrient deficient and not good at retaining water although they are easily worked.

5.4 Infrastructure

With the exception of the main road systems described in Section 5.1, there is limited to no infrastructure within the immediate Project area.

5.4.1 Roads

As described in Section 5.1, there are some sealed roads in the area which run between Lusaka, Chirundu and Siavonga and although they are in fairly good condition, access to the actual Project site is still via poorly maintained gravel tracks which require 4WD access. Local communities rely on bicycles or carts for transport.

The Zyiba Meenda road will be developed, running east from the Dibwe East site and meeting the sealed Siavonga road approximately 1 km south of the Lusitu River and village. The existing right of way will be maintained, but the road will be re-routed to avoid villages and development will include rebuilding and sealing for a total length of 26 km. Once the new road is complete, the total distance from Lusaka to site will be 174 km, all on sealed roads.

5.4.2 Power

There is currently an 88 kV substation at Chirundu which is supplied via 330 kV high voltage transmission lines from the Kariba North Bank Hydroelectricity Scheme. Power lines do transverse the Project area around Njame, although most of the local villages are not connected to the national power network and households near Mutanga and Dibwe rely on wood for heating and cooking plus candles and kerosene lamps for lighting.

Power to the project site will be provided by a new 66 kV power line from the Chirundu sub-station with right of way following the access road. Costs for construction of the line and associated substations is expected to be shared with the Zambian state utility as the system will have surplus capacity to provide power to other users.

5.4.3 Local Villages and Towns

The region is sparsely populated; Chirundu, Siavonga and Lusaka are the closest major urban areas. Siavonga is a small town, but has banking facilities, a post office, hospital and small general stores; there are no defined commercial areas within the immediate vicinity of the project and grocery stores are typically located along the main Lusaka-Siavonga highway. The Siavonga District and Local Government Administration covers an area south of the Zambezi escarpment from and includes the towns of Siavonga and Chirundu. The rural areas are administered by four Chiefdoms, which include Chief Simamba, Chief Sikoongo, Chief Chipepo and Chief Sinadambwe. Much of the housing in the villages is typically wooden structures covered with mud. Communities are predominantly rural, mostly seasonal peasant farmers producing maize, cotton, millet, sorghum and vegetables; the majority of crops grown are for household consumption. Charcoal is also produced for sale and used as a main fuel source alongside wood, for heating and cooking.

Water Supply and Sanitation

The Project area relies on wells and boreholes for potable water and the Kafue River is used as a source of irrigation; sanitation is crudely managed by way of pit latrines in some households. The Southern Water and Sewerage Company (“SWSCO”) has a treatment plant located on the Zambezi River that supplies piped water to Siavonga, but this does not reach to the Project site. GoviEx has provided nine water boreholes to local villages.

Education and Health Care Facilities

There are very few schools and health facilities in the Project area and typically they have insufficient staff and resources. The main challenges faced are long distances, poor staffing levels, inadequate funding and transport. The development of local health and school facilities through sustainable development projects carried out by the Project will benefit the local communities. To date GoviEx has provided clinics for the villages of Mutanga and Chizilika, and a nurse’s home at Mutanga. A small school has been constructed at Mutanga, as well as providing classrooms for the schools at Hachibozu and Chizilika villages. Other projects to develop health and education in the area will be incorporated into a sustainable development program carried out by the mine.

Telecommunications

Telecommunications are provided to the Mutanga area by AirTel and MTN.

5.5 Physiography

The topography is defined by the geology and consists of gentle, low escarpment type hills with steep and/or craggy scarp northwest slopes and gently sloping southeast dip slopes.

6 HISTORY (ITEM 6)

6.1 Introduction

Uranium was first identified in the area in 1957 by ground survey which located five anomalous areas in the vicinity of Bungua Hill, west of Siavonga. In 1958 and 1959 Chartered Exploration found low grade uranium mineralisation that could be followed for over 800 m of strike extent.

The main exploration took place between late 1970s and mid 1980s initially by the Geological Survey of Zambia (“GSZ”), followed by AGIP SpA (“AGIP”), an Italian petroleum company. The AGIP exploration campaign included a regional ground radiometric surveying programme which highlighted numerous radiometric anomalies along the northern shores of Lake Kariba including Dibwe and Chisebuka. Several of the anomalies were investigated via more detailed ground radiometric surveying and subsequent drilling. Their campaign predominantly focused on the Mutanga and Dibwe deposits; and in 1983/4 a small uneconomic resource was outlined at Njame but AGIP ceased work in 1985.

6.2 Property Ownership Dibwe East, Dibwe and Mutanga

Known ownership and work undertaken in the Mutanga area are summarised below:

- Owner unknown – 1957: ground survey located five anomalous areas in the vicinity of Bungua Hill, west of Siavonga.

- Chartered Exploration – 1958 and 1959: found low-grade uranium mineralisation that could be followed for over 800 m of strike extent.
- Chartered Exploration – 1974: confirmation of this uranium mineralisation was further defined in two campaigns after regional airborne magnetic and radiometric surveys had been flown over the area by Geometrics.
- Zambian Geological Survey (GSZ) – 1973 to 1977: ground investigation.
- Italian oil company AGIP S.p.A. (AGIP) – 1974 to 1984: Exploration ground campaign, included investigation of the Mutanga and Dibwe mineral deposits.
- Period of inactivity – 1984 to 2004.
- Okorusu Fluorspar Pty Ltd – 2004 to 2006: exploration unknown.
- OmegaCorp Minerals Limited acquired Okorusu Fluorspar exploration licence – 2006: 11 holes (649 m) at the Mutanga mineral deposit to confirm the uranium deposit identified by AGIP.
- Denison acquired OmegaCorp Limited in August 2007. Denison is a publicly owned, uranium exploration and development company listed on the Toronto (Canada) and NYSE MKT. OmegaCorp became a wholly owned subsidiary of Denison.
- The prospecting licence was converted to two mining licences in 2010 that were held by Denison's wholly owned subsidiary Denison Mines Zambia Limited.
- GoviEx acquired Denison Mines Zambia Limited in June 2016.

6.2.1 Historic Mineral Resource and Reserve Estimates

Numerous resource estimates have been prepared by a variety of companies and consultants using several different methodologies. Taking into account the successive exploration drilling completed at the project, all estimates in general compare favourably and demonstrate similar U_3O_8 grades and tonnages.

A summary of the historic mineral resource estimates is provided in Table 6-1 from 1970s through to 2012. Table 6-2 provides a summary of the most recent historical resources as at 12 September 2013.

Table 6-1: Previous Mutanga Mineral Resource Estimates.

Company Name/ Year of Resource Estimate	Category	Cut-Off	Tonnes	Grade	U_3O_8
		(ppm U_3O_8)	(Mt)	(ppm U_3O_8)	(Mlbs)
AGIP (1970s)	Unclassified*	700	2.40	1,000	5.30
AGIP (1970s)	Unclassified*	600	3.20	870	6.10
AGIP (1970s)	Unclassified*	500	4.30	740	7.00
AGIP (1970s)	Unclassified*	400	4.90	600	6.50
AGIP (1970s)	Unclassified*	300	7.80	530	9.10
AGIP (1970s)	Unclassified*	200	9.70	480	10.30
CRM Apr 2005 (Mutanga)	Unclassified*	200	7.00	400	6.20
CRM Apr 2005	Unclassified*	200	0.90	400	0.80
CRM Nov 2005 (Mutanga)		200	**6.50**	**375**	**5.40**
Mutanga East	Unclassified*	200	0.30	400	0.29
Mutanga West	Unclassified*	200	0.65	350	0.53
Dibwe	Unclassified*	200	5.00	430	4.70
	Total		**12.45**	**396**	**10.92**
CSA (June 2006)					
Mutanga	Inferred**	200	7.00	400	6.20
Dibwe	Inferred**	200	8.20	370	6.60
	Total		**16.40**	**380**	**13.70**
Denison-RPA (March 2012)					
Dibwe East	Inferred	100	39.8	322	28.27

** Reported internally only, unclassified under CIM*

*** Reported to JORC (2004)*

Table 6-2: CSA 2013 Summary Resources (Source: CSA, 2013)

CIM Compliant Mineral Resource Inventory – Mutanga Uranium Project (as at 12 September 2013)										
Deposit	U_3O_8 lower cut-off	Measured			Indicated			Inferred		
		Tonnes (Mt)	U_3O_8 (ppm)	U_3O_8 (Mlbs)	Tonnes (Mt)	U_3O_8 (ppm)	U_3O_8 (Mlbs)	Tonnes (Mt)	U_3O_8 (ppm)	U_3O_8 (Mlbs)
Mutanga	100	1.88	481	2.0	8.40	314	5.8	7.20	206	3.3
Mutanga Extensions	200	-	-	-	-	-	-	0.50	340	0.4
Mutanga East	200	-	-	-	-	-	-	0.20	320	0.1
Mutanga West	200	-	-	-	-	-	-	0.50	340	0.4
Dibwe	100	-	-	-	-	-	-	17.00	234	9.0
Dibwe East	100	-	-	-	-	-	-	39.80	322	28.2
Total		**1.88**	**481**	**2.0**	**8.40**	**314**	**5.8**	**65.20**	**287**	**41.4**

6.3 Property Ownership Gwabe, Njame and Njame South

The earliest known exploration for uranium occurred in the late 1970s to the mid1980s as part of the AGIP campaign. A small, uneconomic resource (unclassified under JORC) containing approximately 980 t U_3O_8 was outlined at Njame in 1983-84. AGIP ceased its work in Zambia in 1985, and no further work for uranium was undertaken in this area until AFR commenced work in 2005.

In October 2005, Albidon Exploration Limited signed a joint venture agreement with AFR for them to explore the eastern part of the Mugoto PLLS250 that had been previously acquired by Albidon as part of their Munali nickel project tenement holding. The area under exploration by AFR was named the Chirundu Uranium JV and covered the Gwabe and Njame Deposits.

In 2006 and 2007 AFR carried out a major exploration programme at their Chirundu site and a pre-feasibility study (PFS) to evaluate the commercial viability of mining and processing uranium ores and Njame and Gwabe was undertaken in 2007 to 2008. Drilling at the Njame deposit led to delineation of an Inferred Resource that was larger than the one initially identified by AGIP and an airborne radiometric survey conducted at Gwabe revealed a significant uranium anomaly that was subsequently investigated by surface radiometric surveying and soil sampling and outlined as an Inferred Resource. In March 2008 AFR's equity was increased to 70% when the PFS reported an Indicated Resource and this was subsequently increased to a 100% interest in the Chirundu and Kariba Valley Projects in March 2011.

In October 2017 GoviEx acquired the Chirundu and Kariba Valley Projects from AFR.

6.3.1 Historic Mineral Resource Estimates

A mineral resource estimate for Njame, Gwabe deposits and the Chirundu project as a whole was conducted in 2009 (Table 6-3).

Table 6-3: Historic Resource Estimate, AFR Projects (Source: AFR, 2009)

Deposit	Resources							
	Measured		Indicated		Inferred		Contained U_3O_8	
	Tonnes (Mt)	Grade (ppm U_3O_8)	Tonnes (Mt)	Grade (ppm U_3O_8)	Tonnes (Mt)	Grade (ppm U_3O_8)	Tonnes	Mlb
Njame North	2.7	350	2.2	252	1.5	223	1,815	4.0
Njame East	-	-	0.6	291	0.5	233	305	0.7
Njame Central	-	-	0.9	222	0.2	219	240	0.5
Njame South	-	-	-	-	4.4	237	1,040	2.3
NJAME TOTAL	**2.7**	**350**	**3.7**	**252**	**6.6**	**233**	**3,400**	**7.5**
GWABE TOTAL	**1.3**	**237**	**3.6**	**313**	**0.8**	**178**	**1,575**	**3.5**
CHIRUNDU PROJECT TOTAL	**4.0**	**313**	**7.3**	**282**	**7.4**	**227**	**4,975**	**11.0**

Note: All reported using a 100 ppm U_3O_8 cut-off grade envelope with appropriate rounding applied

AFR JORC accredited resource statement as of 18th November 2009 (AFR, 2009)

6.3.2 Kariba Valley (Chisebuka)

Radiometric anomalies were previously identified in the Kariba Valley area by AGIP, but very limited follow-up exploration was undertaken.

AFR and Albidon Exploration established a second joint venture, the Kariba Valley JV which contained the Chisebuka and Namakande prospects. AFR had an initial 30% equitable interest which was later increased to 100% holding. Their investigations included ground radiometric surveys, geochemical assessments of soil and rock-chip plus RC percussion drilling which revealed significant uranium mineralisation at Chisebuka and Namakande.

6.4 Production History

To date there has been no historic uranium production from any of the Mutanga Project license areas.

7 GEOLOGICAL SETTING AND MINERALISATION (ITEM 7)

7.1 Regional Geology

The following description of the geology of the area was compiled from descriptions by CSA (2013), AFR, (2013), AFR (2008b) AFR (March 2008) and AFR (March 2009).

The Project area is situated within the Karoo Supergroup, which is thick, Carboniferous to late Triassic, terrestrial sedimentary strata, widespread across much of what is now southern Africa. The Karoo Supergroup was deposited within an extensive foreland basin created when compression and accretion along the southern margin of Gondwana resulted in formation of the Cape Fold Belt to the south. To the north, crustal extension, due to thermal doming following the assembly of the Pangean supercontinent around 320 Ma, resulted in formation of a northeasterly trending series of rift basins (Yeo, G. 2010). The rifting is believed to have been associated with the breakup of Gondwanaland during the Permian Period, 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.

During the Cenozoic the East African Rift System propagated south-westerly across the continent and led to reactivation of the Karoo rift basins as well as formation of new fault depressions, such as the Okavango Rift (Laletsang et al., 2007; Kinabo et al., 2007), the southeastern extension of the mid-Zambezi and Luangwa rift systems.

The Karoo supergroup consists of three Formations within the Lower Karoo, the Siankondobo Sandstone Formation, overlain by the Gwembe Coal Formation, which itself is overlain by the Madumabisa Mudstone Formation (Figure 7-1). The Siankondobo Sandstone Formation consists of fine clastic sediments with a basal diamictite and conglomerate overlain by siltstones and sandstones. The Gwembe Coal Formation is comprised of carbonaceous mudstones and siltstones interspersed with coal seams and sandstones while the Madumabisa Mudstone Formation consists of a thick sequence of non-carbonaceous grey mudstones with calcareous bands. The Madumabisa Formation is unconformably overlain by the Upper Karoo which consists of four formations, the Escarpment Grit overlain by the Interbedded Sandstone and Mudstone Formation, followed by Red Sandstone which is finally capped by the Jurassic Bakota Basalt Formation (Figure 7-1). The Escarpment Grit comprises a 400 m thick series of continental arenaceous silici-clastic sediments with interbedded mudstones. Although locally referred to as Escarpment Grits, this group is a correlative of the Beaufort Group elsewhere in the Karoo Supergroup and contains interbedded mudstones and fine grained sandstones as well as grits and conglomerates.

The Project is situated in the mid- Zambezi Rift Valley. In the region, known uranium mineralisation typically occurs within the Upper Karoo whereas the Lower Karoo hosts much of the coal reserves of Zambia, Zimbabwe and South Africa. At the Mutanga Project all of the known uranium mineralisation occurs within the Escarpment Grit. Similar sandstone-hosted uranium mineral deposits occur in many of the Karoo rift basins including Letlhakane in the Kakalhari Basin of Botswana and Kayelekera in the Rukuru Basin of Malawi (Figure 4-1). The underlying Madumabisa Mudstone appears to have acted as an impermeable barrier controlling the base of the mineralisation. The Escarpment Grit itself shows a wide variation in lithology which is typical of continental sediments. Uranium mineralisation appears to have been introduced after sedimentation (epigenetic), and occurs as fillings into pore spaces, fractures, joints, coatings on sand grains and occasionally along steeply dipping cross beds.

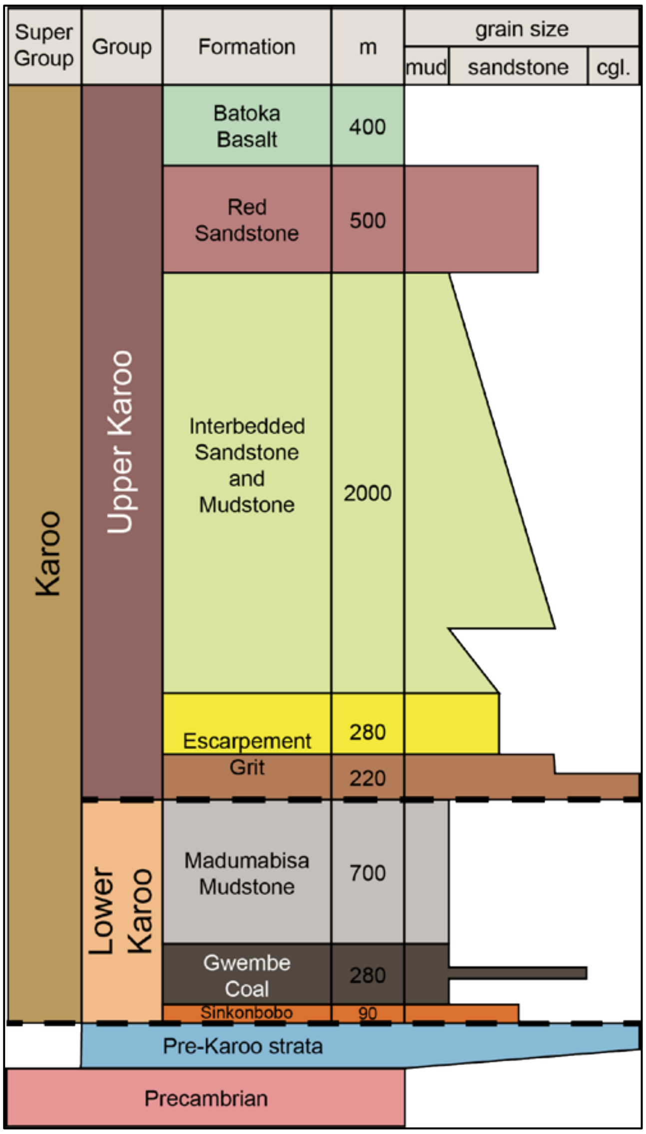


Figure 7-1: **Karoo Supergroup Stratigraphy in Southern Zambia (Source: Nyambe and Utting, 1997 within CSA, 2013)**

7.1.1 Madumabisa Mudstone

The Madumabisa Mudstone Formation in the mid-Zambezi Valley comprises up to 640 m of non-carbonaceous, alternating massive, poorly stratified, homogenous mudstone and laminated silty mudstone and siltstone, with minor interbedded calcilutite, sandstone and irregular concretionary calcareous beds (Nyambe and Utting 1997). The massive mudstone beds have a hackly conchoidal fracture and are predominantly grey to green, silty mudstone with minor, but common, concretionary cacilutite beds up to 1.2 m thick. The laminated mudstone/siltstone units comprise green to grey (greyish-white to khaki weathering) parallel laminated to small-scale cross-laminated mudstone and medium bedded siltstone/mudstone with minor calcilutite and sandstone interbeds. Pinkish grey to dark grey colors are common in the medium bedded (coarser) and thinly laminated (finer) units. Ellipsoidal concretionary calcilutite beds have variable lateral persistence and contain up to 30% ostracods, bivalves and fish scales. Thin, dark, bituminous calcilutites and mudstone conglomerate are locally present. Bioturbation is common.

7.1.2 Escarpment Grit Formation

The Escarpment Grit Formation, and its correlatives in the northern Karoo rift basins, lie immediately above the Permian-Triassic boundary and are characterized by extensive braided river deposits. Such deposits are typical of Precambrian fluvial basins, but uncommon in the Phanerozoic (Ward, Montgomery and Smith 2000) suggesting that these widespread braided river deposits resulted from the die-off of plants during the Permian-Triassic extinction event.

The Escarpment Grit Formation consists of coarse- to very coarse-grained sandstone, locally conglomeratic, that fine upwards into more fine grained sandstones and intercalated mudstones. Silicified wood is abundant locally. AGIP geologists historically distinguished two informal members in the Escarpment Grit suggesting a change in fluvial style. A lower “Braided Facies” member is characterized by relatively poorly sorted sandstones and pebbly sandstones with mudclasts and thin discontinuous mudstones, and an overlying “Meandering Facies” member is characterized by well-sorted upward-fining sandstones (i.e., point bar deposits) with mudclasts and pebble-lag layers, interbedded with laterally extensive mudstones.

In areas of poor exposure, the “Braided Facies” can be distinguished from the Meandering Facies by the presence of abundant quartz pebbles at the surface. The thickness of these members is variable, and they appear to thin towards the rift axis. Paleocurrents in the “Braided Facies” are predominantly south-westerly, subparallel to the axis of the mid-Zambezi Rift, whereas paleocurrents in the “Meandering Facies” are highly variable.

A petrographic study of the Escarpment Grit (Prasad and Lehtonen, 1977) in the Bungua Hill area south of Dibwe reported that the sandstones are texturally immature and range from arkosic to sub-arkosic and sublithic arenites and wackes. Arenites predominate. Feldspar content averages 22% (4 to 39%) and is mainly microcline, with minor oligoclase and albite. Both fresh and kaolinized feldspars may be present in the same sample, suggesting a mixture of fresh and weathered source material, rather than diagenetic alteration. Rock fragments average 2.9% (0 to 12.2%), including quartzite, sericitic quartzite, siltstone, chert and jasper range up to 12% of the sandstones.

Muscovite is common and fresh looking, whereas biotite is less abundant and typically kaolinized and altered to iron oxides. Other accessory minerals comprise less than 0.5% of the sandstones. They include zircon, tourmaline, epidote, rutile, apatite, sphene, garnet and possible augite. Matrix (grains less than fine sand size) averages 9.1% (0 to 23.4%) and includes mica, feldspar, quartz and chlorite, recrystallized from clay. Cements include iron oxide, silica and carbonate. The sandstones range from moderately well to poorly sorted with an average porosity of 6.7%. They are interpreted to be derived from nearby gneisses and granitic rocks of the Katanga Supergroup and Basement Complex.

Stratabound uranium mineralisation in the Escarpment Grit is known in the lower part of the "Meandering Facies" at Njame, and in the upper part at Dibwe. Association with boundaries between sandstone-dominated stratigraphic units suggests that permeability contrast is a factor controlling uranium mineralisation. Widespread soft-sediment folds suggest syn-depositional seismic activity and fault re-activation and hence, that seismic pumping of diagenetic fluids may have been a factor in mineralisation.

7.1.3 Interbedded Sandstone and Mudstone Formation

The Interbedded Sandstone and Mudstone Formation in the mid-Zambezi Valley consists of typically upward-fining very coarse- to very fine-grained sandstone grading into mudstone (Nyambe and Utting 1997). Mudclasts are a dominant feature in these sandstones. The sandstone to mudrock units are interpreted as mainly channel-fill deposits to overbank fines deposited during floods in braided streams transitional to meandering stream systems. The contact between this formation and the Escarpment Grit Formation is gradational and is placed at the base of a sandstone unit underlying the mudstone interbeds. There is approximately 10 m of greyish green muddy siltstone and silty mudstone overlain by 10 m of fining upwards sandstones. The mudstone/siltstone beds range from 8-12 cm thick and become thicker towards the top of the sequence. The thin beds are predominantly horizontally laminated with small-scale ripple lamination better developed in the thick beds towards the top of the unit. Kaolinite is abundant, but illite and mixed layer clays are present in minor amounts. Calcite is present in the lower part of the formation.

Prasad and Lehtonen (1977) interpreted the sandstones of the Interbedded Sandstone and Mudstone Formation to be less arkosic than those of the Escarpment Grit, but the average feldspar content of 25.6% (0.3% to 37.9%) they report is actually higher. Considering the wide range of values, the difference is probably not statistically significant (Yeo, G. 2011). Rock fragments average 4% (0% to 11.1%), which is also higher than in the Escarpment Grit. The major compositional difference between the sandstones of the Escarpment Grit and overlying Interbedded Sandstone and Mudstone formations appears to be in matrix content, which is twice as high in the latter at 19% (6.7% to 38.8%).

The Interbedded Sandstone and Mudstone Formation, which overlies the Escarpment Grit, contain a Scythian – Anisian assemblage (Nyambe and Utting, 1997); hence the Escarpment Grit was deposited early in the Scythian epoch (very early Triassic). In the Mutanga area, the contact between the Escarpment Grit and the Madumabisa Mudstone is a paraconformity (Prasad and Lehtonen 1977). Towards the mid-Zambezi rift margin, the Escarpment Grit oversteps the Lower Karoo to directly overlie basement gneisses, pegmatites and amphibolites. The known uranium mineral deposits in the mid-Zambezi Basin of southern Zambia are all restricted to the Escarpment Grit.

7.1.4 Depositional Sequences

The Karoo Supergroup comprises at least six regional depositional sequences (Catuneanu et al, 2005), which reflect broadly synchronous episodes of basin subsidence and climate change, but vary considerably in detail from one sub-basin to another. Karoo strata typically overlie Precambrian crystalline basement rocks.

1. Sequence 1: Comprises glacial deposits (for example, Dwyka tillite and equivalents) capped by post-glacial lacustrine mudstones laid down in a temperate climate.
2. Sequence 2: Comprises coal deposits and associated clastic strata accumulated in a warm humid climate (e.g. Gwembe Coal Formation in Zambia).
3. Sequence 3: Comprises fluvial sandstones deposited in semi-humid to arid conditions, overlain by lacustrine or marine mudstones and limestones (e.g. Lower Madumabisa Formation).
4. Sequence 4: Comprises lacustrine and fluvial deposits deposited under warm humid to semi-arid conditions (e.g. Upper Madumabisa Formation). A regional unconformity marks the Permian- Triassic extinction event at the boundary between sequences 4 and 5.
5. Sequence 5: Comprises fluvial sandstones deposited under warm, hyper-humid conditions capped by lacustrine or more fine-grained fluvial strata deposited under hot, semi-humid conditions (e.g. Escarpment Grit and Interbedded Sandstone and Mudstone formations). The different “Braided Facies” and overlying “Meandering Facies” observed within the Escarpment Grit marks a change in fluvial style from braided streams to meandering rivers where material was deposited at point-bars or flood plains; this likely reflects the re-establishment of river bank stabilizing vegetation, following the Permian-Triassic extinction event, as suggested by (Ward, Montgomery and Smith 2000). The Interbedded Sandstone and Mudstone Formation has also been interpreted as deposition from a meandering river but the thickness and lateral continuity of the mudstone together with a lack of evidence for scouring and an absence of burrows or rootlet traces suggests that the mudstones may be shallow lake or lacustrine pro-delta deposits, rather than flood-plain deposits (Yeo, G.; Kerr, W.; Staley, R. 2010). The sandstones have characteristics of point-bars; hence they may be delta distributary channel deposits.
6. Sequence 6: Comprises more fine-grained fluvial sandstones capped by Jurassic basalts (for example, Forest Sandstone and Batoka Basalt). Each sequence is punctuated by an episode of crustal extension and subsidence.

7.2 Regional Geological Structures

The mineralised zones are offset and impacted by various faults and fractures but the mineralisation itself does not appear to have any significant structural controls.

Regionally, the Mutanga mineral deposit, and other uranium occurrences in southern Zambia, lie near the northwest margin of the Mid-Zambezi Graben. This structure is essentially a half-graben, with its faulted footwall against the Precambrian crystalline rocks on the northwestern, Zambian side and passive onlap on crystalline basement rocks on the southeastern, Zimbabwean side. The Mid-Zambezi Graben is subdivided into two major sub-basins by the northeast-trending Kamativi - Chizarira - Matusadona basement block. The north sub-basin is fault-bounded on both its margins and is, hence, a true graben. Cyclic upward fining of Karoo strata (Catuneanu, et al. 2005) reflects episodic, fault-controlled subsidence in the graben.

7.2.1 Mutanga, Dibwe and Dibwe East

Northeast-trending faults likely controlled deposition of the Escarpment Grit “Braided Facies” and fault-related folds may control blind mineralisation in the Dibwe and Dibwe East area (Yeo, G. 2011) (Ullmer, E. 2010) (Figure 7-3). The Mutanga area of the Mid-Zambezi Valley is characterized by a series of northeast-trending, fault-bounded cuestas or fault blocks, uplifted to the northwest and dipping to the southeast. Three major northeast-trending anastomosing fault systems can be distinguished in the Mutanga area: the Lusitu, Dibwe and Bungua Mountain fault zones. There are numerous minor faults of limited extent trending northwest to north.

Lusitu Fault Zone

This fault zone roughly follows the valley along the base of the escarpment, where it is obscured by Quaternary and alluvial deposits of the Lusitu and Lusengesi rivers and their tributaries. Along the northwest side of this fault zone down-throw is clearly to the southeast, with Karoo strata at the base of the basement rocks exposed on the escarpment. Madumabisa rocks appear to onlap basement in the Chalala stream area, suggesting that fault offset locally post-dates deposition of the Madumabisa (late Karoo or younger).

Along the east side of the Lusengesi – Kayubila segment of the fault zone, downthrown is also interpreted to be to the southeast of the major fault trace. Younger rocks are exposed to the southeast of older. In the axial part of the Lusengesi – Kayubila segment, the major fault trace is interpreted to be downthrown to the northwest. The relative age of rocks across the fault is uncertain, but moderately to steeply dipping, north- to northwest-trending bedding on the downthrown side is truncated by moderately dipping, northeast-trending. A gentle syncline on the downthrown side is a drag fold.

Dibwe Fault Zone

The Dibwe Fault Zone extends through the area of Dibwe village north. It is a relatively straight, northeast-trending structure, comprising two anastomosing strands along much of its length. Southwest of Dibwe, both strands are interpreted to be downthrown to the northwest. On the northwest and southeast strand, younger strata are downthrown relative to older. A gentle syncline in the hanging wall of the northeast fault strand and parallel to it lie strikes south-southeast sub-parallel to the Lusengesi River. A dome-like feature interpreted to be a diatreme dome lies near Dibwe village. A prominent linear magnetic high coincides with the westernmost strand of the fault. This may represent a concealed dyke of Batoka basalt intruded along the fault, as interpreted by (Symons & Siegfried, Report on the Interpretation of Aeromagnetic and Radiometric Data over the Kariba Uranium Project, Zambian, 2006).

A single fault strand to the north of Mutanga splits into two farther to the northeast. Along these, Madumabisa mudstone is uplifted against Escarpment Grit strata. Although northeast-trending fractures parallel to the cliff edge at Mutanga suggest a fault at the base of the cliff, up-dip projection of the Madumabisa –The Mutanga cliffs have likely eroded back from the Dibwe Fault through undercutting of the mudstone below the sandstone.

North of Mutanga, the southeast fault strand is interpreted to be downthrown to the northwest (e.g. Meandering Facies and Braided Facies downthrown against Madumabisa mudstone). A gentle anticline lies immediately northwest of this fault strand with its axis parallel to it. A gentle syncline lies parallel and to the northwest of the anticline.

The Bungua Mountain Fault Zone

The Bungua Mountain Fault System comprises two northeast-trending anastomosing fault traces with numerous splays. The two main fault traces pass on either side of Bungua Mountain, join into a narrow zone northeast of Bungua Mountain, where the Lutele stream crosses the trace and splits again into two traces which extend on either side of another basement ridge north of Mbendele stream.

Southwest of Bungua Mountain, the east fault trace is interpreted to be downthrown to the northwest, consistent with the presence of younger strata to the northwest and older strata to the southeast. Gentle anticlines lie northwest of both the east and west fault traces with their axes sub-parallel to the faults. Along the northwest flank of Bungua Mountain, the west fault trace is interpreted to be downthrown to the northwest, with younger strata to the northwest and older basement rocks to the southeast. A gentle anticline with its axis subparallel to this fault trace lies just west of Bungua Mountain. Along the southeast side of Bungua Mountain, the east fault trace is interpreted to be downthrown to the southeast, with younger strata to the southeast and basement rocks to the northwest. Note that this sense of offset is opposite to the apparent displacement sense on the same fault trace southeast of Bungua Mountain.

Where the fault traces converge in the valley drained by Lutele stream, downthrow is interpreted to be to the northwest, but exposures are poor and lithologies are indicated to be uncertain. Gentle folds, with axes subparallel to the fault trace, lie northwest of it. The west fault trace which extends along the west side of the basement outlier north of Mbendele stream is downthrown to the northwest.

Prominent linear magnetic highs, comparable to that on the east fault trace of the Dibwe Fault Zone in the Dibwe village area, coincide with the main fault trace along the western base of Bungua Mountain and to the southwest, as well as the fault segment about 10 km northeast of Bungua Mountain that extends along the northwestern base of another crystalline basement block. These too, likely represent concealed Batoka basalt dykes intruded along the fault zone.

Minor Faults

North to northwest trending faults, with extents of less than four kilometers, cross-cut the major fault systems. In contrast with the major faults, they appear to be normal faults. These minor faults likely formed in response to differential uplift on the major faults. One of these extends southerly into the Dibwe East mineral deposit.

A striking feature of all three fault zones is the development of gentle folds on their hanging-wall side, whose fold axes lie subparallel to the faults. The close spatial association of folds with faults and their orientation indicates that the folding is related to fault movement. Hanging wall folds are commonly associated with normal faults. Depending on the shape of the fault plane, either rollover anticlines or synclinal drag folds (Khalil and McClay 2002) may be developed. Synclinal drag folds may be formed on the fault-side of rollover anticlines (Yamada and McClay 2004), (Withjack, Islam and La Pointe 1995)).

As noted above, the extensive linear magnetic highs associated with the Dibwe and Bungua Mountain fault zones are interpreted to result from Batoka basalt dykes, which are not exposed at surface. This suggests that these faults were initiated as extensional features following deposition of the Karoo strata, in a final phase of rifting.

Regional seismic studies indicate present-day northwest-southeast crustal extension in the Mid-Zambezi Basin (Dumisani 2001). Hence, northeast-trending faults are likely to have been reactivated as normal faults. This is consistent with the apparent post-depositional normal offsets of the faults. Although there is no direct evidence for when fault reactivation began or what caused it, it seems likely that it is related to propagation of a little-studied southwest branch of the East African Rift System along the Karoo-aged Luangwa and mid-Zambezi rifts and further southwest along the Deka fault zone ((Chorowicz 2005) and (Dumisani 2001)).

Structural Geology – Dibwe East (Yeo, G. 2011)

Historic AGIP geology maps of the Dibwe East Zone 1 area show it to be cut by a series of east-northeast- to northeast-trending faults 1 to 6 km long. These faults are subparallel to the major regional fault systems, such as the Dibwe and Bungua Mountain faults. This contrasts with the minor faults at Mutanga and Dibwe East, which have predominantly northerly trends.

A series of cross-sections constructed roughly perpendicular to the northeast-trending faults show that most of the minor faults in the Dibwe East area are normal faults dipping steeply and mainly downthrown to the northwest. The southeastern faults, however, dip and are downthrown to the southeast. Hence the fault block between the northwest- and southeast-dipping faults is a small horst.

All of the faults in the Mutanga deposit region are interpreted to be normal faults (Money and Prasad 1977); (Staley, R.; Chapewa, D.; Lusambo, V.; Mbomena, G. 2009), (Titley, M. 2009) and (Ullmer 2009)). Continuity of stratigraphic units and offset of stratigraphic boundaries across the faults indicate that most of the observed fault offsets post-date deposition. Thickness changes, occurrence of hanging wall folds and widespread occurrence of soft-sediment deformation features all suggest, however, that some fault displacement was syndepositional. Hence, two distinct structural events have affected the area. Extensional faulting, associated with subsidence of the Mid-Zambezi rift in Upper Karoo time was followed much later by renewed extensional faulting, associated with the southwest branch of the East African Rift System. Most of the mapped faults are related to the later event.

The change in thickness of the Escarpment Grit “meandering facies” across the Dibwe Fault, from about 180 m west of the fault to about 195 m east of it, and thinning of the “meandering facies” southeast of Dibwe, to about 70 m at Bungua Hill, suggests syndepositional subsidence, controlled by extensional faults. The faults likely propagated upwards as growth faults, since the two distinctive facies units of the Escarpment Grit are continuous across the faults without major thickness changes, except as noted above. The strong southwesterly orientation of Escarpment Grit “braided facies” paleocurrents, suggests deposition in stream systems draining southwest parallel to the axes of one or more half-graben, as noted by (Money and Prasad 1977). The presence of numerous circular or elliptical structures, also commonly in the hanging walls of faults and interpreted by (Ullmer 2009) as diatremes, and the widespread occurrence of soft-sediment deformation structures in the Escarpment Grit sandstones, are also consistent with syndepositional seismic activity and faulting.

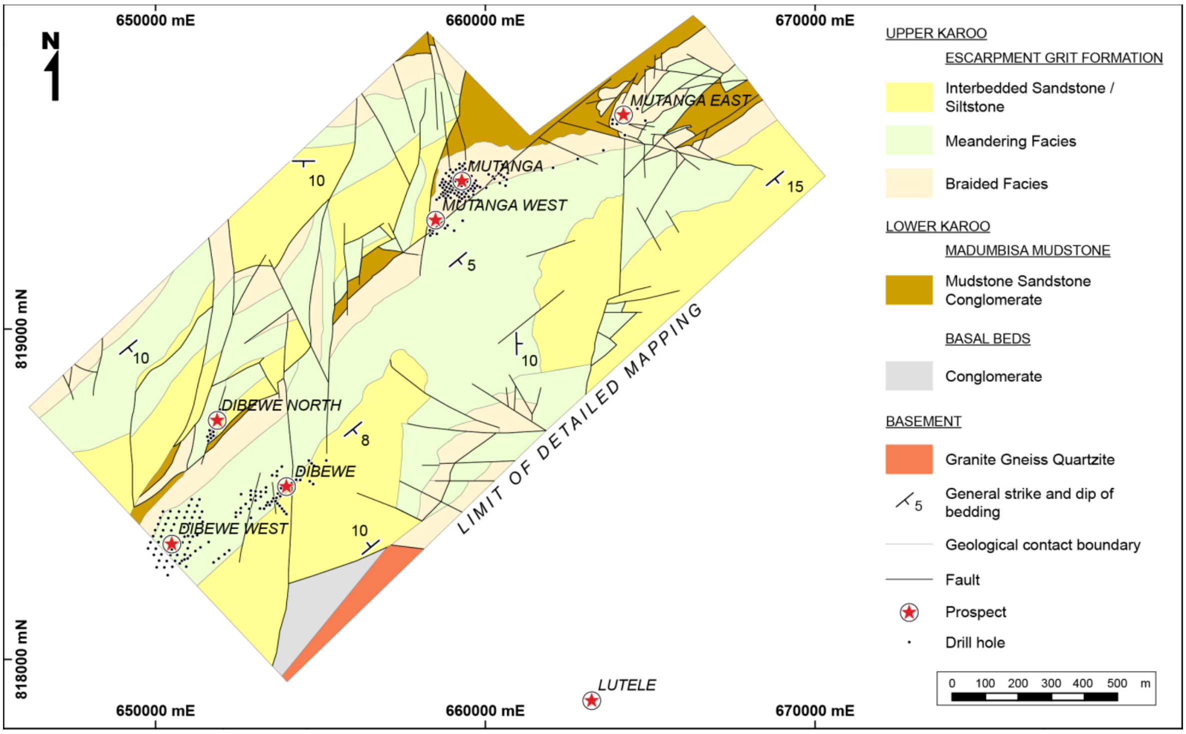


Figure 7-2: **Geological Map of the Dibwe-Mutanga Area (Source: CSR, 2013)**

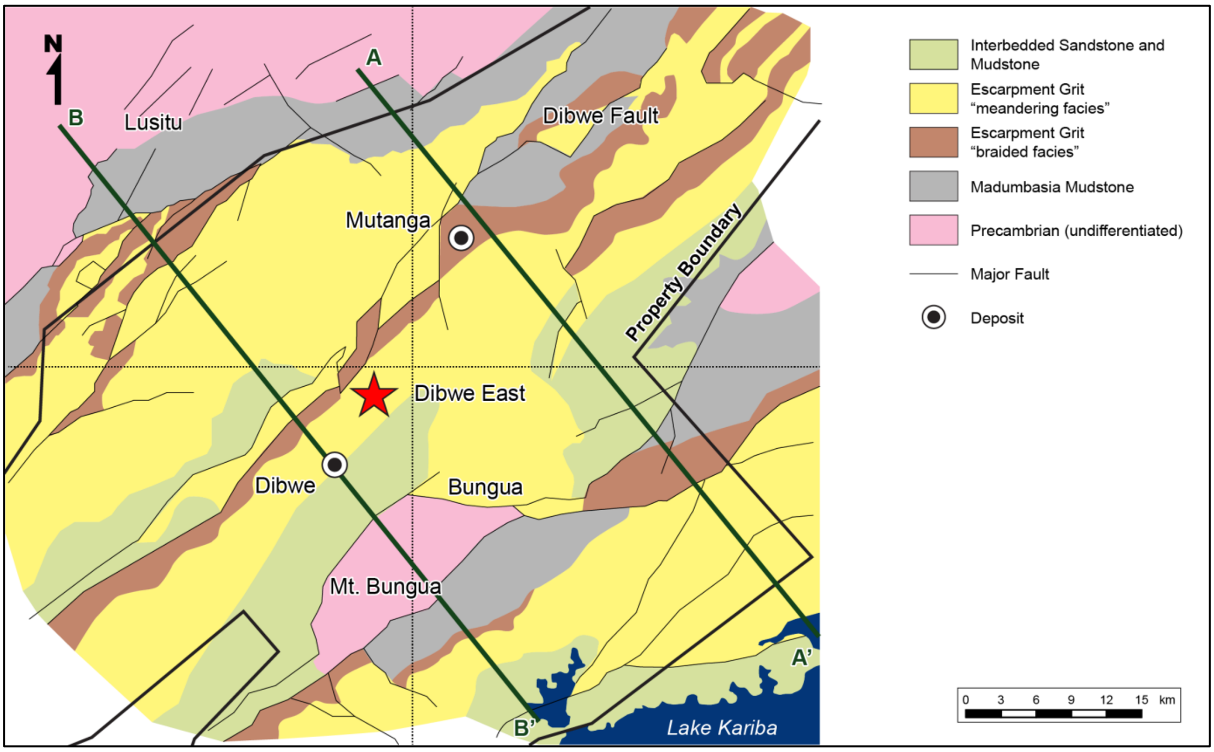


Figure 7-3: **Geological Map of the Dibwe-Mutanga Area (Source: simplified from Ullmer, E. 2010 in CSR, 2013)**

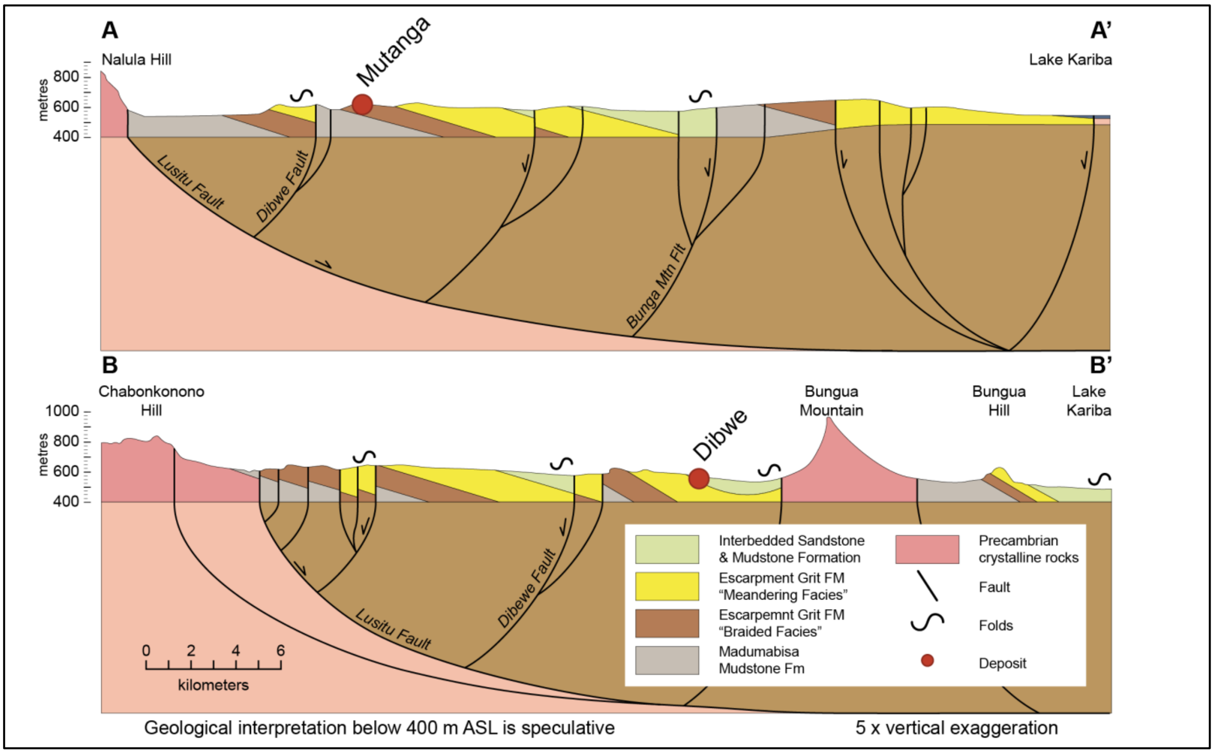


Figure 7-4: **Geological Cross-Section of the Dibwe-Mutanga Area (Area of Cross-Section Shown on Figure 7-3) (Source: Simplified from Ullmer, E. 2010 in CSR, 2013)**

7.2.2 Njame, Njame South and Gwabe

The Njame Prospect consists of Escarpment Grit exposed on a gentle dip slope which faces to the southeast (Figure 7-5). In the northwest, the slope is a much steeper scarp controlled by the position of a northwest dipping normal fault. This fault is down-thrown several hundred meters to the northwest, representing one of a number of faults that has caused imbrication in the Kariba Rift. The sequence is also cut by a number of smaller strike-parallel normal faults, which have caused northwest block down displacements of up to 25 m. Similarly, the eastern limit of the Njame mineralisation is a major southeast trending wrench fault that truncates the slope and the stratigraphy. The sequence is also cut by a number of smaller strike-parallel normal faults, which have caused down displacements of the northwest block.

Gwabe mineralisation forms a broadly tabular body that dips very gently to the southeast, and occurs at very shallow depths between 3 m and 29 m below surface. In the northwest, the slope is a much steeper scarp controlled by the position of a northwest dipping normal fault. Minor post-mineralisation faulting has locally caused meter-scale offsets to the mineralisation, and may have truncated the mineralisation along its southern boundary.

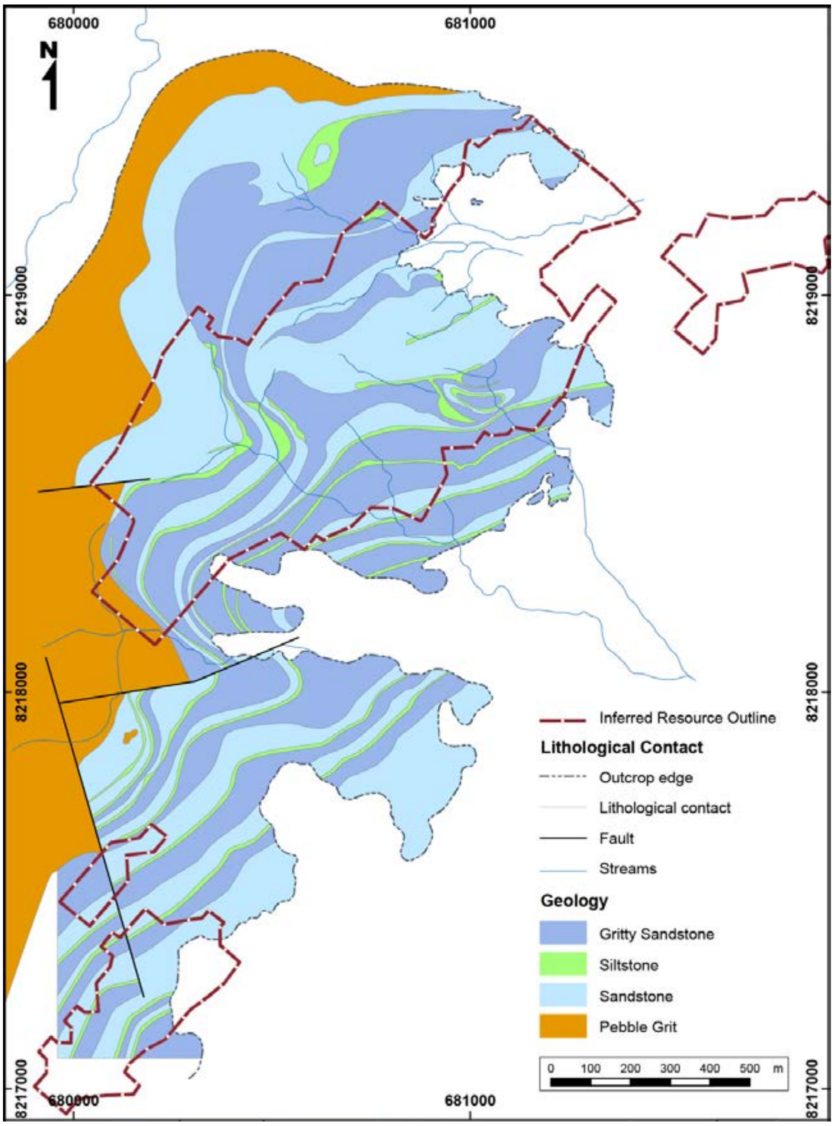


Figure 7-5: **Geological Map of the Njame Prospect (Source: AFR, March 2009 and June 2013)**

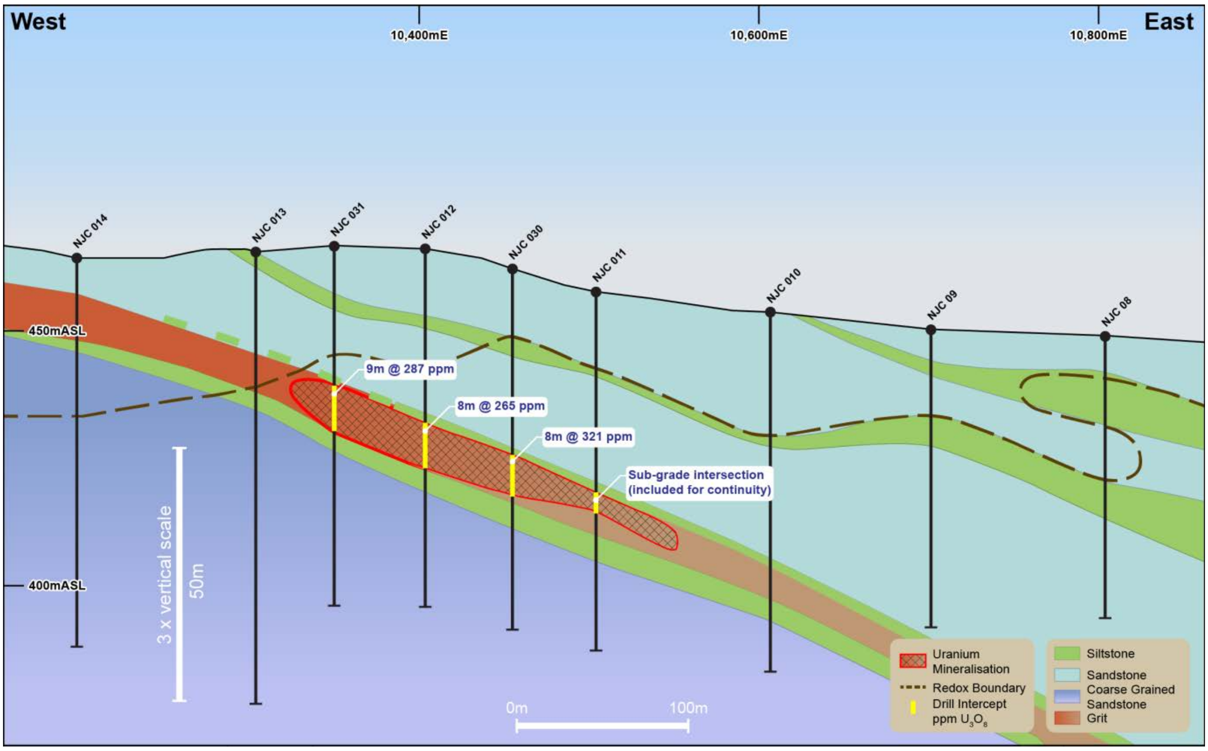


Figure 7-6: **Geological Cross-Sections for Njame Central (Source: AFR, March 2009 and June 2013)**

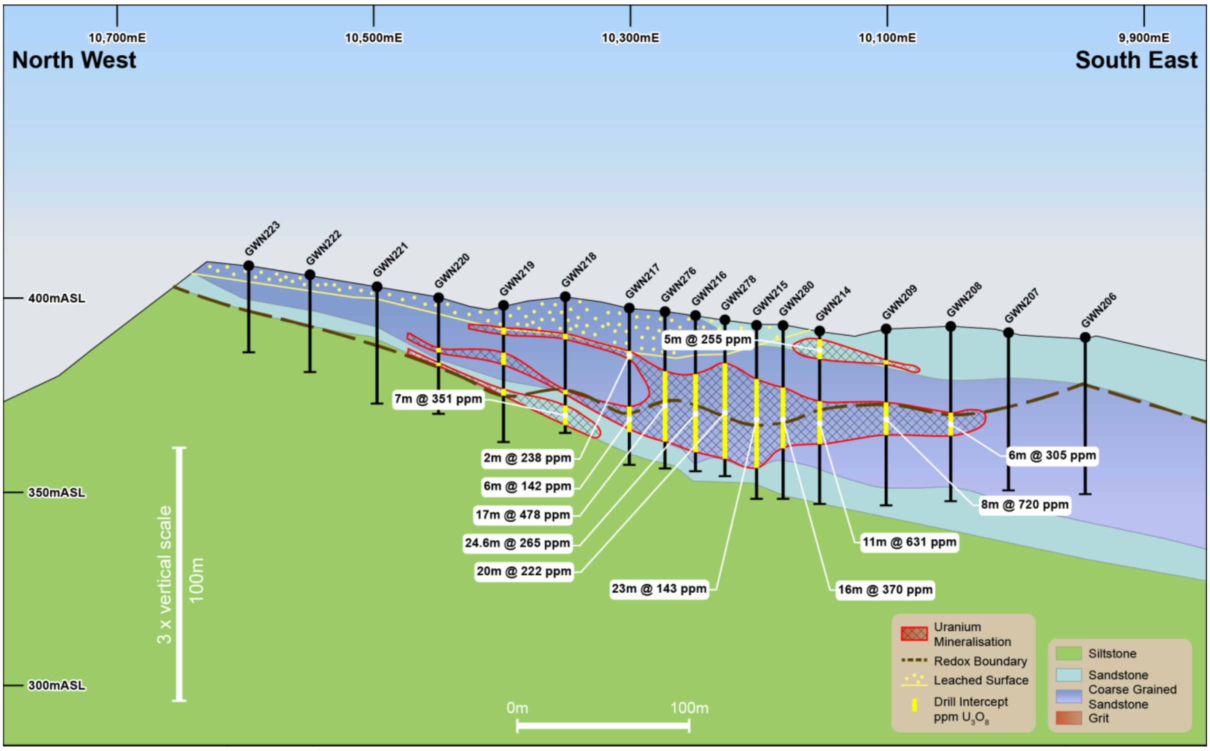


Figure 7-7: **Geological Cross-Sections for Gwabe (Source: AFR, March 2009 and June 2013)**

7.3 Local Geology

7.3.1 Mutanga, Dibwe and Dibwe East

The Escarpment Grit Formation sequence at the Mutanga mineral deposit comprises at least 120 m of sandstone and conglomerates with occasional mudstones and silts. The Escarpment Grit Formation overlies the Madumabisa Mudstone Formation which comprises a grey to dark grey silty mudstone, with a dark red hematised 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 the Madumabisa Mudstone Formation and overlying Escarpment Grit Formation is between two and three meters above the dark red hematised layer.

Mutanga Geology

The Mutanga mineral deposit is located 31 km northwest of Siavonga. Three stratigraphic zones (“Packages”) were historically identified from core logging and 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. The three Packages are detailed as follows:

Package A

‘Package A’ is approximately 24 m thick. Overlying the Madumabisa Mudstone Formation, it 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 are noted. ‘Package A’ is capped by an approximately 5 m 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.

Package B

‘Package B’ is approximately 70 m thick. Overlying ‘Package A’, 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.

Sulfides are observed to within an approximate depth of 50 m 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 Escarpment Grit Formation ‘Package B’ is taken as being the first down hole presence of mudstone.

Package C

‘Package C’ is approximately 25 m thick. Overlying ‘Package B’, it is interpreted from recent drilling as the uppermost unit within the Escarpment Grit Formation in the area. ‘Package C’, although 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.

Dibwe and Dibwe East Geology

The Dibwe prospect (Dibwe and Dibwe East) is located approximately 10 to 15 km west of the Mutanga area. Uraniferous mineralisation in the Dibwe area appears to be hosted by relatively un-faulted meandering facies units of the Escarpment Grit Formation.

Dibwe East is predominantly composed of Escarpment Grit Formation. The surface geology is characterised by a few scattered sandstone outcrops. Two major units can be distinguished in core, the “Braided facies” member of the lower Escarpment Grit Formation and the “Meandering facies” member of the upper Escarpment Grit Formation which appear to be transitional from one another. Most of the Dibwe East mineralisation occurs in the Meandering facies.

Strata dip at about 8^{o} to 15^{o} in the south-easterly direction and strike in the northeast-southwesterly direction. The sandstones are predominantly massive looking with cross beddings indicating that they are channel deposits. Cross-bed foreset orientations are variable suggesting high sinuosity (meandering) river deposition. Sandstone layers 10-50 m thick tend to alternate with 2-5 m thick mudstones and siltstones. Mudstones can be laterally continuous for hundreds of meters.

Manganese nodules are common at the surface. These manganese nodules are composed of pyrolusite and hollandite and usually contain uranium mineralisation. The uranium is homogeneously distributed within the host manganese and phosphatic minerals. The manganese nodules are believed to have formed by compaction of wet sediments which led to the remobilisation and formation of manganese nodules at the aerated sediment-water interface, and uranium enriched phosphorite lenses below the interface in reducing conditions. Epigenesis occurred through the passage of solution fronts which recrystallised the manganese and phosphatic minerals and remobilised the uranium which was leached away. The mechanism of uranium uptake in manganese phases most probably involves adsorption of $((UO_2)_3.(OH)_5)+$ complexes on precipitating minerals.

Mudballs are also present in drill core. These are rounded clasts of clay which bind sediments and minerals to their surfaces. Most of them are pyritic and sticky so they can survive transport of hundreds of meters in a river although they disintegrate eventually.

7.3.2 Njame, Njame South and Gwabe

Njame and Njame South Geology

The geology of the Njame Prospect is relatively simple, consisting entirely of Escarpment Grit exposed on a gentle dip slope which faces to the southeast. In the northwest the slope is a much steeper scarp controlled by the position of a northwest dipping normal fault. This fault is down-thrown several hundred meters to the northwest, representing one of a number of faults which has caused imbrication in the Kariba Rift.

The sequence is also cut by a number of smaller strike-parallel normal faults which have caused northwest block down displacements of up to 25 m. A south-east trending fault appears to have caused a rotational offset between the northern and eastern parts of the Njame deposit. Furthermore, a second series of faults with displacements less than the strike-parallel faults have offset the stratigraphy and the mineralised horizons.

A variety of clastic sediments are developed at Njame, ranging from coarse conglomerate beds several tens of meters thick to thinly bedded or cross-bedded fine to medium grained sandstones. Thin bands of shale and mudstone are intercalated in the sequence. AFR historically identified five facies packages (AFR, March 2008), numbered F1 to F5 from base to top, which showed a general fining upwards trend, often with a thin mudstone or shale horizon defining the top of the sequence and marking the base of the next cycle. Individual sequences also trend towards finer sediments down-dip, reflecting changes from proximal to distal environments. This interpretation is consistent with paleo-current indicators suggesting transport from between the northwest and northeast. The mudstone horizons, which represent quiescent phases in the sedimentation, comprise the most laterally continuous lithologies and are thus useful marker horizons.

Gwabe Geology

Similarly, to Njame and Njame South, the geology of the Gwabe Prospect also consists entirely of Upper Karoo Escarpment Grits exposed on a gentle dipping southeast facing slope. A variety of clastic sediments are developed at Gwabe, ranging from coarse conglomerate beds several tens of meters thick to thinly bedded or cross bedded fine to medium grained sandstones. Thin bands of shale and siltstone are intercalated in the sequence. Below the grits are well-developed calcareous shale and siltstone layers, possibly representing the upper part of the underlying Madumabisa Mudstone.

7.4 Mineralisation

7.4.1 Mutanga, Dibwe and Dibwe East

Mineralisation appears to be later than at least some of the normal faults which cut the Escarpment Grit Formation. This is evident from the good correlation of the radiometric logging data between adjacent holes within the Mutanga mineral deposit separated by interpreted faulting (Lusambo, V. 2011).

The source of the uranium is believed to be the surrounding Proterozoic gneisses and plutonic basement rocks. Having been weathered from these rocks, the uranium was dissolved, transported in solution and precipitated under reducing conditions in siltstones and sandstones. Post lithification fluctuations in the groundwater table caused dissolution, mobilization and redeposition of uranium in reducing, often clay-rich zones and along fractures.

Mineralisation is not strictly associated with a particular unit in the stratigraphic section. It was observed to occur in both the fine-grained and coarser material and mudstones especially where fractures and mud balls occur. Some mineralisation occurred in association with manganese oxide or disseminated with pyrite. Mineralisation in some bore holes was seen to occur where there was grey alteration, limonite and feldspar alteration and in dark grey mudstones (Sakuwaha 2011). The strata dip in the south-easterly direction and mineralisation seems to occur along dip.

Uranium mineralisation occurs in a number of different associations:

- Disseminated mineralisation

  Occurs in sandstones, conglomerates, and within mud layers, mud balls and mud flakes. Uranium present as interstitial fine grained crystals or small amorphous masses constituting less than 1% by volume. Grades vary considerably between zones of disseminations, approximately 20 to 2000 ppm U_3O_8 in mineralisation thought to be solely of a disseminated nature. The presence of sulfides alongside uranium oxides may indicate a transitional zone and/or preferential replacement/reduction of uranium compounds by one chemical route over another (such as decaying organic matter over oxidation of sulfides) as uraniferous groundwaters moved through the lithologies.

- Mineralisation associated with mudstones and siltstones

  Muddy lithologies include mud balls (within sandstones), flakes and interbeds. In some cases, mud balls may be completely replaced by mineralisation. The degree of replacement varies from fully replaced mud balls to those with a thin selvage of mineralisation, whilst others are unmineralized. This is attributed to different ground water chemistry, differing volumes of reducing matter within the mud (fully replaced material may have been a peat like material), and porosity of the muddy lithology during the influx of uraniferous ground water.

- Fracture hosted uranium mineralisation

  Mineralisation is seen as crystal coatings on surfaces and as concentration close to surfaces. Most notably at the Dibwe-Mutanga-Dibwe corridor, these fractures are coated with black Fe/Mn oxides which in turn may be coated with secondary uranium phosphate mineralisation (Autunite, meta-Autunite and selenite).

- Uranium mineralisation associated with pyrite

  Mineralisation may be elevated in some (relatively) pyrite rich zones. Presence of sulfides in close proximity to uranium oxides may indicate a transitional zone and/or preferential replacement/reduction of uranium compounds by one chemical route over another (such as decaying organic matter over oxidation of sulfides) as uraniferous groundwaters moved through the lithologies.

7.4.2 Njame, Njame South and Gwabe

At Njame and Njame South, the uranium mineralisation occurs at the interface between siltstones and sandstones at redox boundaries. Approximately 25% of the Njame mineralisation is siltstone hosted, with the balance in coarser grained sandstones and grits.

Drilling conducted by AFR (AFR, March 2008; April 2012) identified two main mineralised horizons; the thickest, most consistent and highest grade is the lower horizon within the second sequence from the base. Drilling was carried out along the entire length of the 5 km long system, with uranium mineralisation encountered along the entire length. Unlike the high energy sandstone and grit horizons, which show very rapid changes over several tens of meters, the siltstone horizons are generally laterally continuous for hundreds of meters, except where younger grit/sandstone channels have cut through them. There is a clear stratigraphic control on mineralisation at deposit scale, although structural control may be present on a larger scale.

Similarly to Njame, the uranium mineralisation at Gwabe is also related to the redox front; there is one main mineralised horizon which appears to be controlled by both lithology and the redox boundary. It is hosted by the coarse grained sediments that are interpreted to be the along-strike continuation of the Escarpment Grits which host the Njame uranium mineralisation. Uranium mineralisation at the Gwabe deposit occurs in red, oxidised, coarse grained sandstones, grits and pebble conglomerates which overly a green, non-mineralised, reduced silty-shale horizon. This is interpreted to represent a major redox boundary, and may in fact be the regional unconformity between the Upper and Lower Karoo.

8 DEPOSIT TYPES (ITEM 8)

8.1 Summary

The primary uranium mineralisation in the Karoo rocks conforms to sandstone hosted fluvial channel type deposit (Nash et al., 1981; Turner, 1988). Sandstone uranium mineral deposits are generally of three types:

- Roll-front type mineral deposits - arcuate bodies of mineralisation that crosscut sandstone bedding; such as those that occur at the boundary between the up dip and oxidized part of a sandstone body and the deeper down dip reduced part of a sandstone body.
- Peneconcordant or Tabular sandstone uranium mineral deposits - irregular, elongate lenticular bodies parallel to the depositional trend, also called Colorado Plateau-type deposits, most often occur within generally oxidized sandstone bodies, often in localized reduced zones, such as in association with carbonized wood in sandstone paleochannels incised into underlying basement rocks.
- Tectonic/Lithologic mineral deposits - occur in sandstones adjacent to a permeable fault zone; Mineralisation forms tongue-shaped ore zones along the permeable sandstone layers adjacent to the fault. Often there are a number of mineralized zones 'stacked' vertically on top of each other within sandstone units adjacent to the fault zone (McKay and Miezitis 2001).

Sandstone deposits are contained within medium to coarse-grained sandstones deposited in a continental fluvial or marginal marine sedimentary environment. Impermeable shale or mudstone units are interbedded in the sedimentary sequence and often occur immediately above and below the mineralized horizon (Dallenhamp, 1993). Uranium is mobile under oxidizing conditions and precipitates under reducing conditions, and thus the presence of a reducing environment is essential for the formation of uranium mineral deposits in sandstones (Nash et al., 1981).

The Karoo basins of sub-Sahara Africa comprise what may be the world’s largest sandstone-hosted uranium province (Figure 8-1). Compared to the well-known uranium-bearing sandstone basins of the western US, the area of the Karoo basins is about 30% greater, but their known uranium content as of 2003 was only about 7% of that in the US basins. Whereas both areas contain broadly similar, little deformed, predominantly non-marine strata, mainly of Mesozoic age, the order of magnitude lower apparent uranium content of the Karoo basins indicates that they are relatively underexplored (Roux, 1998; Bowell et al., 2009).

Figure 8-1: **Surface Extent of Karoo Basins in Sub-Sahara Africa and Proximity of Known Uranium Deposits**

Only one Karoo deposit, Paladin’s Kayelekera mineral deposit in Malawi, has been developed (but on care and maintenance at the time of writing), others have economic potential (Yeo, 2010). These deposits have some key features in common:

- All are hosted in fluvial arkosic sandstones that have undergone post-depositional faulting and uplift (tectonic inversion).
- All lie at or near the surface and hence, typically have strong surface radiometric expression.
- All appear to have tabular geometry; no classic roll fronts have been convincingly demonstrated.
- Most feature a range of mineralisation styles, including primary uranium oxides and silicates in relatively reduced sandstones, secondary uranyl phosphates or vanadates in more strongly oxidized sandstones, and secondary mineralisation remobilized into surficial calcretes.
- Mineralisation is commonly associated with stratigraphic contacts indicative of a marked drop in stream energy.

9 EXPLORATION (ITEM 9)

9.1 Introduction

In addition to the drilling described in Section 10, extensive exploration work has been conducted on all of the deposits of the Mutanga Uranium Project.

9.2 Mutanga, Dibwe, and Dibwe East

The earliest phase of exploration for uranium in the area covering the Mutanga and Dibwe deposit areas was conducted by AGIP in the late 1970s to the mid-1980s.

AGIP carried out systematic exploration, comprising outcrop mapping, ground radiometric surveys, air-borne photographic and geophysical surveys, trenching and pitting. Regional exploration drilling was also carried out in the broad Mutanga-Dibwe area. A summary of the regional mapping completed is shown in Figure 9-1.

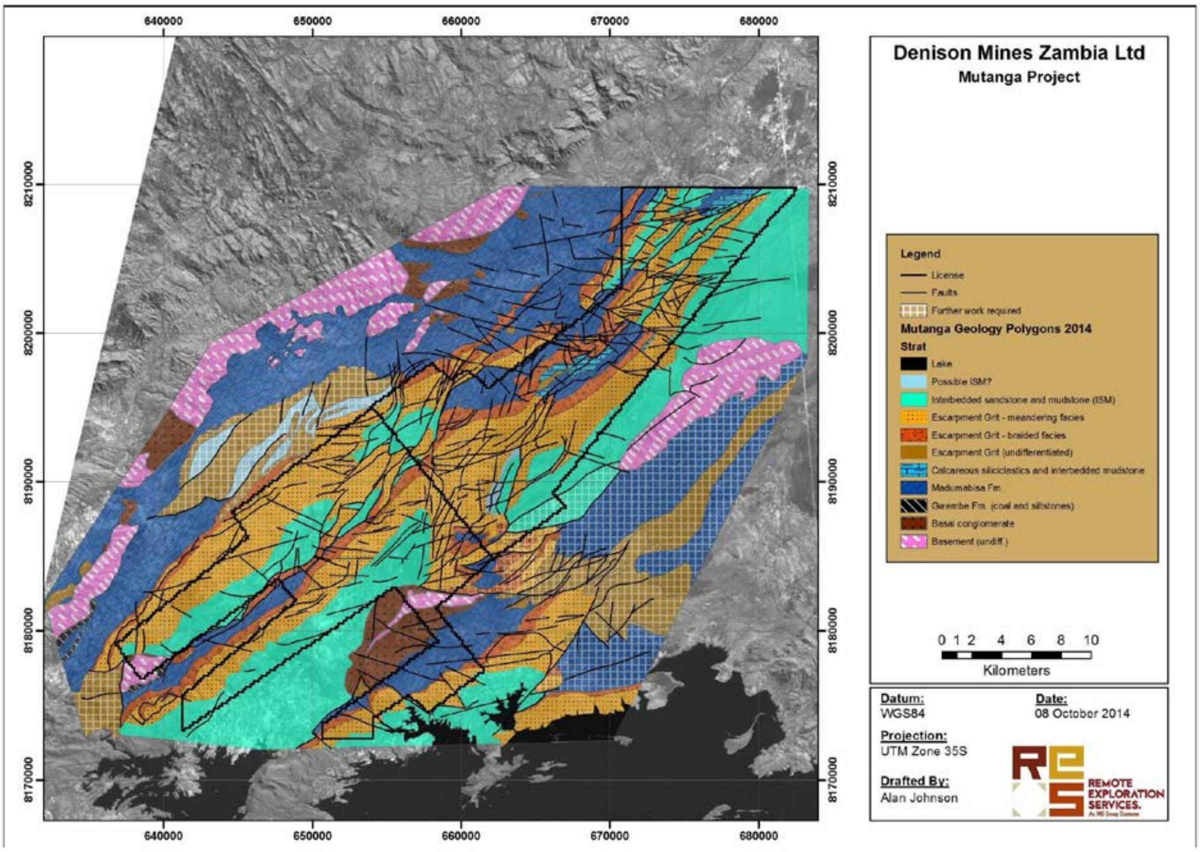


Figure 9-1: Dibwe – Mutanga Geological Map (Source: RES, 2013)

During 2006, a detailed aeromagnetic and radiometric survey was carried out by OmegaCorp which confirmed the position and tenor of the existing uranium prospects and identified additional targets, based on interpreted radiometric signatures. Conclusions of the 2006 airborne survey noted:

1. The Escarpment Grit Formation appears to have two clear radiometric signatures (Figure 9-2).

   a. A reddish brown ternary radiometric signature indicates the presence of potassium ("K") in the Formation, consistent with description of the Escarpment Grit Formation as feldspathic sandstone. This part of the Escarpment Grit Formation was mapped and designated as D1 (Figure 9-3).

   b. The areas marked as D2 appear to have a similar K response but with additional uranium producing a white ternary radiometric signature.

2. The structures identified indicate an extensional half-graben regime with normal faults trending in a generally northeast direction. The movement on these faults appears to down throw blocks to the northwest. Later faulting in a northwest, west-northwest and north-northeast direction crosscutting the Karoo stratigraphy is also noted.

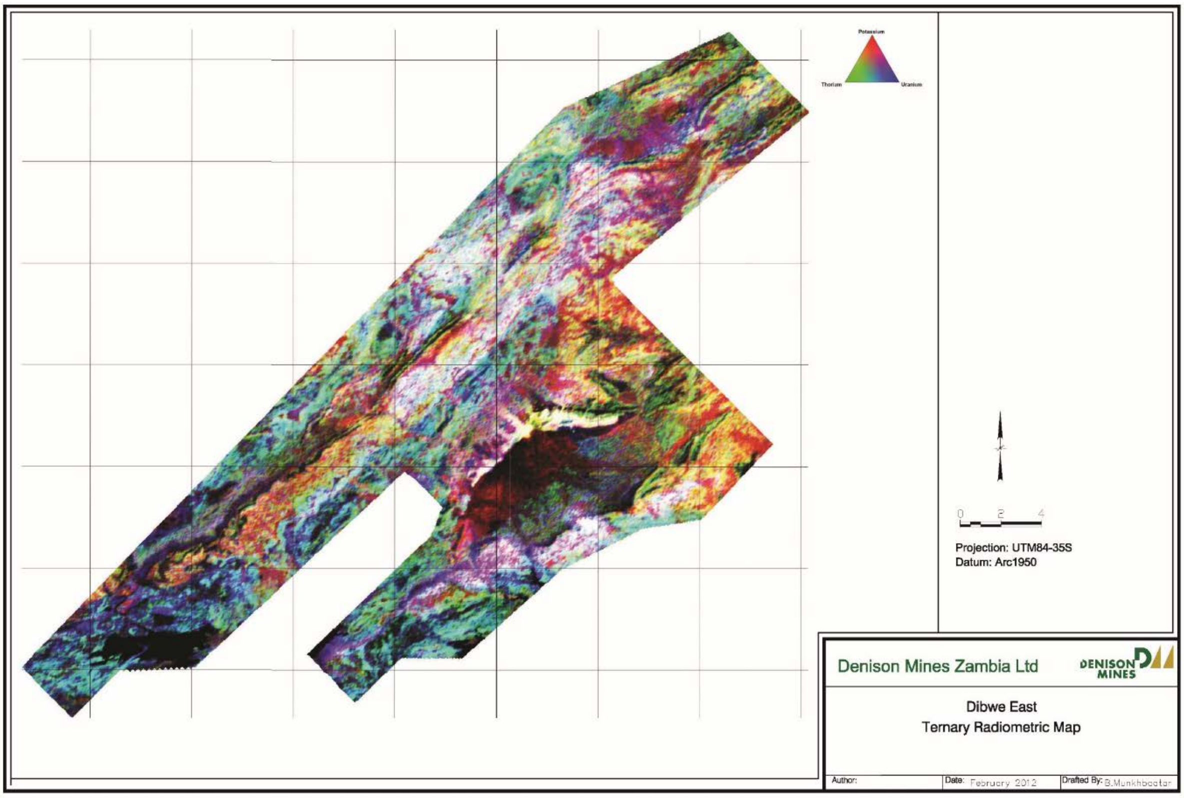


Figure 9-2: Ternary Radiometric Plot (Source: Denison-RPA, 2012)

In 2011, a Denison geophysicist noted some obvious errors in the magnetic data quality and derived products and subsequently had an external processor look at the 2006 data, who confirmed that the gridded data within this region was representative of their processing sequences. Assumptions were made that since the radiometric signal from the equivalent potassium was mapping the near surface expression of the Escarpment Grit Formation; this implied that the high frequency content from the magnetic signature (2nd vertical derivative grid) was also representative of geological variations within the Escarpment Grit Formation. Furthermore, by closely examining the potassium/magnetic datasets on larger formational trends an inverse relationship occurs between mudstones and sandstones. The units are clearly distinguishable with mudstones having a high mag/low potassium signature and the sandstones as a low mag/high potassium signature (Denison-RPA, 2012), and resolution of the magnetic dataset is much better at defining faulting, lineaments and/or edges of magnetic domains as evidence in a provisional interpretation of lineaments and offsets in the area (Figure 9-4).

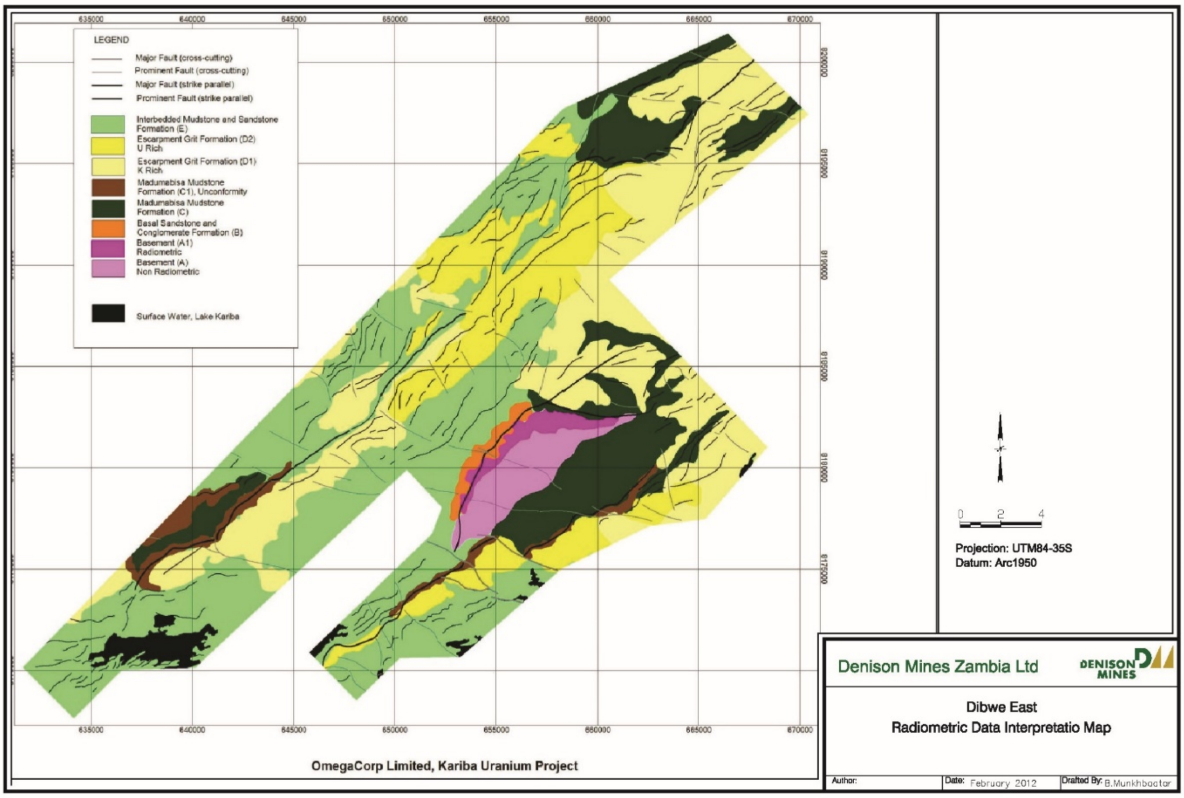


Figure 9-3: Interpretative Map, Based on Radiometric Data Shown in Figure 9-2

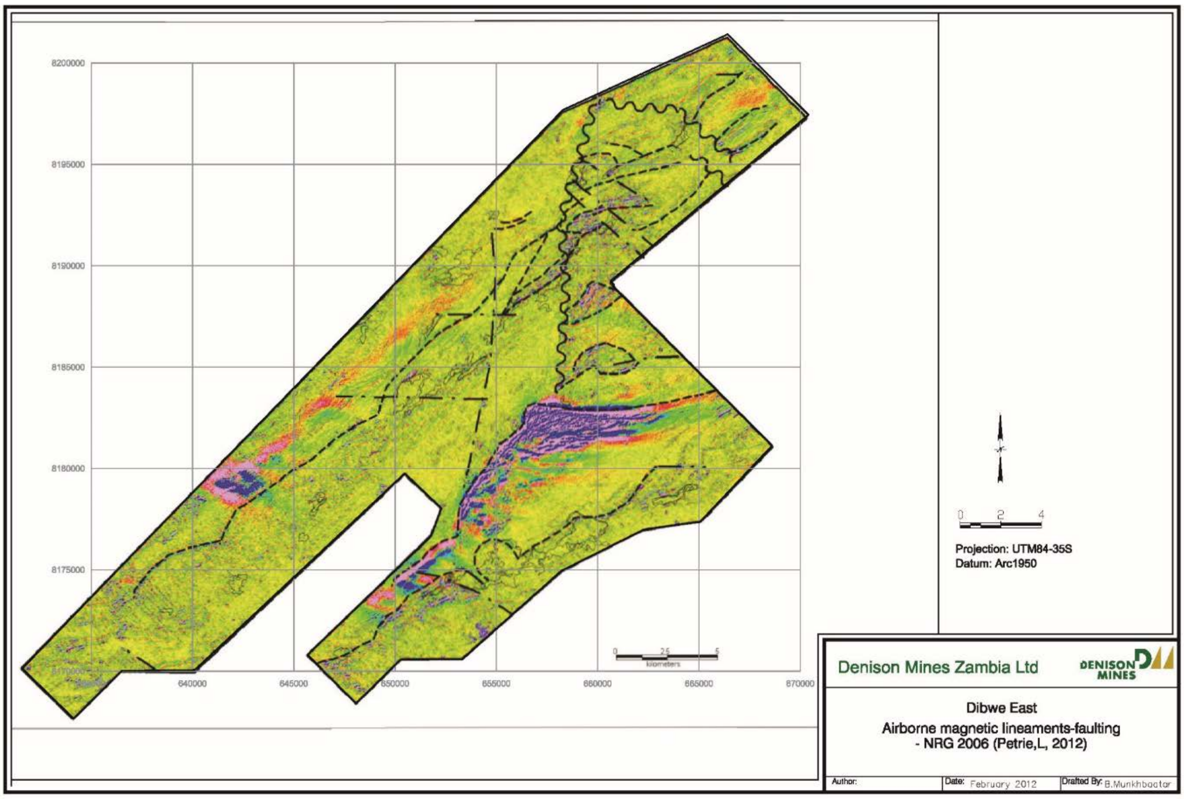


Figure 9-4: Airborne Magnetic Lineaments-Faulting (Denison-RPA, 2012)

During August and September 2013 Geotech Ltd. carried out a helicopter-borne geophysical survey over the Mutanga Project. Principal geophysical sensors included a versatile time domain electromagnetic (VTEMplus) system, and horizontal magnetic gradiometer. Ancillary equipment included a GPS navigation system and a radar altimeter. A total of 1903 line-kilometers of geophysical data were acquired during the survey. In-field data quality assurance and preliminary processing were carried out on a daily basis during the acquisition phase. Preliminary and final data processing, including generation of final digital data and map products were undertaken from the office of Geotech Ltd. in Aurora, Ontario. The processed survey results are available as the following maps:

- Electromagnetic stacked profiles of the B-field Z Component.
- Electromagnetic stacked profiles of dB/dt Z Components.
- B-Field Z Component Channel grid.
- Total Magnetic Intensity (TMI).
- Fraser Filtered dB/dt X Component Channel grid.
- Magnetic Total Horizontal Gradient.
- Magnetic Tilt-Angle Derivative.
- Calculated Time Constant (Tau) with contours of anomaly areas of the Calculated.
- Vertical Derivative of TMI.
- RDI sections are presented.

Digital data includes all electromagnetic and magnetic products, plus ancillary data including the waveform. The survey report describes the procedures for data acquisition, processing, final image presentation and the specifications for the digital data set.

Geological mapping of the Mutanga property was undertaken during August and September 2014 by Remote Exploration Services (RES) of Cape Town, South Africa. A total of 324 line kilometers of mapping traverses were completed including 1815 mapping stations. Field mapping data was integrated with airborne geophysical data, satellite imagery and previous geological maps and interpretations to produce a revised geological map for the Mutanga property (Figure 9-1).

The Mutanga project area was covered with soil geochemical and radon surveys from 2013 to 2015. The objective of the surveys was to delineate any significant exploration targets outside of the drill defined uranium resources. Previous drilling had largely focused on testing airborne radiometric anomalies and the soil geochemical and radon approach allowed for possible detection of blind or buried mineralization, particularly in areas of thick or transported regolith. Surveys were carried out in the dry months between May and November. Coincident soil and radon stations were 100 meters apart on 800 meter spaced northwest-southeast survey lines. Survey data and results have been stored in an Access database. A summary of the soil and radon samples collected from 2013 to 2015 is provided in Table 9-1 and shown in Figure 9-5. Prior to implementation of the surveys, orientation was conducted over know mineralization to establish optimal methodologies.

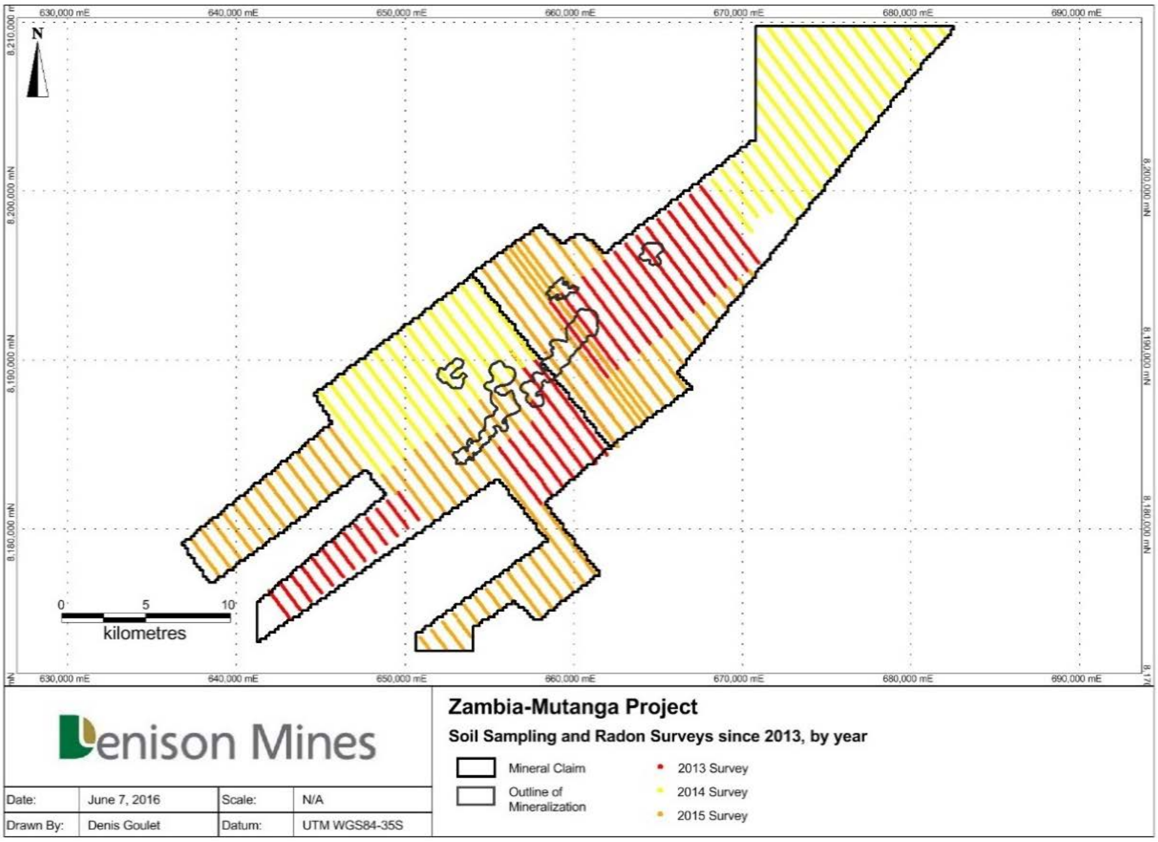


Figure 9-5: Soil Geochemical and Radon Maps, 2013-2015 (Denison-RPA, 2012)

Table 9-1: Summary of the Soil and Radon Samples Collected from 2013 to 2015

Year Date	Soil Samples	Soil Field Duplicates	AlphaTrack	RadonX
2013	1780	93	1680	0
2014	2029	105	0	2028
2015	2248	93	0	2247
TOTAL	**6057**	**291**	**1680**	**4275**

At each sample site a 300 gram unscreened sample was collected from the A-horizon. Sample site information and coordinates were recorded in field note books. Samples were sent to ACME Laboratories in Vancouver, Canada for analysis using Group 1F, aqua regia digestion ultratrace ICP-MS method. Quality control was monitored with field duplicate samples that were collected at a frequency of one duplicate in every 20 samples.

In 2013 the AlphaTrack method was used, following successful orientation work conducted in 2011. AlphaTrack cups are 1 litre plastic cups with a small piece of special plastic film taped to the inside. In use, the cups are buried in an inverted position so that any radon gas percolating upward will be trapped in the cup. The cups are typically left in place for about 4 weeks. Radon gives off alpha particles which leave microscopic trackways on the film. The trackways can be counted in the lab to give a quantitative measurement of the amount of radon trapped in the cup. This in turn, gives an indication of the location and grade of subsurface uranium mineralization.

In 2014 and 2015 the RadonX^{TM} method was utilized, following successful orientation work in 2012. RadonX is provided by Remote Exploration Services (RES) of Cape Town, South Africa. RadonX is based on the Radon-on-Activated-Charcoal (ROAC) technique initially developed by the SA Atomic Energy Board but refined and enhanced by RES. Unlike other radon emanometry methods that rely on alpha-particle detection, RadonX measures the gamma emission from radon’s daughter products, bismuth (214Bi) and lead (214Pb), following adsorption of the radon onto activated charcoal. This method of detection excludes the detection of thoron (220Rn) arising from thorium that may be contained in the bedrock, representing a significant advantage of the RadonX method. Radon gas is adsorbed onto activated charcoal contained within a cartridge fitted into the base of an inverted cup that is buried in the ground. Gamma radiation from the daughter products of the adsorbed radon is then measured using a field scintillometer. Background effects are reduced and corrected for through the use of a lead castle. During the 10 day cup burial period, weather is to be monitored. Rainfall and temperature are known to affect the ability of charcoal to adsorb radon. RadonX cartridges are subjected to stringent quality control measures from time of initial loading of activated carbon through field deployment up to the time of taking scintillometer readings.

The soil geochemical and radon surveys produced numerous anomalies across the Mutanga project area and new exploration targets were defined for follow-up. The soil geochemical and radon methods used adequately detected the drill defined mineralization and showed reasonable correlation with radiometric anomalies, thereby confirming this exploration approach. The new exploration targets were defined based on combinations of anomalous soil uranium, soil uranium pathfinders, radon and soil radioactivity. In some cases the targets corresponded with surficial cover (thicker soils) alluding to a buried source. Targets located over prospective geology and structure were prioritized for follow-up. Figure 9-6 and Figure 9-7 show the gridded soil uranium and gridded radon results respectively.

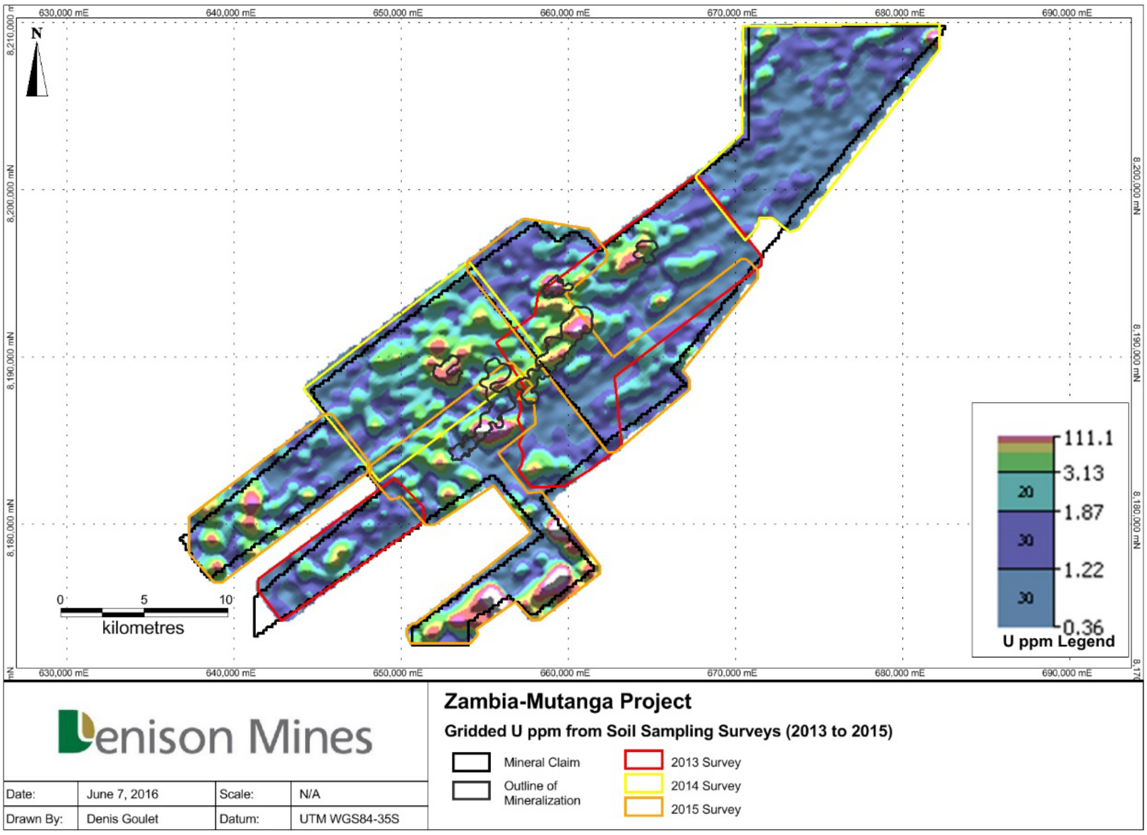


Figure 9-6: Gridded Soil Uranium Results

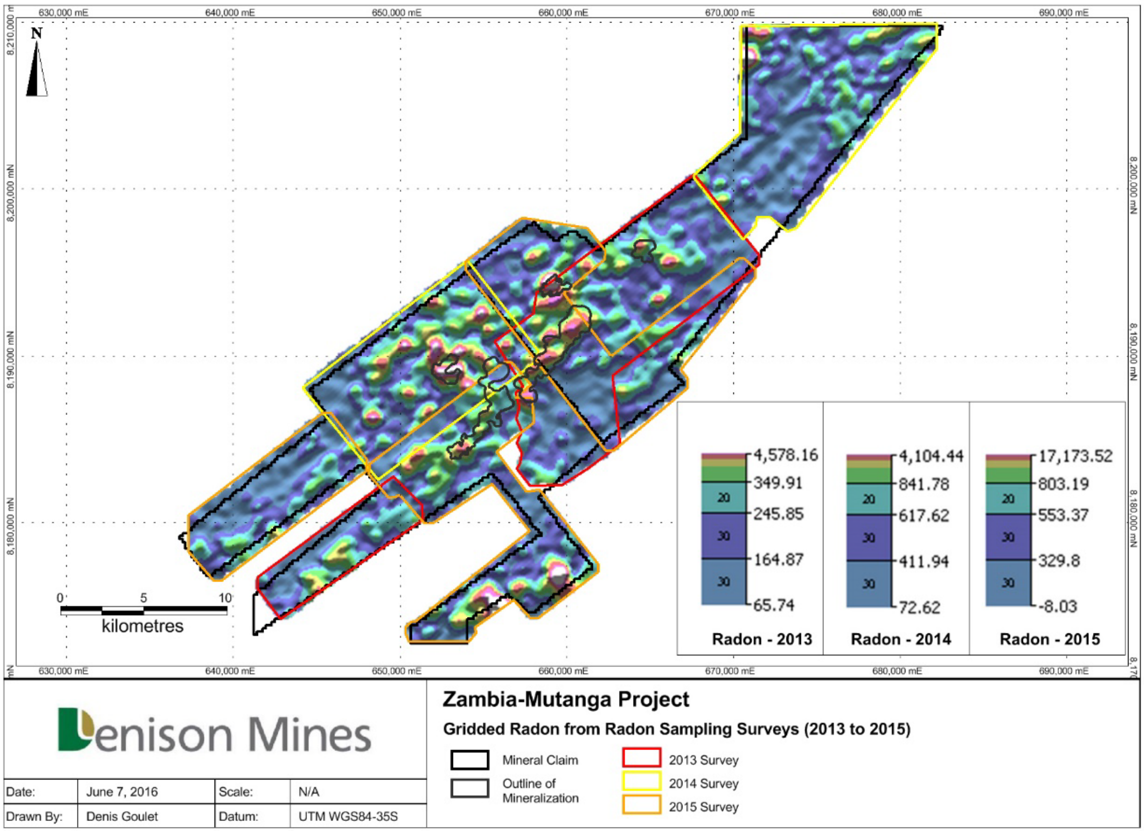


Figure 9-7: Gridded Radon Results

Trenching was undertaken to test for additional mineralized horizons outside of the drill defined uranium resources. The trenching provided a cost-effective follow-up methodology, prior to any drilling, to test targets generated from the soil geochemistry and radon surveying. Trenches provided a means of accessing the fresh bedrock, or otherwise saprock, for the in-situ determination of geology and mineralization.

Trenches were located over priority targets based on interpretation of the soil geochemical and radon results from 2013 and 2014 (soil geochemical and radon results for 2015 have not yet been followed up). Targets also considered a combination of airborne or ground radiometric anomalies and 2014 geological mapping. Trenches were typically located along, and parallel to, the soil and radon survey lines which were roughly perpendicular to stratigraphic strike and known mineralization. The soil and radon anomalies tended to follow stratigraphic strike parallel trends. Trenches were designed to cover the entire anomaly and to extend into background by 1/3 to 1/2 of the anomaly width in each direction. A summary of the trenches excavated in 2014 and 2015 is provided in Table 9-2. Trench locations are provided in Figure 9-8.

Table 9-2: Summary of the Trenches Excavated in 2014 and 2015

Trench Number	Target Area	Year	Length (m)	Average Depth (m)
MCT1	Manchavwa	2014	900	1.3
MCT2	Manchavwa	2014	966	1.6
MCT3	Manchavwa	2014	853	2
MET4	Mutanga East	2014	708	1.5
MET5	Mutanga East	2014	707	1.2
MET6	Mutanga East	2014	698	2
A-1	Kanyanga	2015	242	1.5
A-2	Kanyanga	2015	200	1

Trench Number	Target Area	Year	Length (m)	Average Depth (m)
C&D-1	Mutanga East	2015	274	1
C&D-2	Mutanga East	2015	202	1.5
E-1	Dibwe Mutanga Corridor	2015	420	2
E-2	Dibwe Mutanga Corridor	2015	146	2
F-1	Dibwe North	2015	623	3
G-1	Dibwe West	2015	182	2
G-2	Dibwe West	2015	332	2.5
H-1	Dibwe West	2015	900	3.5
H-2	Dibwe West	2015	210	3
H-2a	Dibwe West	2015	86	1
H-3	Dibwe West	2015	216	2
I-1	Kanyanga	2015	192	1.5
I-2	Kanyanga	2015	74	1
	TOTAL		**9,131**	

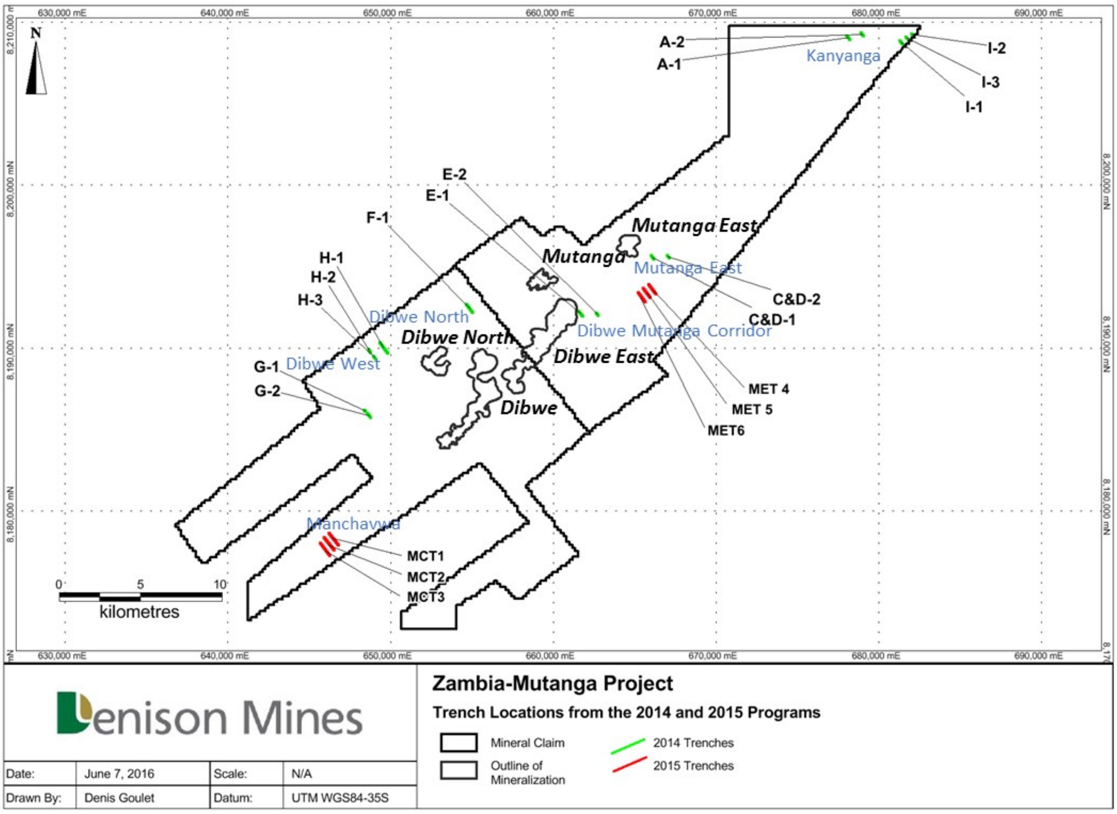


Figure 9-8: Trench Locations

Trenching was undertaken using an excavator and allowed sufficient width (approximately 1 meter) to allow the geologist to work within the trench for mapping and sampling. Trenches were excavated into relatively fresh bedrock and roughly parallel to the regolith-bedrock contact. Where possible bedrock in the sidewall of the trench was exposed to allow for structural geology measurements.

Trenches were viewed as 'horizontal drill holes' in terms of the information collected along them. A 100 m tape was laid out along the base of the trench as reference. Before commencing trench mapping and sampling the trenches were cleaned from excessive soil or rubble. Trench mapping utilized the same logging codes as used previously for Mutanga drilling in terms of lithology, structure, alteration and mineralization.

Continuous total gamma scintillometer readings were taken along the base of the trenches. The readings were visually averaged and recorded for every 2 m interval. The maximum total gamma reading and its location for the interval was also recorded.

Trench sampling was undertaken over intervals where elevated gamma readings were encountered. For each trench an elevated gamma threshold was established using log probability plots. Continuous-chip sampling was undertaken from the base or side-wall of the trench where bedrock was exposed. The sample intervals ranged from a maximum of 2 m to a minimum of 50 cm and were adjusted for geological contacts. At least 2 samples of 2 meters each were collected on either side of elevated gamma zones as ‘shoulder samples’. Samples were approximately 1 kg in weight. A scintillometer reading was taken of the bagged sample away from other samples and in an area of low background. A field duplicate sample was collected every 20th sample (5% field duplicates) and a coarse crush blank inserted every 25th sample (4% blanks). Trenching data and results have been stored in an Access database.

Table 9-3: Summary Statistics of Trench Total Gamma and Uranium

Trench Number	Average Gamma (cps)	Maximum Gamma (cps)	Count of Assay Samples	Average U ppm	Minimum U ppm	Maximum U ppm	Standard Deviation U ppm
A-1	337	1750	1	30	30	30	
A-2	288	620	0				
C&D-1	254	500	0				
C&D-2	297	620	0				
E-1	527	1330	49	20	2	55	13
E-2	306	380	0				
F-1	474	2300	61	17	2	68	13
G-1	695	2630	45	27	2	124	23
G-2	428	1500	38	5	2	10	2
H-1	447	1850	73	13	2	49	9
H-2	371	850	2	6	6	7	0
H-2a	537	1030	13	19	6	32	9
H-3	378	1130	7	13	2	27	10
I-1	406	1200	4	11	8	17	4
I-2	418	1050	4	16	13	19	3
MCT1	336	1134	88	10	1	33	7
MCT2	348	2129	86	11	1	30	6
MCT3	367	1519	119	11	1	69	9
MET4	373	1334	112	7	1	39	5
MET5	435	2098	74	23	1	65	18
MET6	354	1549	66	13	1	52	11

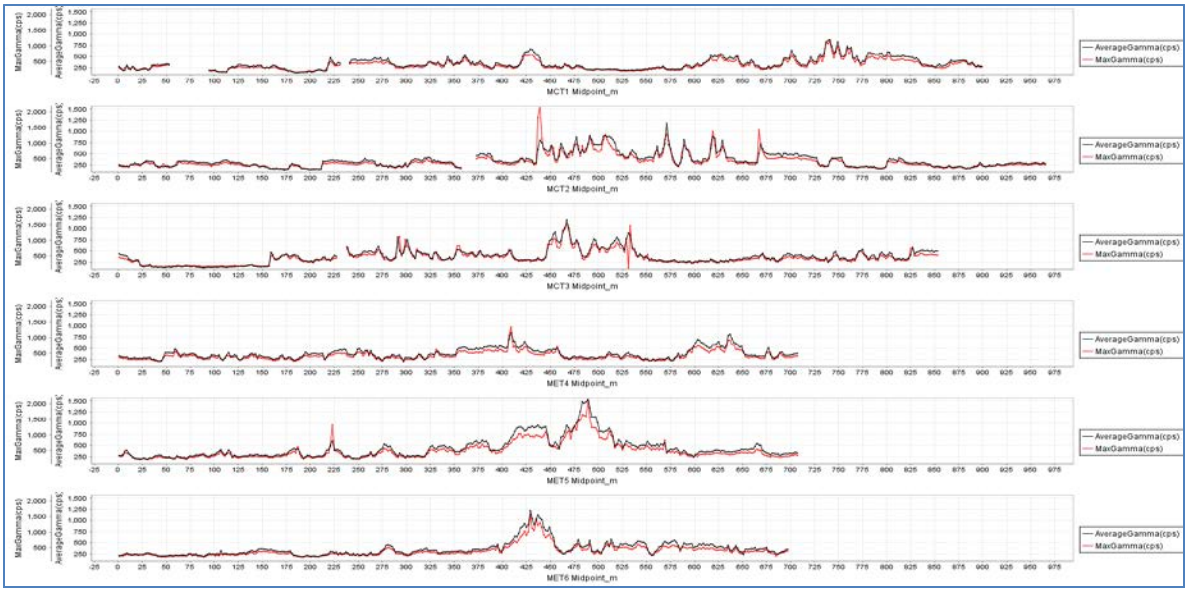


Figure 9-9: **Average and Maximum Total Gamma Readings for 2014 Trenches (0 Meters Represents the Southern End of the Trench)**

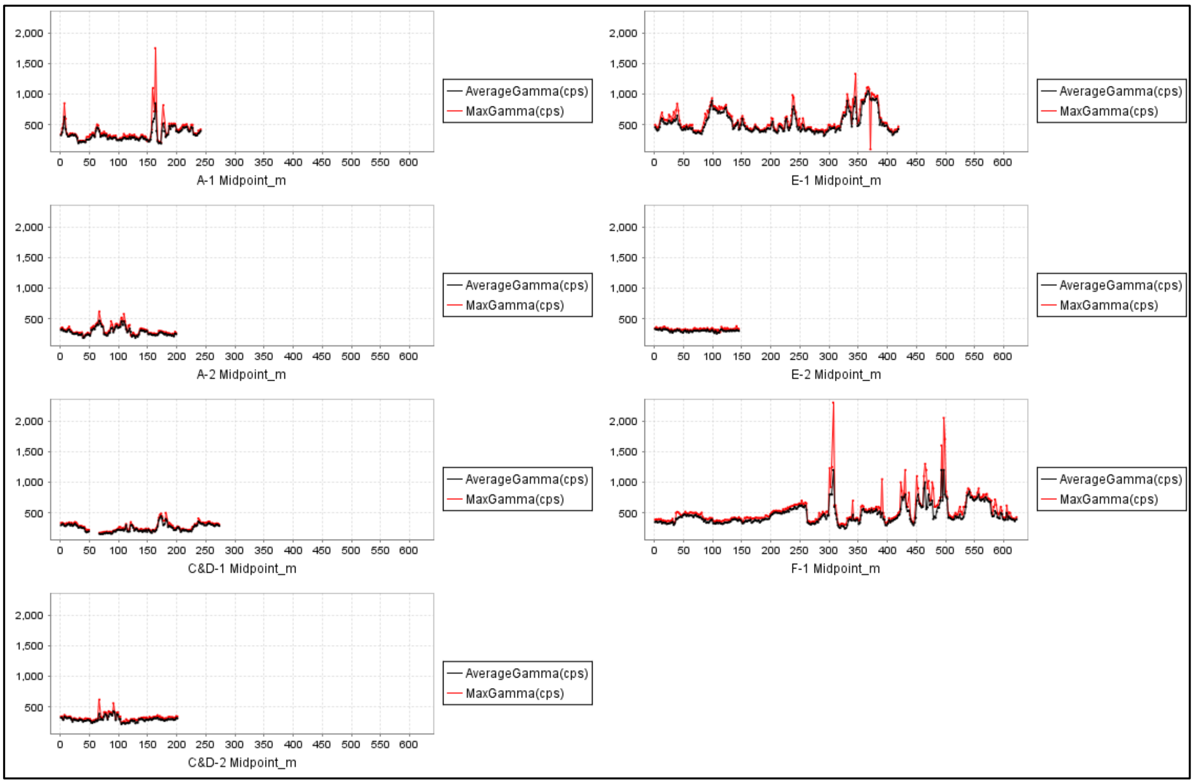


Figure 9-10: **Average and Maximum Total Gamma Readings for 2015 Trenches (A, C&D, E and F Target Areas; 0 Meters Represents the Southern End of the Trench)**

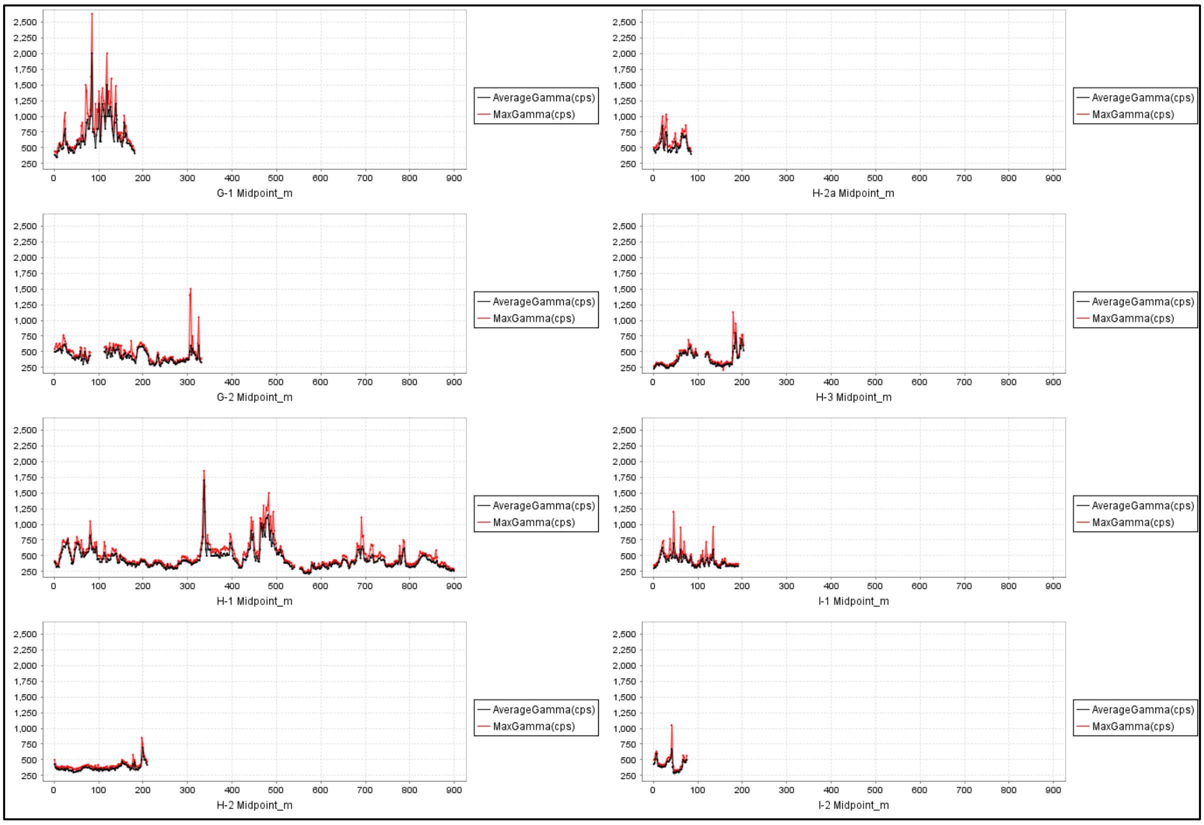


Figure 9-11: Average and Maximum Total Gamma Readings for 2015 Trenches (G, H and I Target Areas; 0 Meters Represents the Southern End of the Trench)

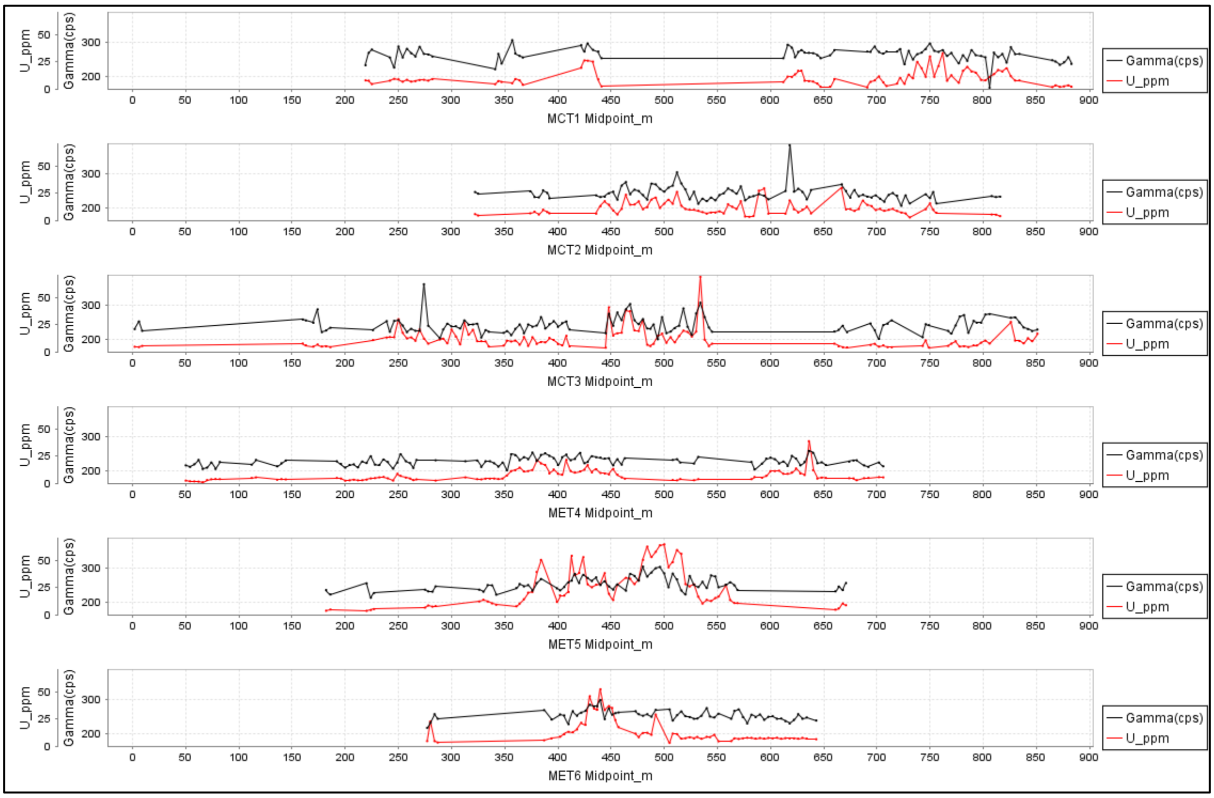


Figure 9-12: Uranium Assay and Sample Total Gamma Readings for 2014 Trenches (0 Meters Represents the Southern End of the Trench)

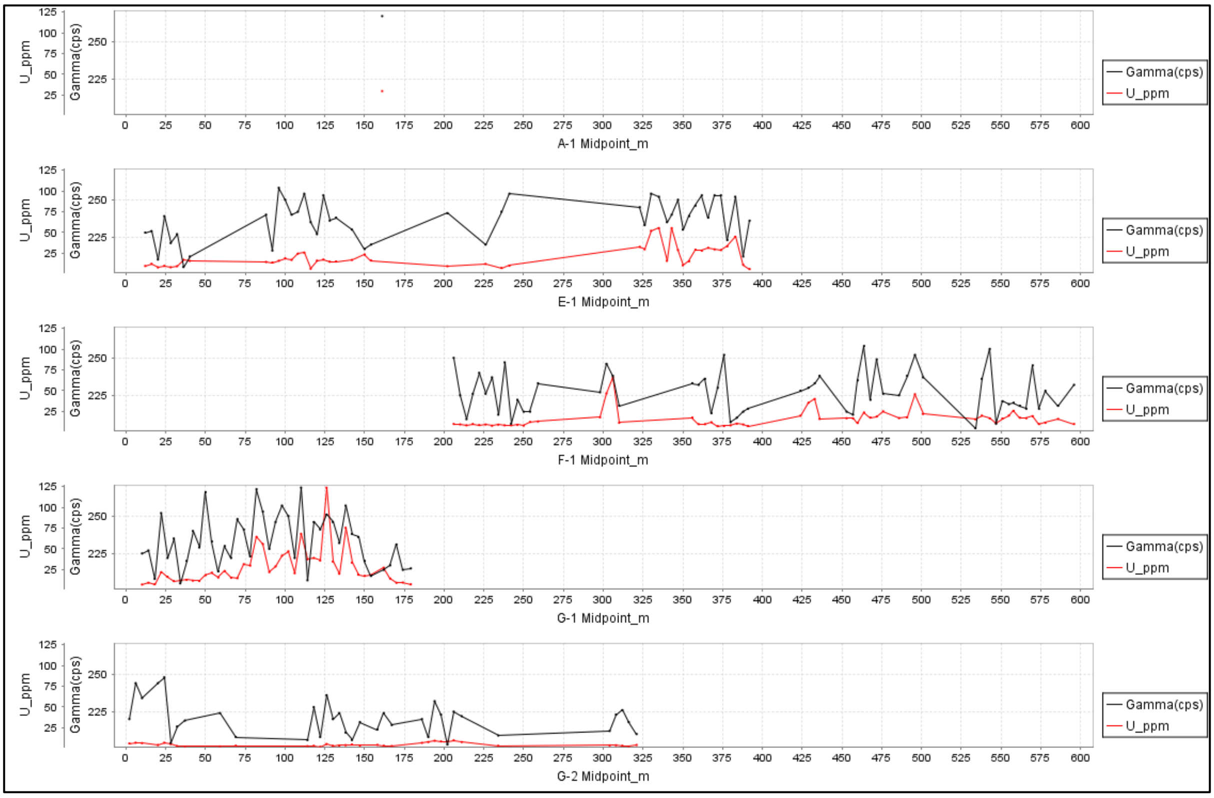


Figure 9-13: Uranium Assay and Sample Total Gamma Readings for 2015 Trenches (A, E, F and G Targets; 0 Meters Represents the Southern End of the Trench

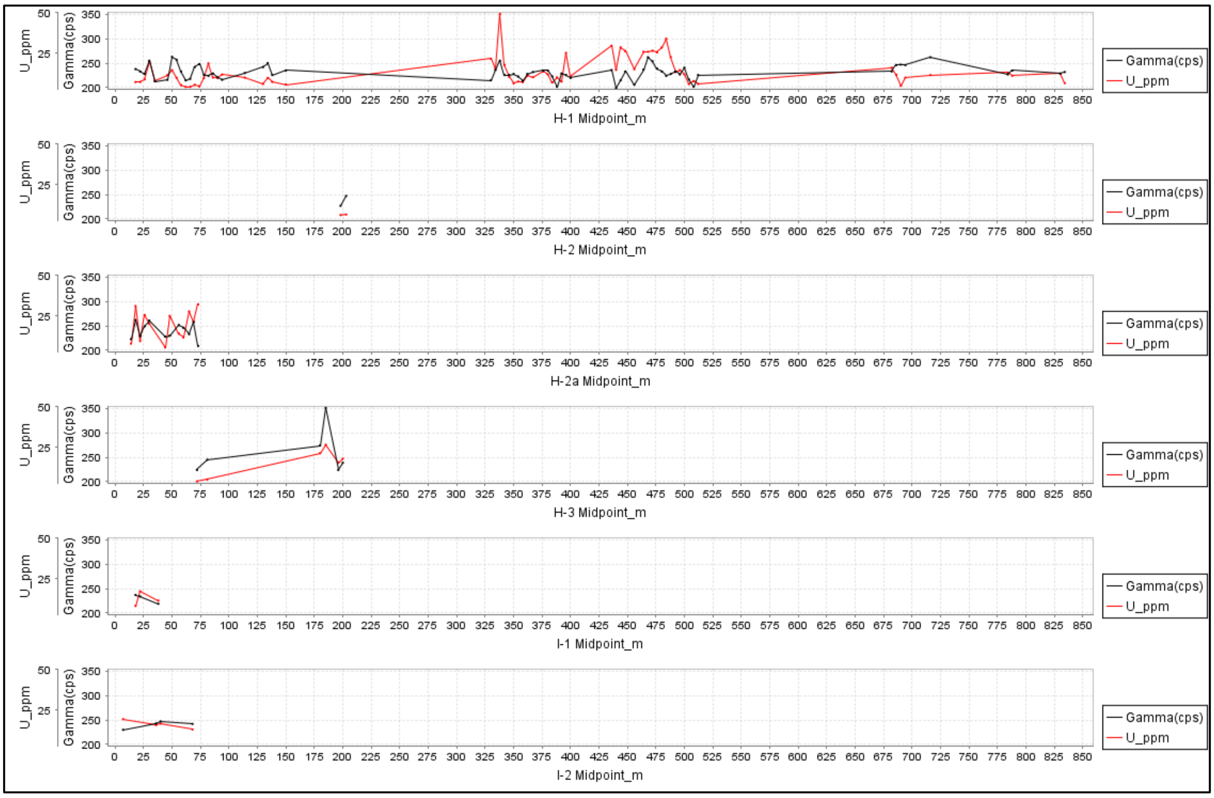


Figure 9-14: Uranium Assay and Sample Total Gamma Readings for 2015 Trenches (H and I Targets; 0 Meters Represents the Southern End of the Trench)

Weak mineralization was encountered in the majority of the trenches and a few distinct mineralized horizons were discovered (Table 9-3 and Figure 9-9 to Figure 9-14). Leaching at the regolith-bedrock interface where trench samples were collected may be the reason higher grades were not encountered. Reconnaissance drilling is recommended as follow-up to trench intersections of interest. Drill holes should be designed to intersect the mineralized trench horizons down-dip and below the water-table where less leaching has occurred. Either RAB or RC drilling is recommended due to the lower costs.

The soil and radon anomalies generated from 2015 surveys warrant follow-up, either through additional trenching or RAB/RC drilling. Geological mapping and ground-truthing is recommended prior to trenching or drilling.

Details of all drilling activities are described in Section 10.

9.3 Gwabe and Njame

The earliest known exploration for uranium in the area covering the Gwabe and Njame deposits was conducted by AGIP in the late 1970s to the mid-1980s. AGIP completed a major regional programme of ground radiometric surveying which identified numerous radiometric anomalies in the area along the northern shores of Lake Kariba. A number of these anomalies were evaluated with more detailed ground radiometric surveying and a small number were subsequently tested with rotary percussion drilling, wagon drilling and in some cases with diamond drilling.

A small, uneconomic resource (non-compliant in accordance with NI43-101) containing approximately 980 t of U_3O_8 was outlined at Njame in 1983-84. AGIP ceased their work in Zambia in 1985, and no further work for uranium exploration was undertaken in the vicinity of the Gwabe and Njame deposit area until AFR commenced work in 2005.

Albidon (Zambia) Limited acquired the Mugoto PLLS.250 in June 2005 as part of their Munali nickel project tenement holding. The tenement was subsequently transferred to Albidon Exploration Limited in 2006 with Ministerial approval. In October 2005, Albidon Exploration Limited signed a joint venture agreement with AFR under which the later would explore the eastern part of the Mugoto PLLS for uranium, coal and coal bed methane. This is the area in which both the Gwabe and Njame deposits are located.

AFR undertook a major exploration programme in 2006 to 2007, which included:

- drilling at the Njame deposit which identified additional uranium mineralisation to that defined by AGIP;
- an airborne radiometric survey identified a significant uranium anomaly at Gwabe; this was tested with surface radiometric surveying and soil sampling; and
- subsequent drilling at Gwabe outlined uranium mineralisation.

Through 2008 and 2009, AFR then completed a series of infill drilling programs, comprising reverse circulation (“RC”) and diamond drilling (“DDH”) to define the extents of both the Njame and Gwabe deposits, as well as tighten the drilling patterns to improve confidence in the geological and Mineral Resource models.

Details of all drilling activities are described in more detail in Section 10.

10 DRILLING (ITEM 10)

This section reports the work undertaken by Denison and AFR and their consultants (CSA, RPA) and has not been separately verified by SRK or GoviEx as drilling has been suspended since 2012

10.1 Introduction

Drilling at the Dibwe East, Dibwe, and Mutanga deposits has been completed in two major phases. Historically, drilling was by AGIP and the Zambian Geological Survey (1973-1984), representing some 20% of the database. The remaining 80% of the database was drilled more recently by OmegaCorp and Denison 2006-2012.

Drilling at the Gwabe and Njame deposits was managed by AFR and completed between 2006 and 2009.

A summary of the exploration data used in the Mineral Resource models is given in Table 10-1.

Table 10-1: Summary of Exploration Data used for the Mutanga Uranium Project Mineral Resource Models

Deposit	Hole Type	Number of Holes	Meters (m)
Dibwe East	RC	171	17,725.0
	DDH	141	15,967.0
Dibwe	RC	152	10,790.5
	DDH	213	20,728.6
Mutanga	RC	338	14,066.3
	DDH	518	30,592.5
Gwabe	RC	286	12,754.0
	DDH	39	1,368.0
Njame	AC	74	3,300.0
	RC	603	33,519.0
	DDH	161	8,311.0
	Total	**2,696**	**169,121.8**

10.2 Mutanga, Dibwe, Dibwe East Deposits

10.2.1 Drilling

Drilling was carried out by a combination of diamond (“DDH”) and reverse circulation (“RC”) techniques.

Most drillholes were completed vertical, or at close to 70º, from surface to the target depth, which typically ranges from 50 m to 140 m. Drill holes were positioned with a resulting sample coverage ranging from 200 x 100 m to 50 x 50 m, and down to 10 m x 10 m in areas of close spaced drilling.

Prior to 2009, collar surveys were registered using the UTM Coordinate: Arc 1950 Map Datum, Zone 35S. Survey control was completed by Datum Surveying Consultants, from Lusaka, Zambia. After 2009, a high precision GPS system was introduced and collars were surveyed in the WGS84 UTM zone 35S reference datum.

No downhole survey data is available for historic drilling prior to OmegaCorp drilling campaigns. The OmegaCorp and Denison drilling measured downhole survey using a single shot camera at approximately 15-30 m intervals down-hole.

Locally, core can be broken and blocky, but in general, core recovery was reported as being reasonable with an average overall recovery of 91%.

10.2.2 Logging and Sampling

All holes were logged for lithology, structure, alteration, mineralisation and geotechnical characteristics. Data was entered into DHLogger software on laptops in the field. The DHLogger data was transferred into a Fusion database. Hard copies of drill logs are stored at site.

The primary method of assaying for uranium at the Mutanga, Dibwe, and Dibwe East Deposits was using a downhole radiometric probe, with RC and core samples completed selectively to review anomalies and for verifying the results of the radiometric probe.

The downhole radiometric (total gamma) probe was used to measure gamma radiation in “counts per second” or “cps” which is emitted during the natural radioactive decay of uranium (U). Downhole cps data is processed using an in-house developed computer program known as GAMLOG to provide an indirect measurement of uranium ("equivalent U_3O_8", referred to as "eU_3O_8") content within the sphere of measurement of the gamma detector.

In addition, all drill core and chips were systematically logged with a Terraplus RS-125 Gamma-Ray Spectrometer/Scintillometer, the data entered into DHLogger software and transferred to the Fusion database. The hand-held scintillometer provides qualitative data only and cannot be used to calculate uranium grades; however, it does allow the geologist to identify uranium mineralisation in the core and to select intervals for geochemical sampling.

RC samples were collected via a cyclone and split on site at the time of drilling. The cuttings for each meter were put through a riffle splitter to give a notional 1.5 kg primary sample; a notional 1.5 kg field duplicate and, depending on the hammer size, a residual bulk sample of approximately 15-20 kg. Approximately 10% of anomalous intercepts (more than twice background level of Counts Per Second as determined by a hand held scintillometer) in RC holes were selected for assay during 2012. During the 2005-7 drilling campaigns, approximately 1.5 kg primary samples representing anomalous intervals of RC holes that collapsed before they could be probed were also sent for pressed powder XRF analysis. Reverse circulation drill chips are stored in numbered and tagged plastic bags. The maximum length of RC samples is 1 m.

Drill core is stored in metal trays where individual drill runs are identified with small wooden blocks, onto which the depth in meters is recorded. Drillcore selected for sampling was split with a hand splitter with one half of the core normally being shipped to the laboratory and the other being half retained. The maximum sample length of core submitted was typically 0.5 m.

10.3 Njame, Njame South and Gwabe Deposits

10.3.1 Drilling

Drilling was carried out by a combination of DDH, RC and air core (“AC”) techniques. The AC method was only used at the early stage exploration at Njame in 2006, and all subsequent drilling, at the Njame and Gwabe deposits was completed by RC and DDH techniques.

The RC drilling technique is the main method for obtaining suitable samples for Mineral Resource estimation at these 3 deposits, and is carried out along drill lines spaced between 25 and 50 m apart along prospective anomalies. All RC drilling at Njame and Gwabe has been completed by Capital Drilling (Zambia) Limited using rig types typically similar to a Schramm 450, medium sized truck mounted rigs with air capability of 1100 cfm/350 psi. All RC drilling was completed with a 5” face hammer.

The majority of the DDH drilling was completed in 2008 and was carried out by Capital Drilling (Zambia) Limited. A truck mounted LF-90 (Rig31) and a track mounted LF-90 (Rig26) rig were used. All DDH drill holes were completed using PQ and NQ wireline tools.

Collar positions for all holes were initially established using handheld GPS. Drill sites and access were cleared using bulldozer if required and the drill position was re-marked using handheld GPS if required. Upon hole completion, each drillhole was left with a PVC collar tube cut at ground level. The collar coordinates were re-checked using handheld GPS. Subsequently, most drillhole collars were surveyed with a DGPS by a professional surveyor (Chris Kirchhoff) and Lusaka based Rankin Engineering.

10.3.2 Logging and Sampling

AFR used well-documented procedures relating to RC and DDH sample logging. In general, RC chips are logged immediately after drilling whereas core is logged after being carefully joined up and marked on a V-trough. Information gathered includes lithological, structural, geotechnical, weathering/oxidation and mineralogical logs. For cored holes, the mineralized zones of each were selected at the discretion of the logging geologist.

The RC samples were collected as follows:

- RC drill chips were collected at 1 m intervals down-hole using a cyclone into PVC bags prior to splitting;
- the collected samples were riffle split using multiple passes through a single stage riffle splitter;
- a final sample of approximately 2 kg was collected for submission to the laboratory for analysis;
- in wet holes, the samples were left to dry as best possible, and then homogenized and quartered by hand; and
- RC chip trays were systematically logged by collecting the sieved RC chips and storing them in a tray, with each labelled compartment of the tray containing the chips from 1 m.

The DDH sampling methodology was as follows:

- Sampling was preceded by radiometric scanning of the core whilst on the V-frame. Scanning was carried out using either a RS-125 spectrometer or an Exploranium GR-110G hand held scintillometer. (Care was taken so as to ensure minimum influence from any possible source of ionizing radiation, thus scanning of the core on the V-trough was carried out at a minimum distance from any suspected ionizing radiation source.)

- The maximum sample length was 1 m and the minimum sample length was 0.25 m.
- The total width of the sampled zone extended 2 m above the assay hangingwall and the same number of meters below the assay footwall as determined by the scintillometer readings.
- The other guiding factor to sampling besides the scintillometer readings was the lithology. Sampling across lithologies was avoided where possible.
- NQ core was half-core samples, while PQ core was sampled using a core saw taking a 25 mm wide ‘fillet’ from the core width;
- The drill core was sampled by trained and supervised technicians. Each sample was taken from the left-hand half of each piece of core for that meter (leaving the half with the orientation line and/or meter marks in the tray) and placing them into the appropriate sample bag.
- Calico sample bags with draw-strings were used for core sampling. Sample tickets were used in the sampling process with one half (identical halves) of each ticket, which have a printed sequence of sample numbers (six figures), placed in the calico sampling bag.
- The sample tickets were annotated with the drillhole number and the sample interval. As part of the quality control protocols, the technician verified that the meter interval marked on the core matched the meter interval written on the sample ticket, and also matched the meter interval on the sample form. The technician also verified that the corresponding sample number on the sample form, for that interval, matched the sample number of the sample ticket, and also matched the sample number written on the sample bag.

11 SAMPLE PREPARATION, ANALYSES AND SECURITY (ITEM 11)

This section reports the work undertaken by Denison and AFR and their consultants (CSA, RPA) and has not been separately verified by SRK or GoviEx as drilling has been suspended since 2012.

11.1 Mutanga, Dibwe, and Dibwe East Deposits

11.1.1 Sample Preparation

Prior to 2009, RC and diamond drilling campaign samples were shipped to Genalysis Laboratories, Johannesburg, South Africa, for preparation. Sample preparation was carried out via a process of drying, crushing and milling of RC and diamond core samples. Crushers were cleaned with a silica rock (waste rock) after every sample. Milling was done in a ring and puck pulveriser and contamination was avoided by cleaning with compressed air and silica rock (waste rock) after every sample.

After 2009, sample preparation was undertaken at ALS Chemex Ltd in Johannesburg, South Africa (“ALS Chemex Johannesburg”). After the samples are received, the following was completed: log samples in the tracking system, weigh, dry, fine crush the entire sample to better than 70% -2 mm, split off up to 250 g and pulverize split to better than 85% passing 75 µm.

Samples were held in secure, quarantined storage whilst at the sample preparation laboratories.

11.1.2 Laboratory Analysis Procedures

Prior to 2009, sample pulps were sent to Genalysis, Perth, Australia for analyses by pressed powder XRF methods. The laboratory was, at the time of analysis, fully certified and accredited by Australian standards.

After 2009, sample preparation was also undertaken at ALS Chemex Johannesburg using a combination of pressed powder XRF methods ME-XRF05 and ME-XRF10.

Access to the assay laboratories premises were restricted by an electronic security system and sample results were stored using encryption and password protection.

11.1.3 Specific Gravity Determinations

A program of density determination was completed from the PQ core available from the Mutanga metallurgical drill hole program. A total of 97 core samples from 12 holes were selected as being geologically representative of the material drilled. The core was dried and density determined by calculating the core volume which was then divided into the weighed dry mass to calculate the in situ dry bulk density.

The mean and median density values are 2.1 t/m^3 with a very low variance. There was no recognisable correlation between density and depth or litho-facies. A global density of 2.1 t/m^3 was used for the estimation of the Mutanga, Dibwe and Dibwe East Mineral Resources.

11.2 Gwabe, Njame South and Njame Deposits

11.2.1 Sample Preparation

Sample preparation on site is restricted to core logging and splitting. Once individual samples were placed in the calico bags, along with the sample ticket, the bags were closed and taped firmly. Quality control samples, including blanks and certified reference materials (“CRM”) are inserted at a rate of one in 50 samples each.

Pool sand, obtained from an area north of Lusaka (Katuba), was put into sample bags and used as “blank” samples.

Three certified standards were also regularly inserted into the sample sequence as part of the quality control protocols. These samples were inserted on a rotating basis (Standard AMIS0004 or AMIS0045, alternating with Standard AMIS0029).

11.2.2 Sample Despatch and Security

Sample preparation on site is restricted to core logging and splitting. Once individual samples were placed in the calico bags, along with the sample ticket, the bags were closed and taped firmly. Quality control samples, including blanks and certified reference materials (“CRM”) were inserted at a rate of one in 50 samples each.

AFR drilling procedures required samples to be taped closed once taken from the RC sampling site or diamond core sampling facility. Samples were then transported directly to Lusaka, Zambia for air freight to ALS Chemex Johannesburg.

Reference material was retained and stored on site, including quarter-, fillet-core or RC chips and photographs generated by diamond drilling, and duplicate pulps and residues of all submitted samples. All pulps were stored at ALS Chemex Johannesburg storage facility for three months, after which they were returned to AFR in Lusaka.

11.2.3 Laboratory Analysis Procedures

ALS Chemex Ltd was used as the principal analytical laboratory company for U_3O_8 analyses. The sample preparation has been completed in ALS Chemex Johannesburg and the ALS Chemex analytical laboratories in Johannesburg and Vancouver, Canada, have assayed the pulps. The ALS Chemex laboratories in Johannesburg and Vancouver are ISO 9001:2000 accredited.

The analytical method used by ALS Chemex is ME-XRF 05. The method description for this is as follows:

"A pressed pellet is prepared and analysed by wavelength dispersive XRF for the selected elements. Uranium (DL – 2.5ppm), converted to U_3O_8 (by ALS Chemex) using conventional conversion factors."

11.2.4 Specific Gravity Determinations

Specific gravity ("SG") determinations were carried out by AFR. The method applied to density collection included sun drying, weighing the core in air followed by plastic wrapping and weighing in water. The bulk density was then determined as a ratio of weight in air over weight in water. The weighing is completed using high quality electronic scales with regular calibration of the scales completed.

Samples were taken from the dominant rock types at both Njame and Gwabe. The average measured density for all samples weighing more than 1.0 kg are presented in Table 11-1 and Table 11-2 for Gwabe and Njame deposits, respectively.

Based on the lithological analysis completed, a global density of 2.09 was used for the estimation of the Gwabe Mineral Resources. For Njame, block model density was applied based on the distribution of host rock lithology, with average densities of 2.01, 2.03 and 2.07 applied to north, central and eastern areas of the deposit respectively. At Njame south, average block model density was applied per mineralised structure, which ranges from 1.98 to 2.08.

Table 11-1: Specific Gravity Measurements for Gwabe by Logged Rock Type (Samples greater than 1.0kg)

Rock Type	Number of Samples	Specific Gravity		
		Minimum	Maximum	Mean
GRIT	20	1.94	2.42	2.06
GSSTN	44	1.86	2.36	2.02
PGRIT	39	1.85	2.62	2.12
PSSTN	33	1.40	2.46	2.13
SLTSTN	2	1.96	2.14	2.05
SSTN	53	1.71	2.44	2.03

Table 11-2: Specific Gravity Measurements for Njame by Logged Rock Type (Samples greater than 1.0kg)

Rock Type	Number of Samples	Specific Gravity		
		Minimum	Maximum	Mean
CNGLM	1	2.26	2.26	2.26
GRIT	29	1.82	2.16	1.97
GSSTN	63	1.77	2.16	1.98
PGRIT	52	1.89	2.26	2.06
PSSTN	24	1.88	2.30	2.13
SLTSTN	66	1.84	2.31	2.06
SSTN	263	1.72	2.68	1.98

12 DATA VERIFICATION (ITEM 12)

This section reports the work undertaken by Denison and AFR and their consultants and has been verified by SRK and GoviEx.

12.1 Introduction

SRK has not carried out any independent collection and verification of individual samples or assay results. SRK has, however, obtained and reviewed the quality assurance / quality control ("QAQC") results produced by both AFR and Denison (including their consultants).

SRK has reviewed the core and samples available on the Chirundu site and cross-checked them against the geological logs and assay records. No detailed examination has been made by SRK.

The following sections have in part been summarised from the following reports:

- CSA Resource Report entitled: NI43-101 Technical Report Mineral Resource Estimates for the Mutanga Uranium Project, Denison Mines Corp, Zambia, Africa. Filed on Sedar by Denison Mines Corp on September 16, 2013.
- AFR Resource Report entitled: Zambian Uranium Projects Information Memorandum, including Appendix 1 - 8 June 2013.

SRK has reviewed the comments in these reports and believes that as described in the reports the work completed is acceptable.

12.2 Mutanga, Dibwe, and Dibwe East Deposits

12.2.1 Data Verification by Denison

Downhole Radiometric QAQC

Limited downhole radiometric QAQC data is available to support the historical drilling completed prior to 2006, however Denison's drilling campaigns which represent some 80% of the drill database, has established a variety of systematic checks and standards for routine checking and calibration of tools.

Probe calibration was undertaken initially in the USA, using the Grand Junction DOE pits prior to delivery to site. Further periodic checks were undertaken using drill hole MTC51600-04 as a standard. If problems are detected in the probes in the test hole located at Mutanga then the equipment was sent back to the USA for repair and calibration.

An exercise of repeat downhole probing was completed by Denison on 14 selected drillholes to review the repeatability of the results from the downhole radiometric probe. Whilst based on a relatively small eU_3O_8 database, results of the study suggested that the downhole probe was performing within acceptable limits, as illustrated in Figure 12-1.

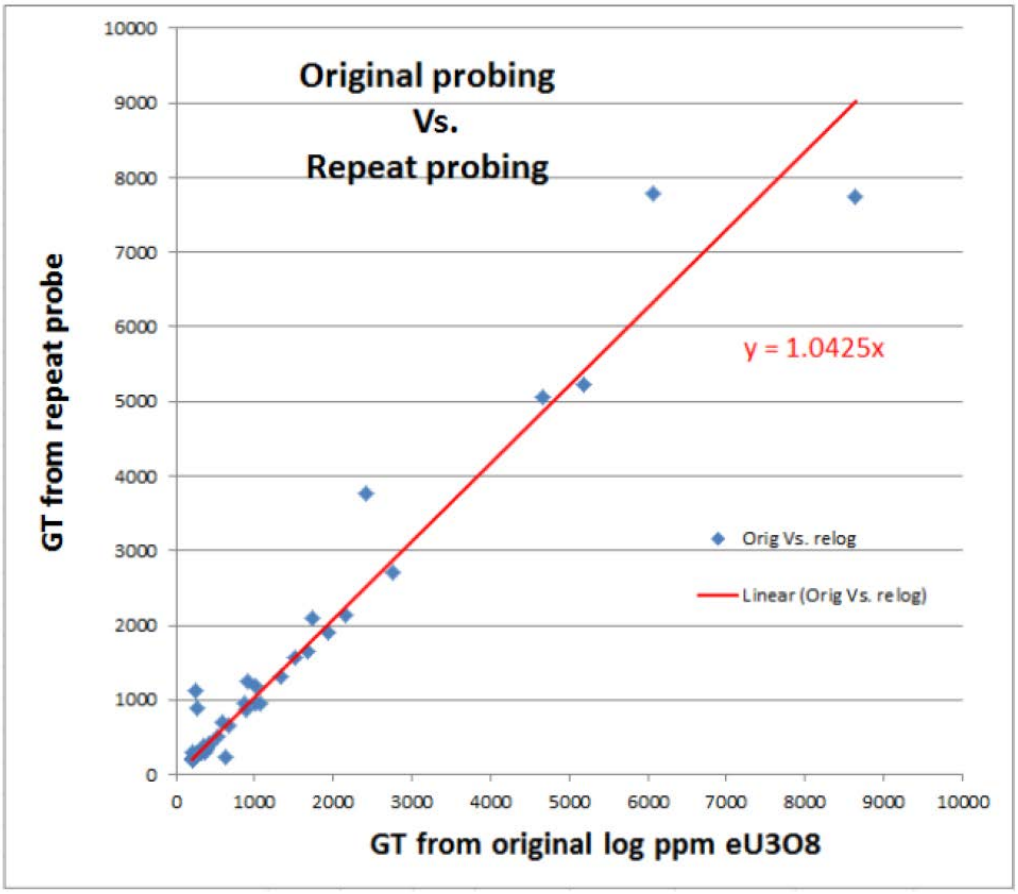


Figure 12-1: Repeat Radiometric Logging of Selected Drillholes

Chemical assay QAQC

Whilst limited chemical assay QAQC data is available to support the historical drilling completed prior to 2006, Denison's drilling campaigns which represent some 80% of the drill database, comprised the submission of duplicates, standards and blank samples.

During Denison's 2007-2008 drilling campaign, initial QAQC sample materials were inserted at a rate of 1-3% in to the sample stream. In general, the field duplicates and blanks, whilst relatively limited in number, suggested a reasonable performance by the laboratory. A greater degree of variability was noted in the standards, with 2 in 3 external standard submissions reporting to within ±10% of their expected values, with recommendations provided by CSA during the analysis to monitor the results and increase the overall submission rates to enable more representative conclusions to be drawn.

Following 2009, assay QAQC procedures comprised inserting in to the sample stream one internal standard, one blank and a field duplicate for every 20 routine sample submissions to the laboratory. With the exception of a limited number of anomalies in the standards and blanks, the results were in general considered acceptable. In addition, internal pulp duplicates were submitted and monitored by ALS Chemex and a total of 187 samples were sent as umpire duplicates to the Setpoint Laboratory, Johannesburg. Results of the internal duplicates suggested good performance by the Laboratory, with a correlation co-efficient in excess of 0.99. The umpire analysis, whilst indicative of slightly lower grade results, result from Setpoint, in general provided support for adequate assaying performance by the primary laboratory.

12.2.2 Data Verification by CSA

At the Mutanga and Dibwe deposits, given that the sample database within modelled mineralised zones comprises a combination of chemical assay and downhole radiometric data as described in Section 14.3, CSA completed a verification study to review the compatibility of the two types of uranium grade data.

Whilst assay and downhole radiometric data was not available for the same sample intervals, making direct correlation difficult, a review of length-weighted histogram plots, mean uranium grades and visual assessments confirmed a reasonable comparison between the two types of data and supported the use of both during grade interpolation. In general, CSA completed checks on all interval table data and verified the assay results against the original results from the laboratory and identified no material issues within the database. With regards to the historical drilling database, CSA excluded the holes at Mutanga and Dibwe with the ‘DDH’ and ‘DWD’ prefix, which did not pass all aspects of data validation against the more recent sampling including drillholes for which there were no samples, superseded single sample intervals across the mineralised zone and drillholes with significant survey errors.

12.2.3 Data Verification by RPA

At the Dibwe East deposit, given that the sample database within modelled mineralised zones comprises a combination of chemical assay and downhole radiometric data as described in Section 14.3, RPA completed a verification study to review the compatibility of the two types of uranium grade data.

During drilling and sampling for Dibwe East, some 25 holes were subject to both chemical assay and downhole radiometric probing. Scatterplot review of the associated sample intervals, on a composite basis, indicated a 25-30% high bias in the radiometric eU_3O_8 grade data when compared with the chemical assays, as shown in Figure 12-2.

Whilst this difference may be attributed to a number of potential causes including sampling errors, given a reasonable assay QAQC performance to support the chemical assays, RPA considered that the high bias in the radiometric data may relate to remobilisation of the uranium mineralisation (under oxidising conditions) and re-deposition elsewhere (in more reduced conditions), which potentially results in a disequilibrium between uranium and its gamma emitting daughters which are less mobile (and incorrectly interpreted as eU_3O_8 by the downhole probe). This is reasonable, but cannot be confirmed by SRK.

To account for this difference RPA applied a correction factor of 0.67 to the raw eU_3O_8 ppm grades in the raw sample database, which significantly improve the correlation between the downhole radiometric and chemical assay data, as shown in Figure 12-3.

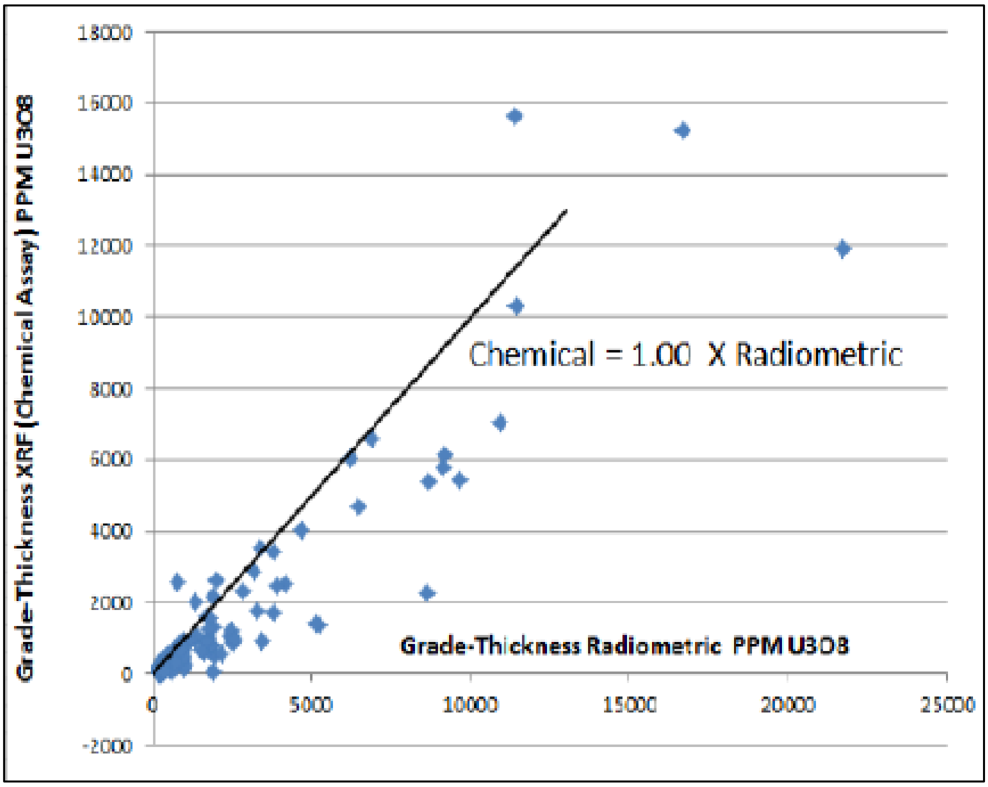


Figure 12-2: Scatter Graph of GT for Radiometric Uranium vs XRF Composites (CSA 2013)

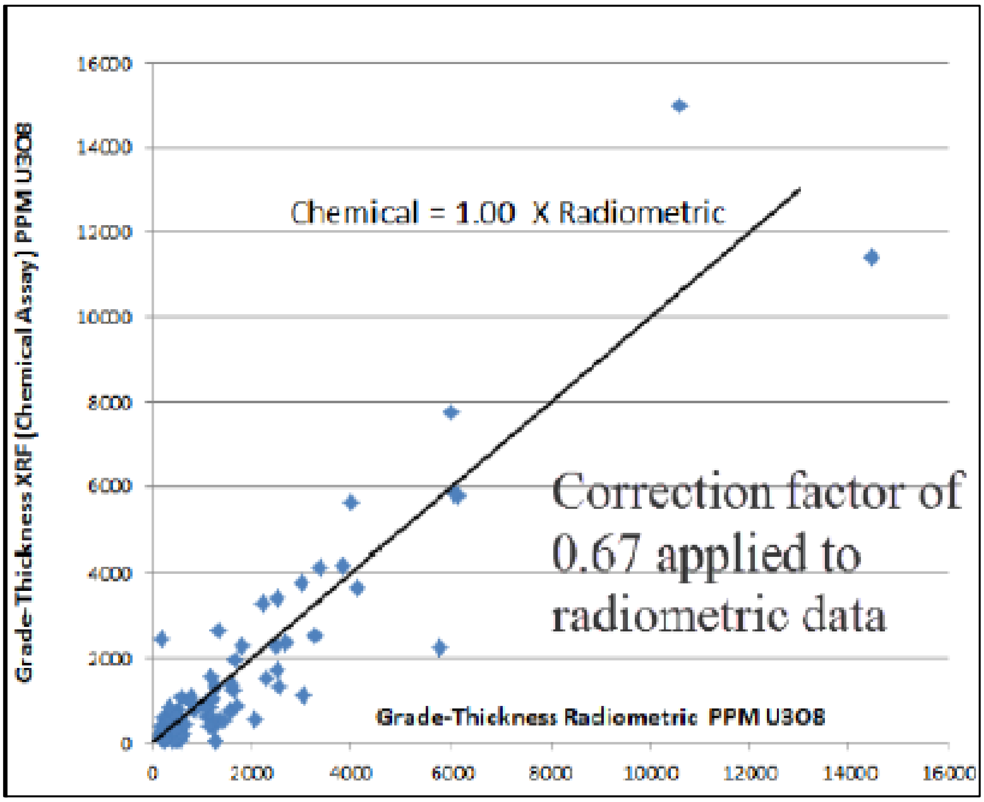


Figure 12-3: Scatter Graph of GT for Radiometric vs XRF Composites after Disequilibrium Correction (CSA 2013)

12.3 Njame and Gwabe Deposits

12.3.1 Data Verification by AFR

AFR has organized the storage of drilling and sampling information for the Njame and Gwabe deposits into well-structured and consistent format within a Microsoft Access database.

AFR also completed twin hole drilling, RC and DDH to confirm AC holes, as well as DDH to confirm RC holes. A total of 23 twins were completed and compared versus the original holes during the exploration programs at Njame and Gwabe. Although some of the holes are not directly comparable due to extra sampling requirements, the results indicate that the comparison between twins is generally acceptable.

12.3.2 Analytical QAQC

As described in Section 11, AFR has routinely inserted QAQC samples into the sample stream for the Njame and Gwabe exploration programs. SRK has reviewed the supplied QAQC data and reports, accepted the results and summarized these in Table 12-1.

Table 12-1: Summary of QAQC Samples Prepared and Submitted by AFR

	RC and Core Samples	% of Total samples
Sample Count	23,332	
Blanks	533	2.3%
QC samples	532	2.3%
Core Coarse Duplicates	66	0.3%
RC Field Duplicates	712	3.1%
Total QC Samples	**1,843**	**7.9%**

Duplicates

RC field duplicates were prepared by AFR and inserted into the sample stream at a nominal 1 in 50 rate. For 2008, core sample duplicates (coarse reject duplicates) were prepared from the submitted sample after primary crushing. The crushed sample was split using a riffle or rotary splitter with a second sample or coarse reject sample collected. A splitting process then further reduced each sub-sample until a sample size of approximately 500 g was attained. Each sample was then pulverised as per standard procedures to produce a pulp.

All submitted duplicates, both field RC (Figure 12-4) and coarse crush core (Figure 12-5), report dominantly within required statistical tolerance.

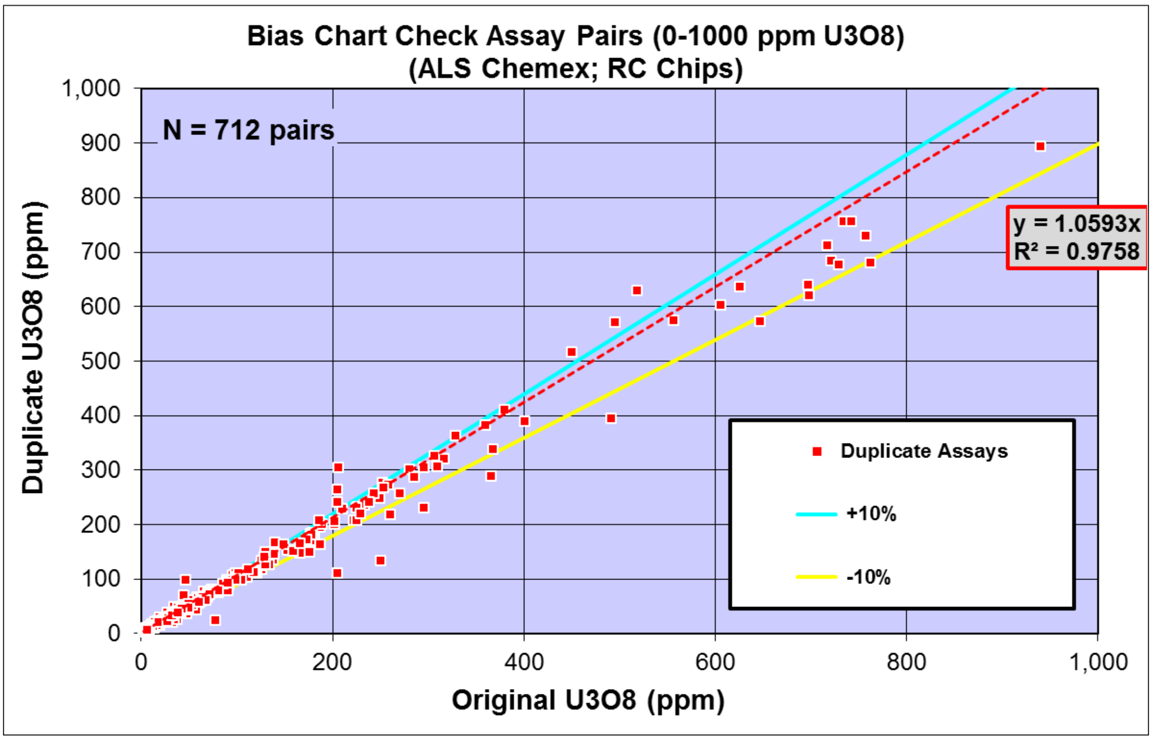


Figure 12-4: **RC Field Duplicates Submitted from the Gwabe and Njame Deposit Exploration Drilling Programs**

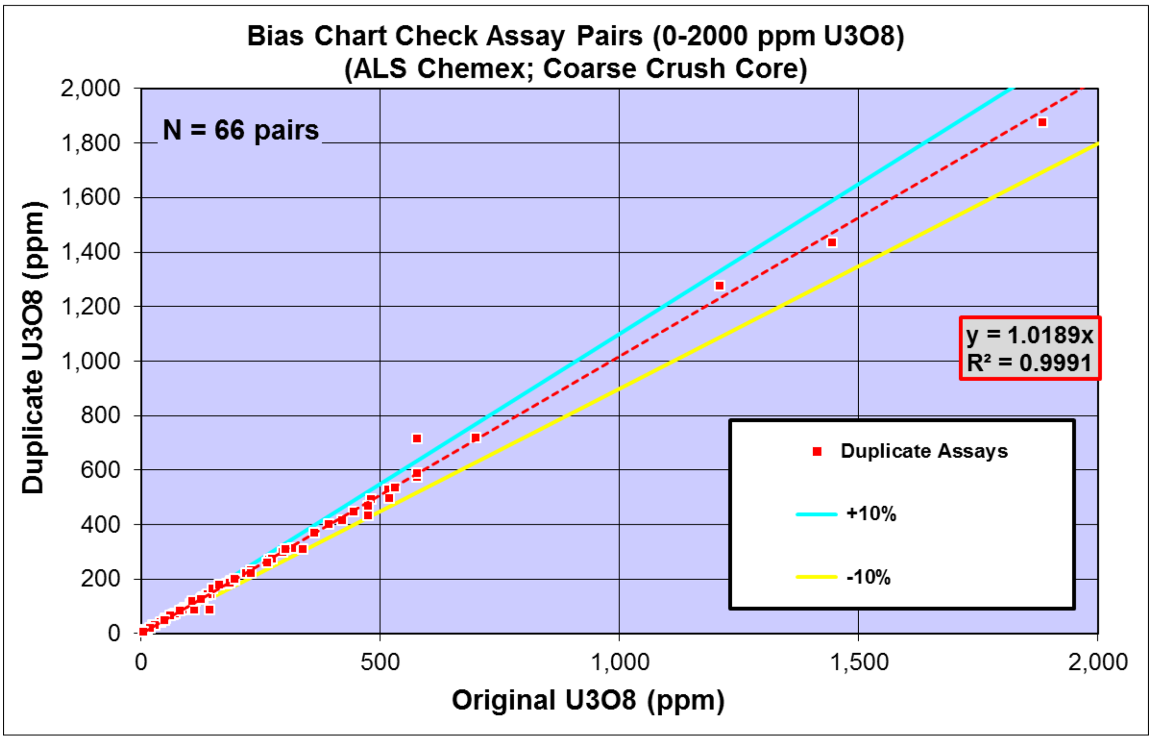


Figure 12-5: **Core Coarse Crush (Reject) Duplicates Submitted from the Gwabe and Njame Deposit Exploration Drilling Programs**

Certified Reference Materials

The standards used were CRM purchased from African Mineral Standards ("AMIS") who specialise in analytical quality control and the production of certified standards. The CRM was inserted into an empty sample bag at sample numbers ending with 25 and 75. Two different standards (targeting high and low grade U_3O_8) were rotated in the sample sequence and the standard's number recorded for QAQC reporting.

The standards used to date from AMIS are AMIS0004, AMIS0029 and AMIS0045. The standards are certified for U_3O_8 and Au. The standards assays were monitored for any assays falling outside certified ranges. Any failed sample batches were flagged and investigated by AFR.

The standards are certified for U (and thus U_3O_8), with the acceptable assay ranges (as defined by AMIS) 2 times the standard deviation of the certified grade. Control plots for these standards are presented in Figure 12-6 to Figure 12-8.

In general, the CRM assaying falls within acceptable ranges, with the majority of samples falling within the tolerance limit (2 times the recommended standard deviation value); however, a small percentage of standards are outside the accepted standard range and no significant material bias was identified for AMIS0004 and AMIS0045. AFR found that there was an issue, generally low reporting, around 1,010 ppm U on average versus the expected of 1,050 ppm U, of the AMIS CRM for AMIS0029; in Figure 12-7 sample series 25 to 43, corresponding in date to mid-2008.

Further investigation was conducted by AFR at the time and included check-assaying (of 662 samples from 54 work orders targeting key samples within 300 -2,000 ppm U_3O_8) and careful review of all other high-grade standards submitted by ALS Chemex indicated there were no errors in the reporting of all workorders since mid-2008. It was also noted that when ALS Chemex included samples of the same standard in recent work orders, it produced similar results (around 1,010 ppm U_3O_8). This suggests that AMIS may have changed the composition of standard AMIS0029, however further investigation is required to confirm this.

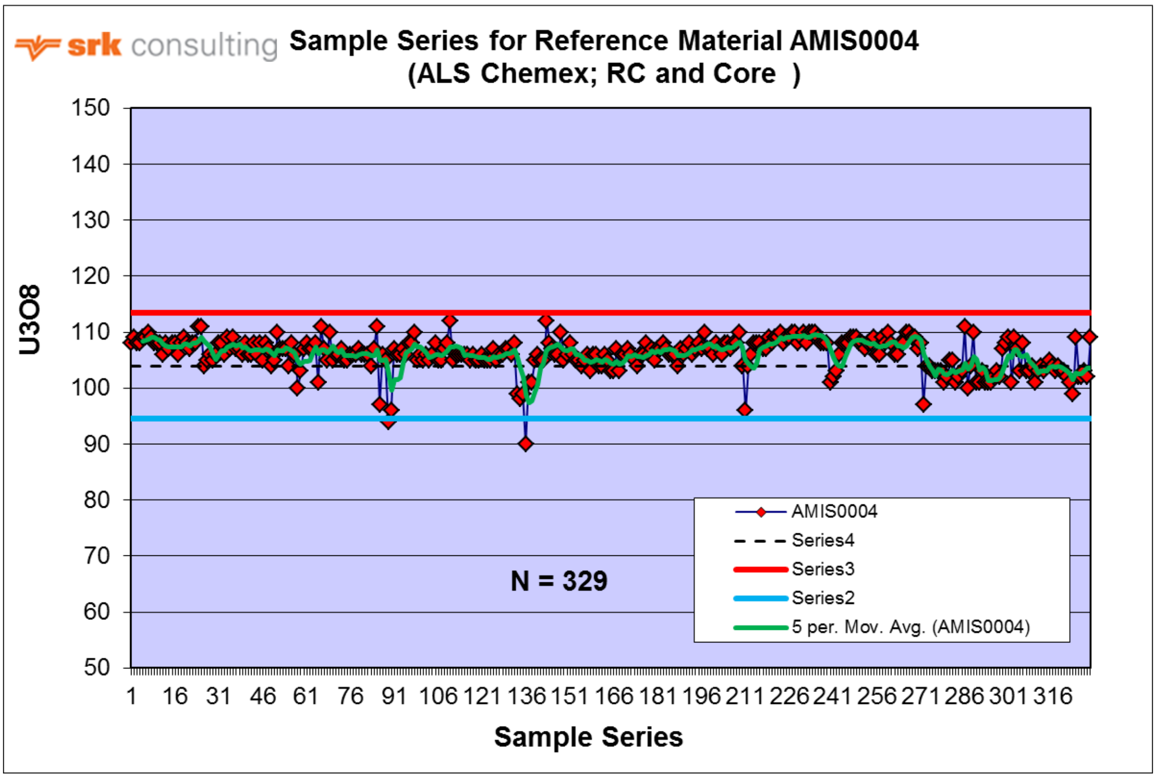


Figure 12-6: **Control Plot for AMIS0004 CRM Submitted by AFR from the Njame and Gwabe Deposit Drilling Programs**

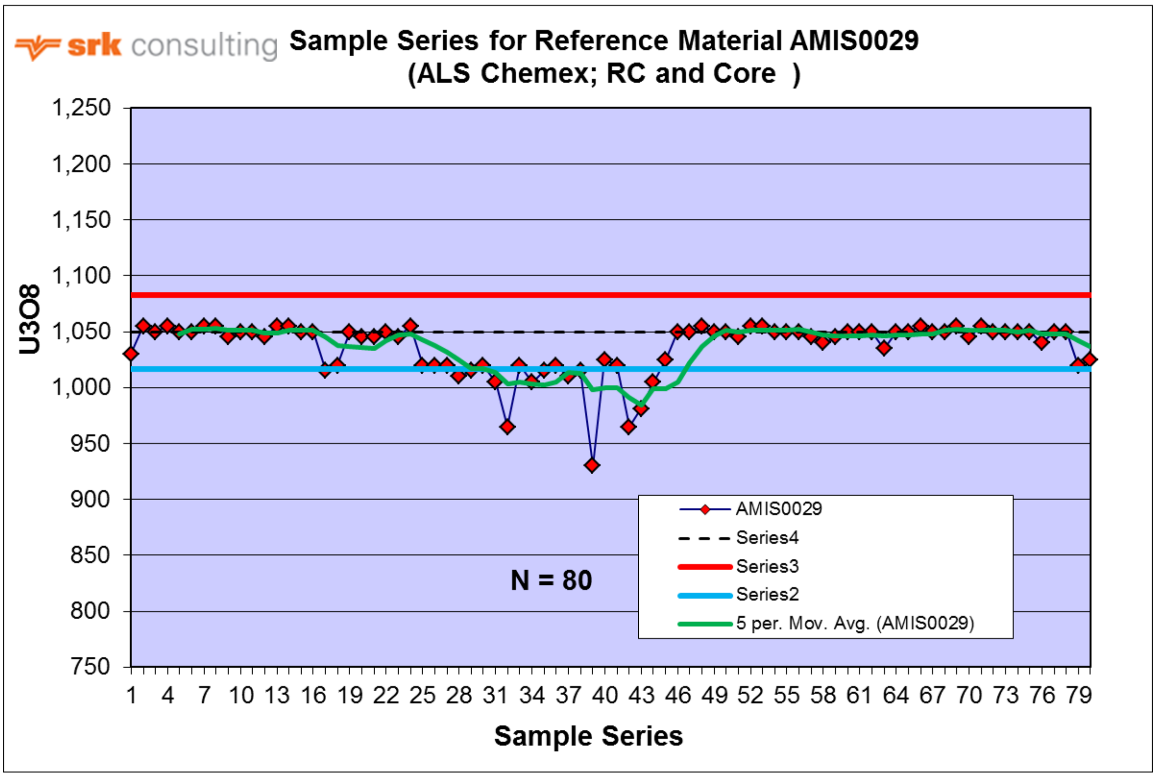


Figure 12-7: **Control Plot for AMIS0029 CRM Submitted by AFR from the Njame and Gwabe Deposit Drilling Programs**

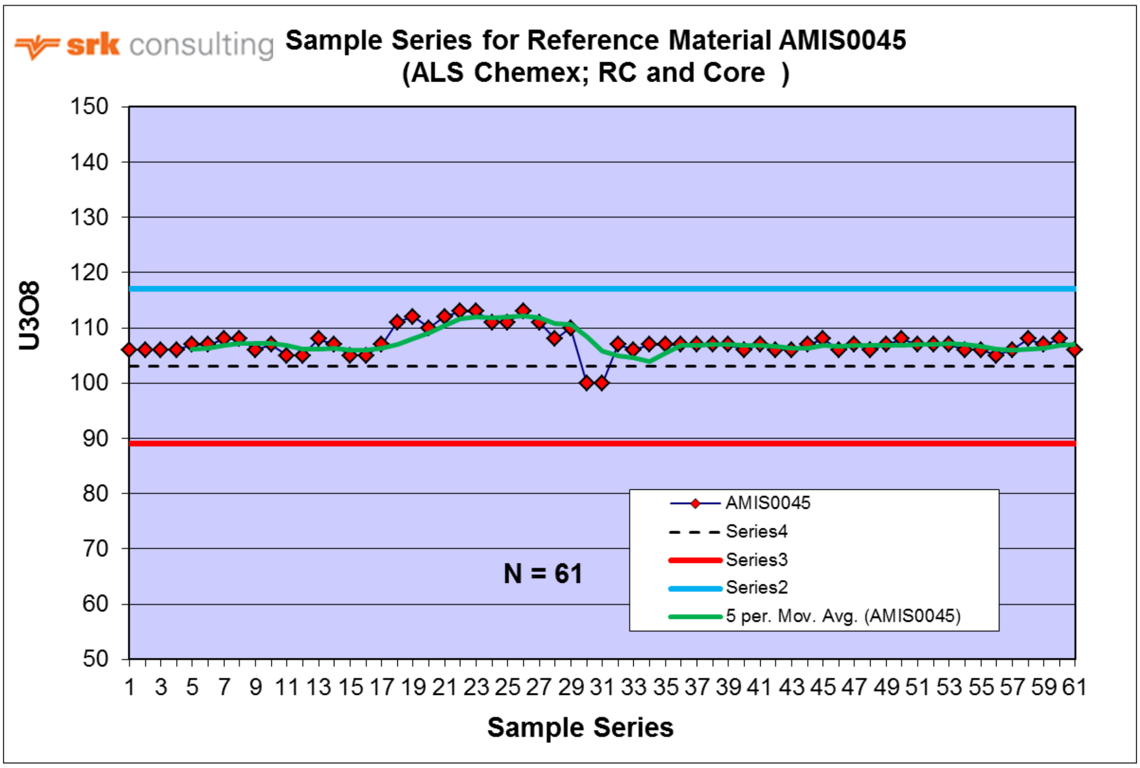


Figure 12-8: **Control Plot for AMIS0045 CRM Submitted by AFR from the Njame and Gwabe Deposit Drilling Programs**

Blanks

The vast majority of submitted blanks (comprising pool sand) report within required statistical tolerance (<5 times the detection limit for U), as shown in Figure 12-9.

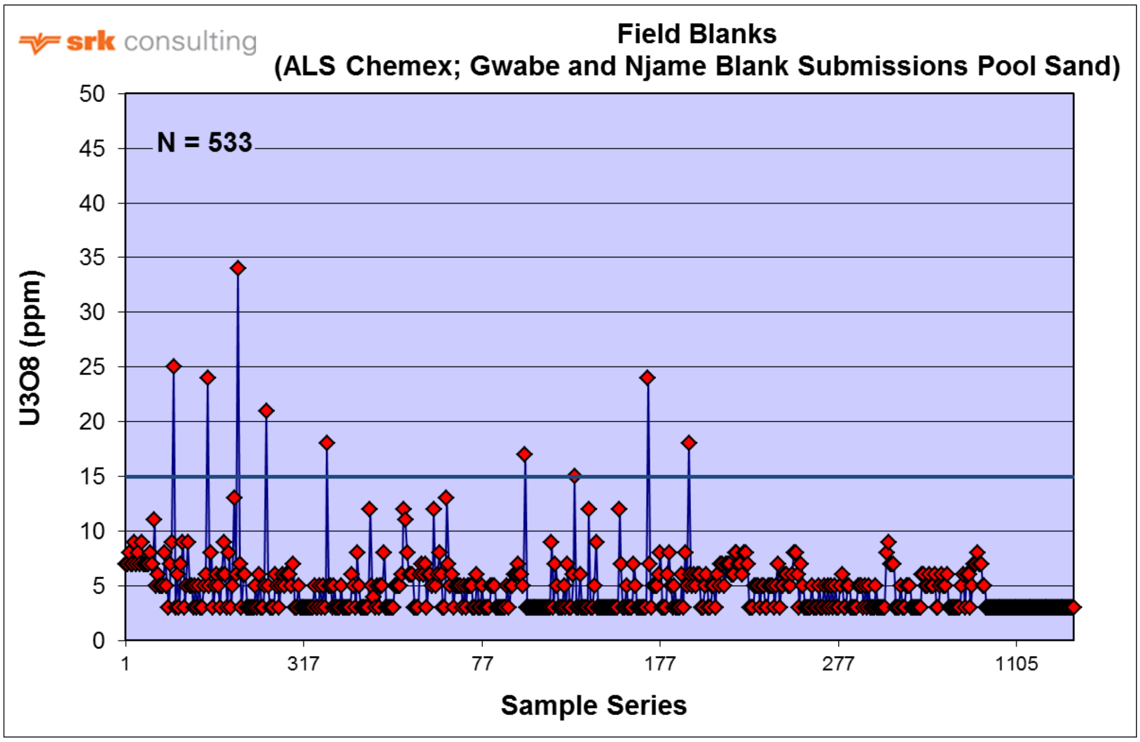


Figure 12-9: **Blank Samples (Pool Sand) Inserted into the Sample Stream by AFR During the Njame and Gwabe Exploration Programs**

Specific Gravity

Reference weights (2 g, 200 g and 2 kg) were used to test the accuracy of the scale used for specific gravity measurements. A quartz vein sample was used to test precision and methodology employed by AFR.

13 MINERAL PROCESSING AND METALLURGICAL TESTING (ITEM 13)

Several bench scale mineralogical studies and column testwork have been completed on the Mutanga and Chirundu deposits by the previous owners. The work is summarized in this section, with the majority of the information extracted from: NI 43-101 Technical Report prepared by CSA Global in 2013 (CSA, 2013) on the Mutanga Uranium Project; AFR Pre-Feasibility Report in 2008 (AFR, 2008) prepared for the Chirundu deposit; the report prepared by Mintek for the Chirundu deposit bankable feasibility study “Determination of Uranium Heap Leach Process Design Criteria for the Chirundu Project in Zambia” (Mintek, 2010); Mutanga Project Feasibility Study (MDM Engineering, 2009); and the Dibwe East NI 43-101 Technical Report prepared by Denison Mines (USA) Corp and Roscoe Postle Associates (Denison Mines (USA) and Roscoe Postle Associates (RPA) Inc, 2012.

The previous mineral processing and metallurgical testing work is discussed below under the different prospects. GoviEx intends to build on considerable previous historic studies for each of the deposits to optimise the suitable process route for exploitation of the Mutanga and Chirundu deposits.

13.1 Mutanga, Dibwe and Dibwe East Deposits

13.1.1 Background

The Mutanga Project uranium mineralisation identified to date appears to be restricted to the Escarpment Grit Formation of the Karoo Supergroup, which occupies the rift through the Zambezi Valley. The Mutanga, Dibwe and Dibwe East deposits averages around 287 ppm U_3O_8 at a cut-off of 100 ppm U_3O_8. A range of metallurgical tests were conducted by AGIP in the 1980s, of which selected reports were available for review. Reported AGIP results are sketchy and provide insufficient detail of metallurgical performance. Anecdotal evidence gained from past employees within the relevant department of the Zambian Government also report on a ‘pilot’ heap leach test that showed uranium recoveries up to 90% at low sulfuric acid consumption rates of less than 5 kg/t ore leached had been achieved.

13.1.2 Geological Details of the Mutanga, Dibwe and Dibwe East Deposits with Relevance to Metallurgical Test Work

The Mutanga, Dibwe, and Dibwe East deposits are located in the Southern Province of the Republic of Zambia about 200 km south of Lusaka and immediately north of Lake Kariba. The licence is within the Zambezi Rift Valley which is hilly with large fault-bounded valleys filled with Permian, Triassic and possibly Cretaceous sediments of the Karoo Supergroup. Rocks of the Karoo Supergroup (Late carboniferous to Jurassic) 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 and carbonaceous siltstones and mudstones (the Gwembe Formation), and finally fine grained lacustrine sediments of the Madumabisa

Formation. The Upper Karoo sediments unconformably overlay the Lower Karro and comprise a series of arenaceous continental sediments overlain by mudstones capped by basalt.

The uranium mineralisation identified to date appears to be restricted to the Escarpment Grit Formation of the Karoo Supergroup. Within the tenement area the Karoo sediments are in a northeast trending rift valley. They 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 Madumabisa Mudstones form an impermeable unit and are thought to have prevented uranium mineralisation from moving further down through stratigraphy.

Mineralisation is associated with iron-rich areas (goethite) as well as secondary uranium being distributed within mud flakes and mud balls as well as in pore spaces, joints, and other fractures.

It is probable that the uranium was eroded from the surrounding gneissic and plutonic basement rocks during weathering and deposition of the immature grits and sandstones. The uranium was transported together with this material in a presumably arid environment. Uranium was precipitated during reducing conditions in certain favourable units. Later fluctuations in the groundwater table caused remobilisation of this material; uranium was again dissolved and then re-deposited in reducing often clay-rich areas with a certain degree of enrichment.

13.1.3 Metallurgical Test Work Programme

Ore Samples Processed

During the metallurgical test work programme a variety of samples were used:

1. Samples from the November / December 2005 verification and in-fill drilling programme were exported from Johannesburg, South Africa in January 2006, to be subjected to leachability tests in Perth. These samples represented the remainder of material processed at SGS Johannesburg for uranium and other chemical analysis; the original samples were one-quarter diamond drill core selected by Geoquest geologists. The quarter core samples received from SGS Johannesburg were of very fine powder (required for sample preparation for analysis by X-ray and ICPOES techniques).
2. Additional half-core material of selected samples above a cut-off grade of 200 ppm U_3O_8 from the above programme were shipped from location in Zambia to Perth in April 2006 to perform further leach tests.
3. Additional samples of core were delivered to Perth in June 2006 to be used in comminution test work and subsequent leach tests.

Other Considerations

A preliminary assessment was performed on assay data received from SGS Johannesburg in January 2006. The objective was to determine any correlation of potentially deleterious chemical species or elements that occur with the uranium mineralisation.

The key finding was that phosphates were strongly correlated with uranium and this is not deleterious to the process. This was expected on the basis of anecdotal evidence from earlier mineralogical assessments in the 1980s that phosphate-complexed uranium was the significant mineralisation present in the ores in the Mutanga area. Potentially deleterious elements like vanadium, etc did not appear to correlate with other uranium values nor were present in gangue material.

Programme Outline

The metallurgical test work programme was developed to narrow down the options for processing of Mutanga deposit ores, specifically:

- develop the optimal leach parameters;
- establish grindability characteristics of the plant feed;
- establish downstream process performance; for example, settling and filtration assessments; and
- establish ion exchange performance.

The results were to be used in selecting the appropriate flow sheet for processing the Mutanga deposit ores, and used as the basis of further test work as well as scoping level project cost estimates and valuation.

Test Work Results

Test work programme overview

The test work programme designed was characterised by the need to amend the programme to cater for unexpected results, given the exploratory nature of the test work. In the end, a number of different tests were required to narrow down the range of optimal leach parameters.

Test work was conducted in two phases:

1. Phase 1 was designed to establish the most promising leach approach, assessing the performance of sulfuric acid vs. sodium carbonate-based alkaline leach options.
2. Phase 2 comprised of tests to narrow down sub-options of the alkaline leach route and compare to acid leach

During Phase 1, specifically, the programme was designed to test two hypotheses:

- establish whether the alkaline leach methods can deliver expected results of a conventional acid method; and
- determine whether resin-in-pulp methodology can be employed, thus reducing capital and operating costs of the full scale plant.

Phase 2 test work was undertaken in the following context:

- alkaline leach approach was selected at the time in favour of an acid leach method;
- resin-in-pulp was dropped in favour of optimising conditions to achieve fast extraction of the uranium minerals; and
- mineralogy suggested that the quartzitic ‘scats’ in the host rock did not contain any uranium and could thus be rejected, thus reducing the volumes to be processed downstream of comminution.

Uranium Extraction

Table 13-1 summarises the extraction results achieved in Phase 1 of the test programme.

Table 13-1: Extraction Results Phase 1 Leach Test Work (Source: SGS, 2007)

Test Number	Feed Type	Particle Size (P_{80})	% Solids	Reagent Type	Na_2CO_3 Reagent Dose (kg/t)	pH Adjust $NaHCO_3$	Leach pH	Resin Charge (m?)	Resin Form	Sample Frequency	Leach Time (hours)	Temp (ºC)	Other/ Results
1	High Compo	Bug Dust	30	H2SO4	24	#REF!	1.6	NIL			6	20	77.3%
2	High Compo	Bug Dust	30	H2SO4	29	0	1.6	NIL			6	20	81.7% 5kg/t MnO2 added
3	High Compo	Bug Dust	30	H2SO4	15	0	1.85	NIL			4	20	30.6%
4	High Compo	Bug Dust	30	H2SO4	19	0	1.9	NIL			4	40	76.2%
5	High Compo	Bug Dust	50	Na2CO3	2	2	8.7	NIL			6	20	43.6% RISING WITH TIME
6	High Compo	Bug Dust	50	Na2CO3	5	2	9.4	NIL			6	20	53.1%
7	High Compo	Bug Dust	50	Na2CO3	20	20	9.4	NIL			6	20	80.0%
8	High Compo	Bug Dust	30	H2SO4	23	0	1.66	50	SO4		4	40	84.0%
9	High Compo	Bug Dust	50	Na2CO3	20	12	9.7	80	CO3		6	20	76.2%
10	High Compo	Bug Dust	50	Na2CO3	20	8	9.7	80	CO3		6	50	83.8%
11	High Compo	Bug Dust	30	H2SO4	23		1.5	50	SO4		4	20	77.3% 5kg/t MnO2 added
12	High Compo	Bug Dust	50	Na2CO3	10	10	9.5	NIL			6	20	61.9%
13	High Compo	Bug Dust	50	Na2CO3	30	20	9.7	NIL			6	20	73.6%
14	HGC	425	30	H_2SO_4	?	?	1.5	?	?	0/0/30/60/120/360	6	20	76.7%
15	HGC	425	50	Na_2CO_3	20	Yes	10.2	?	?	0/0/30/60/120/360	6	50	84.2%
16	High Compo	Bug Dust	50	Na_2CO_3	30	Yes	10.2 (min)	50	CO_3	78.5% after 2 hours	2	50	
17	High Compo	Bug Dust	50	Na_2CO_3	30	Yes	10.8 (min)	50	CO_3	82.1% after 2 hours	2	50	
18	HGC	200	30	H_2SO_4	?	?	1.5	?	?	0/0/30/60/120/360	6	20	80.6%
19	HGC	200	50	Na_2CO_3	20	Yes	10.2	?	?	0/0/30/60/120/360	6	50	83.8%
20	LG Grab	Bug Dust	30	H_2SO_4	?	?	1.5	?	?	0/0/30/60/120/360	6	20	69.8%
21	LG Grab	Bug Dust	50	Na_2CO_3	20	Yes	10.2	?	?	0/0/30/60/120/360	6	50	66.1%
22	Super High Grade Conc	100	50	Na_2CO_3	40	Yes	10.8	100mL/kg	CO_3	0/0/30/60/120/360	6	30	88.5%
23	High Compo	Bug Dust	50	H2SO4	TBC	NIL	1.6	50	SO4	0/0/30/60/120/240	4	40	82.6%
24	High Compo	Bug Dust	50	H2SO4	TBC	NIL	1.6	50	SO4	0/0/30/60/120/240	4	30	78.1%
25	High Compo	Bug Dust	50	Na2CO3	30	Yes	10.8	50	CO3	0/0/30/60/120/360	6	30	77.2%
26	High Compo	Bug Dust	50	Na2CO3	30	Yes	10.8	50	CO3	0/0/30/60/120/360	6	40	81.1%
27	High Compo	Bug Dust	30	H2SO4	TBC	NIL	1.6	50	SO4	0/O/30/60/120/240	4	20	82.5%

The Phase 2 test work centred on optimising the conditions for an alkaline leach route. The following summarises the key results obtained for this phase:

- Effect of size distribution: Little additional extraction benefit appeared to be gained by grinding finer (provided the same leach conditions were maintained), reinforcing the notion that a relatively coarse grind may result in sufficient liberation and provide the opportunity for the rejection of the 'scats'.
- Effect of sodium carbonate / bicarbonate ratio and overall level of concentration: higher concentrations of sodium carbonate as well as a high ratio of this to the bicarbonate favoured extraction.
- Effect of temperature: increasing leach temperature to 60ºC increased extraction.
- Rate of dissolution: it was consistently found that uranium dissolution was extremely fast, and that leaching already appeared to commence in the grinding step, as shown in Figure 13-1.

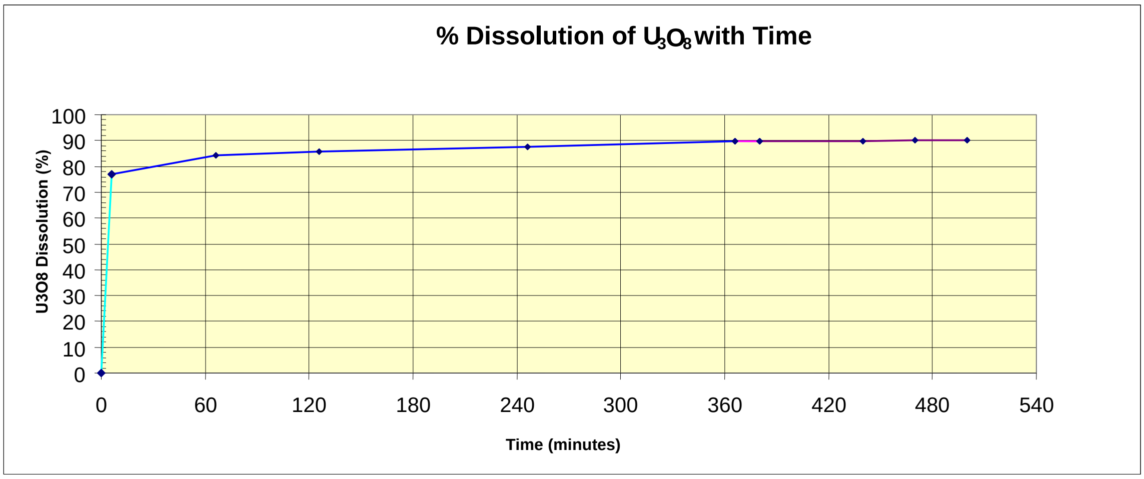


Figure 13-1: Alkali Leach - Dissolution of U_3O_8 with Time (Source: SGS, 2007)

13.1.4 Grindability

Standard Bond Work Index tests were performed on half-core samples received and both rod and ball mill work indices were determined; the results of which are shown in Figure 13-2 and Figure 13-3. In Figure 13-2, the specific work index for rod mill test was 4.9 kWh/t (F80 = 8240 micron; P80 = 864 micron). In Figure 13-3, the specific work index for ball mill test was 25.3 kWh/t (F80 = 998 micron; P80 = 87 micron).

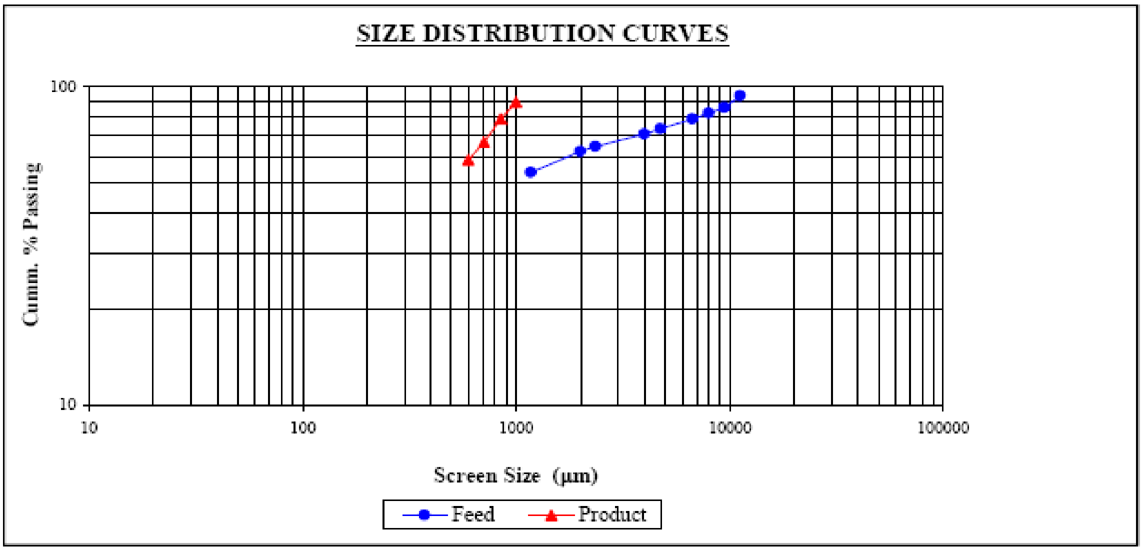


Figure 13-2: Rod Mill Work Index (Source: SGS, 2007)

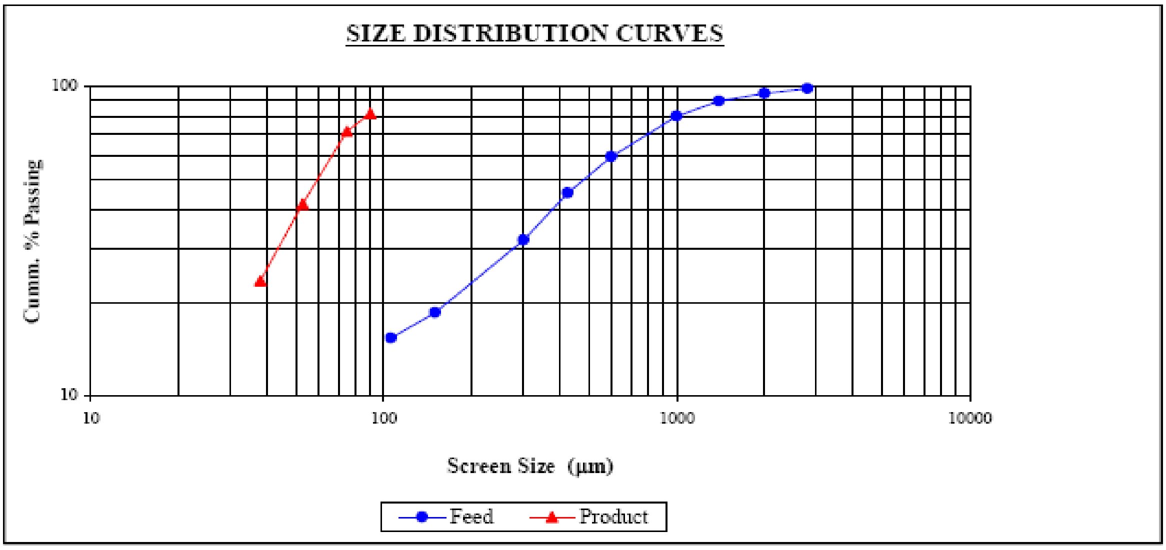


Figure 13-3: Ball Mill Work Index (Source: SGS, 2007)

Orway Mineral Consultants (“OMC”) were contracted to oversee further modelling work as part of the Phase 2 leach test work. The objective of this test work was to establish an optimal liberation size of the sandstone host rock with respect to uranium extraction, and the associated specific energy requirement for the particle size distribution.

- Figure 13-4 represents the observed mill discharge size distribution achieved under varying energy inputs. The work index for this material was determined to be around 4 kWh/t for a P_{80} of 0.8 mm.
- Figure 13-5 reflects the uranium distribution by size class, for the feed and the mill products at varying energy input levels. Of note is that for the mill product for all energy input levels uranium is found predominantly in the particle size range <0.4 mm. This allows for a relatively coarse grind and the rejection by screening of barren oversize material (or ‘scats’ reject).

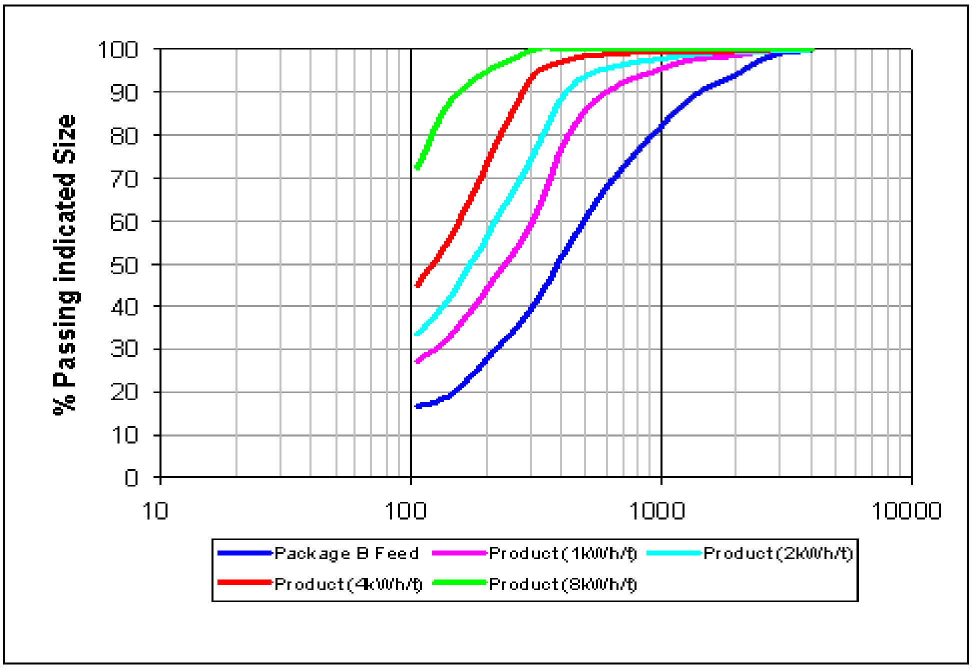


Figure 13-4: Mill Discharge Size Distribution (Source: SGS, 2007)

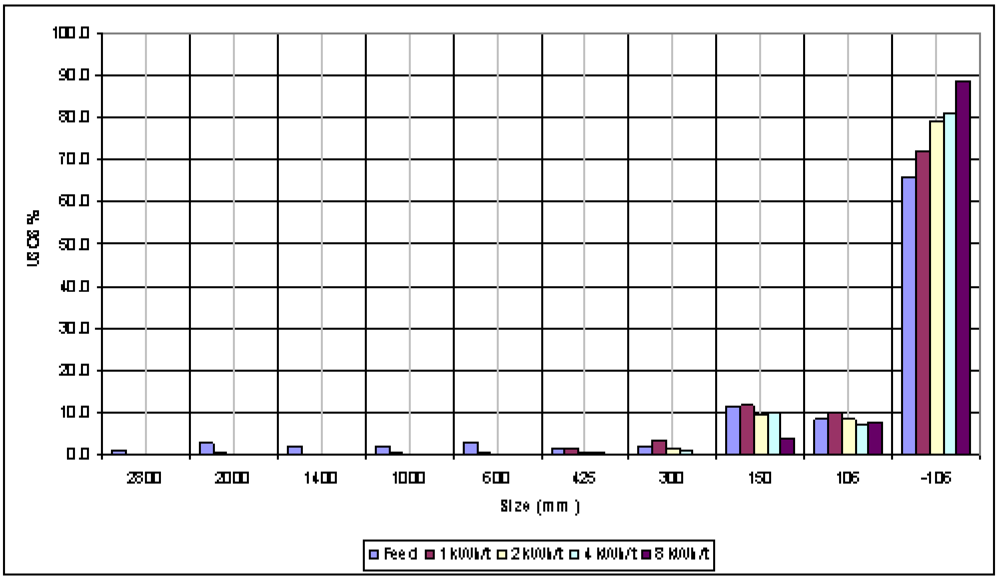


Figure 13-5: Uranium Granulometry (Source: SGS, 2007)

13.1.5 Settling and Filtration

Filtration tests were performed in accordance with ASTM methods. Figure 13-6 demonstrates the results from this test. Settlings tests were carried out to determine the performance of the material leached. Figure 13-7 represents a typical result from these tests.

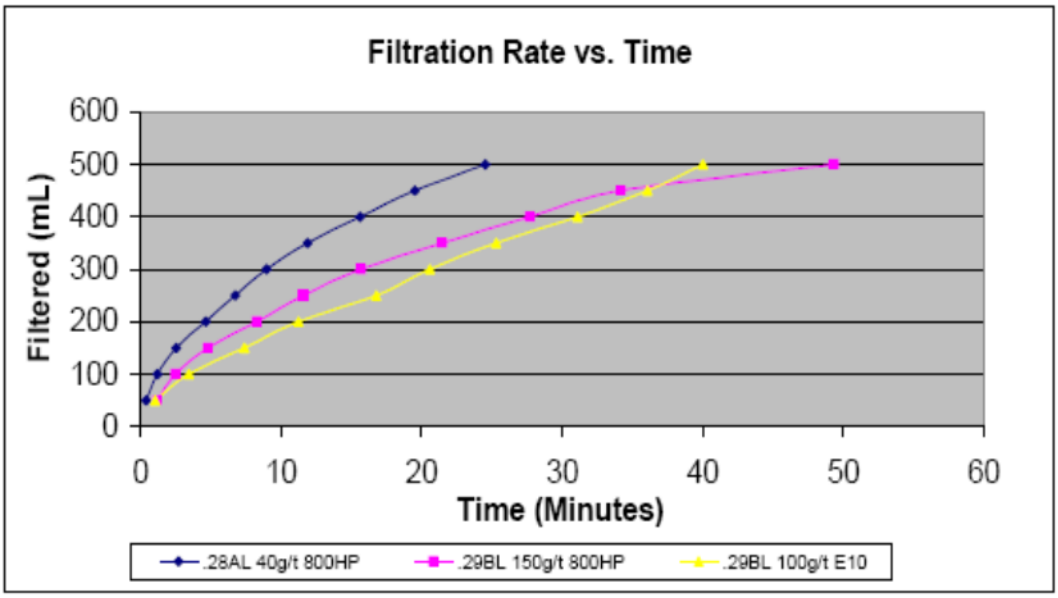


Figure 13-6: Filtration Rate (Source: SGS, 2007)

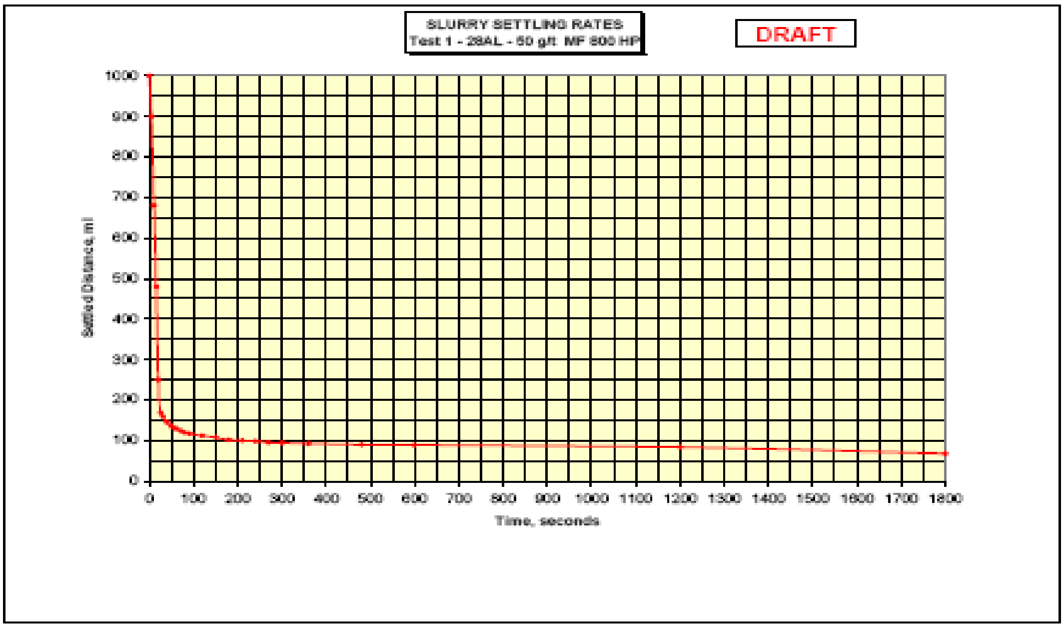


Figure 13-7: Settling Rate (Source: SGS, 2007)

13.1.6 Ion Exchange

The objectives of the ion exchange test work programme were as follows:

- determine loading capacity of resin using (1) Amberjet 4400 and (2) Lewatit K 6367;
- determine stripping capacity of different eluants; and
- understand likely issues associated with this process step.

Loading tests on both resin types indicated that resin loadings of up to 30 g/l U_3O_8 can be achieved. Phosphates are not generally absorbed by the resin, but chlorides will be and will necessitate downstream processes to reduce chloride in the final product. The latter is not expected to be a significant issue.

Elution tests presented in Figure 13-8 showed that sodium bicarbonate was an effective elution agent.

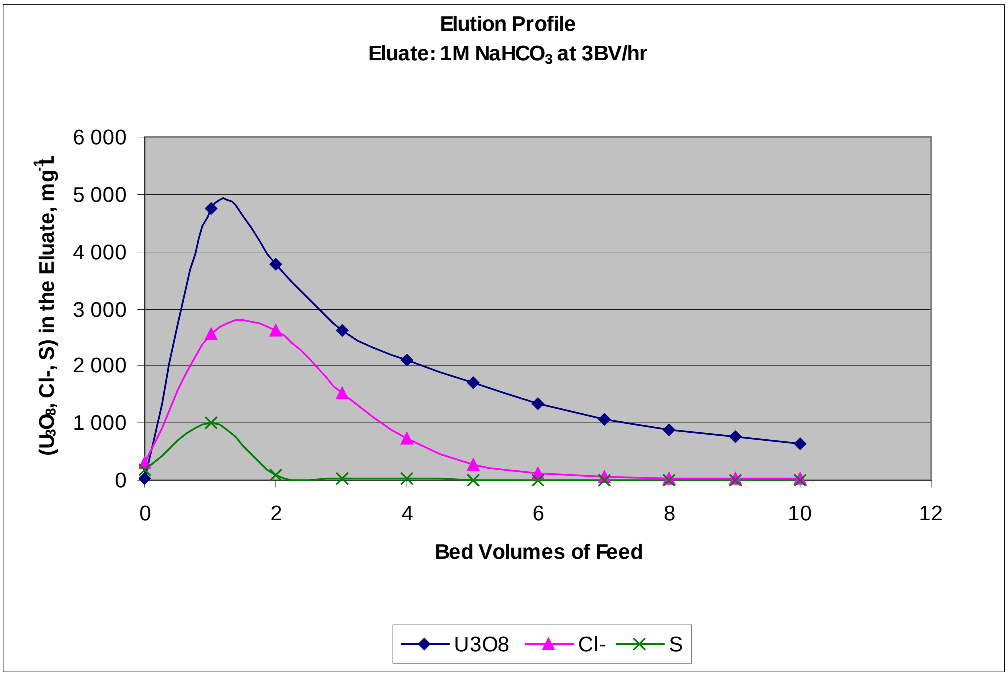


Figure 13-8: Elution Profile (Source: SGS, 2007)

A typical elution profile was simulated as represented in Figure 13-9. The actual elution of uranium complex begins only with the 9th bed volume when the sodium bicarbonate eluant is introduced. Noteworthy is the ratio of uranium concentration from that time relative to the impurities; this would signify that relatively small quantities of impurities are eluted with the resin.

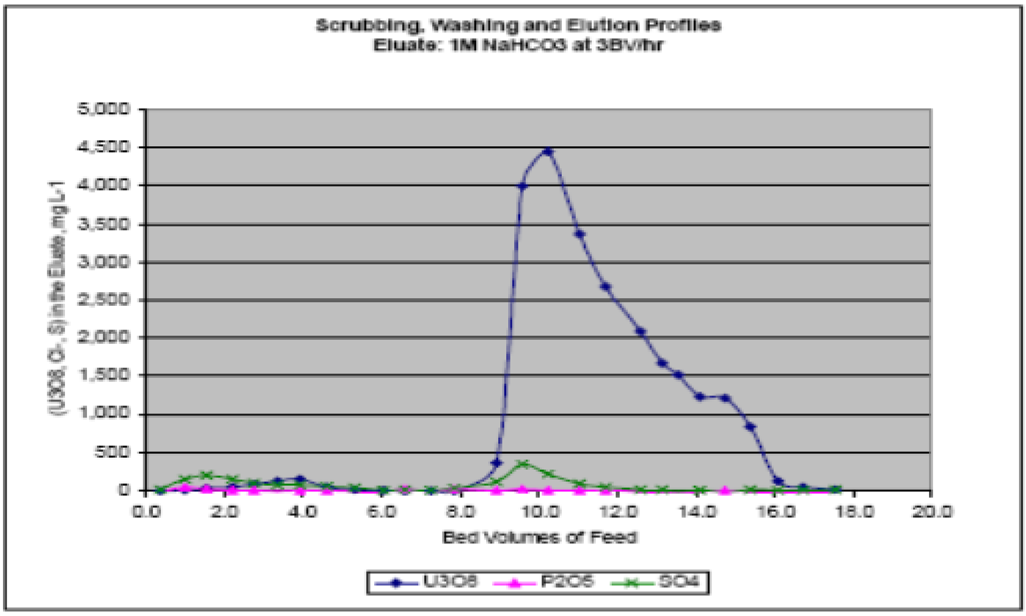


Figure 13-9: Elution Profile (Source: SGS, 2007)

13.1.7 Mineralogy

Selected uranium samples were evaluated by bulk mineralogical analysis ("BMA") and trace mineral search ("TMS") using QEMSCAN at SGS Lakefield Oretest in Brisbane, Queensland/ Australia.

The aims of the tests were to characterise the:

- natural liberation of quartz from the conglomerate phases; and
- The occurrence and mineralogy of uranium phases, including grain size, association and liberation.

Key findings from the evaluation:

1. The majority of the uranium (~95%) was contained in the U-Ca-P phase, nominally referred to as autunite. The 'Other Minerals Group" (which makes up approximately 5% of the U elemental deportment) was comprised predominantly of brannerite and coffinite.
2. The vast majority (>90%) of the U-bearing mineral particles studied in the test programme were liberated to whilst <10% remained unliberated. The U-bearing minerals in the latter category were predominantly attached to the quartz boundaries.
3. The U-bearing minerals generally appeared to be discrete grains (not intergrown with other minerals), suggesting that it should be possible to achieve high levels of liberation of the U-bearing minerals.
4. Between 50-60% of the U-bearing particles in the test programme were associated with quartz, but the average grain size was small so that the proportion of the total deportment was low at ~2%. The dominant U-bearing mineral autunite was associated within the pores of the host rock (sandstone) not within the clay cement.
5. The U-bearing mineral autunite does not occur within the quartz grains. This suggests that it should be possible to upgrade the ore by preferential removal of the quartz grains (~1 mm diameter and more).
6. The data suggests that the timing of the U mineralisation was post depositional, which is supported by the low association between the U-bearing minerals and the quartz grains and clay cement.

13.2 Key Findings and Discussion

13.2.1 Extraction

Phase 1 leach test work findings:

- Extraction results from samples that had been ground to fine powder have slower kinetics than samples ground to coarser size, but there appears to be little difference in ultimate extraction levels. There is no immediate explanation for this phenomenon which will be investigated further in selective metallurgical testing but it indicates that very fine grinding, may not be necessary.
- Extraction kinetics appear very fast for coarse grain sizes, suggesting that little leaching capacity is required, potentially obviating the need for a leach circuit with leaching occurring in the grinding circuit.

- Higher temperatures result in faster kinetics and higher terminal extraction; however, increasing temperatures over 50ºC yielded diminishing returns and this will require further investigation.
- Acid medium process dissolves a wide range of elements and other chemical species potentially deleterious to downstream processes, whereas alkaline process yields a cleaner leachate: phosphates in particular were found to dissolve in significant quantities in the acid medium. Despite this, the more favourable leach kinetics and reagent cost led to acid leach being selected over alkaline leaching.

Phase 2 test work centered on repeating acid leach test results and refining specific economic sets of conditions. Key findings were as follows:

- It will be possible to commence the leach step in the grinding process, to exploit the extremely fast reaction of uranium once the appropriate leach conditions are established.
- Grinding energy will be an important heat source to support the fast reaction, but it will be required to heat some of the liquor streams to achieve an extraction level of around 90% at a temperature of 60ºC.
- ‘Scat’ removal will permit the removal of some 30% of the mill product, for negligible loss of uranium. This tonnage reduction will have favourable impact on downstream capital and operating costs.

13.2.2 Grindability

Rod mill work index is in line with expectations, while the considerably higher ball mill work index reflects the incremental energy required to grind the quartzite grit enclosed in the sandstone matrix. As the uranium mineralisation is expected to be hosted in the matrix of the sandstone, rod milling appears to be a more economic proposal. A coarser grind will require a process step to separate +0.3 mm (approximately) particles from the fines to avoid downstream processing issues. Ball milling would only be justified if the incremental energy is offset by additional uranium recovery.

The comminution test work performed as part of the Phase 2 leach test work demonstrated the feasibility of rejecting the coarse barren ‘scat’ fraction with negligible uranium loss, achieved at relatively low grinding energy of around 4 kWh/t.

13.2.3 Settling and Filtration

Results were in line with expectations for materials of this type. Good settling and filtration results can be expected provided plant feed materials are not milled/ ground too fine. The test results suggest that high rate thickening is a viable alternative.

13.2.4 Ion Exchange

Resin elution by sodium bicarbonate appears both practical and economical; sharp peaks were recorded that allow separation of contaminants and uranium product within a specific elution sequence. Resin loading tests specifically were not performed, but mass balances performed during leach tests indicated that there appeared to be no barriers to uranium loading onto the resin from competing ionic species. Mineralogical work will give further insight into potential issues but no deleterious effects are anticipated that prevent resin-in-pulp (or alternatively similar processes) to be implemented.

13.2.5 Mineralogy

Mineralogical evaluation established that the uranium mineralisation is predominantly secondary uranium, thus reinforcing the favourable acidic leach characteristics found during the Phase 2 test work.

13.3 Recommendations

In order to further improve the understanding of the flowsheet finalisation, the following recommendations are provided:

- continue the optimisation of acid leach conditions, to provide those to be used in the continuous testing part of the feasibility study that will be employed to prepare capital and operating cost estimates;
- continue the refinement of uranium recovery from the enriched liquors post-ion exchange to demonstrate acceptable product quality can be consistently achieved; and
- develop innovative ways of heat recovery and heating of the liquor streams to provide the environment required to support fast uranium dissolution.

13.4 Heap Leach Testwork – Mutanga and Dibwe Samples

The following is summarised from information provided in a report prepared by Mintek, Randburg, South Africa (May 2013) titled “Heap Leach Feasibility Testwork on Mutanga and Dibwe Ores”.

Denison submitted to Mintek 1,170 kg and 1,400 kg of diamond drill core samples from the Mutanga and Dibwe uranium ore deposits respectively. The drill cores were divided into groups according to the production periods planned for the two ore bodies. These were referred to as variability samples in Mutanga Uranium Project Denison Mines Corp Report No: R305.2013 107.

Composite samples were also prepared. Chemical head assays showed uranium contents (as U) of 200 ppm and 210 ppm for the Mutanga and Dibwe composite ores.

Both ores were composed of mainly silica (86%) and alumina (8%) which are known to exhibit low reactivity to acid media. Iron at between 1.3 and 1.9% was found to be the main impurity in both ores.

A summary of testwork is given below:

- At a crush size of 100% <25 mm, both ore types could be stacked to a height of 6 m and still be permeable to reagent (lixiviant) at an application rate of 10 L/m^2/h.
- Acid leach bottle roll tests indicated that uranium extraction rates for Mutanga ore are reasonable, with final acid consumption of 3 kg/t and could be leached within three weeks yielding extraction of 88%.

- The optimum conditions to leach the Mutanga ore were concluded to be the addition of 2.5 kg of concentrated sulfuric acid per ton of dry ore during agglomeration, three days curing time and irrigation of the ore with 3 g/L acid solution at an irrigation rate of 6 L/m^2/h.
- The Dibwe composite sample exhibited higher acid consumption (12.3 kg/t) and required a longer period of time (80 days) for completion of the leach cycle. A maximum uranium extraction of 79% was achieved for the Dibwe ore.
- The Dibwe sample was agglomerated with 10 kg/t of acid, followed by a curing period of 7 days and was then irrigated using leach solution containing of 3 g/L acid at an application rate of 15 L/m^2/h. Under these conditions, the uranium extraction was improved such that a maximum extraction of 82% was achieved, most of it in less than two weeks.
- The acid consumptions expressed in terms of kg acid consumed per pound of U_3O_8 extracted for the Mutanga and Dibwe ores were 3.7 kg/lb and 37.3 kg/lb, respectively.

13.5 Acid Leach Test Results

13.5.1 Results and Interpretation

The key results of the acid leach test program are:

- High uranium extractions, as presented in Figure 13-10.
- Low acid consumptions of 3-12.3 kg/tonne, based on total acid addition.
- Excellent response of the range of ores tested to dilute acid agglomeration as indicated by high flooded permeability rates, low to negligible “slump” (compaction under irrigation) retention of permeability through 60 days of irrigation leaching and retention of visual agglomeration in material dumped from the columns after leaching.
- Low coextractions of contaminant elements (thorium, vanadium) and elements which will accumulate in solution, thus requiring solution bleed and water treatment for removal to maintain a zero water discharge operation.
- High Eh values throughout the leach cycles of all column tests without added oxidant.
- The column leach test results are considered most valuable, since, except for the closed cycle irrigation procedure (no removal of uranium through the period of irrigation), they represent an accurate simulation of field performance of an acid heap.
- Figure 13-10 shows the column leach work, excluding hold-up. The overall recoveries were much higher, once the mass balance was closed and the recirculating solution was accounted for.

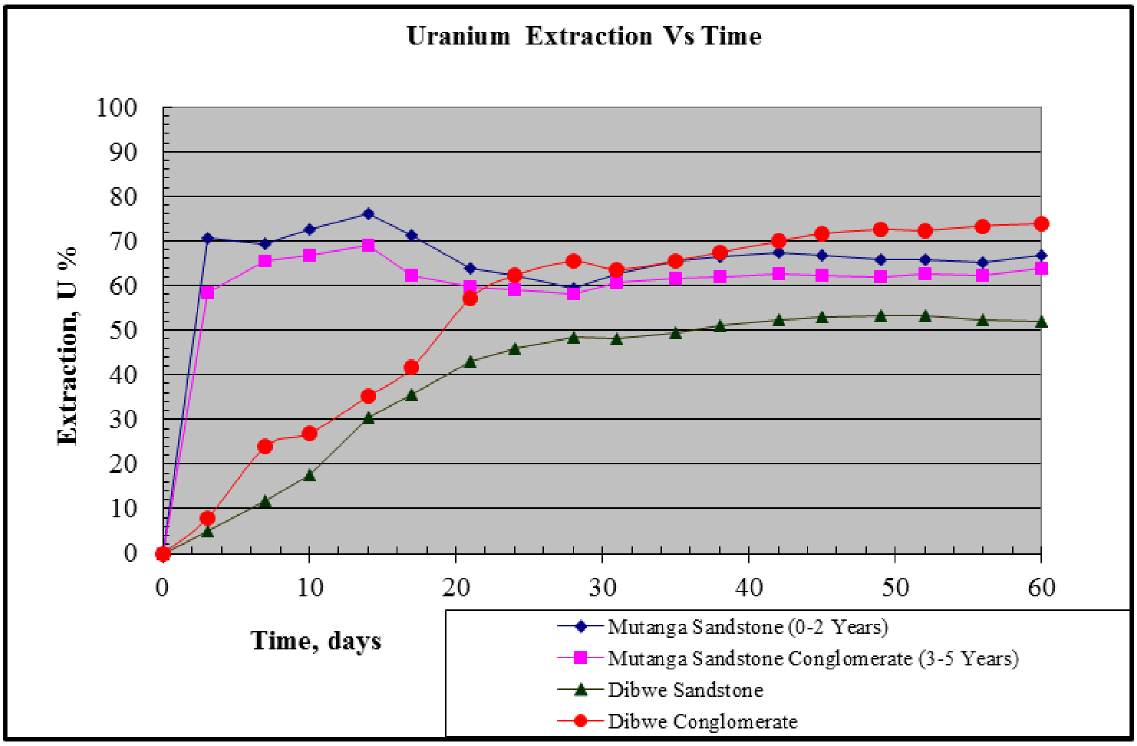


Figure 13-10: Mutanga Column Leach Uranium Extraction (Source: MDM, 2009)

Figure 13-10 illustrates that most of the Mutanga uranium extraction from this column was “prompt”, occurring within the first 2-3 days of irrigation. Further kinetic information cannot be derived from the results as the procedure followed involved recycle of leach solution without uranium removal. The shape of the graph appears to indicate (or is at least compatible with) some re-adsorption of initially dissolved uranium; however, the uranium extraction values for the column leach tests (84.7% for the Y1 Mutanga for example) are rigorously derived from solution recovered, including an acid rinse, which is effectively barren solution from ion exchange (IX) and the uranium content of the residue.

Graphed results for the Mutanga column leach tests appear to indicate (or are at least compatible with) ongoing extraction at the end of the 60 day leach cycle. This may be due to a less than optimal initial acid addition or to slow leaching. Additional testwork is required to determine ultimate extraction.

The bottle roll acid leach tests were conducted on material after further comminution, such extraction results are not considered to be reliable predictors of column (or actual heap) extraction from -25 mm material. The results presented in the SGS report, however, are informative with respect to acid consumption (generally predictive), maintenance of high Eh and relatively low coextraction values. The bottle roll results with added oxidant (manganese dioxide plus ferric sulfate) indicate that the Mutanga materials tested do not respond well to a high level of ferric iron in leach solution; extraction was actually inhibited by the >1 g/L ferric content, perhaps due to ferric phosphate precipitation on the surface of otherwise easily leachable autunite. Bottle roll results do indicate a favourable response of Dibwe material to a higher level of ferric than is observed from leaching with only acid addition.

13.5.2 Acid Leach – Conclusions and Recommendations

The materials tested in columns represent the broad lithotypes of the Mutanga and Dibwe resource materials. Additional testwork is required to optimize leach conditions and confirm extractions for composites representing the ore supply for the full resource indicated by the mine plan, but results to date are considered to confirm the technical feasibility of acid heap leach technology for the Mutanga and Dibwe resource materials.

Additional testwork is recommended to optimize the leach parameters (initial acid addition, lift height, etc) and to confirm leach performance on all scheduled resource materials.

Additional testwork is also required to better define the accumulation on coextracted metals as a basis for determination of the solution bleed and treatment which may be required to maintain zero water discharge, leach performance and uranium product quality.

13.6 Chirundu

13.6.1 Background

The Chirundu Project contains two uranium deposits, namely Njame and Gwabe, both of which have been explored by reverse circulation and diamond core drilling.

13.6.2 Geology

Drilling at Njame by AFR has identified two mineralised horizons which are generally parallel to geological/lithological boundaries. Drilling has occurred along the length of the 5 km long system, with uranium mineralisation apparently encountered along the entire length; however, only at the northern and central sections of this system does the continuity and grade/thickness of the mineralisation support the delineation of resources of sufficient size to support mining operations.

Uranium mineralisation at the Gwabe deposit is stratabound, and occurs in red, oxidised, coarse grained sandstones, grits and pebble conglomerates which overly a green, non-mineralised, reduced silty-shale horizon. This is interpreted to represent a major redox boundary, and may in fact be the regional unconformity between the Upper and Lower Karoo. The mineralisation forms a broadly tabular body, which dips very gently to the southeast, and occurs at very shallow depths between 3 m and 29 m below surface.

13.6.3 Bottle Roll Testwork

Acid leach bottle roll testwork on Njame and Gwabe ore samples have been conducted by Mintek in Johannesburg. The Njame and Gwabe samples were bottle rolled leached at 25^{o}C at three pH ranges (pH 1.2-1.5, pH 1.5-1.8 & pH 1.8-2.0) for 7 days. Extractions of 89% to 91% were achieved during the first 24 hours for the Njame leaches. Sulfuric acid (as 100%) consumption was between 3 kg/t and 7 kg/t.

Extractions of 76% to 78% were achieved for the Gwabe leaches after 7 days of bottle rolling. The sulfuric acid (as 100%) consumption varied between 40 kg/t and 49 kg/t from the highest pH (1.8-2.0) to the lowest pH (1.2.-1.5) ranges, respectively. Modal mineralogy assessments by Mintek indicate that Gwabe contains higher levels of carbonates which consume acid (~2% calcite at Gwabe vs <0.1% calcite at Njame).

From the results obtained from the tests on the variability samples, the maximum uranium extraction from both the Njame and Gwabe samples can be seen to vary mostly between 70 and 90%, with some of the Njame samples yielding close to 100% extraction. The acid consumption figures were mostly around 40 kg/t, but some of the Gwabe samples were more acid consuming, up to 95 kg/t.

These tests were all conducted under the same set of leaching conditions, therefore the variability observed reflects variability in extractive metallurgical behaviour of the ore from different locations (Figure 13-11 to Figure 13-13). Table 13-2 summarises the various extraction efficiencies for the Njame and Gwabe samples, as can be seen there is a significant range of extraction efficiencies from 62 – 97% and acid consumption from 33.5 – 99.5 kg/t.

Bottle roll testwork (broken down by ore lithology), as shown in Table 13-3, reveals that the majority of average extractions were in the range of 85 – 91% and the average acid consumption in the range of 37 – 48 kg/t. There were two outliers of 65% average extraction for the “Pebbly Grit” lithology for Gwabe and 86.5 kg/t average acid consumption for the “Siltstone” lithology at Gwabe.

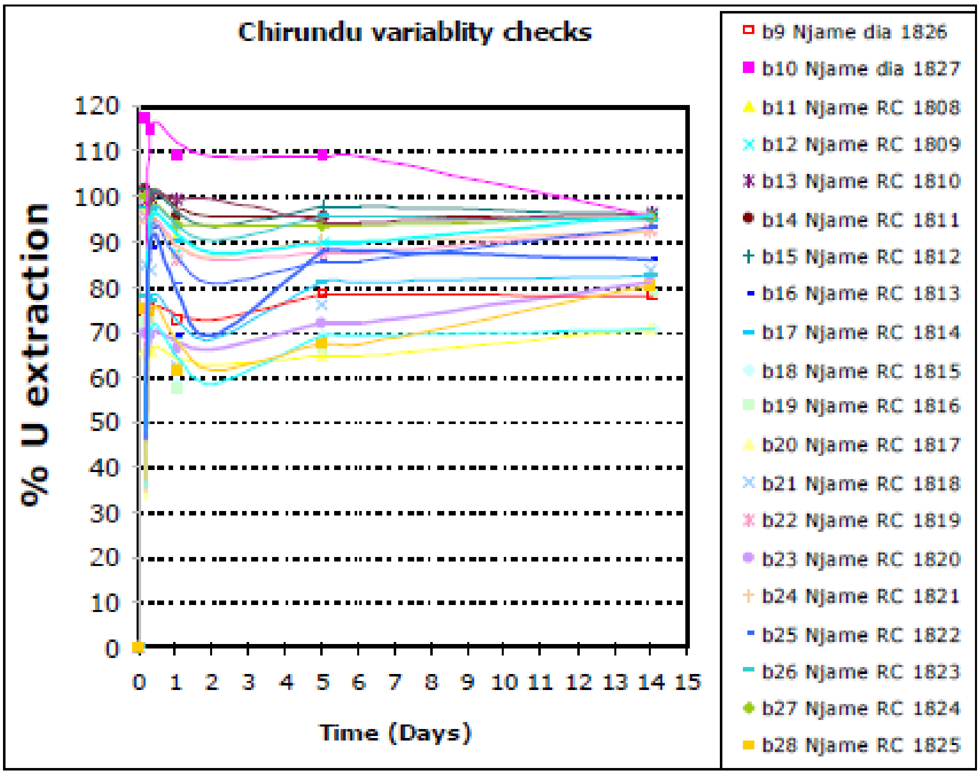


Figure 13-11: Chirundu – Njame - Variability Checks (Source: Mintek, 2010)

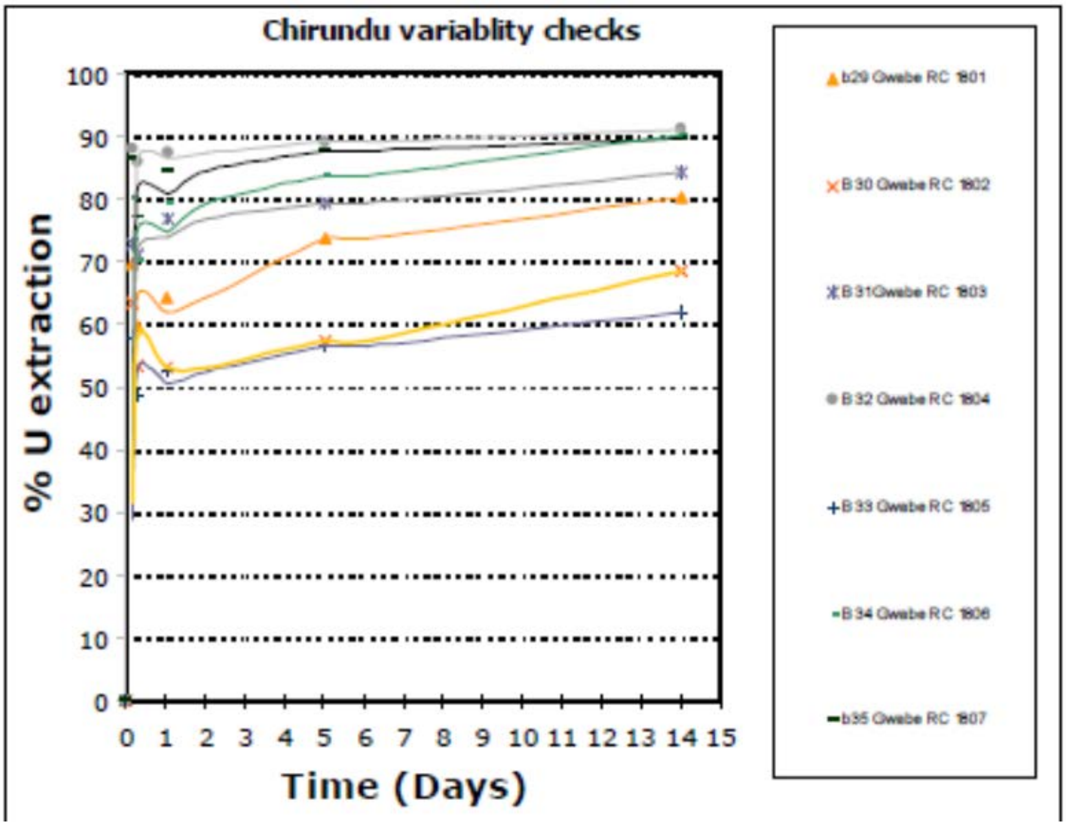


Figure 13-12: Chirundu Variability Checks – Gwabe - U Extraction over Time (Source: Mintek, 2010)

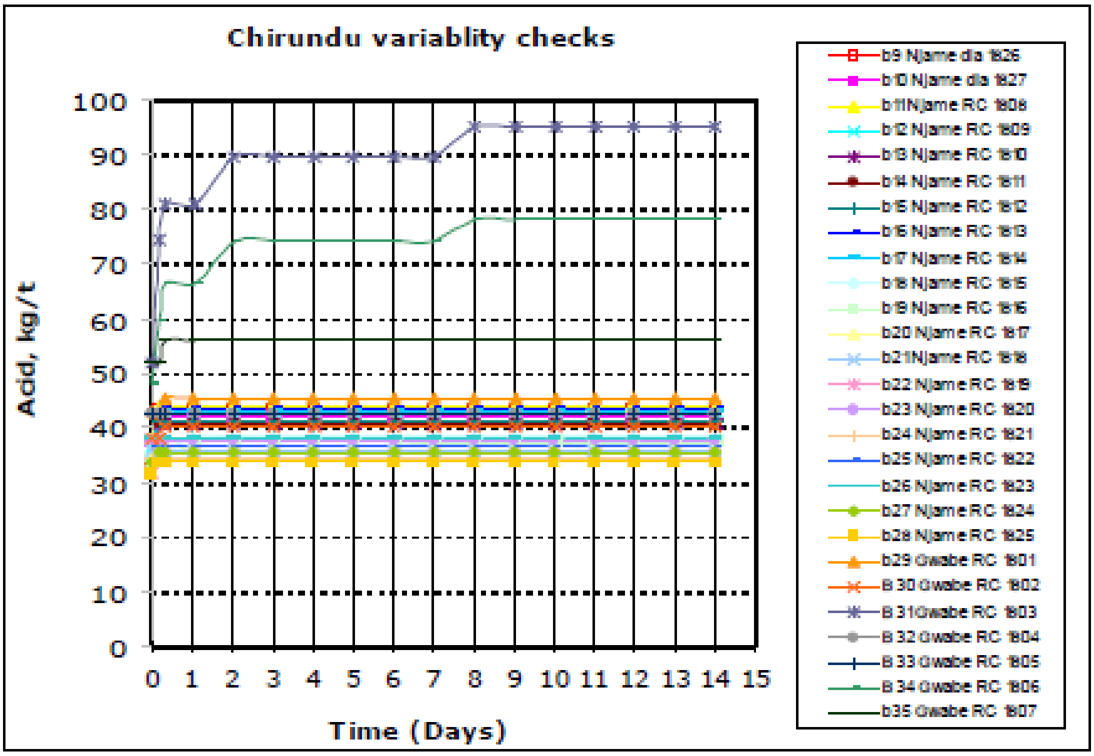
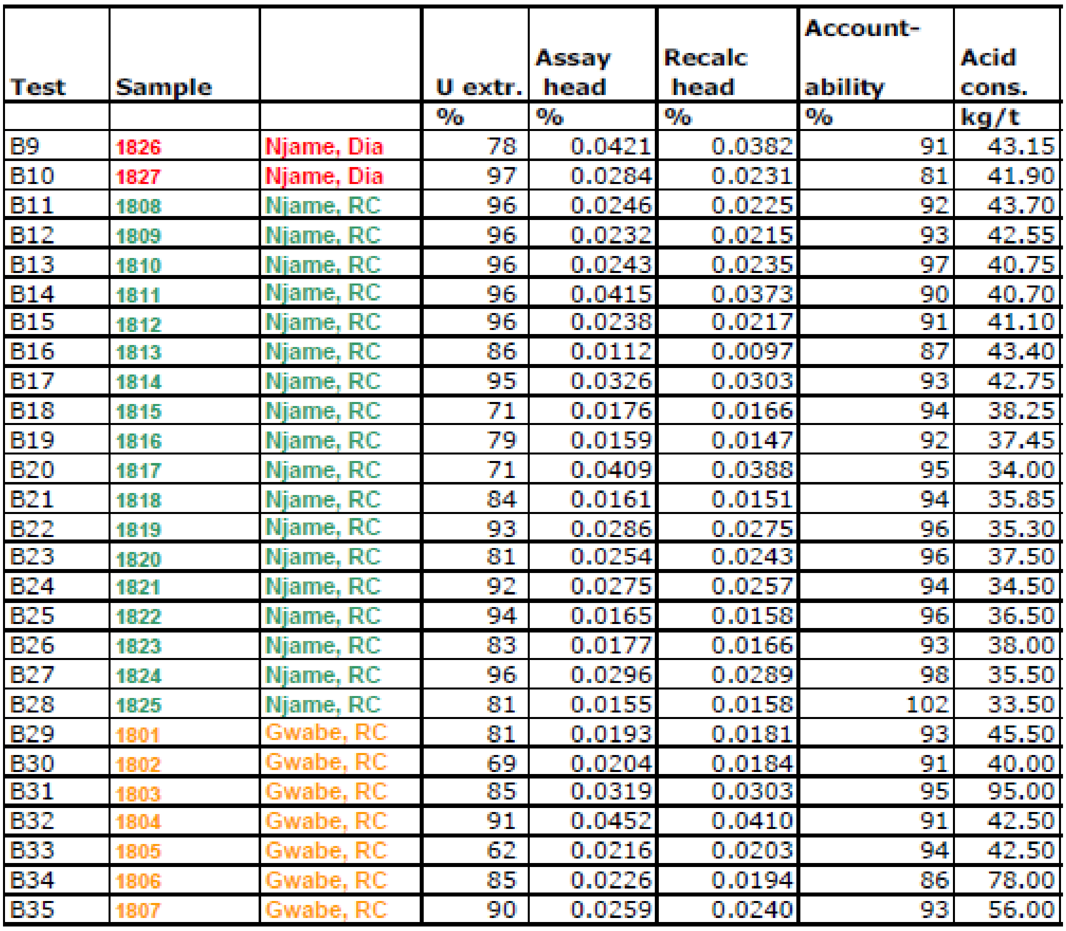


Figure 13-13: Chirundu Variability Checks – Acid Consumption (Source: Mintek, 2010)

Table 13-2: Summary of Variability Results (Source: Mintek, 2010)



Test	Sample		U extr.	Assay head	Recalc head	Account-ability	Acid cons.
			%	%	%	%	kg/t
B9	1826	Njame, Dia	78	0.0421	0.0382	91	43.15
B10	1827	Njame, Dia	97	0.0284	0.0231	81	41.90
B11	1808	Njame, RC	96	0.0246	0.0225	92	43.70
B12	1809	Njame, RC	96	0.0232	0.0215	93	42.55
B13	1810	Njame, RC	96	0.0243	0.0235	97	40.75
B14	1811	Njame, RC	96	0.0415	0.0373	90	40.70
B15	1812	Njame, RC	96	0.0238	0.0217	91	41.10
B16	1813	Njame, RC	86	0.0112	0.0097	87	43.40
B17	1814	Njame, RC	95	0.0326	0.0303	93	42.75
B18	1815	Njame, RC	71	0.0176	0.0166	94	38.25
B19	1816	Njame, RC	79	0.0159	0.0147	92	37.45
B20	1817	Njame, RC	71	0.0409	0.0388	95	34.00
B21	1818	Njame, RC	84	0.0161	0.0151	94	35.85
B22	1819	Njame, RC	93	0.0286	0.0275	96	35.30
B23	1820	Njame, RC	81	0.0254	0.0243	96	37.50
B24	1821	Njame, RC	92	0.0275	0.0257	94	34.50
B25	1822	Njame, RC	94	0.0165	0.0158	96	36.50
B26	1823	Njame, RC	83	0.0177	0.0166	93	38.00
B27	1824	Njame, RC	96	0.0296	0.0289	98	35.50
B28	1825	Njame, RC	81	0.0155	0.0158	102	33.50
B29	1801	Gwabe, RC	81	0.0193	0.0181	93	45.50
B30	1802	Gwabe, RC	69	0.0204	0.0184	91	40.00
B31	1803	Gwabe, RC	85	0.0319	0.0303	95	95.00
B32	1804	Gwabe, RC	91	0.0452	0.0410	91	42.50
B33	1805	Gwabe, RC	62	0.0216	0.0203	94	42.50
B34	1806	Gwabe, RC	85	0.0226	0.0194	86	78.00
B35	1807	Gwabe, RC	90	0.0259	0.0240	93	56.00

Table 13-3: Acid Bottle Roll Extraction Summary, According to Ore Lithology (Source: Mintek, 2010)

Deposit	Lithology	Average Acid Consumption kg/t	Average Extraction %
Gwabe	Pebbly Grit	41.3	65.0
Gwabe	Gritty Sandstone	48.0	87.0
Gwabe	Siltstone	86.5	85.0
Average		**57.1**	**80.0**
Njame	Pebbly Sandstone	40.5	91.0
Njame	Sandstone	37.6	86.0
Njame	Siltstone	38.6	87.0
Average		**38.9**	**88.0**

13.6.4 Alkaline Leach Bottle Roll Testwork

Bottle roll tests using alkaline conditions (45 g/l Na_2CO_3 and 15 g/l $NaHCO_3$) have been conducted on both the Gwabe and Njame composite samples. The results were 71% recovery at Njame and 58.52% at Gwabe, respectively, after a 7-day bottle roll leach test. The extraction efficiencies were not as high as the acid bottle roll testwork, so the column leach testwork was conducted using an acid leach.

13.6.5 Column Leach Testwork

Column leach testwork was carried out at SGS Lakefield, Canada and Mintek.

SGS Testwork

For this phase of the testwork, 150 mm diameter columns with a height of 2 m were selected. Once optimum leach conditions were established, a second phase of work was undertaken in a 3 m column. Diamond drilling to provide representative core samples were used to create two composite samples for the column leach testwork, one each for Njame and Gwabe. Results after 21 days of leaching are presented in Table 13-4.

Table 13-4: Column Testwork Results after 21 Days of Operation (Source: SGS, 2009)

Column Reference	Days to Equilibrium	Relative Extraction[1] %	Acid Consumption kg/t	Acid Consumption at 80% Extraction kg/t	Fe^{3+} Consumption kg/t	Fe 3+ Consumption at 80% Extraction kg/t
Njame no 1	Not Reached	37.6	44.45	N/A	0	N/A
Njame no 2	16	99.3	28.6	17.2	7.98	4.69
Njame no 3	Not Reached	27	47.5	N/A	0	N/A
Njame no 4	19	94.5	37.6	18	10.3	4.66
Njame no 5	15	166.3	47.25	<11.7	12.8	<2.3
Gwabe 1	19	115.6	56.7	31	9.6	2.61
Gwabe 2	Not Reached	16.5	49.14	N/A	0	N/A

[1] Relative Extraction - Reported extractions are based on the estimated content of uranium in the ore (head assay multiplied by the mass of ore) and the uranium in the liquor (concentration multiplied the volume of leachate). Extractions of greater than 100% indicate under reporting of the uranium content in the precursor ore. Reconciliation of the extractions should have been taken on completion of the tests and based on liquor and residue assays.

The results indicate that the addition of an oxidant greatly enhances the rate of extraction (see Table 13-4 and Figure 13-14), leading to excellent leach dynamics. Columns in which oxidant was added all reached complete extraction or equilibrium within 20 days. Further testwork is required to establish the optimum level of oxidant addition. Acid addition was on the basis of pH control. Acid consumptions have been based on based on the quantity added to achieve 80% relative extraction.

The basis for the study has been set at 17 kg/t acid, 0.5 kg/t ferric sulfate, and 3.4 kg/t hydrogen peroxide (equivalent to 4.66 kg/t ferric sulfate). Hydrogen peroxide has been selected in preference to ferric sulfate as the primary oxidant for the commercial scale operation as it generates no residual metals that may require removal from the process. This will require further investigation in the next phase of testwork.

Figure 13-15 illustrates the fast uranium dissolution kinetics for the Gwabe column, with the majority of uranium amenable to leaching by this process leached within seven days.

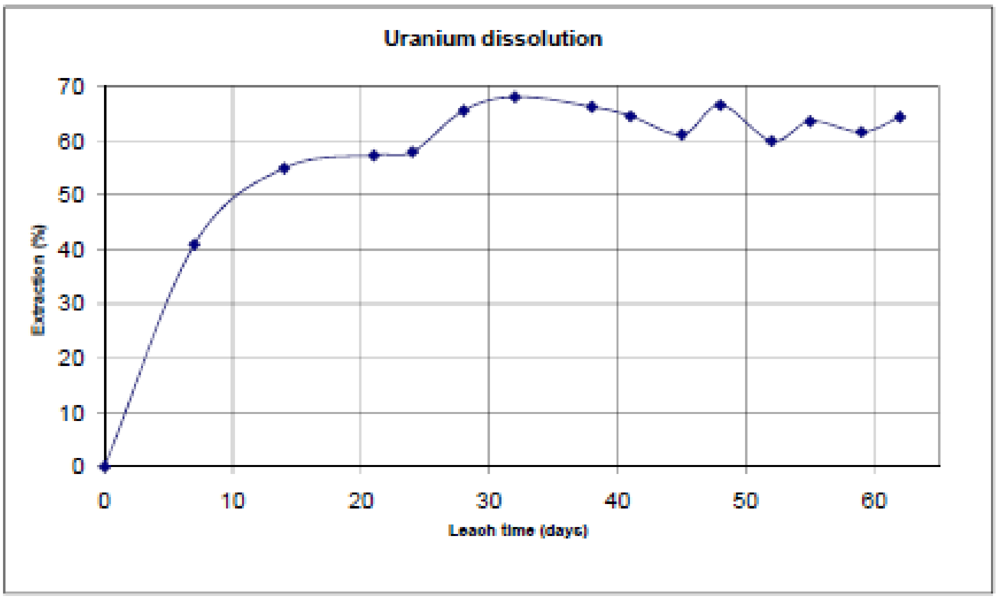


Figure 13-14: Column Leach Tests for Njame 3m Optimum Column after 62 Days Continuous Leaching (Source: SGS, 2009)

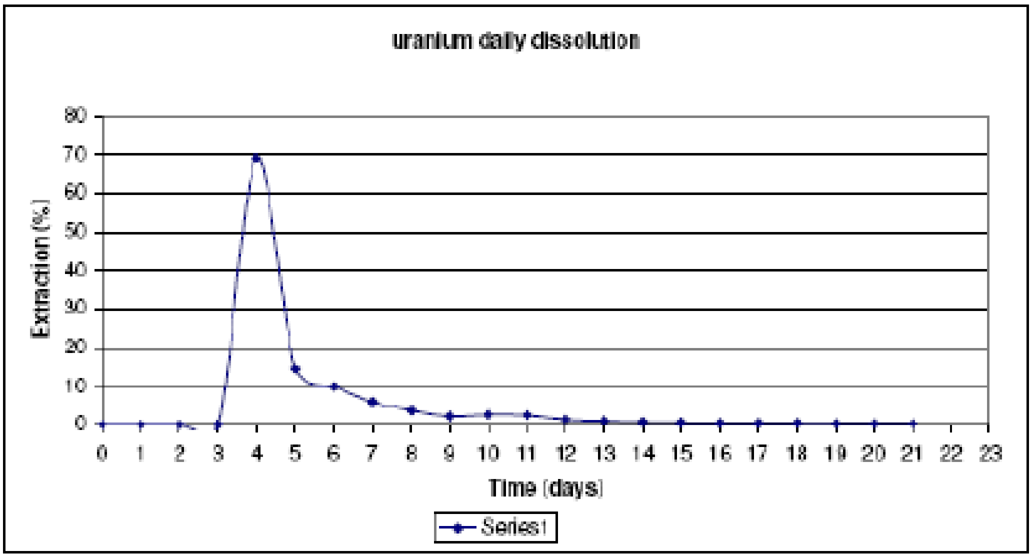


Figure 13-15: Gwabe Column Daily U Dissolution (Ferric Sulfate and Acid Cure) (Source: AERL, 2008)

Mintek Column Testwork

Two composite samples derived from several Njame drill cores were subjected to 2 m acidic column leach tests, one of the feed samples was scrubbed (“scrubbed ore”) and one was unscrubbed (“unscrubbed ore”).

The data for the column leach tests are indicated in the graphs below, with uranium extraction curves based on drainage solution assays and recalculated head. Leaching was complete after 25 days, or an irrigation ratio of 2 m^3/t ore (Figure 13-16). At this point the extraction curve shows a decrease due to the recycle of fresh solution at 100 ppm U into the column as irrigation liquor. This does not reflect precipitation of uranium but rather it is due to the lag between the introduction of lower concentration solution into the column, and the time required for the pregnant leach solution to reach this concentration.

After completion of the irrigation, dye-penetration tests were performed, and the penetrant solution was collected and assayed for uranium, in order to account for additional uranium that was washed from the column during the penetration test. This is observed as an increase in extraction back to the same extraction levels that were observed prior to recycling of the 100 ppm solution, confirming that the uranium extraction had levelled off by day 30.

Columns were irrigated with solution at pH 1.5 (3 g/L sulfuric acid) and 0.5 g/L Fe, adjusted to 600 mV with hydrogen peroxide in the feed tank (Figure 13-17).

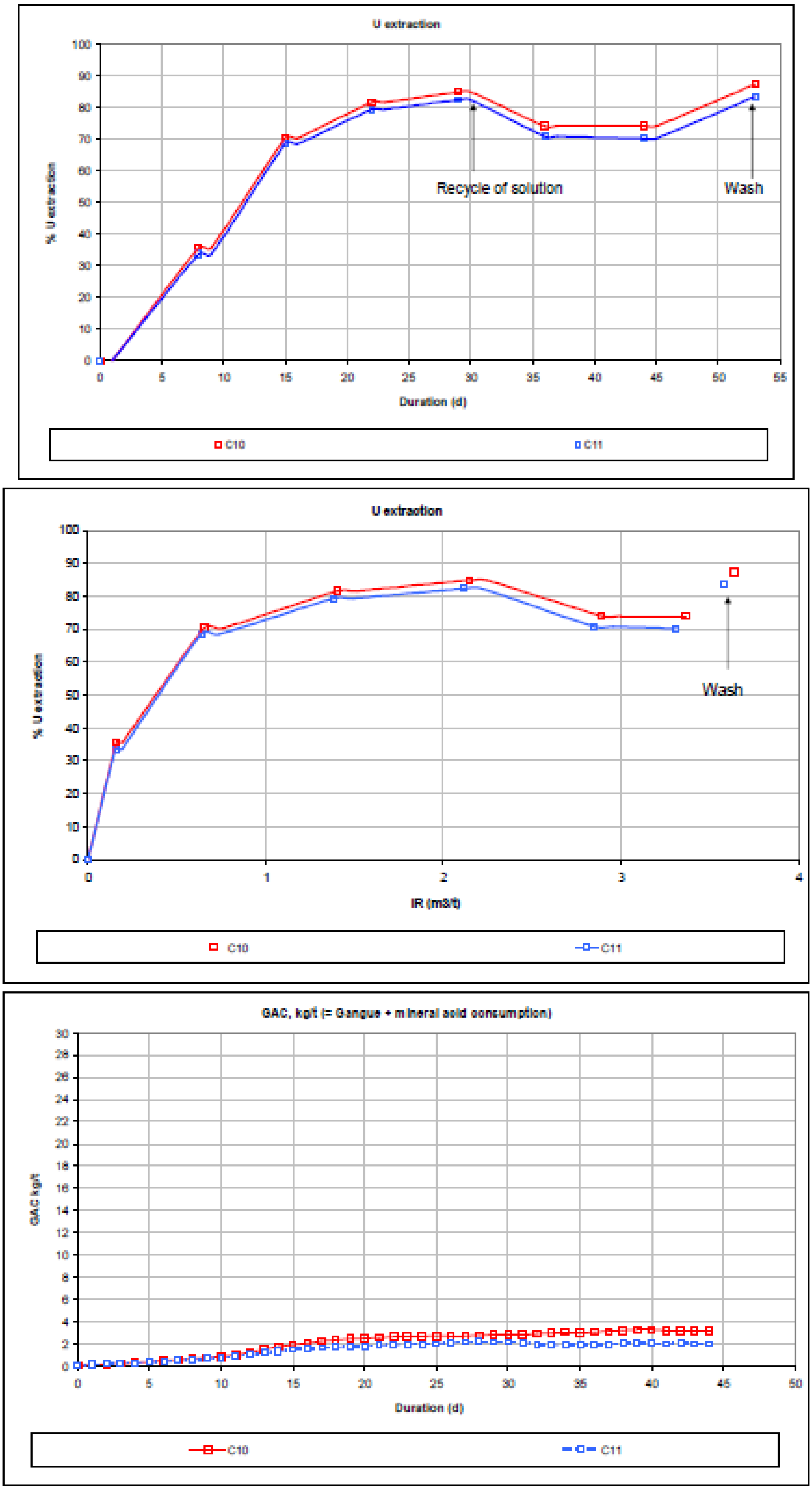


Figure 13-16: Extraction and Acid Consumption - Njame 2m Column (Source: Mintek, 2010)

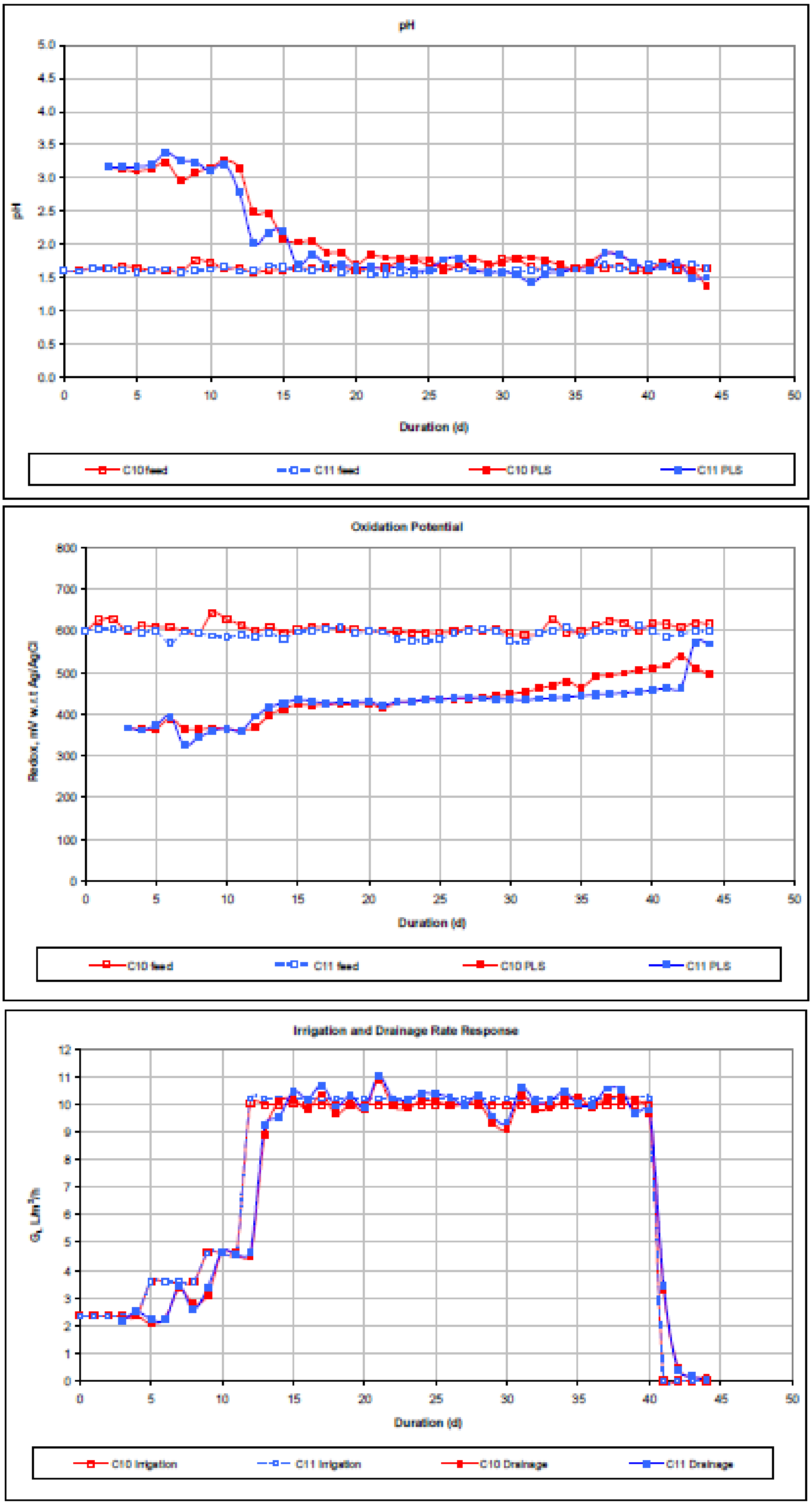


Figure 13-17: Test Conditions for Njame 2m Mintek Columns (Source: Mintek, 2010)

The following conclusions can be drawn:

- The final uranium extraction obtained from the Njame ore was around 85%, with the unscrubbed ore (sample number C10) yielding slightly higher uranium extraction than the scrubbed ore (sample number C11).
- At a stacking height of 2 m, uranium extraction is completed within 30 days, or an irrigation ratio of 2 m^3/t.
- Using irrigation liquor at pH=1.5, the final acid consumption was around a very low 3 kg/t.
- The ore compacted within 5 days by 12 to 15% and then stabilised. The unscrubbed ore actually compacted noticeably less than the scrubbed ore.
- No benefit could be observed from the dry scrubbing of the ore prior to leaching, thereby confirming earlier observations that fines occurring as hard lumps is not a significant problem with the Njame ore.
- The final moisture hold-up in the ore at steady state was a relatively high 20%, but ponding never occurred and the ore material seems to exhibit adequate permeability to irrigation liquor to sustain the irrigation rate of 10 L/h/m^2 applied.

13.6.6 Uranium Recovery

Mintek completed precipitation tests on the recovered uranium (Mintek, 2012), the following is summarised from their report. The U_3O_8 from the pregnant acid leach solution (“PLS”) from the Mintek column testwork (225ppm U_3O_8) was recovered using a counter-current fluidised bed ion exchange in a NIMCIX column. The ion exchange bed was pre-fouled with sulfate and silica, of the two resins tested Rohm & Haas A4400 showed the better adsorption characteristics. The adsorption equilibrium isotherms for uranium loading onto the resin were influenced by sulfate concentration in the feed. Increasing sulfate concentration in the feed from ~6g/L to ~17g/L resulted in supressed U_3O_8 equilibrium loadings, at a barren equilibrium concentration of 100mg/L, the equilibrium U_3O_8 loading was ~51g/L and 40g/L respectively for A4400. A batch kinetic test indicated that >95% of equilibrium loading of U_3O_8 onto A4400 resin could be achieved within four hours.

A4400 resin was pre-loaded with ~35g/L U_3O_8, McCabe Thiele construction indicated seven stages of stripping would be required to achieve a residual concentration <500ppm U_3O_8 on the resin; 9g/L U_3O_8 eluate was produced.

Precipitation of uranyl peroxide was carried out using hydrogen peroxide with caustic addition for pH control. The mass of yellow cake produced during the testwork was 9.1g. Approximately 95% of the mass of yellow cake was UO_4, the rest being impurities.

13.6.7 Summary of Testwork

According to a mineralogical report completed previously at SGS, the uranium was observed as a combination of U-Ti oxides (presumably such as brannerite and betafite) and uraninite. The uranium content varies typically between 300 to 400 ppm U_3O_8. Successful leaching of uraninite would require oxidative leaching to oxidise the U(IV) to U(VI). The U-Ti oxides can be very refractory to leaching, but their leaching behaviour is difficult to predict and is best determined experimentally. The association with, and even occlusion of U-minerals in pyrite was mentioned in that report. The liberation of uranium from pyrite would require oxidation and solubilisation of the pyrite, but uranium locked in pyrite was not frequently observed and would therefore probably not be a major consideration for U extraction. During the testwork programme it was therefore considered important to include tests under both oxidising and non-oxidising conditions. The Gwabe deposit contains about 2% calcite and ankerite which, being carbonate minerals, are acid consuming. The Njame deposit contains virtually none of these carbonate minerals and would therefore be expected to be less acid consuming than the Gwabe ore. For this programme of testwork, it was therefore considered important to include leaching tests under both acidic and alkaline conditions.

Both Gwabe and Njame deposits occur at shallow depth with minimal dip, which permits mining by surface mining equipment. It is the intention to construct a heap leach pad at each of the deposits. Heap height of 10 m is currently envisaged, to be irrigated at 10 L/h/m^2 with mild acidic ferric liquor, being re-oxidised in the ponds using hydrogen peroxide if oxidising conditions are deemed to be required. Counter-current flow of the ore with intermediate leach solution ("ILS") and raffinate will be employed to increase the solution U-tenor. The current assumption has been that the resin can be loaded to 30 g/l U_3O_8.

From the results obtained by the programme of rolling bottle and column leach tests using acid described in this report, the following conclusions were drawn:

- The Ca content of the Njame ore is mostly <0.1%, whereas the Gwabe ore contains >0.1% Ca and variability samples containing up to 1% Ca have been found. This could indicate a higher acid-consuming calcite content in the Gwabe ore, compared to the Njame ore. Several silicates are also reactive to acid and could further increase the acid consumption of the Gwabe ore, but the reaction of acid consuming silicates during heap leaching can often be controlled somewhat by manipulating the acid concentration in the irrigation liquor, highlighting the importance of continual testwork during operations.
- Because both ores contain siltstone, it was suspected there could be a risk of a large proportion of fines occurring as hard lumps which decompose upon wetting which can impair the permeability of the ore during heap leaching. Several tests described in the report, however, indicated that this ore does not exhibit that problem, and additional pre-treatment of the ore like dry scrubbing would be unnecessary.
- It is concluded that the uranium that was extracted from both the Njame and Gwabe ore samples leached by chemical dissolution (be it in acid or alkaline medium), and oxidative leaching does not offer any advantage over non-oxidative leaching.
- During acidic leaching, the maximum uranium extraction from both the Njame and Gwabe ore is independent of the acid strength, between pH values of 1.2 to 1.8.
- For both ores, the maximum uranium extraction is higher during acid leaching than during alkaline leaching. From the Njame ore, a maximum of 80 to 90% extraction can generally be obtained by acid leaching (although individual variability samples yielded close to 100% extraction), but 70 to 80% by alkaline leaching. From the Gwabe ore, a maximum of 70 to 80% extraction can be obtained during acid leaching, but about 60% by alkaline leaching.
- The acid consumption of blends of both ores increase with increasing acidity, increasing from 12 to 70 kg/t on Njame ore and increasing from 75 to 140 kg/t on the Gwabe ore as the pH is lowered from 1.8 to 1.2. On both ore sample blends, it was possible to keep the acid consumption in rolling bottle tests below 3 kg/t during acidic leaching at pH=1.8 under non-oxidising conditions.

- During alkaline leaching, both ore samples consumed zero alkali leach reagent.
- A comparison of the rolling bottle leach results on variability samples and their respective lithologies reveals that the Gwabe ore exhibits greater variation in both acid consumption and uranium extraction amongst the different ore lithologies than the Njame ore.
- During acid column leaching of Njame ore crushed to <20 mm, final uranium extraction of around 85% was obtained.
- At a stacking height of 2 m, uranium extraction during percolation leaching of Njame ore with irrigation liquor at pH=1.5 is completed within 30 days, or an irrigation ratio of 2 m^3/t. Using irrigation liquor at pH=1.5, the final acid consumption was around a very low 3 kg/t. The ore compacted within 5 days by 12 to 15% and then stabilised. The unscrubbed ore compacted noticeably less than the scrubbed ore. No benefit could be observed from the dry scrubbing of the ore prior to leaching, thereby confirming that fines occurring as hard lumps is not a significant problem with the Njame ore. The final moisture hold-up in the ore at steady state was a relatively high 20%, but ponding never occurred and the ore material seems to exhibit adequate permeability to irrigation liquor to sustain the irrigation rate of 10 L/h/m^2 applied.

13.7 Dibwe East

13.7.1 Geology

The Dibwe East uranium mineralization is located in-between Denison's Dibwe and Mutanga prospects and is hosted by a number of relatively flat lying to gently southeast dipping units of Karoo sandstone interbedded with siltstone and shale. Exploration data suggests that the uranium mineralization is hosted within paleochannels in meandering stream depositional systems, with fine- to coarse-grained sands and silts containing some organic and pyrite material acting as a reductant for the precipitation of uranium.

A Colorado plateau-type sedimentary uranium deposit has been discovered within the Dibwe East area and has previously been explored by Denison. The results also suggest that diagenetic fluids have moved through the sedimentary rocks and were part of the process of emplacement of uranium mineralization in the area. The Dibwe East deposit consists of three stacked mineralized horizons extending from surface to depths of 130 m. The A Horizon extends from surface to a depth of 45 m; B Horizon extends from 45 m to 80 m; and C Horizon extends from 80 m to 110 m. Coffinite is dominant at depth in the C Horizon while phurcalite (similar to autunite) is dominant in the A Horizon and B Horizon. The C Horizon is interpreted as primary mineralization from which the A and B Horizons are derived as secondary mineralization.

13.7.2 Mineralogical Testwork

The source of the uranium is believed to be the surrounding Proterozoic gneisses and plutonic basement rocks. Having been weathered from these rocks, the uranium was dissolved, transported in solution and precipitated under reducing conditions in siltstones and sandstones. Post lithification fluctuations in the groundwater table caused dissolution, mobilization and redeposition of uranium in reducing, often clay-rich zones and along fractures.

Mineralization is not strictly associated with a particular unit in the stratigraphic section. It was observed to occur in both the fine-grained and coarser material and mudstones especially where fractures and mud balls occur. Some mineralization occurred in association with manganese oxide or disseminated with pyrite. Mineralization in some bore holes was seen to occur where there was grey alteration, limonite and feldspar alteration and in dark grey mudstones. The strata dip in the south-easterly direction and mineralization seems to occur along dip.

In 2011, Denison Mines Zambia Limited requested ALS Chemex Johannesburg to conduct a mineralogical analysis of four uranium ore samples shown in Table 13-5 to identify the uranium and gangue minerals present in the various strata, including both low and high grade zones. The samples were in the form of drill cores.

Table 13-5: Sample List for Mineralogical Study (Source: Denison and RPA, 2012)

Sample Number	Depth from (m)	Depth to (m)	Sample Type	Weight (kg)	U Grade (ppm)
F000988	96.85	96.95	SPOT	0.3694	2,988
F000989	93.7	93.8	SPOT	0.4562	1,958
F000990	54.3	54.4	SPOT	0.231	724
F000991	17.3	17.4	SPOT	0.2996	1,608

The mineralogical analysis, using an automated Mineral Liberation Analyzer (MLA), was used to determine the uranium minerals (Table 13-6 and Table 13-7) present along with the associated gangue (ALS Minerals, 2011).

The data indicates that the main uranium phase in sample F00988 was coffinite, which accounted for 97 Wt% of the uranium ore minerals in the sample. There was also some Ti-bearing coffinite in the sample.

Coffinite was also the most abundant ore mineral in F00989, accounting for nearly 67 Wt% of the ore minerals. It was predominantly Ti-coffinite (55 Wt%), with lesser coffinite (11 Wt%). Gastunite (28 Wt%) was also a major ore mineral in this sample, which also contained a significant amount of Brannerite (6 Wt%). Despite having the second highest grade of the samples submitted, there was difficulty in finding the ore minerals in this sample, hence the lower particle counts recorded.

Sample F00990 had less coffinite (26 Wt %) than the other two samples, with the most abundant ore mineral being phurcalite (72 Wt%). There was also a small amount (2 Wt%) of gastunite present.

Phurcalite accounted for almost all of the uranium ore minerals in sample F00991, with minor coffinite and gastunite making up about 1 Wt% of the ore minerals.

Table 13-6: Relative Uranium Mineral Abundance (Source: Denison and RPA, 2012)

Mineral	Relative Abundance (Wt%)				Particle Count			
	F00988	F00989	F00990	F00991	F00988	F00989	F00990	F00991
Brannerite	0.1	5.9	0.3	0.0	6	1	23	0
Coffinite	97.3	11.2	23.4	0.6	785	5	296	85
Ti-Coffinite	2.2	55.4	2.6	0.2	239	7	164	37
Phurcalite	0.1	0.0	71.8	98.9	4	0	556	427
Curite	0.0	0.0	0.0	0.0	1	0	0	0
Gastunite	0.4	27.5	2.0	0.3	79	10	134	57
Total	**100.0**	**100.0**	**100.0**	**100.0**				

Table 13-7: Uranium Distribution (%) (Source: Denison and RPA, 2012)

Mineral	F00988	F00989	F00990	F00991
Brannerite	0.03	4.74	0.15	0.00
Coffinite	98.23	15.47	22.53	0.59
Ti-Coffinite	1.33	45.69	1.46	0.09
Phurcalite	0.06	0.00	74.14	99.10
Curite	0.01	0.00	0.00	0.00
Gastunite	0.35	34.10	1.72	0.22
Total	**100.00**	**100.00**	**100.00**	**100.00**

13.7.3 Type of Mineralization

Disseminated Uranium Mineralization

Disseminated uranium mineralization occurs in sandstones, conglomerates, and within mud layers, mud balls and mud flakes. The uranium is present as interstitial fine grained crystals or small amorphous masses constituting less than 1% by volume, if visible at all.

Figure 13-18: Mineralization Associated with Mn Oxide (Black) (Source: Denison and RPA, 2012)

Grades vary considerably between zones of disseminations, approximately 20 ppm to 2052 ppm U_3O_8 (geochemical) in mineralization is thought to be solely of a disseminated nature, although mud replacement material may also have been contained within core and therefore not visible during logging leading to higher values.

Lithological units containing iron-oxide and uraniferous mineralization returned moderate to high assays, as did material containing sulfides (pyrite). Samples from MR05, MR08, MR09, MR10 and MR11 contain both sulfides and micas, and disseminated U_3O_8 and were expected to return low assays.

The presence of sulfides alongside uranium oxides may indicate a transitional zone and/or preferential replacement/reduction of uranium compounds by one chemical route over another (such as decaying organic matter over oxidation of sulfides) as uraniferous groundwaters moved through the lithologies.

Uranium Mineralization Associated with Mudstones and Siltstones

An association between uranium mineralization (as replacements and selvages) is evident at all prospects. The muddy lithologies include mud balls (within sandstones), flakes and interbeds. In some cases, mud balls may be completely replaced by mineralization (Figure 13-19).

The degree of replacement varies from fully replaced mud balls to those with a thin selvage of mineralization whilst others are unmineralized. This is attributed to:

- different ground water chemistry,
- differing volumes of reducing matter within the mud (fully replaced material may have been a peat like material), and
- the porosity of the muddy lithology during the influx of uraniferous ground water.

Figure 13-19: Mudclasts (Source: Denison and RPA, 2012)

Fracture Hosted Uranium Mineralization

Drilling intersected a number of fractures and fault rocks. The fractures intersected in core were generally steep (although several shallower angled fractures were logged). Mineralization is seen as crystal coatings on surfaces and as concentration close to surfaces (Figure 13-20). Most notably at the Dibwe-Mutanga-Dibwe corridor, these fractures are coated with black Fe/Mn oxides which in turn may be coated with secondary uranium phosphate mineralization (Autunite, meta-Autunite and selenite).

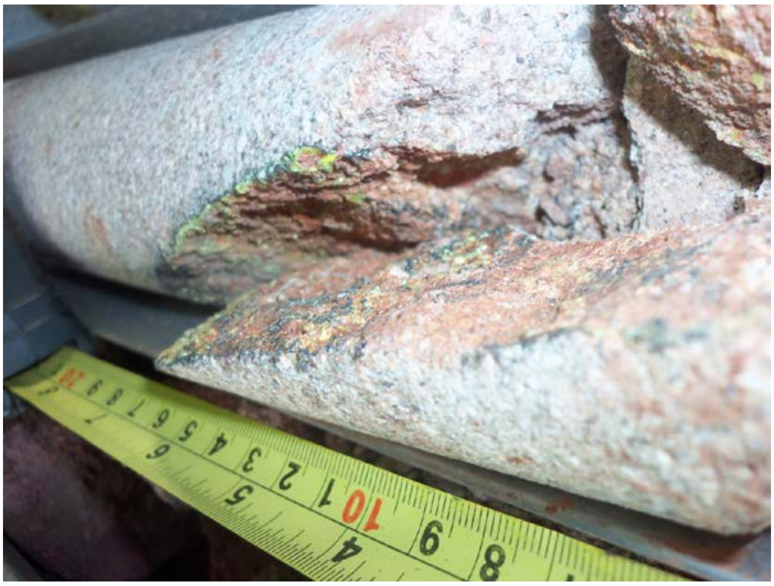


Figure 13-20: Mineralization in a Fracture with the Presence of Mn Oxide (Source: Denison and RPA, 2012)

Uranium Mineralization Associated with Pyrite

Grains and poorly defined blebs of pyrite occur throughout all the sedimentary lithologies of the Project area. Uranium mineralization may be elevated in some (relatively) pyrite rich zones.

The presence of sulfides in close proximity to uranium oxides may indicate a transitional zone and/or preferential replacement/reduction of uranium compounds by one chemical route over another (such as decaying organic matter over oxidation of sulfides) as uraniferous groundwaters moved through the lithologies.

13.7.4 Mineral Processing and Metallurgical Testing

The following information has been summarised from a report prepared by Mintek, Randburg, South Africa (November, 2012) titled “Preliminary Metallurgical Testwork on Dibwe East Deposit Drill Core Samples”.

Denison supplied Mintek with 18 drill core samples, which were sourced from three different zones of the Dibwe East uranium-bearing mineral deposit, for metallurgical testing. The testwork included head sample characterization and preliminary bottle roll leach tests. Mutanga Uranium Project Denison Mines Corp Report No: R305.2013-106.

The samples averaged 275 ppm U_3O_8 for Zone 1438 ppm U_3O_8 for Zone 2, and 1043 ppm U_3O_8 for Zone 3, yielding an average grade of 586 ppm U_3O_8.

In Zones 1 and 2, uranium occurs mainly as U-phosphate and UAlSi-phosphate, with uranium as autunite, coffinite, Ti-coffinite, uraninite, U-phosphate and UAlSi-phosphate in Zone 3. The samples show similar bulk mineralogical compositions; for example, gangue minerals are dominated by albite, kaolinite, microcline, muscovite and quartz, as determined by X-ray diffraction (XRD), but with varying proportions.

Bottle roll leach tests yielded averaged uranium extractions of 85% (Zone 1), 88% (Zone 2), and 81% (Zone 3) on 100% passing 25 mm crushed ore samples, which are comparable to results achieved for Mutanga (85%) and higher than those obtained at Dibwe (75%).

Leaching of fine milled material on six drill core samples achieved similar uranium extractions as for the -25 mm samples, except in the case of two samples (B4 and B5) which yielded higher extractions for the fine-milled material, namely: B4: 96% (fine-milled) vs 70% (-25 mm), and B5: 72% (fine-milled) vs 62% (-25 mm). It therefore seems that the uranium-bearing minerals of the Dibwe East samples are reasonably accessible to leaching at a crush size of -25 mm.

Similar acid consumptions, ranging from 2 kg/t to 6.5 kg/t, were obtained for the samples from Zones 1 and 2. Zone 3 acid consumptions ranged from 5 kg/t to 9 kg/t for some samples and up to 39 kg/t for others, with the higher acid consumption in all likelihood as a result of carbonate present in the latter samples.

Analcime ($Na(Si_2Al)O_6 \cdot H_2O$), an acid consuming mineral, was also found to be present in r sample B17. The average acid consumption of 10 kg/t for the Dibwe East samples is comparable to that of Dibwe (12.3 kg/t); both being higher than for Mutanga (3 kg/t).

Acid (only) and acidic, ferric leaching (at a solution potential of 550 mV vs 3 M KCl, Ag/AgCl) yielded similar extents of uranium extraction. For example, for Zone 1, B2: 98% (acid only and acidic, ferric), B4: 96% (acid only) vs 95% (acidic, ferric), for Zone 2, B5: 72% (acid only and acidic, ferric), B13: 95% (acid only and acidic, ferric), and for Zone 3, B10: 89% (acid only) vs 91% (acidic, ferric), B17: 95% (acid only) vs 96% (acid ferric).

13.8 SRK Summary of the Metallurgical Testwork

The samples tested from each of the deposits indicates that the ore is amenable to leaching using sulfuric acid and similar test conditions used by SGS and Mintek and as outlined in Section 17 the ore can be treated in the same way with one processing method being applied.

Composite samples that are representative of the combined RoM that is outlined in Section 15 should be tested to ensure that the recoveries indicated by each of the individual deposits can be achieved from the likely RoM compositions.

Although mineralogically similar to Mutanga and Dibwe, further metallurgical and mineralogical testwork is required on the Chirundu and Dibwe East deposits to confirm factors that could affect U_3O_8 extraction and recoveries and to confirm the optimum extraction method.

Average acid leach uranium extraction was similar for each of the deposits, with some outliers resulting in higher acid consumption (up to 140 kg/t in one case) and/or lower extraction efficiency (as low as 30% in sub-optimal test conditions) due to varying mineralogy within some of the deposits; however, the extraction efficiency typically varied from 75 to 95%. An overall recovery and acid consumption for each deposit has been selected at this stage and is shown below in Table 13-8. There is further potential to optimise the test conditions to improve the acid consumption and extraction efficiency.

Table 13-8: Summary of Uranium Recovery and Acid Consumption for each deposit

Deposit	U Recovery (%)	Acid Consumption (kg/t ore)
Mutanga	85.4	3.86
Dibwe East	93.3	6.37
Dibwe	74.6	9.34
Njame	85.1	2.61
Gwabe	75.4	18.49

14 MINERAL RESOURCE ESTIMATES (ITEM 14)

14.1 Introduction

The Mineral Resource Statements for the Mutanga Uranium Project presented herein represent the Dibwe East (“DE”), Dibwe (“DI”), Gwabe (“GW”), Mutanga (“MU”), and Njame (“NJ”) deposits and are presented in accordance with the guidelines of the Canadian Securities Administrators’ National Instrument 43-101.

The models reported herein were completed both by Company Staff, in the case of Gwabe and Njame, and consultants, in the case of Mutanga, Dibwe, and Dibwe East:

- Dibwe East – Roscoe Postle Associates Inc. (RPA), 2012.
- Dibwe – CSA Global (CSA), 2009.
- Mutanga – CSA, 2009.
- Gwabe – African Energy Resources Limited (AFR), February 2009.
- Njame – AFR, February 2009 (*and December 2009 for Njame South).

This section describes the Mineral Resource estimation methodology and summarises the key assumptions considered for each of the estimates. In the opinion of SRK, the Mineral Resource estimates reported herein are a reasonable representation of the global U_3O_8 Mineral Resources found in the deposits of the Mutanga Project at the current level of sampling. The Mineral Resources have been estimated in conformity with generally accepted CIM “Estimation of Mineral Resource and Mineral Reserves Best Practices” guidelines and are reported in accordance with the Canadian Securities Administrators’ National Instrument 43-101. Mineral Resources are not Mineral Reserves and do not have demonstrated economic viability. There is no certainty that all or any part of the Mineral Resource will be converted into Mineral Reserve.

The databases used to estimate the Mineral Resources were reviewed by SRK. SRK is of the opinion that the current drilling information is sufficiently reliable to interpret with confidence the boundaries for U_3O_8 mineralisation in the drilled areas and that the assay data are sufficiently reliable to support Mineral Resource estimation. SRK has also reviewed the geological models, Mineral Resource estimation techniques, and Mineral Resource classification design employed by AFR, CSA and RPA in the preparation of the Mineral Resource estimates and is of the opinion that these areas of work conform with generally accepted CIM “Estimation of Mineral Resource and Mineral Reserves Best Practices” guidelines.

The following sections have in part been summarised from the following reports:

- CSA Resource Report entitled: NI43-101 Technical Report Mineral Resource Estimates for the Mutanga Uranium Project, Denison Mines Corp, Zambia, Africa.
- AFR Resource Report entitled: Mineral Resource Report for the Njame and Gwabe Uranium Deposits, Chirundu Project, Zambia.

14.2 Resource Estimation Procedures

The resource evaluation methodology involved the following standard procedures:

- database compilation and verification;
- construction of wireframe models for the boundaries of the mineralisation;
- definition of resource estimation domains;
- data conditioning (compositing and capping) for geostatistical analysis and variography;
- block modelling and grade interpolation;
- resource classification and validation;
- assessment of “reasonable prospects for economic extraction” and selection of appropriate cut-off grades; and
- preparation of the Mineral Resource Statement.

14.3 Resource Database

14.3.1 Dibwe East

SRK was provided with a Microsoft Excel database containing the Dibwe East drilling data as prepared and verified by RPA. Downhole radiometric and assay data is provided in the databases. Downhole radiometric data was adjusted by RPA based on correlation with the available assay data and used for the calculation of Mineral Resources. Within modelled mineralised zones, the sample database comprises 40% assay data, with the remaining 60% representing downhole radiometric data.

The Dibwe East Deposit Mineral Resource estimate is based on the drilling database which contains 171 RC and 141 diamond drillholes for a total of 33,692 m. A summary of the drilling statistics by drill type is provided in Table 14-1. The holes are also shown in Figure 14-1.

In addition to the drilling data, 253 bulk density determinations have been collected and used to support block model density. A topographic survey data has been generated based on the drillhole collars, which were surveyed using a DGPS system.

Table 14-1: Dibwe East Resource Estimate - Summary Drilling Statistics

Drill Hole Series	Number of Holes	Meters
RC	171	17,725
DDH	141	15,967
Total	**312**	**33,692**

14.3.2 Mutanga and Dibwe

SRK was provided with a Microsoft Excel database containing the Dibwe and Mutanga drilling data as prepared and verified by CSA. Downhole radiometric and assay data is provided in the databases, both of which were used for the estimation of Mineral Resources.

At Dibwe, within modelled mineralised zones, the sample database comprises 10% assay data, with the remaining 90% representing downhole radiometric data. Within modelled mineralised zones at Mutanga, the sample database comprises 25% assay data, with the remaining 75% representing downhole radiometric probe data.

The Dibwe deposit Mineral Resource estimate is based on the drilling database which contains 152 RC and 213 diamond drillholes for a total of 31,519 m. The Mutanga deposit Mineral Resource estimate is based on the drilling database which contains 338 RC and 518 diamond drillholes for a total of 44,659 m.

A summary of the drilling statistics by drill type is provided in Table 14-2 and Table 14-3. The holes are also shown in Figure 14-3 and Figure 14-5.

In addition to the drilling data, 91 bulk density determinations have been collected and used to support block model density. A topographic survey data was generated during 2006 based on air borne geophysical survey by New Resolution Geophysics (“NRG”).

Table 14-2: Dibwe Resource Estimate - Summary Drilling Statistics

Drill Hole Series	Number of Holes	Meters
RC	152	10,790
DDH	213	20,729
Total	**365**	**31,519**

Table 14-3: Mutanga Resource Estimate - Summary Drilling Statistics

Drill Hole Series	Number of Holes	Meters
RC	338	14,066
DDH	518	30,592
Total	**856**	**44,659**

14.3.3 Gwabe

SRK was provided with a Microsoft Access database containing the Gwabe drilling data as prepared and verified by AFR. Downhole radiometric data was included in the database, but this was not reviewed by SRK as only assay data was used for the estimation of Mineral Resources. The database also contains information documenting the QAQC data and results of density determinations.

The Gwabe deposit Mineral Resource estimate is based on the drilling database which contains 286 RC and 39 diamond drillholes for a total of 14,122m drilled by AFR. A summary of the drilling statistics by drill type is provided as Table 14-4.

In addition to the drilling data, 291 bulk density determinations have been collected and used as the basis for tonnage reporting. Detailed topographic survey data has also been collected and used to generate a robust digital terrain model.

Table 14-4: Gwabe Resource Estimate - Summary Drilling Statistics

Drill Hole Series	Number of Holes	Meters
RC	286	12,754
DDH	39	1,368
Total	**325**	**14,122**

14.3.4 Njame

SRK was provided with a Microsoft Access database containing the Njame drilling data as prepared and verified by AFR. Downhole radiometric data included in the databases, but this was not reviewed by SRK as only assay data was used for the estimation of Mineral Resources. The database also contains information documenting the QAQC data and results of density determinations.

The Njame deposit Mineral Resource estimate is based on 74 aircore, 603 RC and 161 diamond drillholes for a total of 45,130 m drilled by AFR. These holes fall within the Njame North, East, Central and South areas. In addition to the drilling data, 760 bulk density determinations have been collected and used as the basis for tonnage reporting. Detailed topographic survey data has also been collected and used to generate a robust digital terrain model.

Table 14-5: Njame Resource Estimate - Summary Drilling Statistics

Drill Hole Series	Number of Holes	Number of Samples
RC	603	33,519
AC	74	3,300
DDH	161	8,311
Total	**838**	**45,130**

14.4 Geological Modelling

14.4.1 Dibwe East

RPA generated a mineralisation model for the Dibwe East deposit using Vulcan software. Mineralised horizons were interpreted using plans and cross sections based on a cut-off grade 100 ppm eU_3O_8 from downhole radiometric data, a minimum thickness of 1 m and maximum internal waste of 1 m. Geophysical logs were used as a guide to help interpret the position of uranium mineralised horizons within the host stratigraphy.

Boundaries generated from eU_3O_8 grade contouring in level plan were used to clip polygons created in cross section to derive 3D grade estimation domains.

The modelled mineralisation is shallow dipping to horizontal, NE-striking and interpreted to be broadly parallel to the host stratigraphy. The mineralisation wireframes are geologically continuous along strike for up 2.7 km, with a down-dip extent up to 700 m, and an average thickness ranging from 10-20 m.

A representative plan and cross-section view displaying the interpreted mineralisation model is provided in Figure 14-1 and Figure 14-2.

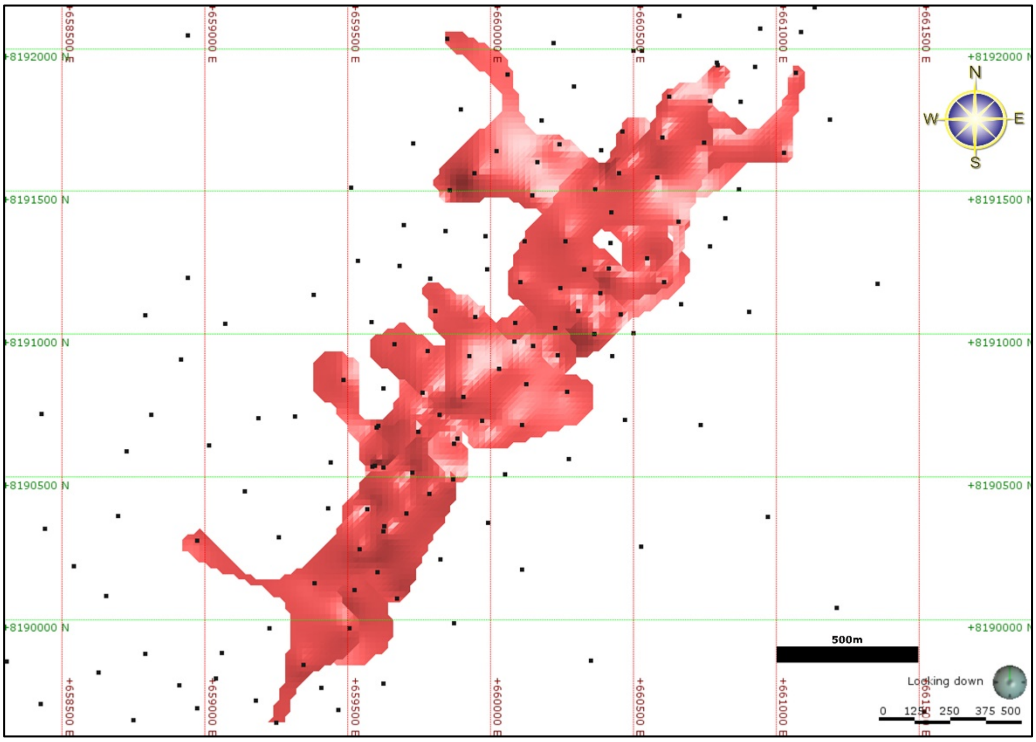


Figure 14-1: **Plan View of Dibwe East Resource Wireframes (Red) and Drill Hole Collars (Black)**

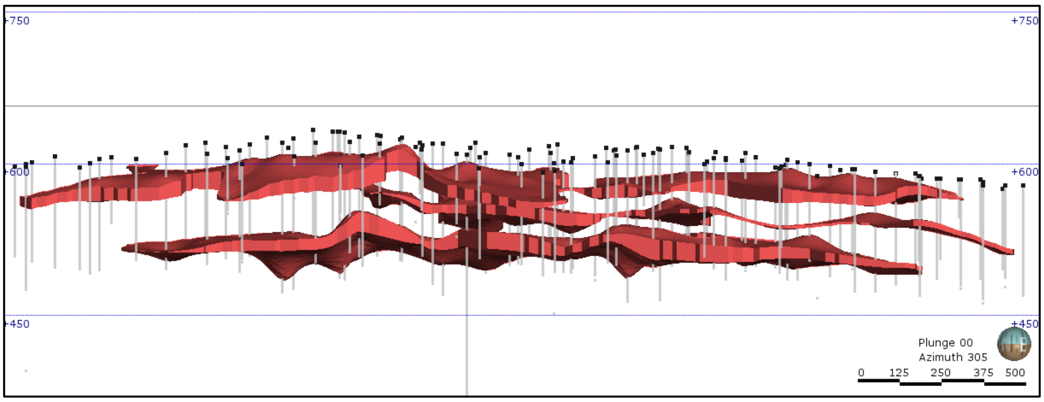


Figure 14-2: **Section View (Looking Northwest with 3x Vertical Exaggeration) of the Dibwe East Resource Wireframes**

14.4.2 Dibwe and Mutanga

CSA generated a mineralisation model for the Dibwe and Mutanga deposits using Micromine software. Mineralised horizons were interpreted in cross-section based on a cut-off grade of 100 ppm U_3O_8 from downhole radiometric and assay data and a minimum thickness of 1 m. Steeply dipping, NW-trending fault interpretations that correlate with step-changes in the U_3O_8 grade data in adjacent drillholes were used to create offsets in the modelled zones of mineralisation.

Polylines were digitised in 2D and then linked together in 3D to create wireframe domains for grade estimation.

At Dibwe, the modelled mineralisation dips between 15 to 20□ towards south east. The mineralisation is NE-striking and has been modelled to reflect a series of relatively narrow parallel, uniformly dipping horizons which are interpreted to relate to stratigraphic control from host sandstones, siltstones and shale units. Mineralisation wireframes are geologically continuous along strike for up 2.6 km, with a down-dip extent up to 500 m, and an average thickness typically ranging from 2-10 m.

At Mutanga, the modelled mineralisation is typically shallow dipping (05□) towards the south east, although closer to horizontal in areas of significant thickening. The mineralisation is NE-striking and is interpreted to be broadly parallel to the host stratigraphy. The mineralisation wireframes are geologically continuous along strike for up 1.2 km, with a down-dip extent up to 800 m, and an average thickness typically ranging from 5-20 m.

Representative plan and cross-section views displaying the interpreted mineralisation models are provided for Dibwe and Mutanga in Figure 14-3 to Figure 14-6.

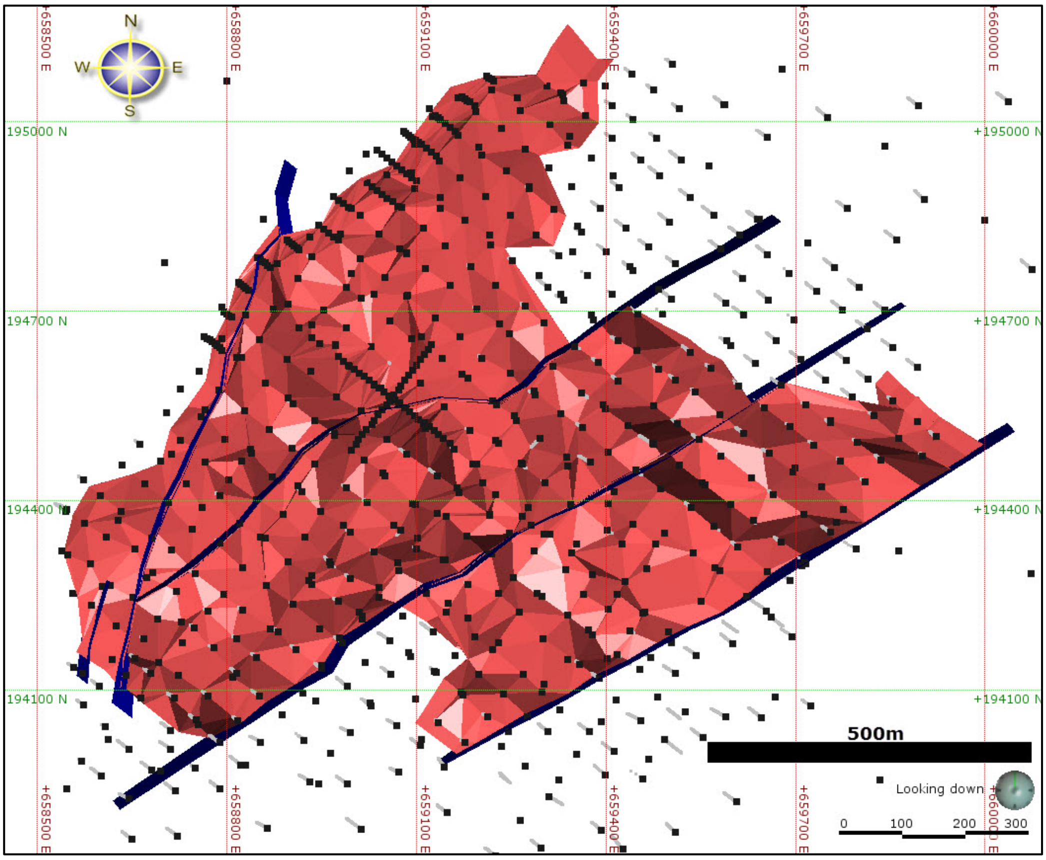


Figure 14-3: Plan View of Mutanga Resource Wireframes (Red), Fault Interpretations (Blue) and Drill Hole Collars (Black)

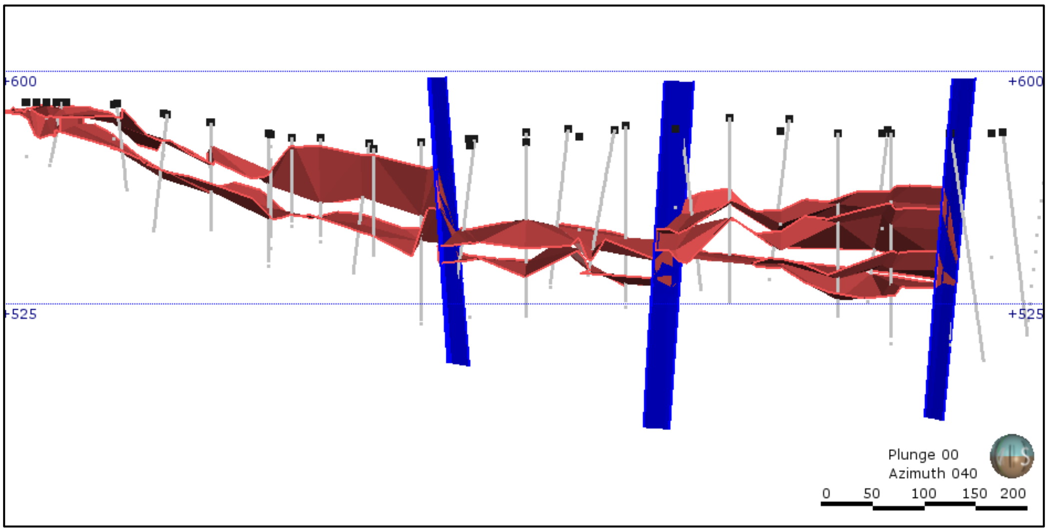


Figure 14-4: **Section View (Looking Northeast with 3x Vertical Exaggeration) of the Mutanga Resource Wireframes**

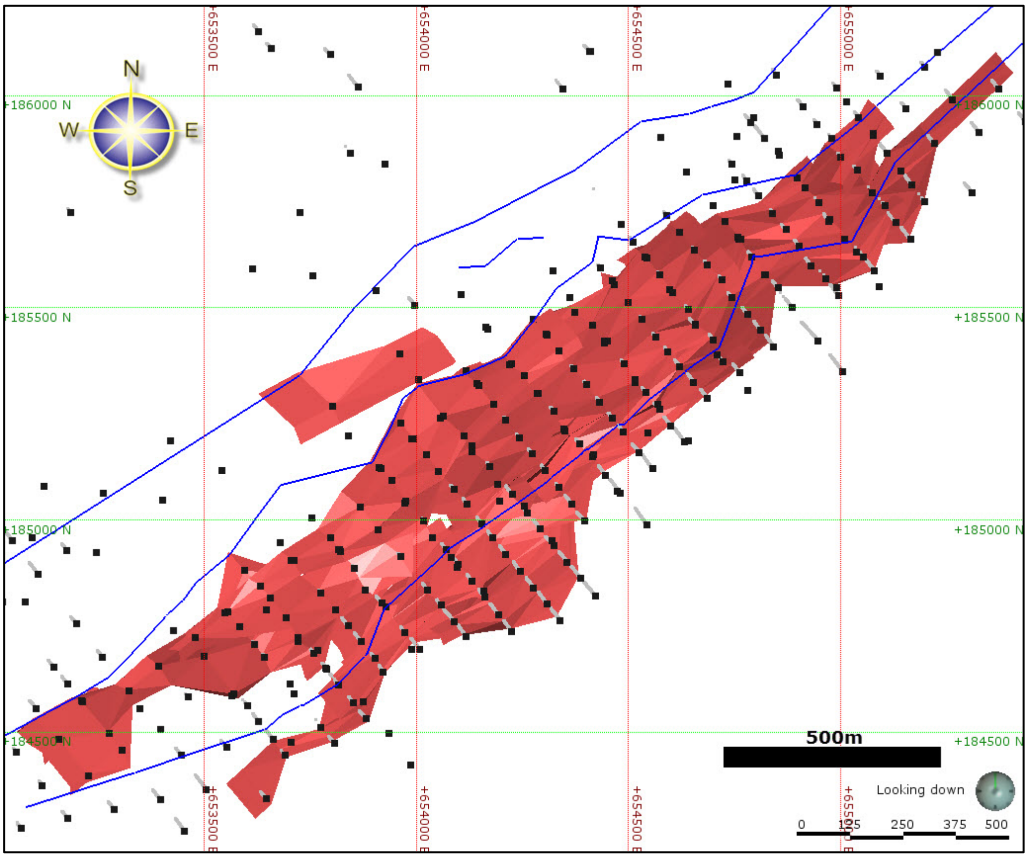


Figure 14-5: **Plan View of Dibwe Resource Wireframes (Red), Fault Interpretations (Blue) and Drill Hole Collars (Black)**

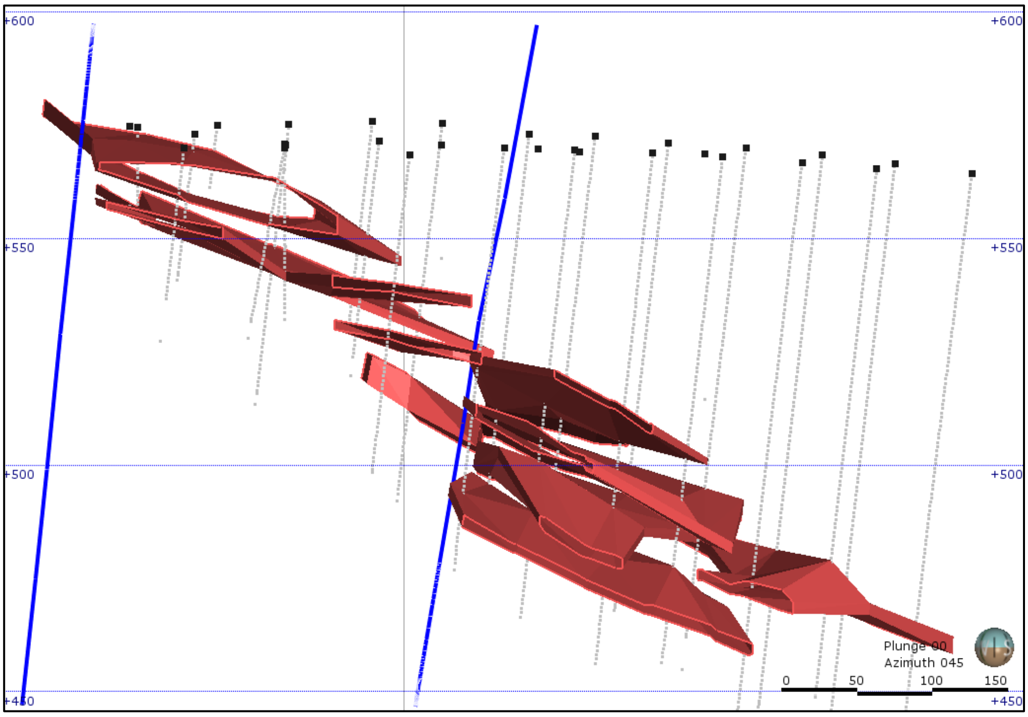


Figure 14-6: Section View (Looking Northeast with 3x Vertical Exaggeration) of the Dibwe Resource Wireframes

14.4.3 Gwabe

AFR generated the geological model for the Gwabe deposit using the 3D software package Gemcom Surpac®. Wireframe surfaces were generated by connecting north-south cross-sectional interpretations to model lithological contacts, mineralised zones and redox boundaries. Uranium mineralisation at Gwabe occurs with fine-to–coarse grained sedimentary sequence.

The typical sequence includes from the stratigraphic 'top' moving downwards:

- siltstones (fine);
- sandstones;
- pebbly/gritty sandstones; and
- grits and pebble conglomerates (coarse).

The lithological contacts have been modelled as sub-parallel layers of very shallow dip (generally between 2□ and 5□) to the north (Gwabe Local Grid). The main concentration of uranium mineralisation is located in a 10-20 m thickness of coarse-grained sandstones above a thick siltstone/mudstone unit. The shallow part of the mineralized zone appears to have been leached to a depth of 10-15 m.

Grade boundaries were defined using a nominal 100 ppm U_3O_8 cut-off. Representative plan view and cross section displaying the interpreted mineralisation model are provided in Figure 14-7 and Figure 14-8.

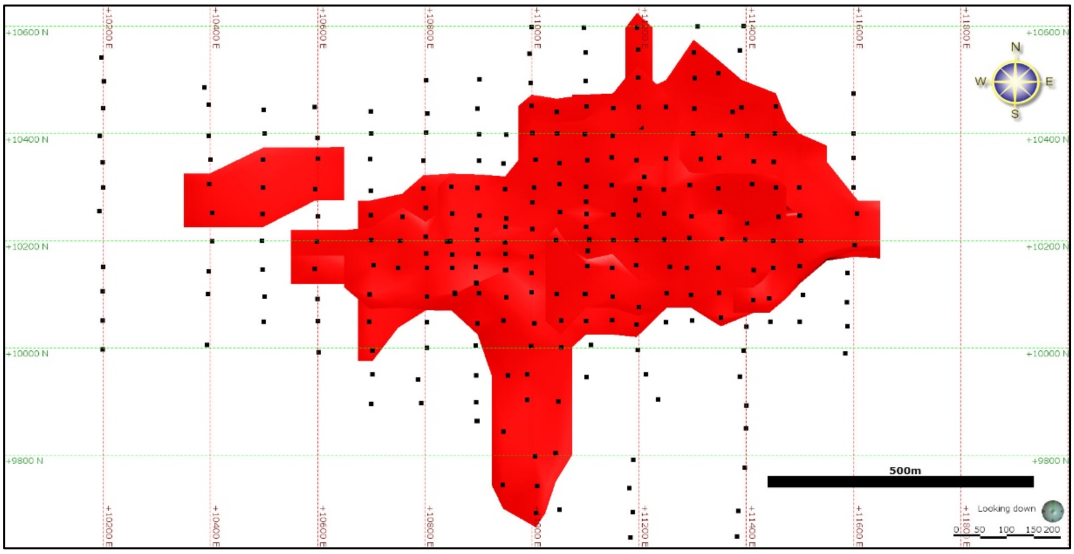


Figure 14-7: **Plan View of Gwabe Resource Wireframes (Red) and Drillhole Collars (Black)**

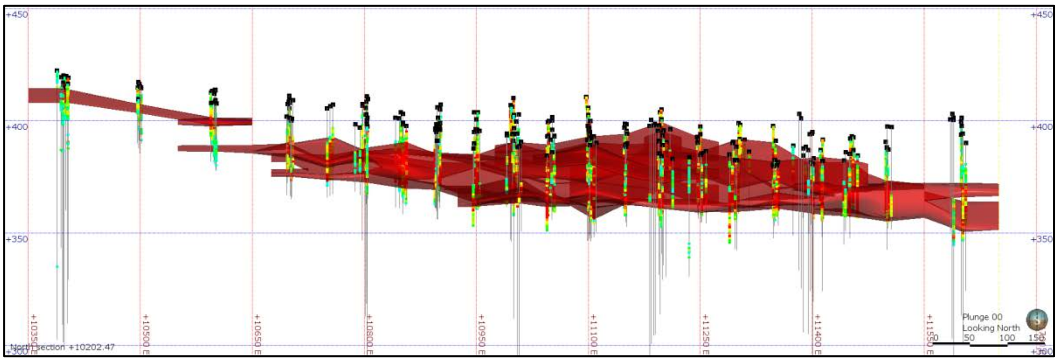


Figure 14-8: **Section View (Looking North with 3x Vertical Exaggeration) of the Gwabe Resource Wireframes**

14.4.4 Njame

AFR generated the geological model for the Njame deposit using the 3D software package Gemcom Surpac®. Wireframe surfaces were generated by connecting north-south cross-sectional interpretations to model lithological contacts, mineralised zones and redox boundaries (Figure 14-9 to Figure 14-10). Similar to Gwabe, uranium mineralisation at Njame occurs with fine-to–coarse grained sedimentary sequence.

The sequence contacts have been modelled as sub-parallel layers of very shallow dip (generally between 2° and 5°) to the east (Njame Local Grid). The main concentration of uranium mineralisation is predominantly located at the contact between these sequences where there is a rapid change from fine to coarse sediments.

Grade boundaries were defined using a nominal 100 ppm U_3O_8 cut-off. Representative plan view and cross section displaying the interpreted mineralisation model are provided in Figure 14-9 and Figure 14-10. The sequence contacts have been modelled as sub-parallel layers which dip generally between 2° and 5° to the east.

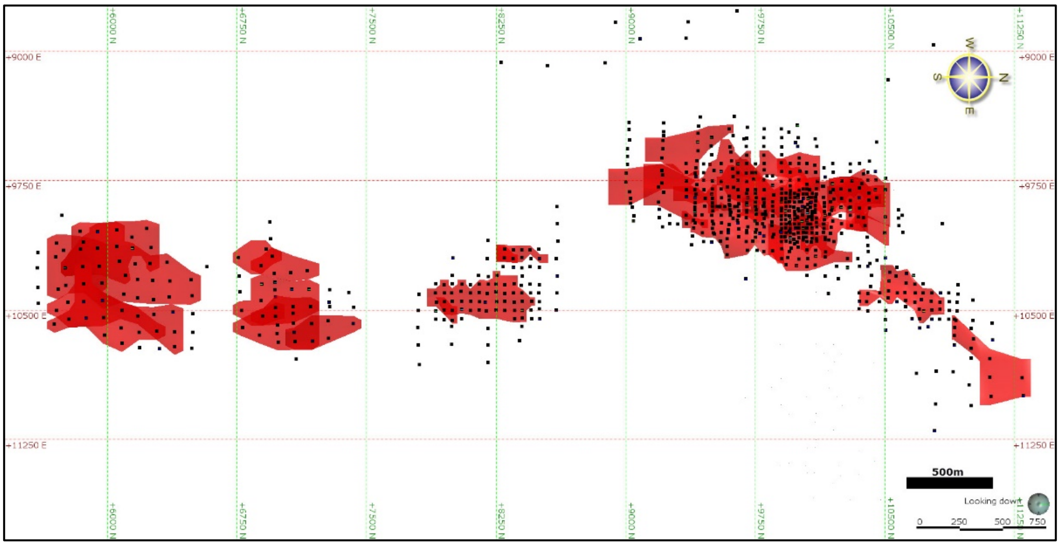


Figure 14-9: Plan View of Njame Resource Wireframes (Red) and Drillhole Collars (Black)

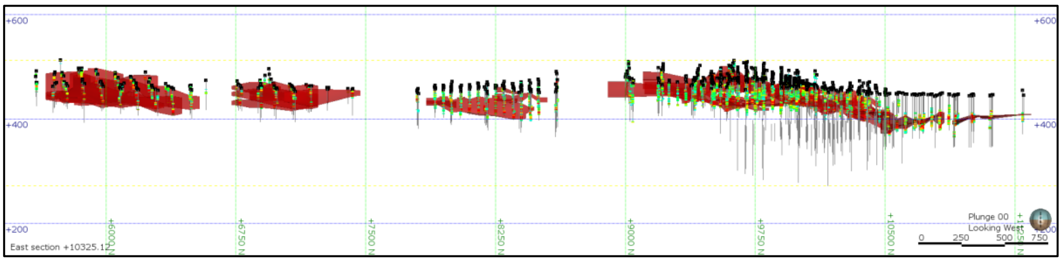


Figure 14-10: Section View (Looking North with 3x Vertical Exaggeration) of the Njame Resource Wireframes

14.5 Statistical Analysis and Variography

14.5.1 Dibwe East

The downhole radiometric data was composited to a 1 m composite interval, within the modelled resource wireframes.

Based on a review of cumulative frequency and histogram plots, high grade capping was applied to the composite data at 3000 ppm eU_3O_8.

Variography was attempted for all three mineralized horizons. However, meaningful variograms could not be established given the relatively wide sample spacing (100-200 m) and high grade variability.

14.5.2 Dibwe and Mutanga

The drillhole data for Mutanga and Dibwe was composited to a 1 m downhole composite interval, within the modelled resource wireframes.

Based on a review of domain covariance, visual analysis of histogram high grade tails and consideration of sample support, high grade capping was applied to the composite data per estimation domain.

For Dibwe, given the relatively low number of samples available, estimation domains were grouped in to spatially similar zones and top cuts were then applied to the following mineralisation (MIN) domain groups: MIN17+19 (750 ppm), MIN8 (1200 ppm), central MIN sub-domain (1660 ppm) and SE MIN sub-domain (1350 ppm.) At Mutanga, high grade capping was applied for U_3O_8 per mineralisation domain using the following limits: MIN1 (800 ppm), MIN2 (2000 ppm), MIN2_HG (2000 ppm), MIN3 (3000 ppm), MIN4 and MIN5 (900 ppm).

At Mutanga, given the variation in the sample coverage (typically 50 m, but 100 m in less well drilled zones) variography was completed based on close spaced (10 m) drilling (“CSD”) from a geostatistical cross, which covers an area of 200 x 200 m. The resulting variogram model, summarised in Table 14-6, was applied to all estimation domains.

For Dibwe, given the difficultly with generating a robust variogram model at the relatively wide spaced 100 x 50 m sample coverage, the CSD variogram model from Mutanga was applied to the estimation domains.

Table 14-6 CSD Variogram Model for Mutanga

Type	Model Parameters		
Domain	Close spaced drilling		
Nugget (%)	21		
Continuity Direction	DIR1	DIR2	DIR3
Dip	6	6	81
Azimuth	132	223	357
Range (m)	75	40	10

14.5.3 Gwabe

The drillhole database was composited to a 1 m downhole composite interval, within the modelled resource wireframes. 1m was chosen as an appropriate composite length as more than 90% of samples, within the modelled mineralisation, were 1 m length or less and the mining approach is assumed to be reasonably selective. Residual (partial) composites less than 40% of the 1 m interval were rejected from further study.

Basic statistics of the U_3O_8 composites within all of the modelled mineralisation lenses is presented in Table 14-7. The composites have been grouped as the main modelled lens comprises more than 95% of the total model volume and the smaller lenses contain statistically insignificant number of samples (<30 samples each).

As presented in Figure 14-11, the U_3O_8 grade distribution displays positive skew with moderate coefficient of variation. An assessment of the high-grade composites was completed to determine the requirement for high-grade capping. A review of the basic statistics and histogram charts required that a cut of 1,700 ppm U_3O_8 as highlighted in Figure 14-11 be applied before estimation.

Grade continuity was modelled using the geostatistical software Isatis, and in the mining package Gemcom Surpac. Variography was generated for the variable U_3O_8 based on the 1m capped downhole composites.

In summary, the key aspects of the variography, also presented in Figure 14-12, are:

- the relative nugget has been modelled from a downhole variogram at approximately 25%;
- 30% relative variance is modelled to a range of 110 m; and
- the overall range of 350 m major, 170 m semi-major, and 8 m minor, is noted to be in excess of the current drill spacing.

The variography indicates that moderate levels of short range variability exists, which is consistent with this mineralisation style. Applying the variogram model to estimation with ordinary kriging (”OK”), is expected to result in moderate levels of smoothing.

Table 14-7: Gwabe Resource Estimate - Raw Composite Summary Statistics

Statistic	Modelled Resource
Samples	1,270
Minimum	0
Maximum	4,920
Mean	273.16
Std. Dev.	373.27
CV	1.36
Variance	139,330

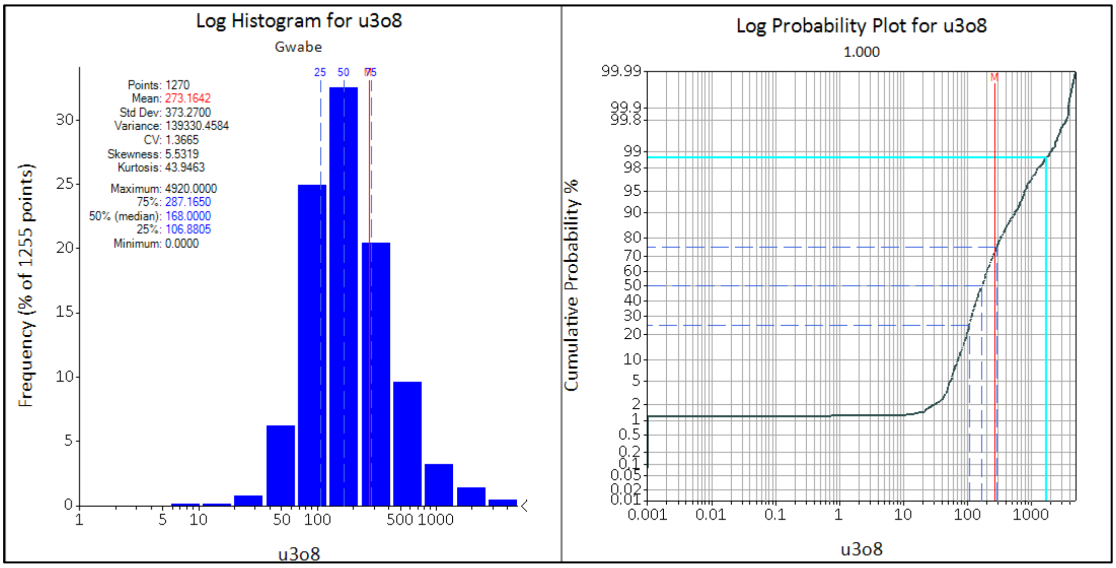
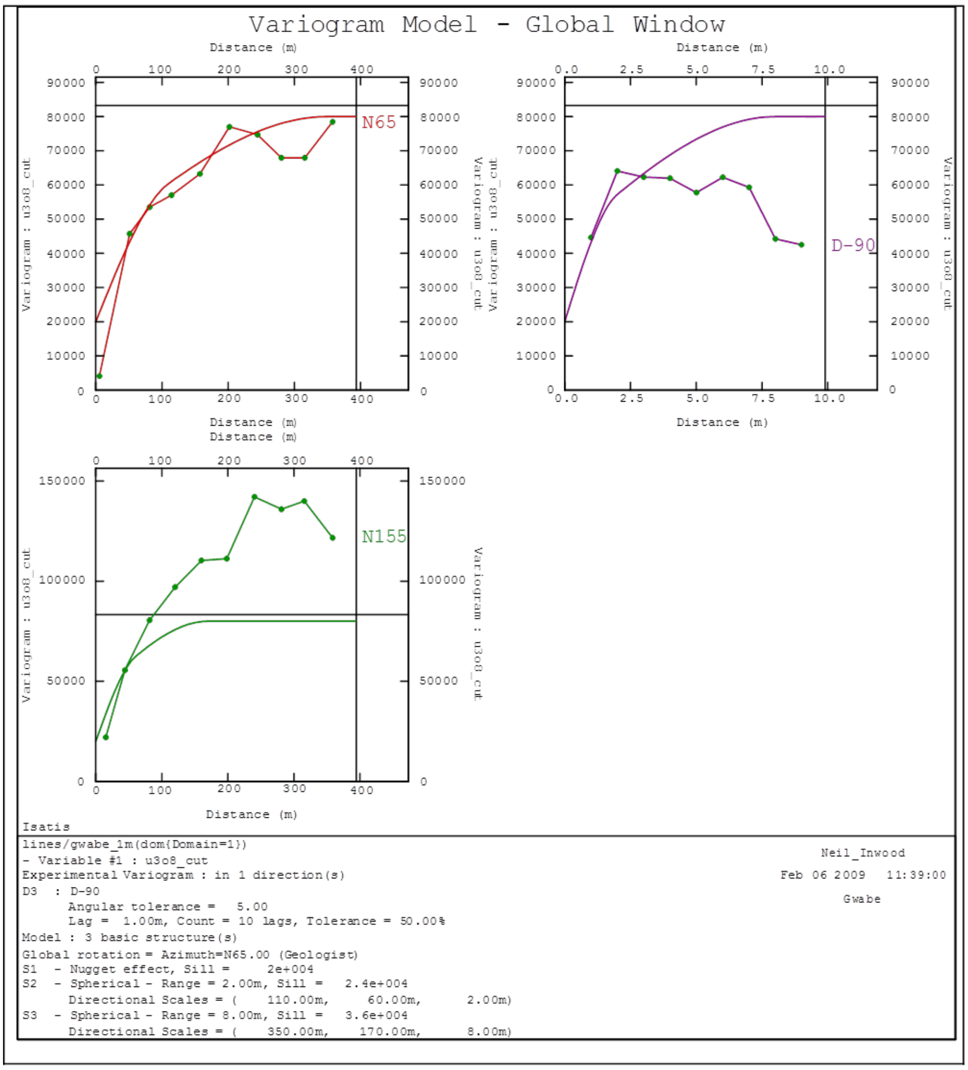


Figure 14-11: Histogram (Left) and Log-Probability Plot of Raw U_3O_8 Composites for the Modelled Mineralisation at Gwabe

Note the Chosen 1700 ppm Cap Level Illustrated in Cyan on the Log-Probability Plot.



```
lines/gwabe_1m(dom{Domain=1})                                Neil_Inwood
- Variable #1 : u3o8_cut
Experimental Variogram : in 1 direction(s)              Feb 06 2009   11:39:00
D3   : D-90
      Angular tolerance =   5.00                                Gwabe
      Lag =  1.00m, Count = 10 lags, Tolerance = 50.00%
Model : 3 basic structure(s)
Global rotation = Azimuth=N65.00 (Geologist)
S1   - Nugget effect, Sill =     2e+004
S2   - Spherical - Range = 2.00m, Sill =   2.4e+004
      Directional Scales = (    110.00m,     60.00m,      2.00m)
S3   - Spherical - Range = 8.00m, Sill =   3.6e+004
      Directional Scales = (    350.00m,    170.00m,      8.00m)
```

Figure 14-12: Variogram Model for Gwabe

14.5.4 Njame

The drillhole database was composited to a 1 m downhole composite interval, within the modelled resource wireframes; 1 m was chosen as an appropriate composite length as more than 90% of samples, within the modelled mineralisation, were 1 m length or less and the mining approach is assumed to be reasonably selective. Residual (partial) composites less than 40% of the 1m interval were rejected from further study.

Basic statistics of the U_3O_8 composites within all of the modelled mineralisation lenses is presented in Table 14-7. The composites have been grouped into two main modelled zones, Njame and Njame South as many of the individual modelled lenses are small and contain statistically insignificant numbers of samples.

As presented in Figure 14-13 and Figure 14-14, the U_3O_8 grade distribution displays positive skew with moderate coefficient of variation. An assessment of the high-grade composites was completed to determine the requirement for high-grade capping. A review of the basic statistics and histogram charts required that a cut of 2500 ppm U_3O_8 for Njame as highlighted in Figure 14-13 be applied before estimation.

Grade continuity was modelled using variography calculated and modelled within the geostatistical software Isatis, and in the mining package Gemcom Surpac. Variography was generated for the variable U_3O_8 based on the 1 m capped downhole composites.

In summary, the key aspects of the variography, presented as well in Figure 14-15, are:

- the relative nugget has been modelled at approximately 35%;
- 40% relative variance is modelled to a range of 40 m;
- the overall range of 120 m major, 90 m semi-major, and 8 m minor, is noted to be in excess of the current drill spacing.

The variography indicates that moderate levels of short range variability exists, which is consistent with this mineralisation style. Applying the variogram model to estimation with OK, is expected to result in moderate levels of smoothing.

Table 14-8: Njame Resource Estimate - Raw Composite Summary Statistics

Statistic	Njame	Njame South
Samples	2,451	257
Minimum	0	0
Maximum	9,650	1,090
Mean	309.80	262.76
Std. Dev.	388.98	197.49
CV	1.26	0.75
Variance	151,309	39,003

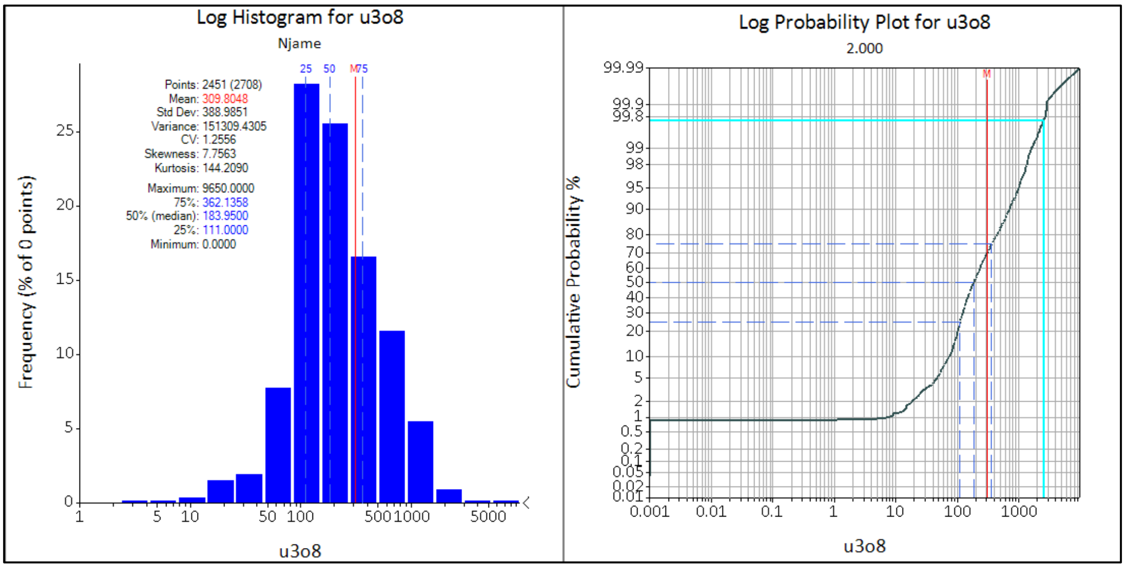


Figure 14-13: Histogram (Left) and Log-Probability Plot of Raw U_3O_8 Composites for the Modelled Mineralisation at Njame.

Note the Chosen 2500 ppm Cap Level Illustrated in Cyan on the Log-Probability Plot.

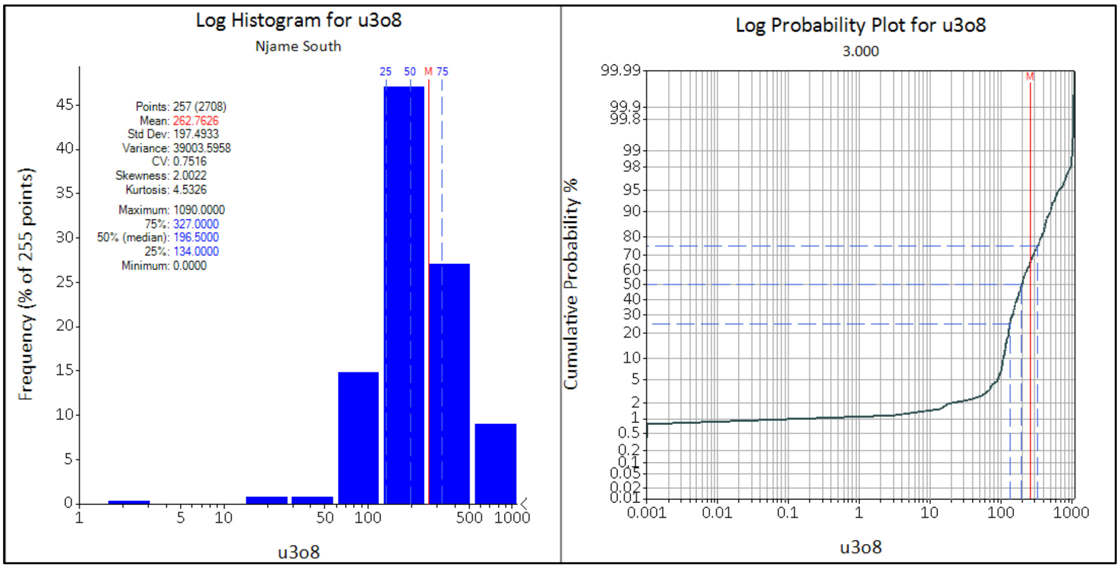
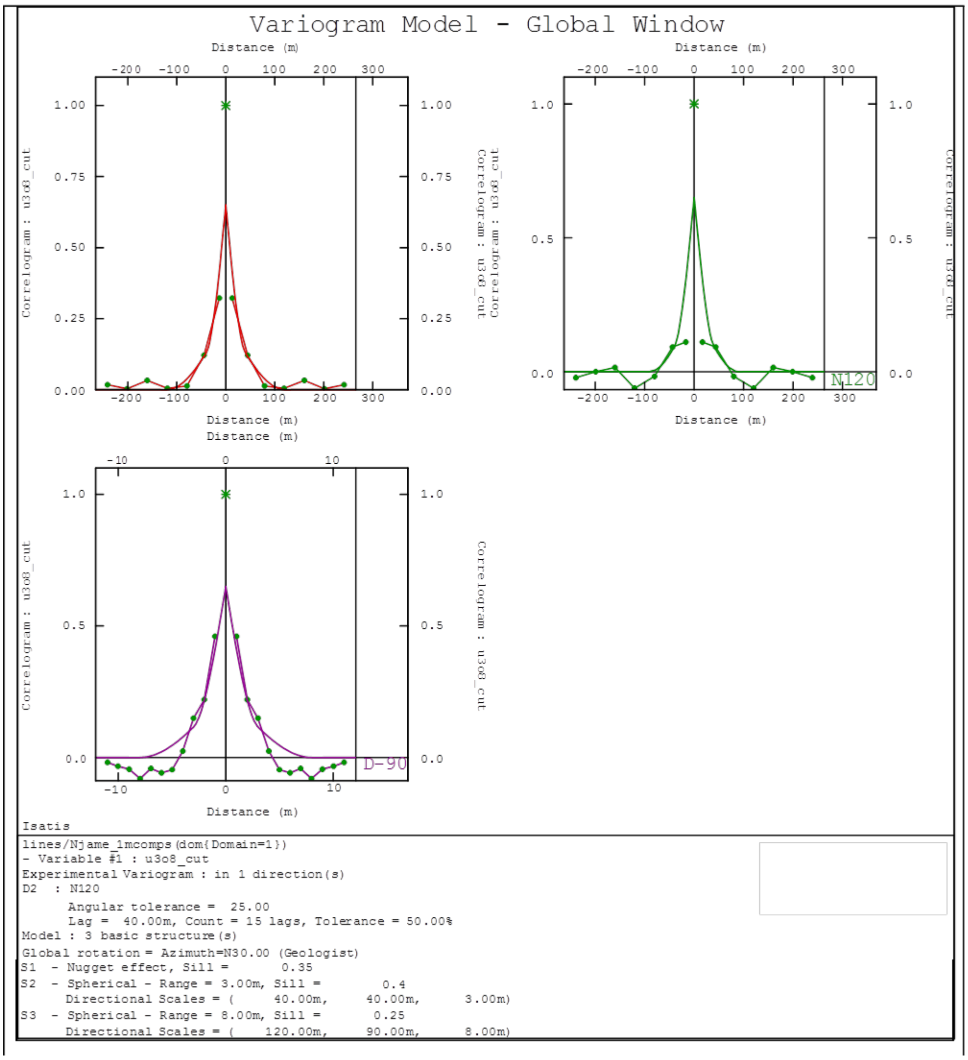


Figure 14-14: Histogram (Left) and Log-Probability Plot of Raw U_3O_8 Composites for the Modelled Mineralisation at Njame South



```
lines/Njame_1mcomps(dom{Domain=1})
- Variable #1 : u3o8_cut
Experimental Variogram : in 1 direction(s)
D2   : N120
      Angular tolerance =  25.00
      Lag =  40.00m, Count = 15 lags, Tolerance = 50.00%
Model : 3 basic structure(s)
Global rotation = Azimuth=N30.00 (Geologist)
S1  - Nugget effect, Sill =       0.35
S2  - Spherical - Range = 3.00m, Sill =        0.4
      Directional Scales = (     40.00m,     40.00m,      3.00m)
S3  - Spherical - Range = 8.00m, Sill =       0.25
      Directional Scales = (    120.00m,     90.00m,      8.00m)
```

Figure 14-15: Correlogram Model for Njame

14.6 Mineral Resource Estimation Methodology

14.6.1 Dibwe East

For the 2012 Mineral Resource Estimate, RPA completed the following to interpolate eU_3O_8 ppm in to the resource model:

- Created a block model with block dimensions of 20 x 20 x 2 m (xyz), Table 14-9. Sub-cells were used to achieve accurate shapes and tonnages, with minimum cell sizes of 2 x 2 x 0.5 m (xyz).
- Interpolated eU_3O_8 ppm grades into the block model using an inverse distance weighting squared algorithm and hard boundaries for each of the estimation domains and a fixed search ellipse orientated to follow the average domain geometry.
- Two search volumes were used to estimate block grades. The first search had a minimum dimension of 200 x 100 x 10 m (xyz), requiring a minimum of four samples and a maximum of 12 samples with a maximum of two samples used from each drillhole. An expanded search was used to estimate blocks which did not satisfy the initial search criteria.
- Block model density was applied as the average value (2.1 g/cm^3) as derived from volumetric testwork.

Table 14-9: Dibwe East Block Model Parameters

Description	Easting (X)	North (Y)	Elevation (Z)
Block Model Origin (Lower left corner)	657800	8186800	470
Parent Block Dimension	20	20	2
Number of Blocks	330	160	85
Rotation	0	0	-40

14.6.2 Dibwe and Mutanga

For the 2009 Mineral Resource Estimate, CSA completed the following to interpolate U_3O_8 ppm in to the resource model:

- Created models with block dimensions of 20 x 20 x 5 m (xyz), Table 14-10 and Table 14-11. Sub-cells were used to achieve accurate shapes and tonnages, with minimum cell sizes of 4 x 4 x 1 m (xyz) at Dibwe and 2 x 2 x 0.5 m (xyz) at Mutanga.
- Interpolated U_3O_8 ppm grades into the block model using ordinary kriging, hard boundaries for each of the estimation domains and a fixed search ellipse orientated to follow the average domain geometry.
- Four search volumes were used to estimate block grades.
- at Mutanga, the first search had a minimum dimension of 35 x 50 x 3 m (xyz), requiring a minimum of 5 samples and a maximum of 20 samples with a minimum of three drillholes per block estimate;
- for Dibwe, the first search had a minimum dimension of 100 x 65 x 7 m (xyz), requiring a minimum of 5 samples and a maximum of 20 samples with a minimum of 3 drillholes per block estimate; and
- expanded searches were used to estimate blocks which did not satisfy the initial search criteria.

- Block model density was applied as the average value (2.1 g/cm^3) as derived from volumetric testwork.

Table 14-10: Dibwe Block Model Parameters

Description	Easting (X)	North (Y)	Elevation (Z)
Block Model Origin (Lower left corner)	652980	184230	437.5
Parent Block Dimension	20	20	5
Number of Blocks	127	115	35
Rotation	0	0	0

Table 14-11: Mutanga Block Model Parameters

Description	Easting (X)	North (Y)	Elevation (Z)
Block Model Origin (Lower left corner)	658390	193790	497.5
Parent Block Dimension	20	20	5
Number of Blocks	81	71	25
Rotation	0	0	0

14.6.3 Gwabe

Resource estimation was completed within an area encompassing all of the modelled Gwabe mineralized zones with block model geometry and extents as presented in Table 14-12. A parent block size of 25 x 25 x 2 m, sub-blocked to 6.25 x 6.25 x 0.5 m, representing the approximate drill spacing of the tightly infilled drilling area, was chosen for the model.

The resource estimation methodology was based on the following:

- 1 m capped composite data were used for the estimation;
- hard boundary conditions were employed in the estimation;
- only samples from within individual mineralisation model domains were used to estimate blocks within those domains;
- U_3O_8 was estimated by Ordinary Kriging, using the modelled variogram presented in Figure 14-12;
- sample search parameters were broken into two passes:
  - Pass 1 minimum of 8 and maximum of 24 composites collected within a 75 m (major axis) x 50 m (semi-major axis) x 25 m (minor axis search) sample search; a maximum of five 1m composites could be used from any one drillhole;
  - Pass 2 minimum of 8 and maximum of 24 composites collected within a 150 m (major axis) x 120 m (semi-major axis) x 50 m (minor axis search) sample search; a maximum of five 1m composites could be used from any one drillhole.
- sub-block grades were assigned the grade of the parent block;
- a discretization level of 3,3,3 was set for all estimates; and
- a mean bulk density value was calculated and applied to the blocks for tonnage reporting.

Table 14-12: Block Model Parameters

Description	Easting (X)	North (Y)	Elevation (Z)
Block Model Origin (Lower left corner)	8987.5	8987.5	200
Parent Block Dimension	25	25	2
Number of Blocks	161	101	200
Sub-Block Dimension	6.25	6.25	0.50
Rotation	0	0	0

14.6.4 Njame

Resource estimation was completed within two areas encompassing the modelled Njame mineralized zones, and the modelled Njame South mineralized zones with block model geometry and extents as presented in Table 14-13 and Table 14-14. A parent block size of 25 x 25 x 2 m, sub-blocked to 6.25 x 6.25 x 0.5 m, representing the approximate drill spacing of the tightly infilled drilling area, was chosen for the model.

The resource estimation methodology was based on the following:

- 1 m capped composite data were used for the estimation;
- hard boundary conditions were employed in the estimation;
- only samples from within individual mineralisation model domains were used to estimate blocks within those domains;
- U_3O_8 was estimated by Ordinary Kriging, using the modelled variogram presented in Figure 14-12;
- sample search parameters were broken into three passes:
    - Pass 1 minimum of 8 and maximum of 24 composites collected within a 75 m (major axis) x 50 m (semi-major axis) x 25 m (minor axis search) sample search; a maximum of five 1 m composites could be used from any one drillhole;
    - Pass 2 minimum of 8 and maximum of 24 composites collected within a 150 m (major axis) x 120 m (semi-major axis) x 50 m (minor axis search) sample search; a maximum of five 1 m composites could be used from any one drillhole;
    - Pass 3 minimum of 8 and maximum of 24 composites collected within a 150 m (major axis) x 120 m (semi-major axis) x 37.5 m (minor axis search) sample search; a maximum of five 1 m composites could be used for any block estimate;
- sub-block grades were assigned the grade of the parent block;
- a discretization level of 3,3,3 was set for all estimates; and
- a mean bulk density value was calculated and applied to the blocks for tonnage reporting.

Table 14-13: Block Model Parameters for Njame

Description	Easting (X)	North (Y)	Elevation (Z)
Block Model Origin (Lower left corner)	8987.5	8987.5	200
Parent Block Dimension	25	25	2
Number of Blocks	161	101	200
Sub-Block Dimension	6.25	6.25	0.50
Rotation	0	0	0

Table 14-14: Block Model Parameters for Njame South

Description	Easting (X)	North (Y)	Elevation (Z)
Block Model Origin (Lower left corner)	8987.5	4987.5	350
Parent Block Dimension	25	25	2
Number of Blocks	101	109	125
Sub-Block Dimension	6.25	6.25	1
Rotation	0	0	0

14.7 Mineral Resource Estimation Validation

14.7.1 Dibwe East, Dibwe and Mutanga

Validation Completed by CSA

CSA completed visual and statistical validation of the grade estimates, including RPA’s model for Dibwe East, which included:

- visual review of the block estimate and the composite data in cross section and long section;
- comparison of the mean grade of the estimate versus the mean grade of the block model; and
- comparison of composite grades and block model grades on validation plots, reviewed separately for grade trends in Northing Easting and RL.

CSA’s validation for the block models indicates that estimates are considered appropriate, demonstrating in general good comparison between local block estimates and nearby samples, without excessive smoothing in the block model.

Validation Completed by SRK

SRK validated the grade estimates by reviewing the geological and spatial domaining, statistical parameters, block model estimation parameters and by completing a thorough visual and statistical validation check on the models. In the opinion of SRK, the CSA and RPA Mineral Resource models for the Dibwe East, Dibwe and Mutanga deposits are reasonable representations of the global U_3O_8 Mineral Resources at the current level of sampling.

14.7.2 Gwabe and Njame

Validation Completed by AFR

AFR completed visual and statistical validation of the grade estimates, which included:

- review of the block estimate and the composite data in cross section, long section and plan views;
- comparison of the mean grade of the estimate versus the mean grade, subdivided by estimation domain; and
- comparison of composite grades and block model grades broken down into Northing and RL zones.

AFR's validation indicates that the Mineral Resource model replicates the source input data well in regions of higher density drilling. The regions where the data density is lower, smoothing is evident, however the estimates are considered appropriate.

The restriction of the sample search for high-grade composites has ensured reasonable limits on the extrapolation of high-grade data. When the mean grade of the input data, declustered where appropriate, is compared with the overall grade of the estimate a high degree of correlation is noted, except in regions of lower data density.

Validation Completed by SRK

SRK reviewed the grade estimates by conducting independent estimates using reasonable estimation parameters and found that the results agreed very closely to those achieved in the AFR models. In the opinion of SRK, the AFR Mineral Resource models for the Gwabe and Njame deposits are reasonable representations of the global U_3O_8 Mineral Resources at the current level of sampling.

14.8 Mineral Resource Classification

14.8.1 Dibwe East, Dibwe and Mutanga

Block model quantities and grade estimates for the Dibwe East, Dibwe, and Mutanga deposits were classified by CSA and RPA according to the CIM Code.

When classifying the block models, CSA and RPA incorporated several aspects. These included the confidence in the geological and grade continuity, data quantity and quality, quality of the block grade estimates and distance from the block to the samples used to estimate it. Where appropriate, the classification applied to the block model was determined through the digitisation of 3D solids.

Dibwe East and Dibwe

At Dibwe East and Dibwe, all block estimates are reported as Inferred (as shown in Figure 14-16 and Figure 14-17), based on the relatively wide sample coverage (100 x 200 m at Dibwe East and 100 x 50 m at Dibwe) in context of the relatively high geological and grade variability shown by the drilling to date and the need to further verify the relationship between downhole gamma readings (eU_3O_8) against the chemical assays (U_3O_8) analysed by XRF.

In addition, the lack of meaningful results from variography is considered by CSA to further justify the Inferred confidence in local block grade estimates.

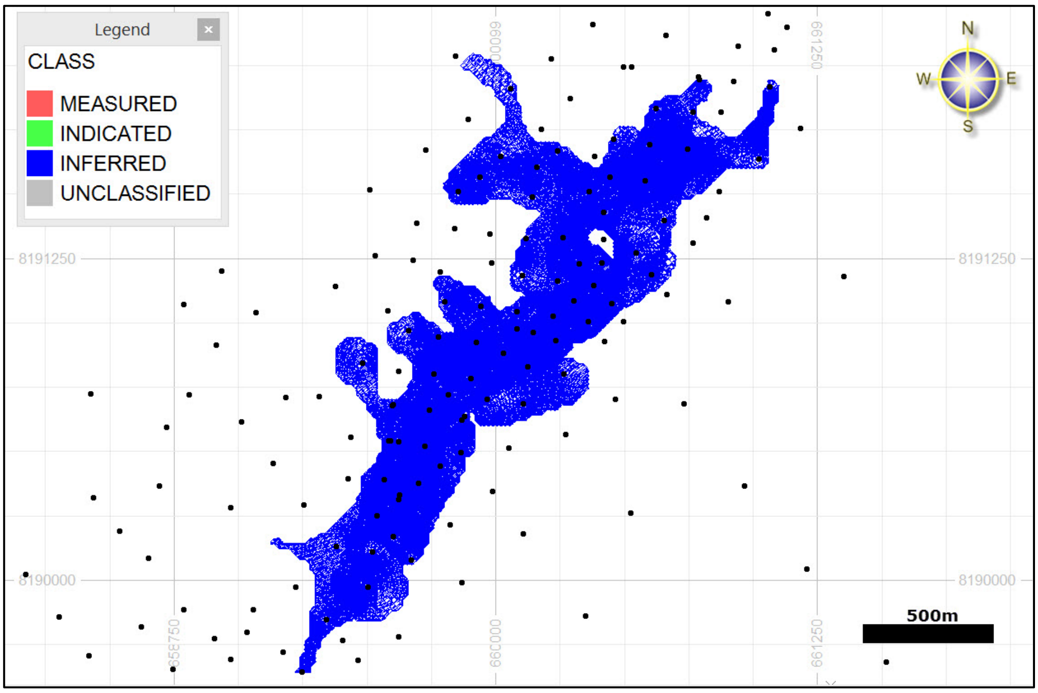


Figure 14-16: Plan View of Dibwe East Block Model Coloured by Mineral Resource Classification Code; Drillhole Locations Indicated in Black

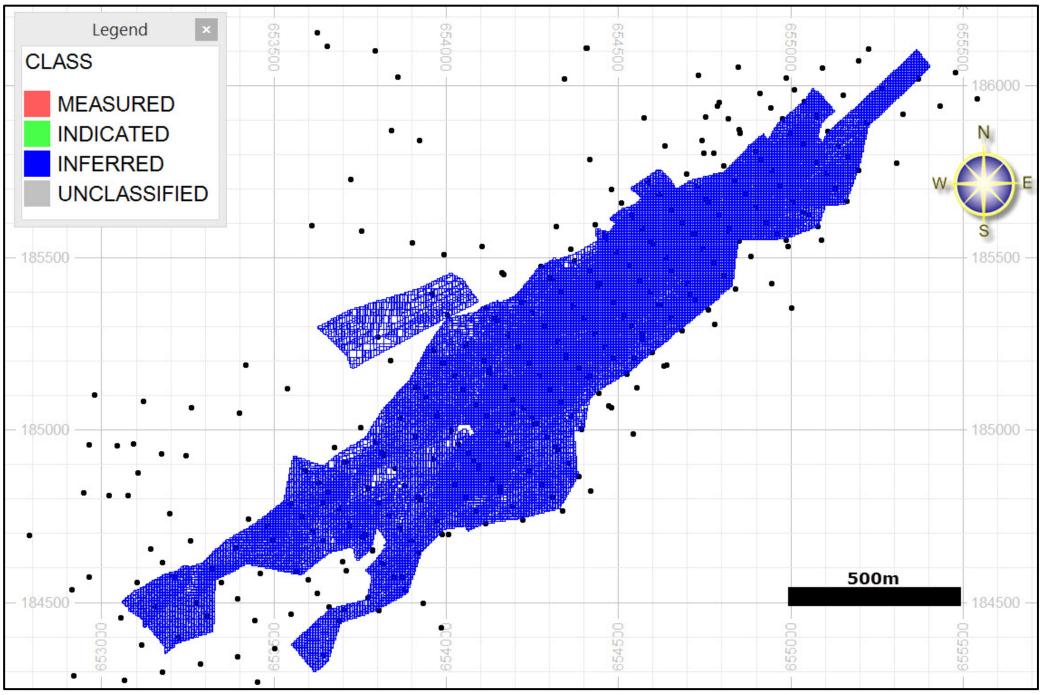


Figure 14-17: Plan View of Dibwe Block Model Coloured by Mineral Resource Classification Code; Drillhole Locations Indicated in Black

Mutanga

At Mutanga, the area surrounding the close spaced (10 m), geostatistical cross data has been classified as Measured, with Indicated resources comprising the areas of 50 m sample coverage where there is good confidence in the geological model, as shown in Figure 14-18.

SRK has reviewed the selection and application of the Mineral Resource classification criteria completed by CSA and RPA and concludes that the approach is consistent with that required by the Canadian Securities National Instrument 43-101 (NI 43-101) and the CIM standards on Mineral Resources.

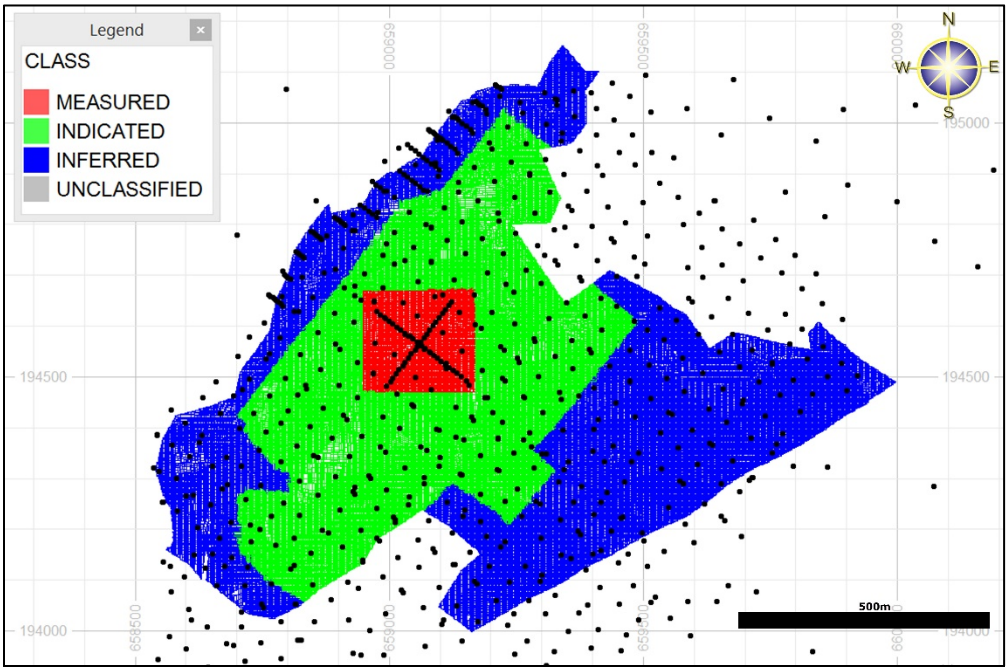


Figure 14-18: Plan View of Mutanga Block Model Coloured by Mineral Resource Classification Code; Drillhole Locations Indicated in Black

14.8.2 Gwabe and Njame

The Mineral Resources for the Gwabe and Njame deposits have been classified by AFR in accordance with the Australasian Code for the Reporting of Mineral Resources and Ore Reserves of December 2004 (the Code) as prepared by the Joint Ore Reserves Committee of the Australasian Institute of Mining and Metallurgy, Australian Institute of Geoscientists and Mineral Council of Australia (JORC). A combination of Measured, Indicated and Inferred Mineral Resources have been defined in consideration of the following:

- confidence of geological continuity;
- confidence of mineralisation continuity; and
- drillhole density/spacing.

Specifically, Measured Mineral resources are a portion of mineralized domains where the drillhole spacing is less than 50 x 25 m. The surrounding Indicated Mineral Resources are a portion of the mineralized domains where the drillhole spacing is less than 50 x 50 m. Inferred Mineral Resources comprise all remaining blocks estimated within the modelled mineralisation wireframes. Plan views are shown in Figure 14-19 to Figure 14-21.

SRK has reviewed the selection and application of the Mineral Resource classification criteria completed by AFR and concludes that the approach is consistent with that required by the Canadian Securities National Instrument 43-101 (NI 43-101) and the CIM standards on Mineral Resources.

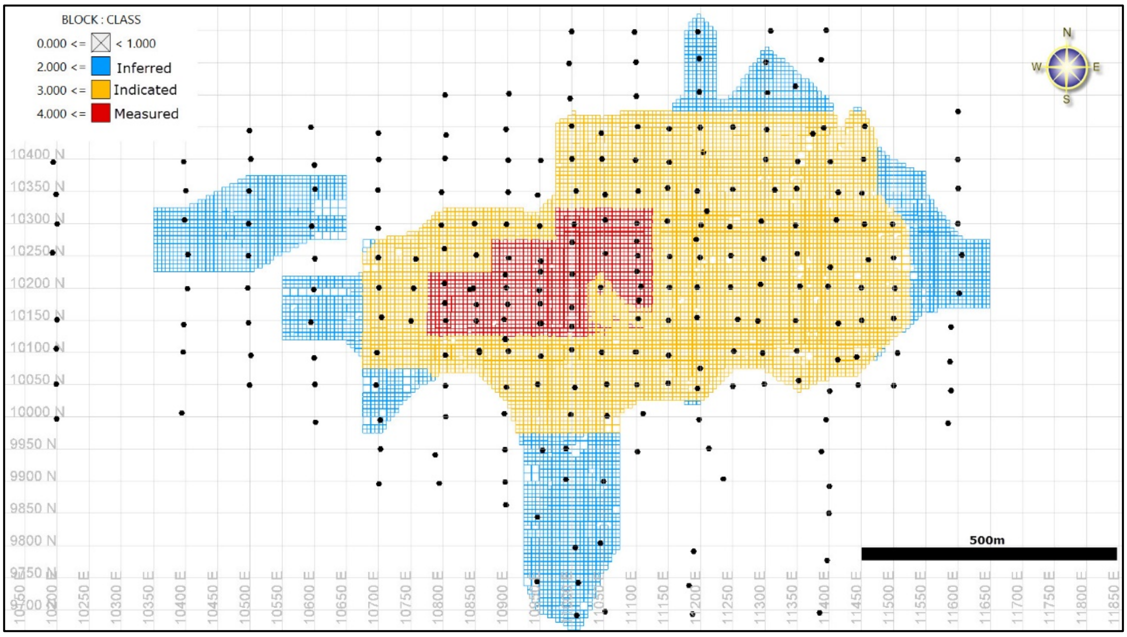


Figure 14-19: Plan View of Gwabe Block Model Coloured by Mineral Resource Classification Code; Drillhole Locations Indicated in Black

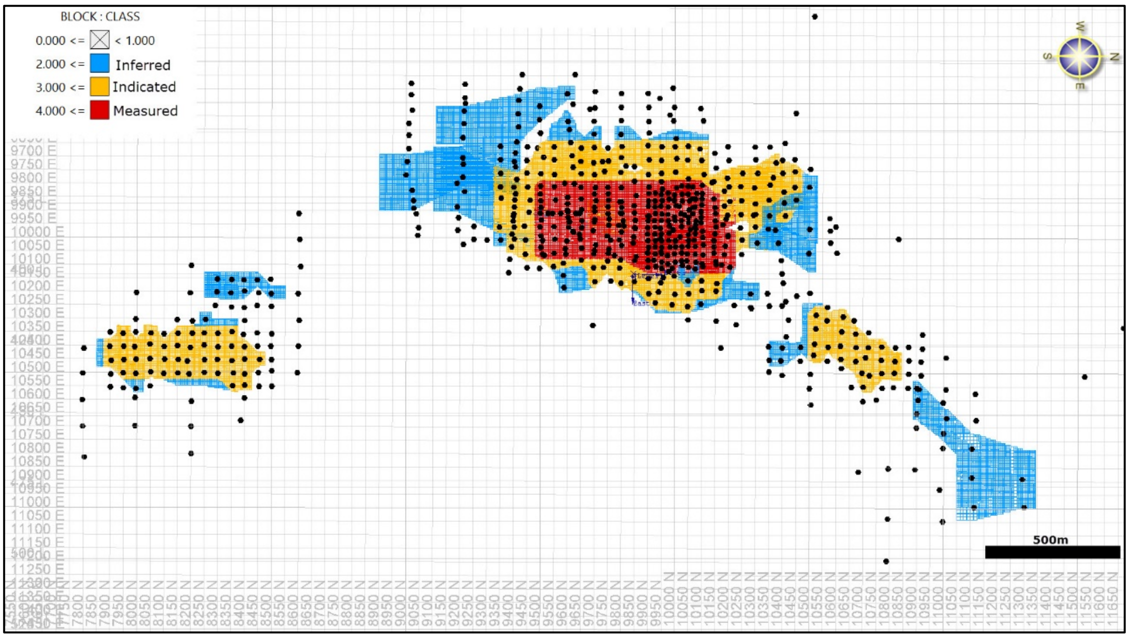


Figure 14-20: Plan View of Njame Block Model Coloured by Mineral Resource Classification Code; Drillhole Locations Indicated in Black

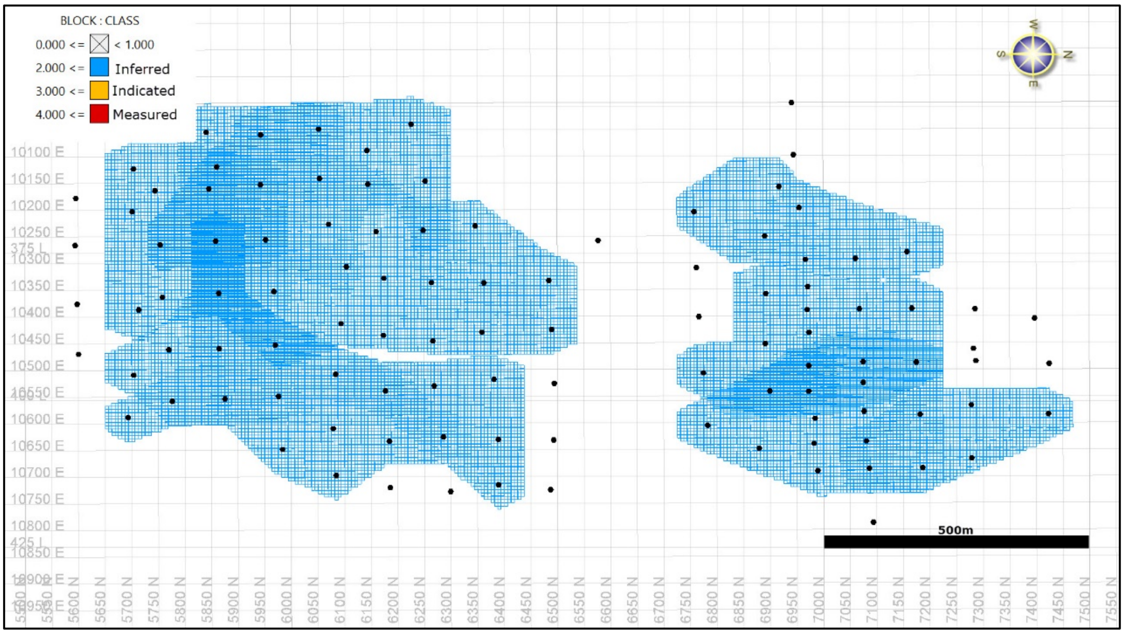


Figure 14-21: Plan View of Njame South Block Model Coloured by Mineral Resource Classification Code; Drillhole Locations Indicated in Black

14.9 Mineral Resource Statement

CIM Definition Standards for Mineral Resources and Mineral Reserves (May 2014) defines a Mineral Resource as:

“(A) concentration or occurrence of solid material of economic interest in or on the Earth’s crust in such form, grade or quality and quantity that there are reasonable prospects for eventual economic extraction. The location, quantity, grade or quality, continuity and other geological characteristics of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge, including sampling.”

The “reasonable prospects for eventual economic extraction” requirement generally implies that the quantity and grade estimates meet certain economic thresholds and that the Mineral resources are reported at an appropriate cut-off grade taking into account extraction scenarios and processing recoveries. In order to meet this requirement, SRK considers that major portions wireframed deposits are potentially amenable for open pit extraction. Table 14-15 presents the Mineral Resources for the Mutanga project.

Table 14-15: Mineral Resource Estimate[1], Mutanga Uranium Project, Zambia, SRK Consulting (UK) Ltd, November 20, 2017

Deposit	Category	Tonnes (Mt)	U_3O_8 Grade (ppm)	U_3O_8 Mlb
Mutanga[2]	Measured	1.9	481	2.0
	Indicated	8.4	314	5.8
	Inferred	7.2	206	3.3
Dibwe[2]	Inferred	17.0	239	9.0
Dibwe East[2]	Inferred	43.1	304	28.9
Gwabe[3]	Measured	1.3	237	0.7
	Indicated	3.6	313	2.5
	Inferred	0.7	178	0.3
Njame[3]	Measured	2.7	350	2.1
	Indicated	3.7	252	2.1
	Inferred	2.1	225	1.1
Njame South[3]	Inferred	4.4	250	2.4
Sub-total Measured		5.9	366	4.8
Sub-total Indicated		15.7	299	10.4
Measured and Indicated		21.6	317.5	15.1
Inferred		74.6	273.0	44.9

[1] Mineral Resources have not been constrained by pit shells, however, almost all of the mineralisation occurs within 125 m of surface with uranium grades which are, in general, considered to have reasonable prospects for eventual economic extraction by open pit mining.

[2] The cut-off grade used for reporting the Mineral Resource is 100 ppm U_3O_8, which is applied directly to block model cells.

[3] No U_3O_8 ppm cut-off is applied to block model cells for reporting the Mineral Resource. However, the outer limits block model was constrained within a 100 ppm U_3O_8 wireframe used for geological modelling.

15 MINERAL RESERVE ESTIMATES (ITEM 15)

No Mineral Reserves have been defined as part of this report.

16 MINING METHODS (ITEM 16)

16.1 Introduction

The preliminary mining plan for the Mutanga Uranium Project includes the flowing deposits: Dibwe East (“DE”), Dibwe (“DI”), Gwabe (“GW”), Mutanga (“MU”) and Njame (“NJ”). SRK considers these plans to be at scoping study level; some sections in the technical part of the study are based on factored or assumed input parameters.

The preliminary mining plan has been developed assuming open pit extraction and conventional truck and shovel mining method. Pit optimisations were run to determine pit limits and pushback development. This work was based on the five block models as described in Section 14. Subsequently, a production schedule has been prepared for each deposit assuming the same cut-off grade for all of them and an overall plant feed rate of 4.0 Mtpa.

16.2 Pit Optimisations

16.2.1 Approach

Pit optimisations have been undertaken on the Mutanga Project deposits using CAE's NPV Scheduler to assess potential pit limits and the deposit sensitivity to metal price. Each optimisation has been run inclusive of Inferred Mineral Resources. SRK notes that Dibwe and Dibwe East did not contain any mineralized material classified higher that Inferred.

16.2.2 Optimisation Parameters

The parameters applied to the pit optimisation process are shown in Table 16-1. SRK was not commissioned to design any new inputs for this process, therefore they are based on the available studies done to date that appear reasonable. This includes NI43-101 Technical Report "Mineral Resource Estimates for the Mutanga Uranium Project" by CSA Global (UK) Ltd and Malcolm Titley as the Qualified Person ("QP") and "Mutanga Project Feasibility Study" by MDM Engineering. Origins for each parameter are described in Table 16-1.

Table 16-1: Pit Optimisation Input Parameters

Parameters	Units	Value	Source
Geotechnical			
Footwall	(Deg)	40	43-101 by CSA Global (UK) Ltd
Hangingwall	(Deg)	40	43-101 by CSA Global (UK) Ltd
Mining Factors			
Dilution	(%)	10.0	Project defined input
Recovery	(%)	90.0	Project defined input
Processing			
Recovery U_3O_8	(%)	80.0	MDM, Mintek – average of testwork
Operating Costs			
Mining Cost	(USD/t_{rock})	1.91	Project defined input
Additional Ore Mining Cost	(USD/t_{ore})	0.41	Project defined input
Fixed Mining Cost	(USD/t_{ore})	0.77	Project defined input
Processing	(USD/t_{ore})	8.69	Project defined input
G&A	(USD/t_{ore})	1.31	Project defined input
Royalty	(%)	3.0	Project defined input
Metal Price			
U_3O_8	(USD/lb U_3O_8)	50	Project defined input
Other			
Discount Rate	(%)	8	Project defined input
Cut-Off Grade			
Marginal	(USD/t_{ore})	10.00	
Diluted	(ppm U_3O_8)	117	
In Situ	(ppm U_3O_8)	129	

SRK notes that there was no geotechnical report or description in the work done to date, therefore geotechnical parameters were not verified. Since this is one of the drivers for pit optimisation results and one of the most important parameters in open-pit mining design, it is strongly recommended to verify applicability of this value. Rock mass characteristics and potential geotechnical conditions are described in Item 7 and Section 16.7 of Item 16. To better understand the influence of geotechnical conditions on the Mutanga Project, SRK performed pit optimisation sensitivities presented Table 16-2.

Processing recovery is described in more detail in Item 13; however, it should be noted that one unified value of 80% was used in the optimisation for each deposit and material type.

It should also be noted that no allowance was made in the Pit Optimisation process for any potential constraints located on the surface, like roads or houses. In the case of Njame mineralization, it is partially located underneath the D500 national road and no associated road re-location cost has been applied in the optimisation process.

16.2.3 Pit Optimisation Results

The pit optimisation produced a series of nested pit shells at a range of metal price factors, assuming Revenue Factor (“RF”) of 1.0 corresponding to 50 USD/lb U_3O_8. The cash flow for each shell was calculated using the input metal prices and provided an indication of the economic sensitivity for various pit shells. Essentially, pit shells for RF = 1 were selected for all deposits. It needs to be remembered that Pit Optimisation process did not include any capital costs in cashflow calculations. Figure 16-1, Table 16-2, Table 16-3 and Appendix C present sensitivities and results for selected pitshells. Attention needs to be given to the difference between results for uranium spot and long term selling prices. Additional undiscounted cashflow curve (CF Roy 9%) was included in the Figure 16-1 to show undiscounted cashflow for Royalties of 9%, as opposite to 3% which were used in the process. This variation itself gives around 70 USDm less cashflow on undiscounted basis and at RF = 1.0.

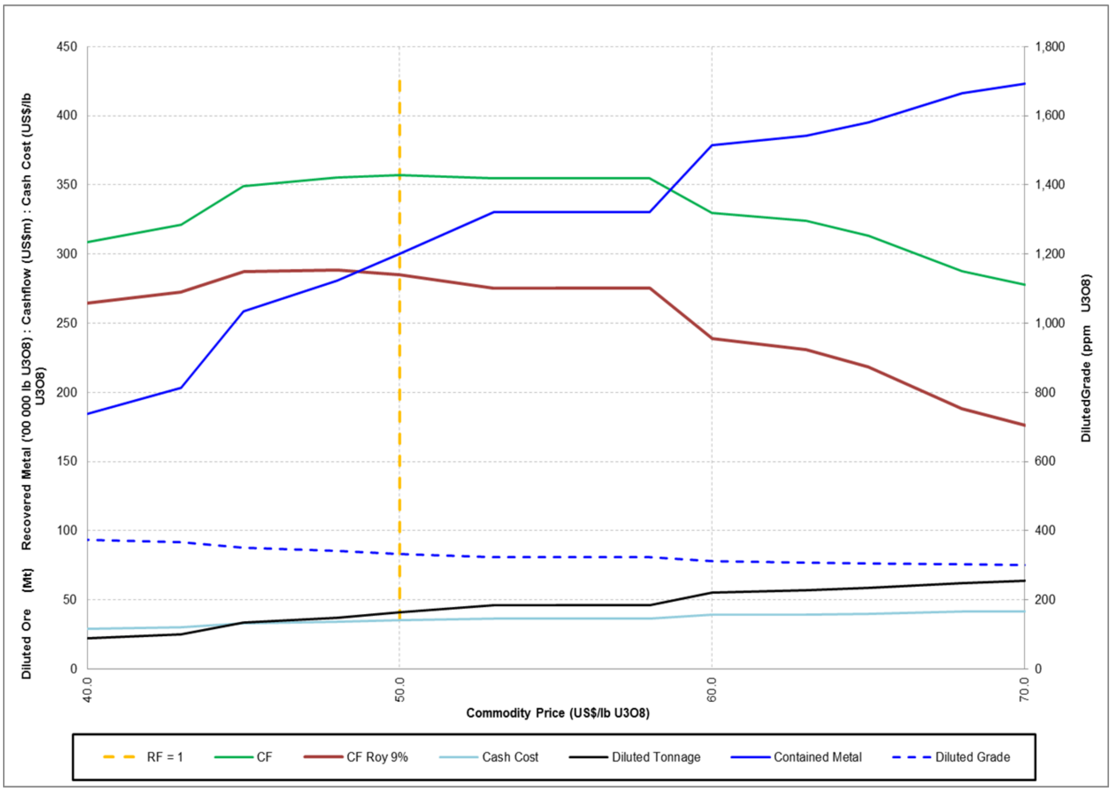


Figure 16-1: Price Sensitivity – Inventory

Table 16-2: Slope Angle Sensitivity

Slope Angle	SR	Waste	RoM	U_3O_8		CF	Proj. Life
(deg)	(t:t)	(Mt)	(Mt)	(ppm)	(Mlbs)	(MUS$)	(yrs)
55	3.0	128.3	42.6	335	31.5	410	10.6
50	3.2	139.4	43.5	332	31.9	392	10.9
45	3.2	132.5	41.3	333	30.3	375	10.3
40	3.4	138.0	40.8	333	30.0	357	10.2
35	3.7	145.0	39.7	335	29.3	332	9.9

Table 16-3: Pit Optimisation Results

Optimisation Results	Units	50	60	70
Revenue Factor		**1**	**1.2**	**1.4**
Insitu				
Inventory	(Mt)	41.2	55.8	64.2
	(ppm U_3O_8)	366.83	342.10	331.87
	(t U_3O_8)	15,125	19,094	21,320
Modifying Factors				
Mining Dilution	(%)	10.0	10.0	10.0
Dilutant	(ppm U_3O_8)	0.0	0.0	0.0
Mining Recovery	(%)	90.0	90.0	90.0
U_3O_8 Metallurgical Recovery	(%)	80.0	80.0	80.0
Diluted				
Inventory	(Mt)	40.8	55.3	63.6
	(ppm U_3O_8)	333.48	311.00	301.70
	(t U_3O_8)	13,612	17,184	19,188
Quantities				
Total Rock	(Mt)	178.8	265.9	333.2
Mineral Inventory	(Mt)	40.8	55.3	63.6
Waste + OM	(Mt)	138.0	210.6	269.6
Stripping Ratio	(t:t)	3.4	3.8	4.2
Operating Expenditures				
Mining	(USD/t_{mined})	2.23	2.21	2.18
	(USD/t_{ore})	9.78	10.63	11.44
Processing + G&A	(USD/t_{ore})	10.00	10.00	10.00
	(USD/lb U_3O_8)	17	18	19
U_3O_8 Selling Cost	(USD/lb U_3O_8)	1.5	1.5	1.5
Total Cash Cost	(USD/lb U_3O_8)	35	39	42
Product				
Recovered Metal	(t U_3O_8)	10,890	13,747	15,351
Economic Summary				
Metal Price	(USD/lb)	50	50	50
Cashflow	(USDm)	357	330	278
Discount Rate	(%)	8.0	8.0	8.0
Project Life	(years)	10.2	13.8	15.9

16.2.4 Pit Designs

SRK did not make pit designs for the deposits and used the pitshell wireframes for further analysis. It needs to be noted that no allowance for ramps or any other potential infrastructure have been included in the geotechnical parameters used in pit optimisation. Taking into account relatively low depth of the pits (about 60 m), those features are not expected to have significant impact on the final results. Sensitivity to slope angles was presented earlier in Table 16-2. Notwithstanding that, it is clear that there will be some differences in reported pit inventories once appropriate designs are done; it is usual to have differences of -3% mineralised material and +8% of waste, but due to the shallow nature of the pits in Mutanga Uranium Project the differences are expected to be lower. Pit outlines and cross-section are attached in Appendix A. Summarised pit inventories are presented in Table 16-4 on a diluted basis. It should be noted that pits for Dibwe East and Dibwe contain only material classified as Inferred and the entire pit inventory used for this PEA comprises almost 70% Inferred Mineral Resource.

Table 16-4: Pit Inventories

	Measured (Mt)	Indicated (Mt)	Inferred (Mt)	Total RoM (Mt)	U_3O_8 (ppm)	Waste (Mt)	SR (t:t)	Total (Mt)
Dibwe East			21.4	21.4	339	90.5	4.2	112.0
Dibwe			4.1	4.1	250	12.1	2.9	16.2
Gwabe	0.8	2.2	0.1	3.1	345	5.9	1.9	9.0
Mutanga	1.7	6.0	1.7	9.4	346	13.0	1.4	22.4
Njame	1.6	0.5	0.6	2.7	360	16.4	6.0	19.2
TOTAL	**4.1**	**8.7**	**28.0**	**40.8**	**333**	**138.0**	**3.4**	**178.8**

16.2.5 Waste Dump Designs

SRK has not made a detailed geotechnical analysis or engineer study of the waste dumps slope configuration. Values used for the designs presented as a part of this Study were assumed based on experience with similar projects and materials, and are appropriate for the level of study. It should be noted that no detailed layouts for the areas were provided and SRK based the dumps location using satellite imagery available on the internet. Dumps are located a minimum of 100 m from the pit shell crest;

- swell factor of 60%;
- contingency of 25%; and
- overall height limited to ≈ 60 m.

Table 16-5: Waste Dumps Capacities

Pit	Total Waste (Mt)	Total Waste (Mbcm)	Designed Dump Capacity (Mlcm)
DE	90.55	43.12	88.93
DI	12.13	5.78	11.75
GW	5.93	2.82	6.58
MU	13.01	6.20	14.96
NJ	16.41	7.81	17.61

16.2.6 Cut-off Grade and Stockpiling Strategies

A marginal cut-off grade of 129 ppm U_3O_8 was calculated for the Project and no other cut-off grade or stockpiling strategies were considered.

16.3 Mine Schedule

This PEA is preliminary in nature and includes mineral resources classified as Inferred that are considered too speculative geologically to have economic considerations applied to them that would enable them to be categorized as Mineral Reserves. There is no certainty that the results presented in this PEA will be realized.

16.3.1 Approach

The mine schedule was undertaken using CAE’s NPV Scheduler. The mine plan has been run at annual increments and covers an 11-year period. The key scheduling parameters used by SRK as a basis for the mine scheduling were as follows:

- 2-year construction period;
- feed rate of 2.0 Mtpa in Year 1 and 4.0 Mtpa thereafter;
- not to exceed sink rate of over 60 m per year; and
- Inferred Classed Mineral Resource materials were included in the production plan.

16.3.2 Material Movements

Mining of the deposits is initiated in sequence as presented Figure 16-2 and, in some years, pits are being depleted simultaneously. This sequence should be considered preliminary, but was defined based on cashflows observed during the pit optimisation process, described in Section 16.2. Material movements are shown in Figure 16-2, Figure 16-3 and Figure 16-4. The highest strip ratio occurs in Year 3, but generally remains fairly flat for the entire LoM, decreasing in last two years. Since only a high level scheduling was made for this Study, a bench by bench schedule has been developed; SRK therefore believes that some of waste tonnages could potentially be deferred through more detailed planning. Generally, waste stripping is at a level of about 15 Mtpa. As mentioned in previous section, 69% of the pit inventory is made of Inferred Mineral Resource. Figure 16-4 shows that Inferred Mineral Resource is distributed over the LoM period and it makes significant part of the production in each period, starting from year 1. The U_3O_8 grade shown on Figure 16-5 remain variable over the LoM exceeding 400 ppm U_3O_8 in Year 7 due to some local high grade geological blocks located at depth. This aspect has been described in more detail under Item 14. Average U_3O_8 grade over the LoM is 333 ppm. More detailed presentation of the mining schedule is included in Table 16-6.

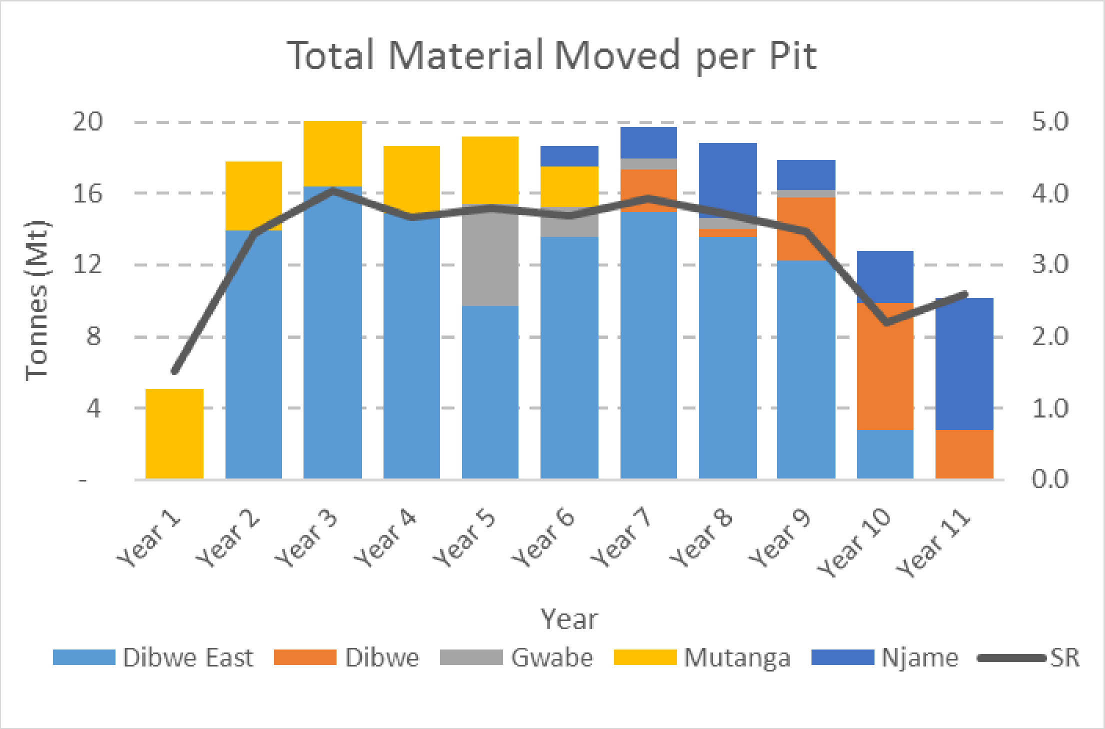


Figure 16-2: Total Material Movement per Pit

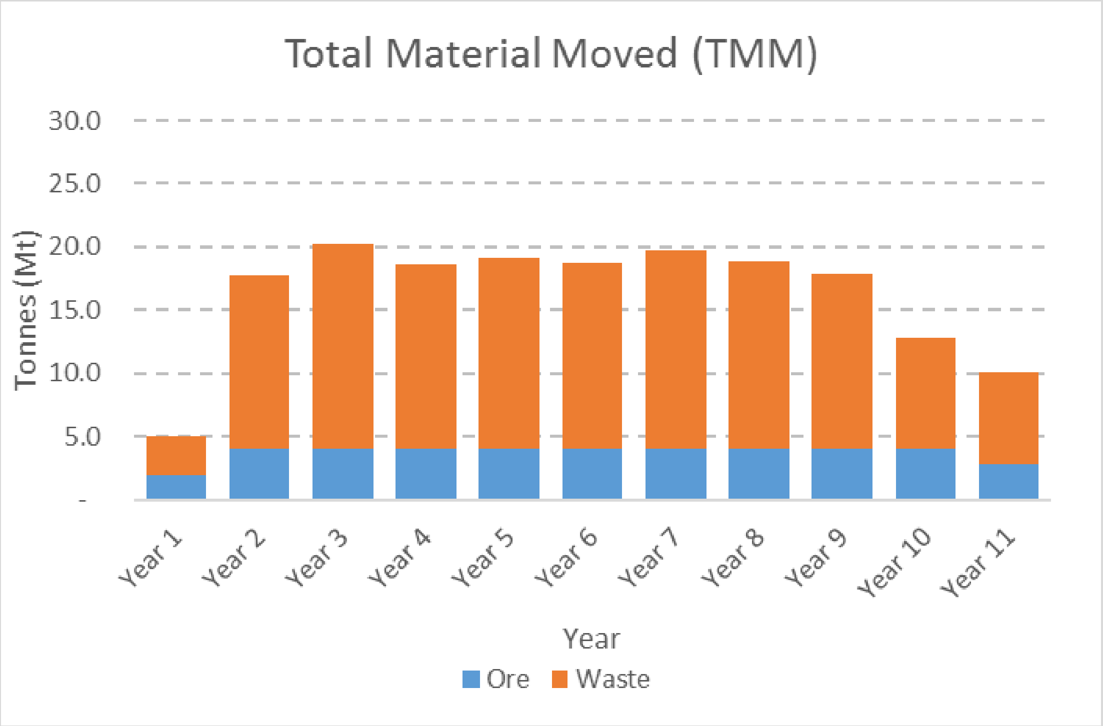


Figure 16-3: Total Material Movement

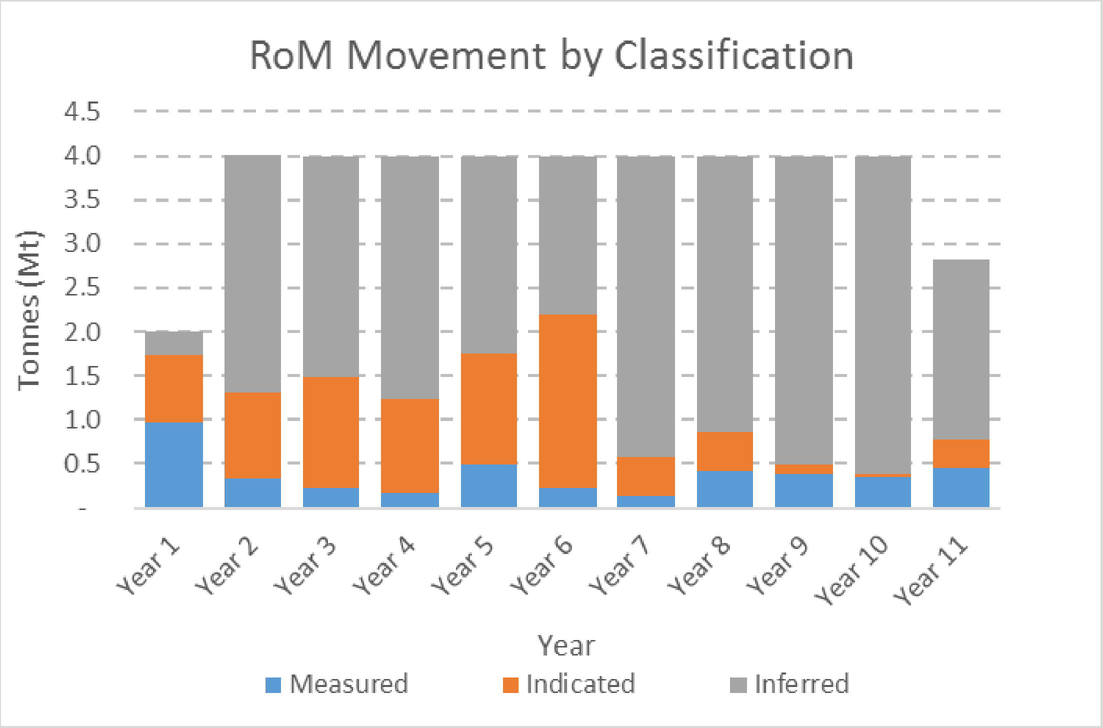


Figure 16-4: RoM Movement by Classification

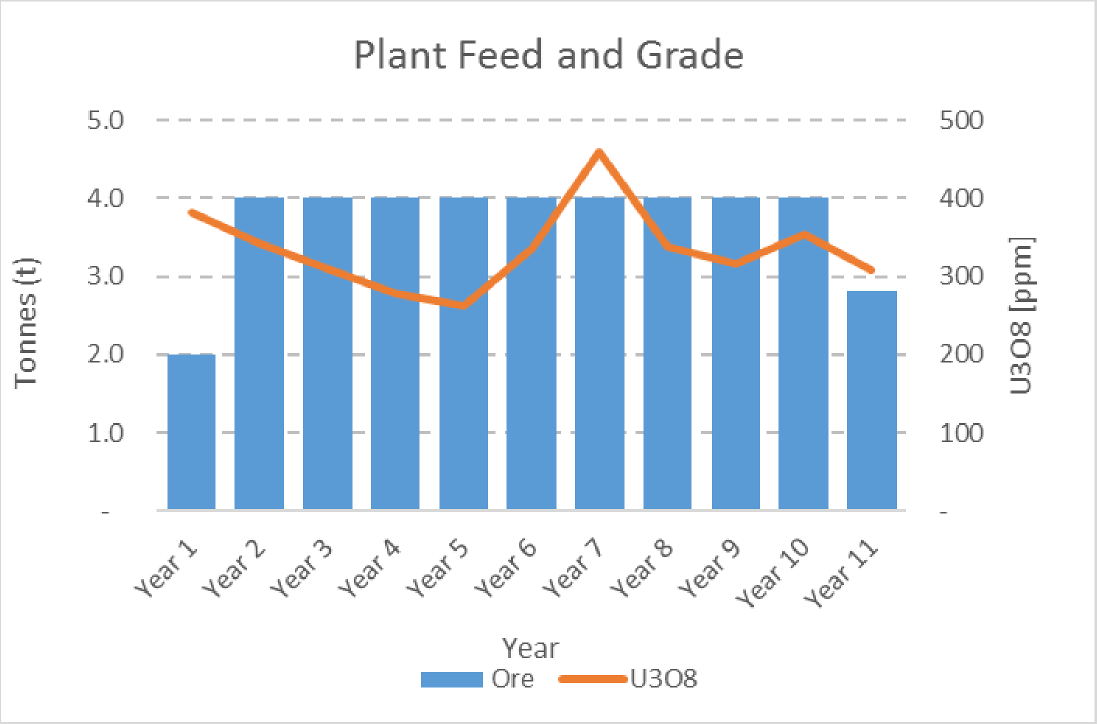


Figure 16-5: Plant Feed

Table 16-6: Mining Schedule

	Unit	Total	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11
Total Material													
Rock	(Mt)	**178.8**	5.0	17.8	20.2	18.7	19.2	18.7	19.7	18.8	17.9	12.8	10.1
Waste	(Mt)	**138.0**	3.0	13.8	16.2	14.7	15.2	14.7	15.7	14.8	13.9	8.8	7.3
RoM	(Mt)	**41**	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	2.8
U_3O_8	(ppm)	**333**	381	341	310	277	263	337	459	337	316	354	309
SR	(t:t)	**3.4**	1.5	3.4	4.0	3.7	3.8	3.7	3.9	3.7	3.5	2.2	2.6
RoM Mea	(Mt)	**4.1**	1.0	0.3	0.2	0.2	0.5	0.2	0.1	0.4	0.4	0.4	0.5
RoM Ind.	(Mt)	**8.7**	0.8	1.0	1.3	1.1	1.3	2.0	0.4	0.4	0.1	0.0	0.3
RoM Inf.	(Mt)	**28.0**	0.3	2.7	2.5	2.8	2.2	1.8	3.4	3.1	3.5	3.6	2.0
Pit													
Dibwe East													
RoM	(Mt)	**21.43**		2.5	2.5	2.5	1.5	1.5	3.0	3.0	3.0	1.9	
U_3O_8	(ppm)	**339.0**		287	264	270	286	343	500	317	314	455	
Wst	(Mt)	**90.5**		11.5	13.9	12.4	8.2	12.1	12.0	10.5	9.3	0.8	
TMM	(Mt)	**112.0**		14.0	16.4	14.9	9.7	13.6	15.0	13.5	12.3	2.8	
SR	(t:t)	**4.2**		5.6	6.5	6.0	6.5	9.0	5.0	4.5	4.1	1.4	
Dibwe													
RoM	(Mt)	**4.1**							0.4	0.1	0.5	1.7	1.4
U_3O_8	(ppm)	**249.9**							249	243	263	242	256
Wst	(Mt)	**12.1**							2.0	0.4	3.0	5.4	1.3
TMM	(Mt)	**16.2**							2.4	0.5	3.5	7.1	2.8
SR	(t:t)	**2.9**							5.9	4.7	6.9	4.3	1.9
Gwabe													
RoM	(Mt)	**3.1**					1.0	1.0	0.5	0.5	0.1		
U_3O_8	(ppm)	**344.6**					239	364	436	437	286		
Wst	(Mt)	**5.9**					4.7	0.7	0.1	0.1	0.3		
TMM	(Mt)	**9.019**					5.7	1.7	0.6	0.6	0.4		
SR	(t:t)	**1.9**					5.7	1.7	1.2	1.2	3.8		

	Unit	Total	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11
Mutanga													
RoM	(Mt)	**9.4**	2.0	1.5	1.5	1.5	1.5	1.4					
U_3O_8	(ppm)	**346.1**	381	431	388	289	256	318					
Wst	(Mt)	**13.0**	3.0	2.3	2.3	2.3	2.3	0.8					
TMM	(Mt)	**22.4**	5.0	3.8	3.8	3.8	3.8	2.2					
SR	(t:t)	**1.4**	2.5	2.6	2.6	2.5	2.5	1.6					
Njame													
RoM	(Mt)	**2.7**						0.1	0.1	0.4	0.4	0.4	1.4
U_3O_8	(ppm)	**360.2**						183	207	387	409	336	364
Wst	(Mt)	**16**						1.1	1.7	3.8	1.3	2.5	6.0
TMM	(Mt)	**19**						1.2	1.8	4.2	1.7	2.9	7.4
SR	(t:t)	**6.0**						19.7	17.9	10.5	4.3	7.3	5.3
Plant													
Feed	(Mt)	**40.8**	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	2.8
	(ppm)	**333.5**	381	341	310	277	263	337	459	337	316	354	309
U_3O_8	(t)	**13,612**	764	1,364	1,241	1,109	1,052	1,346	1,837	1,348	1,264	1,416	870
	(Mlbs)	**30.0**	1.7	3.0	2.7	2.4	2.3	3.0	4.1	3.0	2.8	3.1	1.9

16.4 Operating Strategy

16.4.1 Introduction

It has been assumed that entire mining operation will be worked by a contractor. The contractor will be responsible for such activities as:

- drill and blast;
- load and haul;
- maintenance;
- quality control; and
- roads maintenance.

SRK has not obtained any quotes for mining services for this project, but the Client has made its own investigation which has indicated some preliminary operating mining costs. In order to verify its magnitude, SRK has developed a high level independent cost model, assuming certain mining fleet and productivities. As a result of that exercise, SRK obtained unit mining cost comparable to the value mentioned above and used for this Study. This process did not include any capital costs and thus, no mining related capital cost for Mutanga Uranium Project has been included anywhere in this Study. Taking the above statement into consideration, the mining cost remains at a level of assumed parameter and in order to see its influence on the Project, a sensitivity analysis has been included and presented on Figure 22-2. Results of the high level mining fleet estimate are presented in the following sections.

16.4.2 Load and Haul

SRK assumes the truck and shovel configuration presented in Table 16-7 will be suitable for the Project.

Table 16-7: Load and Haul Productivity

Item	Unit	Value
Loading		
Bucket Size	(m^3)	5.0
Loading Spot Time	(min)	0.70
Loading Cycle Time	(min)	0.35
First Bucket Dump	(min)	0.05
Haulage		
Capacity	(t)	44.2
Capacity	(m^3)	31.3
Dump & Spot Time	(min)	1.20
Loading Parameters		
Bucket Fill Factor	(%)	90
In-Situ Density	(t/bcm)	2.10
Loose Density	(t/lcm)	1.62
Loading Productivity		
Total Loading Cycle Time	(min.)	2.50
Loader Operator Efficiency	(%)	75
Loader Productivity	**(t/doh)**	**758**
Loader Productivity	(lcm/doh)	469
Loading Unit Utilisation	(%)	59.9
Loading Productivity	**(Mtpa)**	**3.8**

The estimated productivities were applied to the mining schedule as presented in section 16.3 to assess fleet levels shown in Figure 16-6 and Figure 16-7. It needs to be noted that haulage distances were assumed outside of the pit and in its nearest vicinity; however, infrastructure and site layout has not yet been developed, therefore, depending on the final dumping point location, the fleet levels may vary. It has therefore been assumed that RoM material will be transported and dumped nearby the pit and travel time will generally not exceed 10 minutes. This may influence the mining operating cost that has been discussed in Section 16.4.1 and Section 16.6.

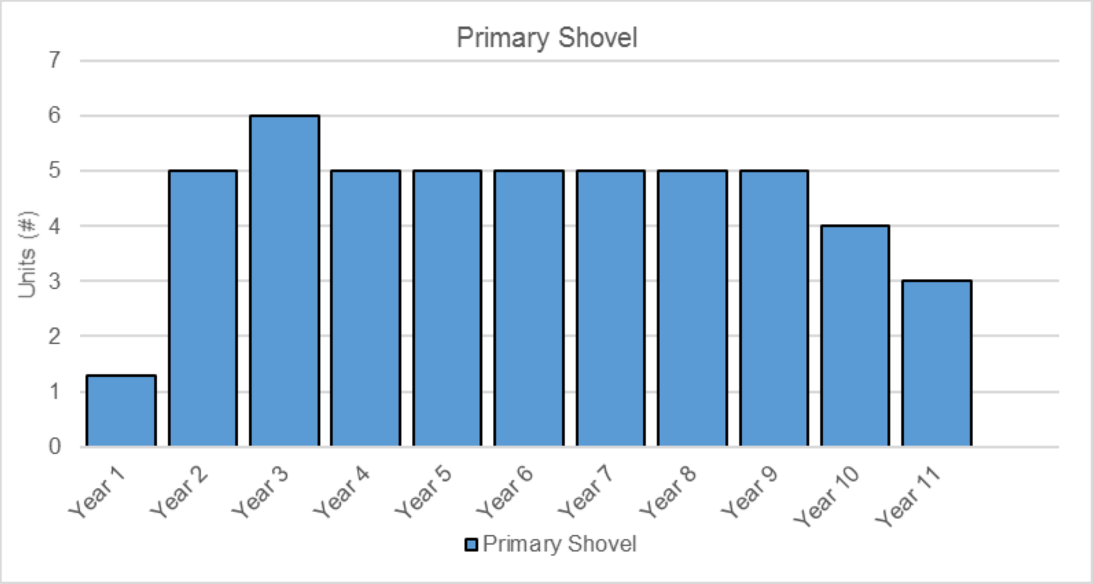


Figure 16-6: Loading Units Levels

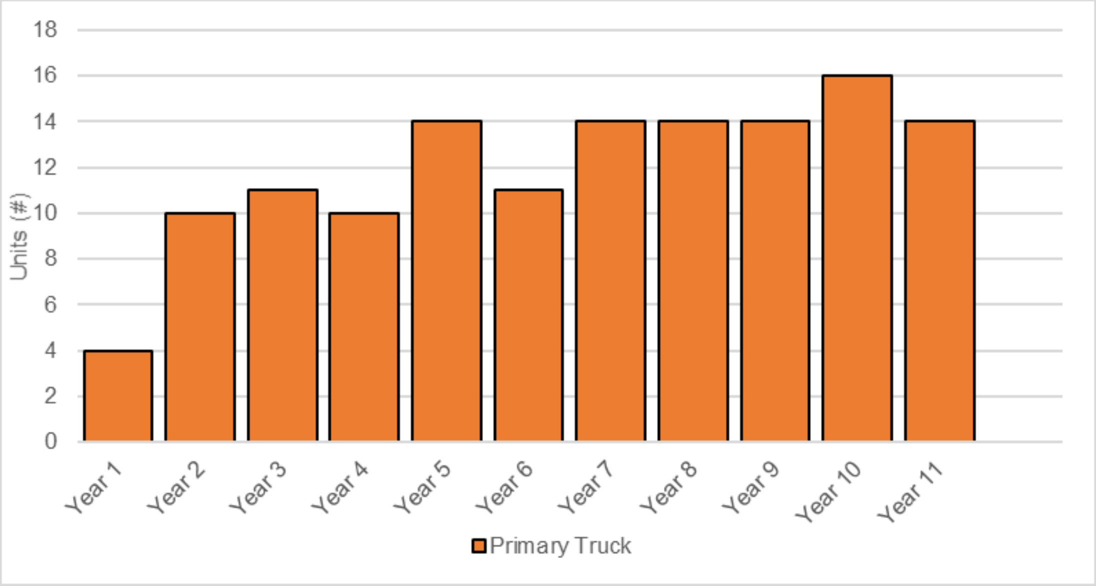


Figure 16-7: Hauling Units Levels

16.4.3 Drill and Blast

The drill and blast equipment estimate was based on the production schedule ex-pit material movement. It has been assumed that drill and blast activities are required for all material types.

In-fill grade control drilling will provide information for planning and grade control purposes. The in-fill drilling will be undertaken on each bench in mineralized material on a 25 x 25 m pattern. SRK recommends that conventional blasthole drilling, geological logging, drill cutting sampling and assay are undertaken for grade control purposes. It can be combined with the blasthole drilling campaign.

Production drilling is designed to be undertaken on a 4.5 x 4.5 m spacing with a 170 mm blasthole diameter. Grade control sampling will be undertaken on all production holes that are in ore. SRK assumes 100% of the production holes to be sampled.

The blasting requirements have been based on average rock densities and pattern type. A 0.7 kg/bcm powder factor has been assumed. It should be noted that compressive strength analyses or excavatability assessment have not been completed. Drilling and blasting requirements will have impact on operational mining cost for which sensitivities are given on Figure 22-2.

It is estimated that there will be minimum one drill rig per considered deposit.

16.4.4 Mining Labour Requirements

Labour requirements have been estimated based on three 8 hour shifts, 350 days per year for equipment operators and maintenance operators. A total of four crews are required for 24 hour roles.

16.4.5 Labour Estimate

The labour requirements have been estimated for the mine operations, mine technical services and mine maintenance groups. The labour requirements have been estimated from the outcomes of the production schedule and the equipment levels. The labour estimates have been based on the following criteria according to the position:

- material movement rates;
- equipment fleet levels; and
- number of shifts.

The mining maintenance and mining operation groups are determined through the equipment requirements. The technical services department includes mining engineers, geologists, surveyors etc. The mine personnel requirements are shown in Figure 16-8.

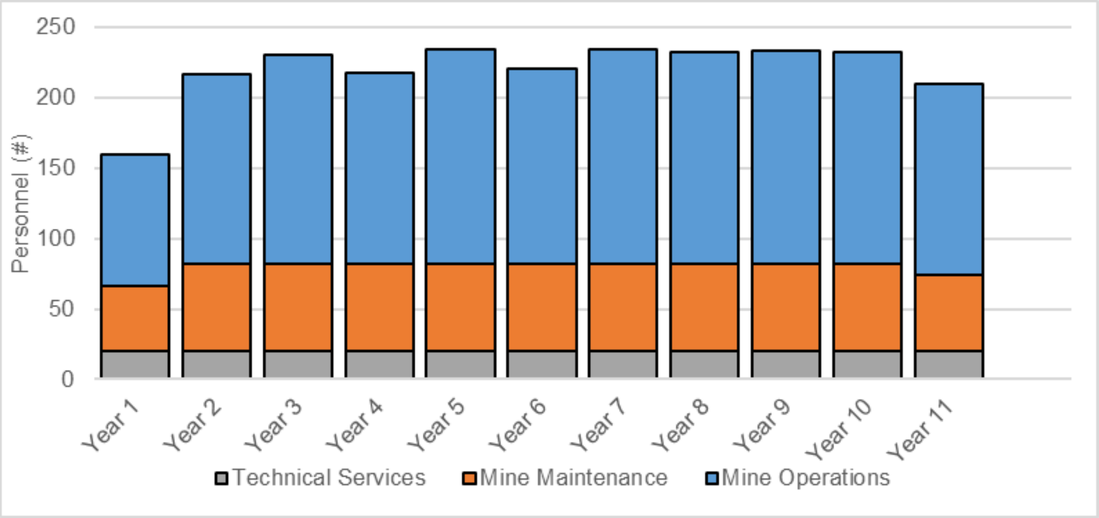


Figure 16-8: Mine Labour Requirements

16.5 Mining Capital Costs

Since the mining activities will be all contracted, there is no mining capital cost predicted for Mutanga Uranium Project. It is estimated that mobilisation fee for contractor will be required as explained in more detailed in Item 22.

16.6 Mining Operating Costs

As mentioned earlier, the Client has investigated some preliminary operating mining cost which was defined as 2.2 USD/t plus an additional 15% to represent contractor's margin. In order to verify this number, SRK has developed an independent but very conceptual cost model to estimate mining cost from first principles and obtained a comparable unit mining cost which has been used for this Study. It needs to be remembered that mining cost has influence on pit optimisation results as well as on final project economics. Sensitivity to that cost has been presented on Figure 22-2.

16.7 Geotechnics

16.7.1 Mutanga, Dibwe and Dibwe East

Basic geotechnical logging of drillcore was undertaken as part of the exploration drilling but no geotechnical assessment has yet been completed for these deposits.

16.7.2 Njame, Njame South and Gwabe

AFR undertook a geotechnical assessment on Njame ores and the results showed that the sediments are very soft with low tensile strengths and low abrasive index. The assessment involved comminution testing on six samples and Drop Weight Testing on one sample; the results are summarised in Table 16-8. A more detailed geotechnical assessment is required for each of the deposits to determine final pit slopes, bench heights, berms etc as well as waste rock dump design specifications.

Table 16-8: Geotechnical Results for Njame Ores

Brazilian Tensile Strength	1.70 to 4.85 Mpa
Uniaxial Compression Strength	14.6 to 33.2 Mpa
Pennsylvania Abrasion Test	0.06 average Abrasion Index
Bind Work Index	1.5 to 7.4 kWh/t
Bond Ball Mill Work Index	15.35 kWh/t
Bond Rod Mill Work Index	4.37 kWh/t
Impact Breakage A*b	363.8 (Very soft resistance, in lowest 1%)
Abrasive Index ta	3.60 (Very soft abrasive range, in lowest 1%)

Source: AFR (March 2008, Appendix 25, Test Work Results)

16.8 Dewatering

16.8.1 Mutanga, Dibwe and Dibwe East

During a 2008 hydrogeological study conducted by Knight Piesold on behalf of Denison Mines, relatively high yielding aquifers were encountered. It was therefore concluded that a total of 349 L/s will be abstracted from the aquifers when the dewatering systems for both the Mutanga and Dibwe are operational. Water will be abstracted concurrently from the Mutanga pit area with a minimum of 13 proposed boreholes, pumping at different rates during the Life of Mine. Four of these are existing characterisation boreholes, while nine new boreholes are proposed for the dewatering system, although more may be required depending on the aquifer conditions encountered on site. The Dibwe pit will be dewatered with a minimum of 18 boreholes, of which three are existing characterisation boreholes and an additional 15 are proposed, although more may be required depending on the aquifer conditions encountered on site. Due to the maximum depths of the pits, the boreholes for the dewatering of the Mutanga Pit are recommended to be drilled to 100 m depth, while the boreholes in the Dibwe Pit are recommended to be 130 m deep. To increase the efficiency of the dewatering system in both Mutanga and Dibwe pits, gravity drained horizontal boreholes (drains) will be drilled to a length of 30 m at every stage of the open pits at every 40 – 50 m intervals.

At the current proposed rates, mining of the Mutanga pit will commence approximately six years ahead of Dibwe, and will be largely completed when Dibwe mining commences. Thus a dewatering rate 172 L/s from the Mutanga Pit area will be needed to keep the Mutanga pit free of hydrostatic pressure for the first six years, after which an additional 177 L/s will be abstracted from the Dibwe Pit area. As a result, for the limited time when both dewatering systems are online and operational, a combined 349 L/s will be abstracted from the aquifers on site; however, it must be remembered that the interception of a large fracture in any of the pits will result in higher inflow rates than estimated and more boreholes might need to be drilled to intercept this inflow. The proposed dewatering rate is expected to keep the water level approximately 20 m below the depth of the open pits at all times during mining and related activities. This is expected to minimise the hydrostatic pressure on the open-pit walls, thereby maintaining safe mining conditions and stable open pit walls. After monitoring the water quality and conducting rehabilitation work, if required, the dewatered water will primarily be used for the process and water consumption purposes for the mine employees and local communities in the vicinity of the mine.

Dewatering of the open pits will cause an increase in the depth of the groundwater in the project area; however, as there are no communities within the impacted area that rely on groundwater, the environmental significance is rated as moderate. The groundwater levels are expected to return to their original levels in approximately 65 years after mine closure in the Mutanga domain and 82 years in the Dibwe domain. The groundwater will be restored through recharge of the aquifers by precipitation and lateral ingress from the regional aquifer system once dewatering has ceased.

Dewatering Requirements

To keep the open pits dry from groundwater ingress at all stages of operation, the dewatering programme will commence nine months ahead of the operation phase. If, however, the mining schedule is changed so that the excavation rates are increased, the dewatering operation will be commenced one year ahead of the mining operation.

To some extent, the technical feasibility of the mining cost of the Mutanga project might be dependent on the ability to control groundwater flow. The reason for dewatering the open pits can be summarised as follows:

- intercepting seepage that would enter the mining pit and interfere with mining activities, and could result in flooding and costly interruption;
- improving the stability of slopes, thus preventing slope failure;
- preventing the bases of excavations from heaving due to excessive hydrostatic pressure;
- dewatering improves the compaction characteristics of the sediments in the bottom of the mining pit in unconsolidated lithologies;
- expensive waterproof explosives are needed in wet conditions;
- wet pit conditions increase wear and tear on equipment and provide uncomfortable working conditions; and
- if water is stored in the pits for any length of time, minerals (such as sulfides) may react with water and oxygen and produce acid rock drainage. Contaminated water abstracted from the pits may require costly treatment prior to disposal.

The dewatering rates and design must be programmed properly to minimise or avoid impact to the surrounding ecosystem, but maximise the working conditions in the pit. Dewatering may have an adverse impact on nearby boreholes in the project area and this conflict has to be minimised so that the water quantity and quality of the Mutanga area will be protected.

Alternative Dewatering Scenarios

Dewatering rates of 172 L/s and 177 L/s are required to keep the Mutanga and Dibwe Pits respectively dry throughout the life of mine. If, however, only 138 L/s can be abstracted from boreholes within the Mutanga domain and 89 L/s from boreholes in the Dibwe domain.

Due to costs of borehole drilling, it is recommended that the remaining rates (34 L/s for Mutanga and 88 L/s for Dibwe) be obtained from horizontal gravity drained boreholes (drains). These drains are recommended to be 30 m in length drilled in every stage of the pits at 40 – 50 m apart. The drains can be drilled by the blasting rig and this is expected to decrease the cost of drilling and could even be more effective for the dewatering of vertical/sub-vertical faults. Water drained from these boreholes will be collected in sumps at the base of the pit that will be pumped out using a centrifugal pump.

Dewatered Groundwater Management

The total amount of water that will be dewatered during the LoM is 349 L/s. Preliminary information indicates that the amount of water needed for mining operations is 30 L/s, therefore the dewatered water will be primarily be used for this purpose.

An estimated 10 L/s will be used for water consumption by the mine employees and communities in the vicinity of the mine; however, before the dewatered water is distributed, it will be monitored for quality and quantity and undergo proper rehabilitation if necessary. An alternative to the discharging the excess abstracted water in to drainage channels is the artificial recharge of the water in to the subsurface; however, the water quality has to be monitored and deemed suitable before such a process is followed, and must be addressed if the quality is found to be unacceptable.

16.8.2 Njame, Njame South and Gwabe

Dewatering is likely to be required in this project region during the rainy season in which 600 mm of rain falls.

Knight Piesold historically conducted a preliminary estimate of the effect of pumping in the Njame area on behalf of AFR. This was based on a Theis analytical model which was developed based on the Theis equation. The results were only first order estimates to allow a general idea of the effects of pumping in the area. The Theis model assumed that a theoretical borehole was placed in the centre of an imaginary circle drawn around Pit 1 and Pit 2. The radius of this circle was approximately 1500 m to include both pits. The theoretical borehole was pumped at a specific rate and the drawdown created by the pumping on the perimeter of the circle, 1500 m away from the borehole, was calculated. The number of boreholes required to reach this drawdown was simply calculated by dividing the required pumping rate for the theoretical borehole by the average sustainable yield of boreholes in the study area.

Due to the lack of data, the following assumptions were made:

- the pits (Pit 1 and Pit 2) will be excavated during the same period;
- the pits will be excavated to a depth of 20 m during the first year of mining and thereafter the depth will increase by 10 m per year for the remaining LoM;
- LoM expected to be 5 years;
- there are no aquifer boundaries;
- the homogeneous aquifers are of infinite extent; and
- the boreholes penetrate the entire thickness of the aquifer.

In the calculations a current static water level of 12 mbgl was chosen to be the shallowest worst-case scenario. The static water levels recorded by AFR ranged from 11.2 mbgl to 44.97 mbgl. For safety reasons, it was assumed that the groundwater level should always be 20 m below the pit floor; thus, during the first year of mining, excavation will reach a depth of 20 mbgl and the groundwater level will have to be 40 mbgl. The results of the theoretical drawdowns are shown in Table 16-9.

Table 16-9: Theoretical Drawdowns from Theis (Source Knight Piesold, 2008)

Year	Pit Depth	Required Dept to SWL	Required Drawdown	Required Pumping Rate	Actual Drawdown	Number of Boreholes Required @ 2.0 l/sec Each	Number of Boreholes Required @ 1.3 l/sec Each	Number of Boreholes Required @ 0.9 l/sec Each
	(m)	(m)	(m)	(l/sec)	(m)			
1	20	40	28	65	28.2	33	50	72
2	30	50	38	65	38.8	33	50	72
3	40	60	48	70	48.7	35	54	77
4	50	70	58	76	58.2	38	59	84
5	60	80	68	83	68.2	42	64	92

The required drawdown from the current static water level (12 mbgl) will thus be 28 m; a pumping rate of 65 L/s is required to reach a drawdown of 28.2 m after 1 year of pumping. Knight-Pieshold historically recommended that between 6 and 10 suitably sited holes should be sufficient for mine dewatering. The required number of boreholes will change significantly as mining progress and also depends largely on the sustainable yield of boreholes.

The limited hydrogeological studies which have taken place historically have revealed that borehole yields are highly variable across the study area with relatively high yields encountered in deeper, weathered zones and low yields observed on rocky ridges with very shallow weathering. These low yields may present a problem for dewatering since the underlying lithologies may be able to store a significant volume of groundwater but due to the lithologies' low transmissivity, is not able to allow water flow in significant quantities into the proposed dewatering boreholes.

16.9 Conclusions

16.9.1 Results

It is clear that the majority of RoM (69%) included in this Study is based on an Inferred Mineral Resource. It is also a fact that a number of economic and technical parameters used for this study are based only on assumptions or historical studies requiring update. That introduces very low level of confidence to the Project, which is nevertheless considered appropriate for this PEA. Using a metal price of 50 USD/lb U_3O_8 for pit optimisation results there is enough RoM inventory to cover 11 years of production from the five deposits. Although, mining in those several shallow pits should be fairly simple, they are located a few or dozens of kilometers apart each other. Based on the work done it appears that potential further work should focus on increasing level of confidence in geological information, hopefully exploring more high grade resource at low strip ratio. The main findings are summarised and listed below:

- 69% of RoM material included in the Study is classified as Inferred Mineral Resource;
- Dibwe and Dibwe East have only Inferred Mineral Resource;
- pit optimisations were run for all five deposits to define pit limits, with selected pits are based on revenue factor of 1.0 representing selling price of 50 USD/lb U_3O_8;
- royalties of 3% were used for pit optimisation which may require an update to 9%;
- unified processing recovery rate of 80% was used for pit optimisation in each deposit and material type;

- mining losses and dilution were applied as 10% and 90% global values, diluting grade was at 0.0 ppm U_3O_8;
- pit optimisation results indicated relatively high sensitivity to the selling price, especially in Dibwe East;
- environmental, closure and material handling costs to the plant were not included in the pit optimisation parameters;
- total pit inventory for mineralized material is around 40.8 Mt at 334 ppm U_3O_8;
- overall strip ratio for the project is 3.4 (t:t), but varies from 1.4 to 6.0 (t:t) depending on the deposit;
- there was no pit design made at this stage, but appropriate sensitivity analyses were made and showed the influence;
- mining production schedule has been developed at a feed rate of 2.0 Mtpa in Year 1 and 4.0 Mtpa thereafter;
- very conceptual waste and RoM mining fleet estimates are based on 5.0 m^3 excavators and 45 t articulated trucks;
- it has been assumed that waste and RoM materials will be drilled, blasted and mined on 10 m benches;
- it has been assumed that all material will require drilling and blasting; and
- 170 mm blasthole drills will be used for production, pre-split and infill drilling.

17 RECOVERY METHODS (ITEM 17)

17.1 Introduction

This section describes the metallurgical process at Mutanga. As discussed in Section 13 Process Test Work, acid heap leach has been selected as the most viable method of uranium extraction and recovery.

17.2 Process Selection

The following process route is planned:

- primary crushing using a toothed roller crusher (MMD) sizer;
- secondary crushing to -25 mm;
- recycle crushing of the oversize to secondary (cone) crusher;
- agglomeration of the fine and coarse material using low pH acidic process water;
- stacking of agglomerated material on a heap leach pad; and
- acid heap leaching of agglomerated material by sulfuric acid solution by gravity percolation.

17.3 Heap Leach Site Locations

Mining will start first at the Mutanga pit and be complete by Year 5. Dibwe East will be mined from Year 2 to Year 10. In Year 2, ore will be mined from Dibwe East and both provide the majority of ore until Year 5 when satellite heap leach operations will start from Gwabe. In Year 6, satellite mining at Njame and Dibwe will continue through to the end of mine life. Crushing equipment will be moved from Mutanga to Gwabe and ore trucked from Njame to Gwabe for crushing and stacking. The Dibwe ore material will be moved by truck to the heap at Dibwe for processing, such that stacking of heaps will occur at only two heaps at any one time, although solution recovery will take place at all three over the life of mine.

Ore will be trucked from the pits to ore preparation areas located near each pit for crushing and conveying to adjacent heap leach pads. Pads will be irrigated with an acid solution to leach the uranium. The solution will drain to a pond and then be pumped to a located near the Mutanga pit.

A leach pad area will be located adjacent to each pit. The crushing and conveying equipment will first be installed at the Mutanga-Dibwe East pad area. When the Mutanga ore is exhausted the equipment will be relocated to the pad adjacent to the Dibwe pit. Reclamation of the pad areas will be ongoing during the life of mine as pads reach full height and leaching is completed.

A summary schematic of the process scheme is shown in Figure 17-1; however, exact locations of heap leach pads and ponds will be determined once final geotechnical information is available. It is planned to have these facilities located as close as practical to the pits in areas of gently sloping topography while avoiding watercourses.

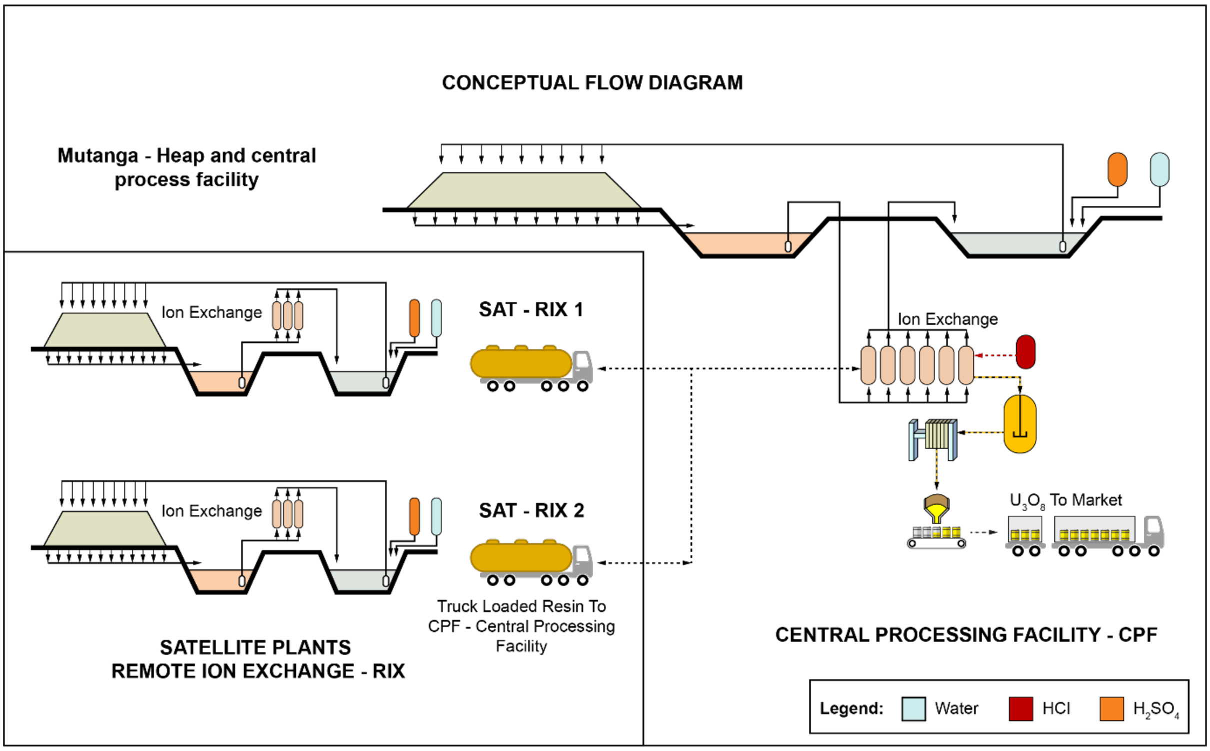


Figure 17-1: Schematic Process Flow Sheet, Mutanga Projects

17.4 Plant Design Basis & Criteria

17.4.1 Source Data

The basis for the design of the processing facilities should be read in conjunction with the Process Flow Diagrams.

The design criteria presented in the following sections are based on the following sources:

- testwork and plant data;
- Client advice;
- experience gained from previous projects of a similar nature;
- generally accepted practice;
- calculated data; and
- published literature.

17.5 Benefication

17.5.1 Primary and Secondary Crushing

All equipment in this section will be covered appropriately to minimise dust and operator exposure to uranium oxide, radiation, and radon. Mine trucks will discharge into the crusher feed hopper by direct tip. The hopper will have a live capacity of approximately 285 t or 60 minutes' residence time equivalent.

Ore will be withdrawn from the hopper by an apron feeder and will be fed directly into the primary mineral sizer. Feed rate will be controlled to an operator set-point for the agglomerator feed belt weightometer. Oversize rocks (+700 mm) will be scrolled off the sizer into a bunker. These boulders will be broken using a mobile rock breaker and periodically returned to the circuit.

The crusher conveyors will be designed to have a relatively slow belt velocity of approximately 1 m/s to facilitate tramp metal removal. Tramp metal rejected by cross belt magnets will be deposited in bunker areas.

Two stages of metal detection will help prevent metal entering the secondary (cone) crusher. Upon detection of tramp metal, the bypass gate at the head of the conveyor will be activated and the ore stream will bypass the cone crusher for a predetermined period. Bypass pebbles will be deposited directly on the crushed pebble conveyor.

The recycle conveyor will discharge into the cone crusher surge bin. Feed to the crusher will be controlled by a vibrating feeder.

The cone crusher will crush the pebbles from a nominal maximum feed size of 100 mm to a P_{80} of approximately 25 mm. The cone crusher will operate at a closed side setting of 20 - 25 mm, depending on the ore competence, moisture content and crusher power draw.

17.5.2 Vent Scrubbing

Dust collection will be installed at all transfer points and where operators may be stationed, using a low energy venturi type wet scrubber. The slurry from the scrubber underflow will be recycled to the agglomerator section.

All equipment described in this section is to be covered appropriately to minimise dust and operator exposure to uranium oxide and radon. Dust generated beyond the agglomerator at conveyor transfer points and final discharge onto the pad will be minimal due to the moisture content of the ore introduced by the addition of the leaching solution.

17.5.3 Agglomeration

The agglomeration feed belt will be equipped with on-line measurement devices for moisture and U_3O_8 content. Both these measurements will be integrated with a belt weightometer to provide the operator with real-time measurements to control throughput and feed blend to maintain a relatively consistent uranium feed to the plant.

The recycle crusher product will be discharged onto the agglomerator feed belt with the screen undersize. Acid leach solution is used to moisten the dry crushed product so that agglomeration can take place. The control loop will be configured on a solution ratio based on the sum of the screen undersize and the recycle crusher product, minus feed moisture.

Variable speed control of the agglomerator will be provided. This will provide consistent and cost effective processing of the various ore types and blends. The agglomerator product will discharge onto a vibrating screen, with 25 mm deck aperture. The undersized pebbles (<25 mm) will be recycled to the agglomerator.

Dust generated at the transfer points will be extracted to a wet gas scrubber.

17.6 Materials Handling (Stacking)

The stacking system will convey the crushed and agglomerated ore from the ore preparation area to the adjacent pads and then deposit the ore onto the pad using a stacker system. Portable ‘grasshopper’ type conveyors will be used to convey the ore. It is planned to deposit the ore in three individual 4 m high lifts using a stacking conveyor system. The stacking system will consist of an extendable conveyor with tripper and spreader which will feed the stacker.

The system will operate 24 hours a day and seven days a week, so flood-lighting will be provided on the machine and tripper structure to provide good lighting for safe operation at night.

Storm brakes and outriggers will be used to secure the stacking equipment during high wind conditions for safe operation in winds up to 80 km/h. In higher winds, the system will be shut down. An anti-runback device will be fitted to the travel drive of the spreader to prevent run back down the slope.

This system will form a dump by depositing material along the width, typically about 400-1100 m. The spreader will travel on rails that straddle the conveyor. When a level is formed along the length of the conveyor, the whole system is shifted forward by the length of the boom.

17.7 Heap Leach Pads

Several days after deposition of a lift and as soon as sufficient area is available, a small low ground pressure bull dozer will level the area. Irrigation piping and drippers will then be laid on top and a dilute acid solution will be pumped through the irrigation system and percolate through the heap, dissolving the uranium into solution. The solution will gravitate through the heap into the perforated drainage pipes located in the heap above the membrane and into the solution collection trenches and enter the intermediate PLS pond. This solution will be re-pumped to the heap via the irrigation system on a continuous basis until the uranium concentration is sufficient for extraction. The solution will then be transferred via drainage trenches to the PLS pond and pumped to the continuous ion exchange circuit ("CIX") at the processing facility.

It is planned to irrigate the ore for an initial period and occasionally thereafter until leaching is complete, then preparations for the next lift will begin. Mutanga will likely require a 60-day initial irrigation period, while Dibwe may require up to 90 days. It is also planned to investigate a leach-rest-leach mode of operation, where an initial 60 days of leach will take place, followed by a 30 day rest period, followed by another 60 days irrigation.

The height of each lift is dependent on the permeability of the ore. The higher the permeability the higher can be the lift can be. Optimum lift height will be determined after start up. Tests conducted on Mutanga and Gwabe ore indicate that a high degree of permeability will be achieved and irrigation rates of 10-12 L/m^2/min are not unreasonable.

17.8 Leach Pad Construction

The plan is for three separate leach pads to be constructed. The largest leach pad will be situated between Mutanga and Dibwe East which will be designed to ultimately hold 30.83Mt of ore. A second smaller satellite heap will be constructed for Dibwe (4.1 Mt of ore), with a third heap planned for Njame and Gwabe deposits which will be designed for 5.8 Mt of ore. An initial pad area equal to approximately two years production will be constructed at Mutanga and Dibwe East and, thereafter, an annual construction programme will be undertaken to prepare sufficient pad area at these and satellites heaps for the following year. Pad decommissioning and closure activities on the first pads will commence early in year two as pads reach their full height and leaching is completed. This will cycle be ongoing on subsequent pad areas.

The heap leach pad design criteria are as follows:

Crushed/agglomerated ore:	4 Mtpa
Total storage capacity required:	40.82 Mt (in three heaps)
Assumed dry density of ore in place:	1.6 t/m^3
Required volumetric storage capacity:	11.7 Mm^3
Moisture Content of delivered material:	85% solids by mass
Final slope of completed heap after decommissioning;	18º
Total area of the footprint of the heap facility:	variable
Design basis earthquake for seismic loading:	1 in 500 year event.
Maximum stack height:	12 m

Although the South African standard for rainwater run-off is 1:50 years, the heap leach containment pond capacity has been calculated based on a more conservative 1:100 storm event.

To construct a leach pad, the area is first to be cleared of vegetation and shaped on a gently sloping area towards the solution ponds. Location will be selected to minimize excavation and fill as well as avoid existing water courses. Irrigation trenches and solution collection trenches will then be cut into the pad surface. Any large stones will be removed to present a smooth surface that will not damage the liners.

Liners for pads, trenches and ponds will all use a two liner system. Shallow trenches will underlay the pads to aid in directing leach solutions out of the heap and into adjacent collection trenches that will drain by gravity to the solution ponds and leak detection sumps.

For pads and ponds, the bottom liner will be comprised of a clay or geosynthetic clay liner. A permeable drainage layer for leak detection will then be placed which will be overlain by an ultra violet resistant 60 mm high density polyethylene top liner (HDPE). For the pads, a protective layer of fine grained permeable low grade ore will be placed on top of the HDPE liner to provide physical protection during the pad stacking operation. Within this low grade material HDPE perforated pipe will be installed and covered with coarse stone and sand to prevent clogging of the perforations. These pipes will act as drains to direct leach solution out of the heap to adjacent ditches. From there, the solution will drain by gravity to the ponds.

Once leaching of a lift is complete preparations for the next lift will begin. The top surface will be scarified and the next lift deposited. If permeability through multiple lifts is expected to be a problem, an impermeable membrane and drainage system will be placed on the surface prior to the next lift

Leakage detection systems will be incorporated in all pads and ponds. The systems will consist of leak detection sumps that will connect to the permeable drainage layers between the liners. In the event of a leak, the leach solution will report to the sumps. The sumps will be monitored regularly during leaching and afterwards for seepage detection.

Prior to installing new liner systems, an experienced third party inspection agency will be engaged to confirm the integrity of the liner and leak detection systems. The inspection agency will provide a quality assurance programme that will include requirements for a liner manufacture inspection and test programme, installation procedures and quality control activities such as liner weld testing and record keeping. Qualified inspectors will then be engaged to carry out the programme. Compliance with the quality assurance programme will be a requirement for contractors and suppliers. All ponds will be water tested prior to use.

17.9 Pad Decommissioning and Closure

Once a pad has reached full height and leaching is complete, it can be decommissioned and closed. Leach pad decommissioning and closure will be in accordance with internationally accepted good practice, for example as recommended in the IAEA document TECDOC-1403 “The long term stabilization of uranium tailings”, August 2004.

The general objectives of decommissioning and closure of the leach pads are to ensure long term chemical, physical and radiological stability. The specific objectives include:

- prevent exposure of radioactive and any other hazardous constituents of the leach pads;
- prevent emission of radon;
- prevent ingress of surface water and facilitate shedding of rainfall runoff;
- prevent erosion of the cover; and
- long term durability of all these measures.

De-commissioning will involve rinsing the heap with raw water until the pH of the discharge water has reached stable to neutral conditions. This will be followed by spreading neutralizing material over the surface of the pad to induce further neutralisation over time (should this be necessary). The surface of the decommissioned pads will also be used as a containment area for water treatment sludge. This sludge is alkaline in nature and this will assist in neutralising the heap. Areas of steep side slope will be graded for long term stability.

Closure will require that the decommissioned pad be covered with a radon barrier and then capped with a 0.5-1.0 m thick surface layer (dependent on monitoring results) of topsoil, landscaped and vegetated to ensure that all rainwater falling onto the area is shed and does not infiltrate into the heap. The top surface will be contoured to facilitate diversion of runoff water to spillways and routing to a settling pond before discharge to the environment.

17.10 Leach Solution Management

Leach solutions will be managed using three containments, each equipped with submersible pumping systems: intermediate PLS pond; PLS pond; and the emergency containment pond ("ECP").

17.10.1 Intermediate PLS Pond

Leach solution draining from the pads will be directed to the intermediate PLS pond. The intermediate PLS pond will be used as a "catch" for any solids that may be entrained in the PLS. Leach solution will be recycled back to the surface of the heap until the required concentration of uranium is achieved when it will be transferred to the PLS pond and leaching will continue.

17.10.2 PLS Pond and Pipeline

The PLS pond will be provided for storage of final pregnant liquor prior to pumping to clarification and ion exchange (the process plant). Once uranium is removed from the PLS at the process plant, it will be returned as barren solution and piped to the barren solution pond. The pipelines to and from the process plant will be by surface run HDPE. During detailed design, considerations will be made to ensure that the pipe-lines are of suitable materials of construction to cater for the higher pressure and duties of the line. When Dibwe and Njame/Gwabe come into operation, separate adsorption columns will be located at these satellite process areas. The loaded resin from these operations will be transported by tanker to the central elution plant for extraction and concentration of the uranium. Eluted resin will be recycled back into the Dibwe and Njame/Gwabe ion exchange columns.

17.10.3 Barren Solution Pond (Emergency Containment Pond (ECP))

The barren solution pond will store barren leach solution returned from the process plant and will also act as a containment to provide storage for contaminated rain water runoff from pad areas being leached or pad areas that have been leached but have not been closed. The volume will be sized to accommodate a 1:100 year storm event, the current volume of these ponds will be 60,000 m^3 at Mutanga and Dibwe East and approximately 35,000 m^3 at Dibwe and Gwabe.

17.10.4 Leach Solution Bleed Stream Treatment

A bleed stream is required from the leach solution for the periodic removal of impurities. These impurities accumulate over time and have to be removed so as to prevent contamination of the resin used to extract uranium from the leach solutions.

The bleed water treatment system will comprise of lime treatment (with sludge recycle for densification) to precipitate soluble impurities including magnesium. A CO_2 carbonation system (notionally with diesel exhaust or CO_2 supplied from a reagent supplier) will be added to precipitate the lime alkalinity from the supernatant. Carbonate settling/storage and a treated water storage pond will also be provided. The accumulated sludges would be reclaimed and placed on top of the exhausted heaps as part of the closure plan, since they will have a significant amount of useful alkalinity (magnesium hydroxide and calcium carbonate) to neutralize any residual acidity. The detail of this is part of the overall closure/reclamation plan (see Environmental Section). This system supports the Mutanga objective of zero discharge of process water into the environment.

17.11 Leach Pad Storm Water Management

Rain water runoff from the leach pads in areas not closed will be classed as contaminated. Principal containment will be the barren water pond, but other containment areas may be provided. Runoff water from leach pads that have been closed will be discharged to settling ponds before release into the environment.

For the purposes of determining pad area for runoff water storage requirements, it is assumed that pad areas will be reclaimed within 18 months of the start of leaching. Based on this, it is assumed that ponds will need sufficient capacity to contain runoff from 16 ha of pad or 32,000 m^3. Currently, the barren solution pond (emergency containment pond) is designed at 60,000 m^3 for Mutanga and Dibwe East, and 35,000 m^3 for Dibwe and Gwabe. This volume may, in the future, be designed to be contained in a combination of process ponds: barren pond, PLS pond, and intermediate PLS pond. The decant pumping systems for the ponds will be designed to maintain their water levels to ensure that sufficient freeboard is maintained to allow for 1:100 year 24 hour rainfall event of 200 mm to be contained even at the height of the wet season. Due to the lack of sufficient climatic records to carry out statistical analyses, the wettest year on record (see the climatic data in the Hydrology Section) was examined to determine the design storm event. One set of in-pond submersible pumps will be installed for normal operation, a second set on standby to be brought into operation whenever it may be necessary to decant additional water (generally after major storms) between the ponds before release into the environment.

During the wet season and following major rainfall events, heap leach solution make-up water and process make-up water will be sourced as a priority from the barren solution pond (emergency containment pond (“ECP”))

Clean storm water runoff from the external catchments uphill of the leach pads will be diverted and discharged to the environment.

17.12 Leach Pad Monitoring

The following monitoring observations will be recorded by the operators in a logbook during operation:

- Weather: daily rainfall, pan evaporation, temperature and winds recorded at a weather station to be set up on the site.
- Agglomerated ore delivery: daily tonnage and agglomerated material percentage moisture.
- Water return: daily quantities pumped from PLS pond to plant.
- Seepage water: daily water levels and quantities pumped out of any drain outlets chemical quality of seepage weekly.
- External monitoring boreholes: weekly water levels and water quality measurements.

17.13 Leach Pad Slope Stability

Based on current conservative assumptions of permeability, it is initially planned to stack to a height of 12 m. Once operations are underway and more experience is gained, it will be desirable to increase this height. A slope stability analysis was performed on the leach pad constructed in three lifts to a height of 18 m. It was assumed that there is no phreatic surface since the agglomerated ore is highly permeable and all the water will be discharged using the solution drains located on the floor of the heap leach pad facility. The agglomerated ore body was modelled on a slope of 1:2.5 with a 5 m-wide bench at a 4 m-high increment. Parameters used for the analysis are given in Table 17-1.

Table 17-1: Material Properties for the Heap Leach Pad

Material	(kN/m^3)	C	Φ(º)
Rock	21	50	42
Sand	22	0	35
Agglomerated ore deposit	22.2	0	35
Base soil	22	0	30

When the analysis was done, it was assumed that the water from the rain will percolate through and be discharged into the ECP via the solution drains and trenches.

No water is expected to be stored on the heap leach pad and the lowest factor of safety of 2 is to be used (determined using an analysis program called SLIDE as indicated in Figure 17-2). Interbench set-back will be confirmed during initial operations.

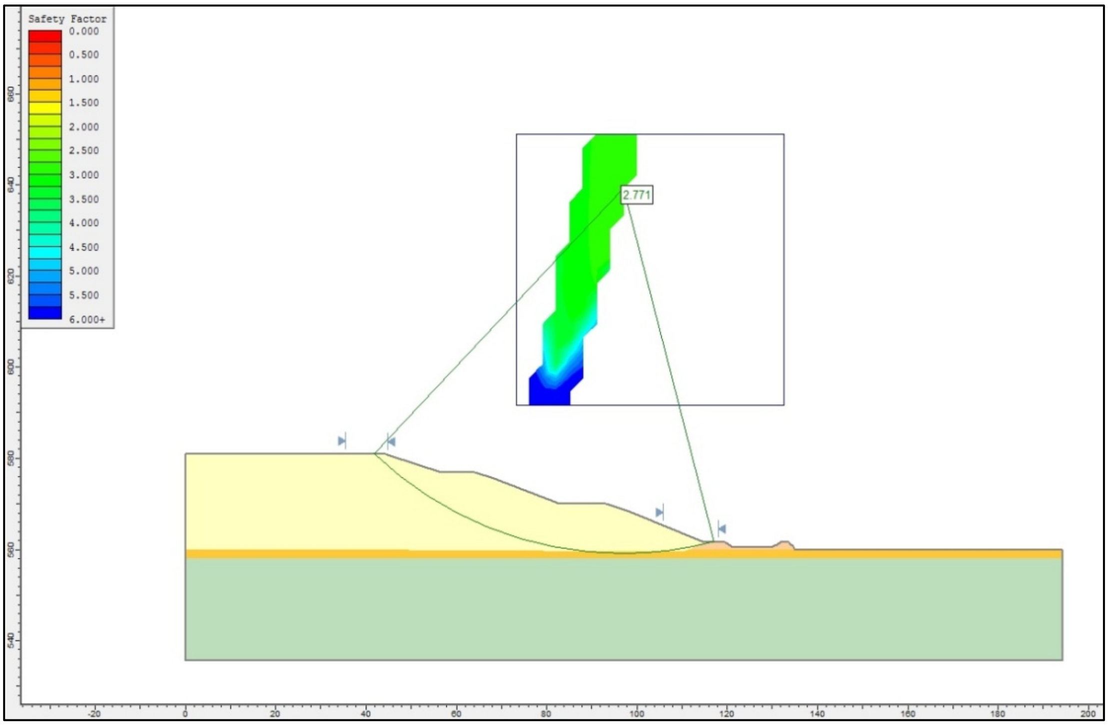


Figure 17-2: Slope Stability Analysis – Heap Leach Pads (Source: MDM, 2009)

Overall pad slope from toe to crest will be 18º. As part of closure operation, heap slopes will be graded to 20º. Based on experience and information currently available, these design criteria are likely to provide positive results with respect to stability. During initial operations, slopes will be monitored and corrective actions taken as necessary to ensure stability during leaching and closure. Slopes will be monitored during stacking and closure, particularly until experience is gained during the early years of operation.

Slope failures will be most likely to occur during active leaching due promoted by the elevated pore pressure from solution percolation. Closure of pads will start in Year 2 of operation, so adequate monitoring time will be available to ensure long term stability of the heaps. In the event that slope failure occurs prior to or after closure of the pad, consequences are not expected to be significant and remedial work could be carried out quickly and cheaply. In the event of a failure, the following corrective actions could be considered:

- Immediate remedial work involving cleanup of the material and re-deposition on the pad. Other measures could include increasing the pad area beyond the toe of the slope to allow failure to occur.
- If failure occurred prior to closure, the setback distance would be increased. If failure occurred after closure, the pad area could be extended further and slopes re-graded to a lesser angle.
- Improving drainage within the heap.
- Slopes will be monitored during stacking and closure, particularly until experience is gained during the early years of operation.

17.14 Continuous Ion Exchange (CIX)

The pregnant solution will be pumped from the pregnant solution pond at Mutanga and Dibwe East to the processing area where the uranium will be loaded onto the ion exchange resin. When the resin has reached the appropriate loading level, the uranium will elute from the resin beads. The eluate (concentrated uranium solution) will be then be pumped to the uranium oxide extraction circuit, for further refining and concentration.

When the Njame, Gwabe, and Dibwe pits are put into operation and leaching is underway, PLS will be pumped to an adjacent uranium adsorption facility where the solution will be stripped of uranium and returned to the pad. The uranium loaded resin will then be transported by truck for further processing at the CPF. Barren resin will be trucked from the CPF back to the adsorption facility for recycle. It is estimated that approximately 24,000 L/day of resin (one truck load a day) will be transported each way. Loading and unloading of trucks will done in contained areas, all run off and clean-up water will be captured in sumps and returned to process. Transport of resin by pipeline was considered, but was rejected due to high cost and risk associated with multiple pumping stations and double containment systems.

Other supporting facilities such as acid storage, loaded resin storage, barren resin storage, process water storage, and the bleed stream water treatment plant will be required to support the adsorption facilities at the satellite operations.

17.14.1 Clarification

A hopper clarifier system will be incorporated prior to the CIX to remove any entrained solids prior to CIX. A final polishing filtration step may also be included at a later stage should the PLS still have some remaining ultra-fines.

17.14.2 Ion Exchange

The PLS (from the heap leach pad) will be clarified and fed continuously to an ion exchange carousel where the absorption, elution, washing and conditioning steps occur in a sequential fashion. See a detailed description of the CIX circuit below.

17.14.3 Primary, Secondary, Tertiary and CIX Elution

Sodium bicarbonate is used as an eluant for stripping of the resin. The concentrated eluate from this circuit is advanced to the concentrator area

The CIX process flow diagrams provide the general flow arrangement for this circuit. The mechanical equipment selection is given in the area equipment list.

The primary PLS (from the scrub circuit) and the secondary PLS (from the leach circuit) are clarified and fed continuously to an ion exchange carousel where the adsorption, elution, washing and conditioning steps occur in a sequential fashion.

- The step frequency of the columns is controlled by the mass feed rate of uranium. Internal flow rates are controlled by uranium values delivered by the in-line XRF unit.
- The concentrated eluate from this circuit is advanced to the refinery section.
- The barren liquor, where it is not directly returned to the process, is a source of hydration fluid for flocculant, sealing fluid for slurry pumps, etc.

The CIX flow sheet and equipment selection has been made to deliver a PLS to Concentrated Eluate concentration ratio in excess of 70:1.

A further requirement of the circuit is to minimise impurity “carry-forward” to the refinery circuit. The primary impurity of concern is vanadium.

17.14.4 CIX Resin Handling

Resin washing and handling takes place in this section. Used resin is washed using a vibrating screen, whereas fresh resin is injected via Venturi system.

17.15 Concentrator

The concentrator areas are as follows:

17.15.1 Sodium Diuranate Precipitation

Dissolved uranium is precipitated using sodium hydroxide and a controlled temperature. Sodium diuranate (“SDU”) seed crystals are added to initiate the precipitation process. The SDU slurry is then pumped to the SDU thickener.

Extract ventilation and equipment selection has been provided to target an air quality index (“AQI”) for uranium of approximately 2 mcg/m^3.

The concentrated eluate is committed to a seeded sodium diuranate precipitation circuit in which sodium hydroxide is employed as the precipitant.

The SDU is thickened and washed in settlers before being converted to oxide.

A fraction of the barren liquor from the SDU step is converted to fresh eluant employing carbon dioxide whilst the balance is added to the primary PLS and returned to the ion exchange carousel.

Process liquors from the thickening and washing circuit are filtered in polishing filters and the uranium recovered from the residue via an in-situ leach employing sulfuric acid.

The washed SDU is finally processed to oxide via a two stage process of:

- re-dissolution in sulfuric acid; and
- precipitation by sodium hydroxide with concomitant addition of a diluted (20 – 30%) hydrogen peroxide and precipitated as UO_4.

17.15.2 Sodium Diuranate Thickener

SDU is thickened in preparation for the SDU washing step.

17.15.3 SDU Washing Circuit

SDU is washed using clean raw water and four wash settler units.

17.15.4 SDU Polishing Filtration Washed

SDU is filtered and rinsed will SDU thickener overflow for the removal of further impurities.

17.15.5 SDU Resolution Circuit

SDU filter cake from the polishing filtration step is repulped and redissolved in sulfuric acid.

17.15.6 Uranium Oxide Precipitation and Final Product Handling

The concentrated eluate is committed to a seeded SDU precipitation circuit in which sodium hydroxide is employed as the precipitant.

The SDU is thickened and washed in settlers before being converted to oxide. The washed SDU is finally processed to an oxide via the process of precipitation by sodium hydroxide with concomitant addition of a diluted hydrogen peroxide.

The off-white oxide is thickened and washed in a two stage decanter centrifuge circuit before the solids are dried under partial vacuum (see Section 17.15.9). The final dry oxide is delumped, sampled and drummed in 140-210 L drums. Further information on product handling is included in Section 18.9 Transport and Logistics.

The materials selection for the equipment in this circuit is a low grade stainless steel with the floors adequately protected with a polymeric coating.

A fraction of the barren liquor from the SDU step is converted to fresh eluant employing carbon dioxide whilst the balance is added to the primary PLS and returned to the ion exchange carousel.

Process liquors from the thickening and washing circuit are filtered in polishing filters and the uranium recovered from the residue via an in situ leach employing sulfuric acid. There are several key design criteria to follow, including:

- the final product concentrator will be located in a secure area;
- reagent control for optimal process outcomes is important;
- temperature control is essential for product morphology; and
- all barren liquors will be polished filtered before leaving the concentrator area and will be returned to the leach circuit for recovery of any residual uranium.

17.15.7 Centrifuge

The primary centrifuge will remove moisture to below 10% solids by the action of high revolution spinning and the resultant centripetal forces. A certain fraction of the solids will be misplaced. These misplaced solids will then be fed to the secondary centrifuge for collection. The centrifuged product is then fed to the next area, which is vacuum drying.

17.15.8 Concentrate Polishing Filtration

The filter cake from the centrifuge is then polished further by filtration. The cake is repulped using demineralised water.

17.15.9 Vacuum Pan Drier

The vacuum pan drier removes virtually all the remaining moisture. UO_4 will be loaded into drums which are sealed, washed and transported to the adjacent storage area.

17.15.10 Recovery and Concentrator Vent Scrubber

All ventilation products from the refinery steps are processed through the vent scrubber. The scrubber collects any SDU or uranium bearing material which then reports to a collection tank. This product is then pumped to the SDU precipitation circuit.

17.16 Reagent & Utilities

A large component of this section is comprised of package plants, which will require more definition in the PFS phase of the project. The layout of the reagents and utilities circuits are not centralised but rather dispersed within the process building blocks.

17.16.1 Bleed Stream Water Treatment

Periodically, the process water will be treated to remove any build-up of ions in the circuit (as described previously). These ions will be removed by precipitation by the use of powdered limestone to raise the pH of the water. The precipitated sludge will contain a range of base metal hydroxides including iron, magnesium, aluminium etc and will contain traces of uranium and thorium. The sludge will be thickened and then pumped to the surface of a spent heap leach pad to aid in decommissioning.

17.16.2 Gland Water Supply

Gland water is treated by filtration of the raw water supply.

17.16.3 Potable Water

See Section 18 Infrastructure

17.16.4 Cooling Water

Cooling water will be supplied by an evaporative cooling system and will be a vendor supply package.

17.16.5 Hot Water Generator

Hot water will be generated by passing raw or process water via a heat exchanger and will be electrically supplied.

17.16.6 Sewerage Treatment Plant

See Section 18 Infrastructure.

17.16.7 Flocculant Hydration

A modular, self-contained flocculation plant will be sourced as a package and will be supplied by a vendor.

17.16.8 Plant and Instrument Air

Three compressors will be situated in a covered structure inside the plant area. Two units will run with the third on standby. If air demand becomes excessive, all pumps may be run in parallel. Air driers and filtration will be provided for the instrument air.

17.16.9 Reagent Make-Up

This section of the plant accommodates the following reagent make-up circuit:

- sulfuric acid 98% concentration delivered by road tanker;
- sodium hydroxide;
- sodium bicarbonate;
- flocculent; and
- lime slaking and hydration (for water bleed stream treatment)

In all of these circuits the raw materials are received in bags.

Only in the case of the sodium bicarbonate is corrosion protection needed to vessels and floors.

17.16.10 Hydrogen Peroxide

The hydrogen peroxide (60%) will be stored in low grade stainless steel vessels. Appropriate cleanliness in fabrication of the vessels and whilst in operation will be necessary.

17.16.11 Gases

The compressed air products are standard services within a process plant of this type. The following gases are reticulated:

- instrument air (700 kPa(g)); and
- process air (700 kPa(g)).

17.16.12 Sodium Hydroxide

This section of the plant accommodates the following reagent make-up circuit:

- sodium hydroxide

17.16.13 Sodium Bicarbonate

Granular Sodium bicarbonate will be used on site. It will be transported and stored in iso-tainers and pumped to the concentrator section as required.

17.16.14 Hydrogen Peroxide Storage

Hydrogen peroxide will be transported and stored in iso-tainers and pumped to the concentrator section as required.

17.16.15 Sulfuric Acid

Sulfuric acid is received at 98% grade. The storage and dispensing system is standard for this material.

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

17.17 Water Balance

The following water circuits will be reticulated:

- fire water (employing raw water);
- potable water (for ablutions, safety showers, etc.);
- demineraliser plant (reverse osmosis);
- cooling water (employing potable water); and
- process water.

Process water will be recovered from the barren CIX solution and pumped to the process water tank. As necessary, makeup water will be delivered to the process water tank to make for losses incurred primarily from evaporative losses on the heap leach pad and agglomeration water.

Sources of makeup water in order of priority will be: contaminated water type B (reference Section 20 Environment); contaminated water type A; and raw water from the pit perimeter dewatering system. Makeup water will be transferred to the process water tank or the process water makeup tank that will be located within the plant area.

The inflow of both types of water will be controlled by float valves on the delivery pipelines. The floats will be situated so that the raw water delivery, controlled by the lower float valve, is only used if the flow of barren process water is insufficient to match the demand.

Raw water for make-up will be delivered to the raw water tank. Sources of raw water will include the raw water pond or a dedicated borehole in the process plant area. Raw water will be pumped to points of usage in the plant that require water, free of suspended solids or chemical contamination with acid. Raw water will be used in the crusher area for dust suppression; the elution section for making up eluant solutions, resin transfer; reagent make up for making up fresh bicarbonate solution. Potable water will be used for fire water and safety showers. Potable water will be pumped from an independent borehole and will deliver water that is suitable for purification to potable standard (see block-flow). The other raw water demands will be of intermittent demand.

Raw water will also be used for pump gland service. A gland water pump will be installed, delivering to the plant gland service network via a filtration section.

Filtered raw water will be used for all dust suppression operations both within the processing area and the mine.

17.18 Ventilation, Dust Suppression and Dust Extraction

All transfer points and tipping areas will have either dust extraction or dust suppression or both. Dust collection will be installed at all transfer points and where operators may be stationed, using a low energy venturi type wet scrubber. The slurry from the scrubber underflow will be recycled to the agglomeration section and will be deposited on the heap leach pads.

17.18.1 Dust Suppression

Dust suppression will be via high pressure atomising sprays. The water feeding the dust suppression system will be of potable quality and will be filtered to 1 µm via in-line cartridge filters, operating in a duty and stand-by mode, so that the cartridges can be cleaned without taking the dust suppression system off-line.

Dust suppression sprayers will be located so that a fine mist curtain is maintained within the mining area and RoM building. These sprays will be fed via a ring-main system. A truck de-dusting station will be installed so that the dust present on the mining haul trucks can be whetted. Excavation areas and transfer points within the pit will be supplied with dust suppression.

17.18.2 Dust Extraction

Dust extraction will be achieved by vacuum pumps via a wet dust scrubber. The scrubber underflow will be extracted in the form of a slurry and returned to the agglomeration area.

The ROM tipping bin will be housed in an enclosed steel clad building. Dust extraction points will be strategically located in the area to eradicate any dust that has escaped the dust suppression system.

Crushing and Screening

The crushing and screening areas will be protected from dust leakage as above. The crushing and screening circuit will be contained within an enclosed building. The dust will be prevented through dust suppression methods and escaping dust will be extracted.

Concentrator and Final Product

The concentrator will be located in a secured, enclosed building (see the Infrastructure section). After filtering and drying, the uranium oxide product will be bagged and sealed in standard drums, specially manufactured for the transport of this material.

The concentrator section will be well ventilated and will have a negative displacement pressure extraction system. All dust will be collected in a wet scrubber and returned to the SDU precipitation circuit.

17.19 Control Philosophy

17.19.1 General

A PLC and SCADA control and monitoring system will be implemented.

All conveyors will be fitted with pull switches along their entire accessible length for emergency stop, as well as under-speed detection.

A facility for lockout of each drive for maintenance purposes will be installed within the MCC cubicles.

The agglomeration and conveyor motor starts will be fitted with a 10 second time delay on start-up and an audible warning siren.

Electrically powered cranes and hoists will be equipped with a hand held remote control operating keypad, and a continuous audible siren will sound when the hoist is travelling.

Spillage sump pumps will be started and stopped manually when required.

Positive displacement pumps (helical rotor type) used for flocculent dosing and eluate pumping will be equipped with pressure relief valves.

An assay laboratory will be provided on site for mine grade control, exploration and plant sample analyses. The plant will also be equipped with sample preparation facilities (filter presses, ovens, riffles) and sufficient equipment to perform some routine procedures such as particle size analyses by sieving. The assay laboratory will fall under the plant manager and will be supervised by a qualified mine assayer. The assayer will be responsible for storage of reserve duplicate samples typically for a 30-day period. Critical long-term samples will be archived for the life of the mine for external auditing purposes. Periodically, check samples will be sent to an independent external laboratory for verification and cross-referencing.

A facility for such routine process control tests such as titrations for alkalinity determination will be present in the shift laboratory, located on the plant. The plant operators will staff this facility.

17.19.2 Crushing

One single idler mass meter will be provided to account for the tonnages of crushed ore. The mass meter will have a local display of instantaneous and totalised tonnage. Regular samples will be taken to determine the ore moisture, and the factor used to compensate the belt weigher reading to calculate the dry tonnage processed.

17.19.3 Thickening (SDU)

A pressure transducer fitted to the hydraulic power pack will provide thickener torque indication. If an increase in solids loading raises the torque to 55% of the installed torque, the pressure transducer activates the high torque alarm and a siren sounds. This warns the operator to take corrective action to prevent an excessively high torque in the thickener. The alarm will continue to sound until the operator accepts the alarm condition.

If the torque continues to rise to 65% of the maximum torque, the rake lifting action will start and the system alarms as previously described. The rake will rise until the torque drops below 55%. The rake will then stop rising. If the torque drops below 50% of the installed torque, the rake will begin to drop. If the torque rises to 100% of the installed torque, the hydraulic motor will trip and the very high torque alarm will be activated.

Bed level indication and a pressure transducer at the thickener cone will be provided to alert operators of any build up in inventory in the thickener.

The level of the process water tanks will be controlled by float valves on the return water and raw water delivery lines into the tank.

The level of the raw water pond will be controlled manually by the operator observing the level in the pond and arranging for the water supply to be reduced or stopped if the pond is full. A high level alarm will be fitted to alert for overflow conditions.

The flocculent make-up system will be manually operated.

17.19.4 Reagents

Each compressor will have an automatic controller, which senses the system pressure and starts and stops the unit when required. The operator should only need to restart the machine after shutdown. The air receiver will be fitted with an automated drain valve that periodically drains any accumulated moisture from the vessel as well as a pressure gauge.

Level indicators will be provided in all the reagent storage tanks. Safety showers will be located near every reagent tank and bulk tanker delivery points.

18 PROJECT INFRASTRUCTURE (ITEM 18)

This section presents the proposed infrastructure assets for the Mutanga Project, as well as an evaluation of the transport options to site for consumables and equipment.

18.1 Site Layout

Operations will comprise five open pits at Mutanga, Dibwe, Dibwe East, Gwabe, and Njame (Figure 18-1). There will also be three heap leach pads at Dibwe East, Mutanga and Gwabe/Njame and a CPF between Dibwe East and Mutanga. Uranium ore will be removed from the open pits by truck and dumped directly onto the leach pads. Ore surplus to the pad's immediate requirement will be dumped onto the RoM ore stockpiles adjacent to the leach pads and reclaimed later. The ore will be crushed and agglomerated and fed by conveyors along a stacking unit onto the heap leach pads. The heap leach pads will be lined with a double layer of non-woven geotextile liner with an interlayer leak detection system. The PLS from the pads will be stored in the PLS pond and pumped into tankers for transport to the Mutanga CPF. At the CPF, ion-exchange methods will be used to produce yellowcake (U_3O_8). There will also be a satellite ion exchange at Gwabe and Njame.

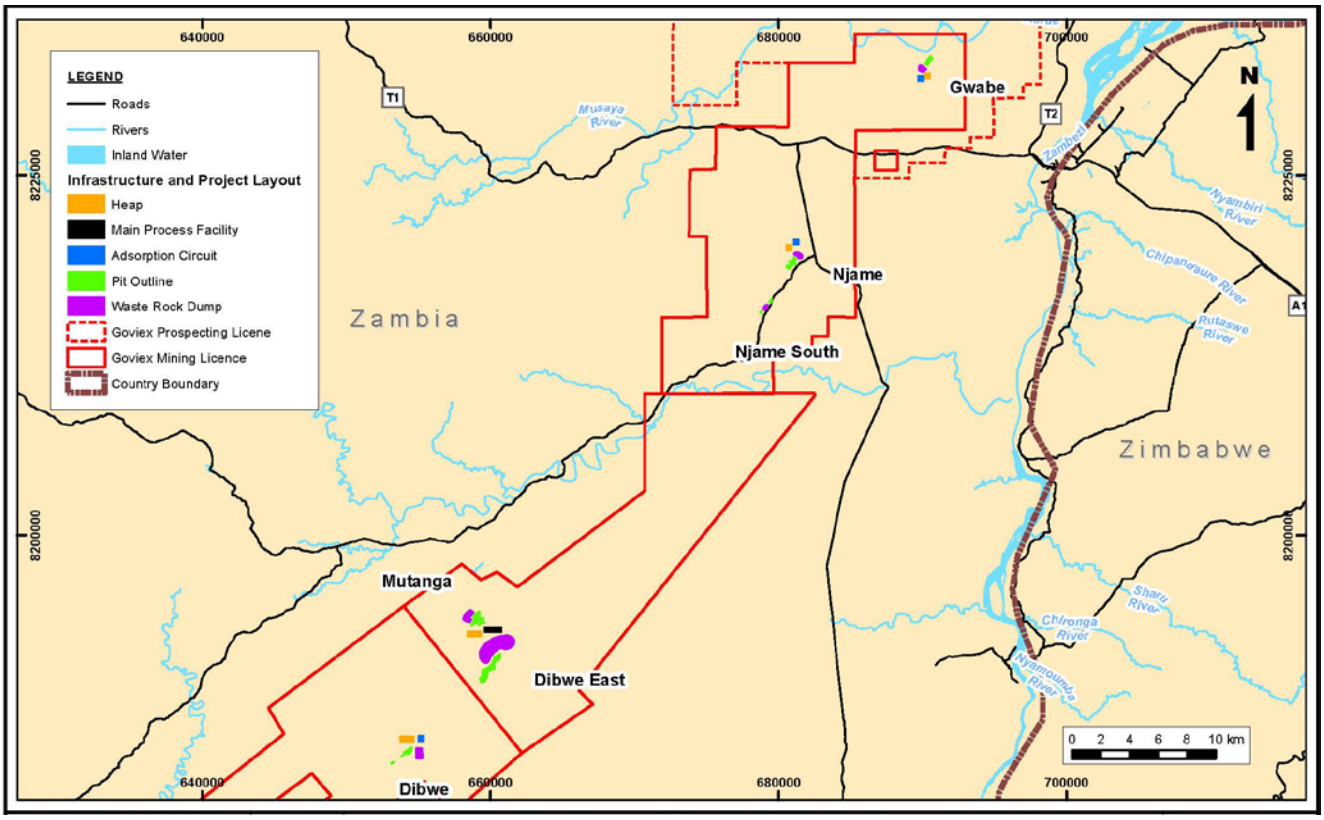


Figure 18-1: **Infrastructure and Project Layout**

Other project infrastructure includes waste rock dumps, RoM stockpiles, mine workshops, mine stores, mine camp, power supply, pollution control dam, sewage treatment plant, raw water tank, administration building, assay laboratory, and other facilities.

A camp will be constructed with living and normal recreational facilities. Onsite facilities for storage of fuel and reagents will have a live capacity equivalent to approximately thirty days usage.

18.1.1 Light and Heavy Vehicle Roads

A new site access road will be constructed using the existing right of way occupied by the current Zyiba Meenda road. The road will be re-routed to avoid villages, rebuilt and sealed for a total length of 26 km. Once the road is complete, the total distance from Lusaka to site will be 174 km, all on sealed roads.

Roads at the plant site will be stripped of organic material and surfaced with granular materials. Site haul roads will be 17 m wide and constructed to meet the requirements of haul trucks. Other roads on site will be 5 m wide. Drainage ditches and culverts will be placed in accordance with site drainage requirements.

18.1.2 Light and Heavy Vehicle Maintenance

The fleet of mining support equipment will comprise primary trucks (16), dozers (9), graders (2), water trucks (4), fuel trucks (4), explosives trucks (2), a backhoe, and light vehicles (31).

18.1.3 Plant Services

The plant services will consist of:

- A fresh water pond: this clay-lined pond will receive fresh water from the bore fields. Fresh water from this pond will be used as makeup water for the process water pond, wash water for the centrifuges and will also feed the reverse osmosis (“RO”) plant.
- A potable water tank: this fibre glass tank will be installed with pumps to feed potable water. Water from the RO plant will be discharged into this tank for distribution.
- A process water/fire water pond: this plastic lined pond will receive water from the ion-exchange circuits. Process water will then be circulated around the site via a ring main.
- A catch-all dam: to receive excess water from the process water pond and waste dump pond. Lime will be used to neutralise the water prior to it being pumped as make-up water for the barren liquor pond.
- An excess eluent/evaporation pond.
- A sewage system.

18.1.4 Workshop/Warehouse

The plant maintenance workshops are fabricated steel structures with galvanised sheeting. One workshop will be located close to the crushing plant and the other will be located near the main process plant.

The workshops will include two indoor mobile equipment repair bays equipped with a 5 t overhead travelling crane, a small vehicle repair bay and one outdoor wash bay equipped with high pressure water monitors and a sloped concrete pad to an oil/water separator. An independent tyre store has been allowed for. The workshops / vehicle store will also include a machine shop and welding shop with a compressor, high pressure water and steam cleaning equipment, lubricant distribution pumps, electrical/instrumentation work areas and a tool crib. Offices for warehouse, maintenance and planning personnel will also be provided. The warehouse will be located adjacent to the truck shop and will include personnel access doors, an interior office area, manually operated service door and interior shelving. An outdoor secure service area surrounded by a chain link fence will be located between the warehouse and workshop.

Suitable lighting will be provided. External lighting will be HPS floodlights for lighting immediately around the buildings.

18.1.5 Administration Building

The administration building will be a block type building housing general areas for engineering, geology and administration personnel and offices for the general manager, mine manager, plant superintendent, administration superintendent, chief geologist, chief engineer and security chief. There will be conference rooms, a kitchenette and entrance / secretary areas for the plant and mine operational personnel. The offices will be situated near the process plant, but outside the restricted access area.

18.1.6 Training Centres

The training facilities are of block work construction plastered internally. The facilities will be air conditioned and will be equipped with audio/visual equipment.

18.1.7 Sub Station and Control Room

The two buildings are of concrete and blockwork construction with concrete floors all designed for the accommodation of the various control panels. The main MCC building, near the project substation, will be a double storey building housing the control room on the top floor and will be equipped with SCADA control equipment. The buildings will have double door access for MCC panel installation as well as single access doors. The rooms will be fitted with an air conditioning unit and/or a pressurising fan for dust and heat control and ventilation. Lighting will be provided using fluorescent light fittings.

18.1.8 Plant and Camp Laundry Facilities

Two laundry facilities will be provided, one located within the plant area and the other located in the Accommodation Camp area.

18.1.9 Plant Medical Facility

The medical facility will be of block work construction plastered internally and housing the paramedic and day nurse, a reception, a pharmacy and a sick bay with six beds. The medical facility will be located close to the plant administration offices and outside of the plant restricted area. This facility will be made available to all onsite personnel.

18.1.10 Plant Ablutions and Change Rooms

All process plant personnel access the process plant via the plant ablution and change rooms. The building has a security office from where access to the plant will be controlled, workers enter through the clean locker room, change out of their day clothes, pass through security and enter the dirty locker room where they change into their overalls prior to entering the plant. All dirty work clothes will be washed at the plant laundry on a regular basis and will not leave the plant site. The reverse procedure applies when leaving the plant. The building will be of block work fabrication and has a security office for access control, plus change rooms and ablution facilities.

18.1.11 Assay Laboratory

The plant site will include a fully-equipped, single-storey assay laboratory, designed for preparation and analysis of mine grade control samples, process streams, final product and bio-analysis. The laboratory will consist of a sample preparation area, wet laboratory, atomic absorption spectrum room, ICP, balance room, and sample store.

18.1.12 Main Stores Building

The main stores building will be located adjacent to the process plant restricted area. It will consist of a steel fabricated building for the storing and despatching of operating and maintenance supplies. The building has two roller shutter doors for access purposes. The building will be equipped with a pallet racking system for the storage of plant spare parts. Offices and ablutions are provided for the stores personnel. The offices are of block work construction.

18.1.13 Security Offices

A security office will be situated at the main access gate to facilitate access control. The main security office will be located adjacent to the administration building.

18.1.14 Emergency Response Centre

The emergency response centre will be where emergency response vehicles and equipment are stored. It will be located adjacent to the main administration building.

18.1.15 Camp Buildings

Two bed-roomed flat

Approximately 11 two bedroom flats will be constructed. Each flat will be self-contained, air conditioned and will be equipped with a lounge, kitchenette and two bedrooms sharing a common ablution facility. The units are generally as per the drawing and are of block work construction plastered internally.

Camp single quarters

Approximately 14 accommodation blocks of 8 rooms each will be constructed. Each room will be equipped with a bed, a table and chair, and a built-in cupboard. Each room has an ablution facility with a shower, hand basin and WC and will be as per the drawing. The units are air conditioned and are of block work construction plastered internally.

Unskilled labour accommodation

Approximately 10 blocks of 8 rooms will be constructed. Each room will be equipped with two beds, a table and chair, and a built-in cupboard. Each block has a communal ablution facility with showers, hand basins and toilets, as per the drawing. The units are equipped with ceiling fans and are of block work construction plastered internally.

Camp kitchen and mess

The camp kitchen and mess area will be of plastered block work construction with suitable stores and freezer rooms attached. The kitchen will be fully equipped and will be run by the mine catering personnel. The dining room will accommodate a total of 220 people at a sitting. The centre has wash hand basins on the external wall near the entrance and will be generally as per the drawing 1061-LO-110. The kitchen will be fully equipped and will be run by the mine catering personnel.

Recreational area and gymnasium

The recreational area and gymnasium will be of plastered block work construction with suitable stores and toilet facilities. The area will have bar facilities and will be equipped with DSTV, a pool table and darts area. Two recreational areas will be provided, one for senior staff and one for other workers, both of which will be run by the mine catering personnel. The centre has both male and female toilet facilities and will be generally as per the drawing.

18.2 Onsite Personnel Transportation

All personnel will be living in the camp accommodation area, which will be within 5 km of the process facilities. Buses will be provided to transport people to and from the operations on a daily basis.

18.2.1 Fuel Storage and Distribution

Diesel fuel will be delivered to the site by tanker truck. Diesel fuel requirements for the mining equipment and process and ancillary facilities will be supplied from a diesel fuel storage tank located at the truck shop. The central onsite fuel storage and dispensing facility will have capacity to store 4 weeks (500,000 L) supply of fuel. Run off from fuel dispensing areas will be directed to oil water separators. Satellite fuel storage and dispensing facilities of approximately 60,000 L capacity will be located near each pit. All fuel storage tanks will be bunded or have double wall containment. Mine tracked vehicles and miscellaneous day tank storage will be serviced by a mobile fuel truck. Lubricants will be delivered to the site in drums, which will then be stored in a secure area. The lubricants will be distributed to hose reels in the truck shop service bay with barrel pumps.

18.2.2 Uranium Oxide Concentrate Storage and Loading

The uranium concentrate storage building will be a steel fabricated building adjacent to the concentrator. This building has two roller shutter doors for access purposes and has a concrete floor slab with block work dwarf wall to contain any spillage. A loading dock will be provided within the building to facilitate loading of transport vehicles. The uranium oxide concentrate storage building will be located in a restricted access area and will be equipped with a dust extractor and ventilation system (see also Section 18.10).

18.2.3 Plant Reagents Store

This will be a steel fabricated building for the storing of three month’s supply of solid reagents, including flocculants and lime, required for the process. The building has two roller shutter doors for access purposes and has a sloped concrete floor slab with block work dwarf wall to contain any spillage.

Sulfuric acid will be stored outside in steel tanks within bermed areas near the heap leach facilities. Other liquid and gaseous reagents will be stored in outside tanks within the process plant restricted area.

18.3 Human Relations

The mine will operate year round and 24 hours a day on three 8 hour shifts. A total of approximately 384 persons will be employed single status on a turnaround basis.

The project will be developed and operated based on the principle of maximizing opportunities for participation by Zambian nationals. Skills training will begin during the construction phase and continue during operations. Opportunities will be sought to build the capacity of Zambian companies with the potential for ongoing opportunities during operations.

GoviEx will develop HR policies and procedures and ensure that these are agreed to and implemented before the mine commences production to ensure smooth running from the outset.

18.4 Health, Safety and Security

A safety and health management programme (SHMP) will be developed based on the principles of the GoviEx Health and Safety Policy. Procedures, guidelines and work instructions from other GoviEx operations will be used as starting points for development of site specific documents for Mutanga. Facilities will be built and operated in compliance with all applicable laws and regulations within the relevant jurisdiction.

GoviEx will comply with the following acts and regulations:

- The Mines and Minerals Development Act, 2008;
- The Mines and Minerals Development (Prospecting, Mining and Milling of Uranium Ores and Other Radioactive Mineral Ores) Regulations, 2008;
- The Ionising Radiation Protection Act, 2005; and
- The Environmental Protection and Pollution Control Act.

A programme to manage the identification, mitigation and avoiding hazards such as radiation and radon will be in place prior to the start of operation. This programme will be part of the overall SHMP and will include community awareness, worker training, personal protective equipment, preventive measures, monitoring and emergency response.

Onsite facilities for emergency response will include a medical facility, ambulance, fire truck and fire fighting equipment. A trained medic will be on site at all times as will a trained volunteer emergency response team.

The site access road will remain a public road. Open pits, leach pads, ore preparation areas, process plant areas and camps will all be fenced to restrict access which will be controlled by a trained security team. The security team will work closely with local communities.

The process site, offices, warehouses, oil bunker, explosive magazine and accommodation will be surrounded by a 2 m high range fence and access to the plant site will limited to one access point at the main gate, which will include a gatehouse that is manned 24 hours a day. A 2 m high chain link security fence will be erected around the process plant, ponds and substations.

Two types of fencing will be used in and around the plant site:

- Type A: diamond wire mesh 75 x 75 mm aperture x 2.5 mm diameter. The fence will be 1.8 m high with razor wire. The total height of this fence will be approximately 2.3 m. This fencing will be used to isolate and control entry to each controlled area: process plant; warehouse and lay down and accommodation camp.
- Type C: Four strand barbed wire. The total height of this fence will be approximately 1.2 m. This fencing will be used to isolate and control entry to general project areas including mining operations, heap leach pads, process plant area and administration facilities.

18.4.1 Drainage

Positive surface drainage will be promoted to provide drainage away from site infrastructure. Drainage ditches and culverts will be placed in accordance with site drainage requirements and will route surface run-off around the plant site and heap leach pad.

18.4.2 Potable Water

Potable water will be trucked in or supplied and pumped from remote wells suitable for human consumption, or river water to be treated by RO and chlorination water treatment plant.

18.4.3 Sewage Collection and Treatment

Sewage treatment facilities will be installed at each of the accommodation camp and the process plant facilities. The sewage collection treatment and disposal system will comprise a buried gravity collection system from the ancillary facilities to the sewage treatment plant. The collection system will consist of buried PVC pit and concrete manholes. The sewerage system that will be utilised will be a bio - filter system or equivalent. Each plant will have a capacity for approximately 200 people. The operational process of the plant is simple and proven and comprises of a primary combined settlement tank and anaerobic digester, a secondary aerobic process comprising of a rotary bio converter (“RBC”) fixed film reactor unit, followed by a humus settlement tank and a disinfection tank. The RBC process is simple and requires a minimum of attention, is clean and aesthetically pleasing, and is designed to produce an effluent to the specified standards. Sewage collection in remote areas will be in holding tanks and will be pumped out by truck to be deposited in the sewage treatment plant. Effluent from the sewage treatment plant will be pumped to a tile field for below ground disposal, and there will be no surface disposal to the environment.

18.4.4 Waste Handling

All combustible solid waste will be removed off site to a waste disposal site for incineration. All used spares, scrap, used oil, and redundant ‘safe’ products will be removed from site by the various contractors for disposal in one of the closest towns where these products could be sold as scrap. All contaminated scrap will be stored and handled in accordance with the relevant Radioactive Waste Disposal Policy.

18.5 Power Supply

Power will be provided by the national grid. A new 132/88/66 kV substation will be constructed at Chirundu and connected to a new 66 kV power line to site and a 66/11 kV substation at Mutanga. The transmission line right of way will follow the Zybiba Menda access road. The Chirundu substation will be supplied via the 330 kV high voltage transmission lines from the Kariba North Bank Hydroelectricity Scheme.

The power supply will be sized to account for the process loads of the crushing plant, conveyors and process plant in addition to the ancillary building requirements (including workshop, warehouse, canteen, and administration buildings). Spare capacity will be available to allow for limited future expansion of the process plant.

18.5.1 Electrical Distribution

Local power will be distributed via an 11 kV overhead power line with trenches for local distribution. Motors will be supplied at 400 V 50 Hz.

18.6 Communication

A satellite communications network will be available at the plant site; the proposed solution will utilise a Very Small Aperture Terminal (“VSAT”) with a 2.4 m antenna to provide a permanent, reliable, cost effective solution for internet and voice communications. This will provide sufficient bandwidth to support email, phone and limited internet availability. A connection port will be provided from this system to, the IT System, the phone system and the PCS System.

Communication will be done by cabling, which will be supported on messenger wire under-built to the pole line and/or run underground in 5 cm conduit to the respective buildings.

Operational communications at site will be facilitated by the use of radios. A cell tower with data capacity is installed and provides cell phone coverage over a 30 km radius from the Mutanga site.

18.7 Capital Costs

A total infrastructure capital cost is taken from the current scoping studies and is discussed in item 21.

18.8 Operating Costs

An infrastructure operating cost is currently included in site G&A and is taken from the scoping studies and is discussed in item 21.

18.9 Transport and Logistics

This section covers the handling and transportation of goods and materials for the Mutanga Project. It will cover bringing goods and material to the site and the transportation of final product, uranium concentrate to port.

18.9.1 Airports

The main international airport in Lusaka, approximately 175 km, from the project. It is currently serviced by the following airlines to the respective destinations;

- Air Zimbabwe (Harare);
- Emirates Airways (Dubai);
- KLM (Amsterdam);
- Ethiopian Airlines (Addis Ababa);
- Kenya Airways (Nairobi, Lilongwe);
- Kulula.com (Johannesburg);
- Proflight Commuter Services (Livingstone);
- South African Airways (Johannesburg);
- TAAG Angola Airlines (Luanda); and
- Zambia Skyways (Lubumbashi).

The airport also has extensive cargo facilities.

18.9.2 Customs Clearance

An agency will be engaged to support and facilitate the import of equipment, materials and supplies and the export of product.

18.9.3 Supply Routes

Access to the mine site, for all imported cargo, will be either through the port of Durban in South Africa, Walvis Bay in Namibia and/or Dar-es-Salaam in Tanzania. All capital equipment sourced from South Africa and from the various ports listed above will be transported by road to site.

Durban Port Facilities

The Durban port is strategically located on the world shipping routes, and is the busiest and largest in terms of container capacity on the African continent. The port handles 31.4 Mt of cargo annually. Forty-four per cent of South Africa 's break-bulk cargo and 61% of all containerised cargo flows through the port, and an average of 83,000 containers per month are handled. The Durban port also handles uranium concentrate produced in South Africa.

Walvis Bay Port Facilities

Walvis Bay is the principal port of Namibia and is situated on the west coast of southern Africa. There are good road connections. The port is currently handling in excess of 2 Mt of cargo annually and has been handling uranium shipments from Namibian operations for several years.

Dar es Salaam Port Facilities

Dar es Salaam is the principle port of Tanzania and is a major sea outlet for Zambia, Burundi, Malawi, Rwanda, Uganda, Zimbabwe, and eastern parts of the Democratic Republic of the Congo. Dar es Salaam Port Container Terminal is currently being operated by The DRC International Container Terminal Services and is equipped with two ship to shore gantry cranes, each having a capacity of 35.6 t. These are supported by six rubber tyred gantry cranes for stacking containers in the yard.

Back up facilities for the container terminal includes an inland container depot located about 2 km outside the port. The container terminal has three deep water berths with a capacity of handling 120,000 TEUs per annum.

18.9.4 Road Routes

A map of the regional road network is shown in Figure 18-2. It is assumed that all exported uranium oxide will be via Walvis Bay, Namibia and the route from Project site to Walvis Bay Port is shown in Figure 18-3.

Figure 18-2: Map of the Regional Road Network

Walvis Bay

The Trans-Caprivi Corridor, operated by the Walvis Bay Corridor Group (WBCG), provides the shortest route between the Namibian west coast port of Walvis Bay and Mutanga. The tarred highway runs from Walvis Bay via Otavi, Katimo Mulilo, Shesheke, Livingstone to Mazabuka to Mutanga (Table 18-1).

Table 18-1: Road Route and Distances from Walvis Bay

	Centre Name	Type of Centre	Point to Point Distance in km	Accumulated Distance in km
NAMIBIA	Walvis Bay	Port	0	0
	Swakopmund	Port/Town	34	34
	Okahandja	Town	284	318
	Otjiwarongo	Town	164	482
	Otavi	Town	117	599
	Rundu	Town	353	952
	Muhembo	Village	252	1,204
	Katimo Mulilo	Border Post	307	1,511
	Sesheke	Border Post	0	1,511
ZAMBIA	Kazangula	Town	131	1,642
	Livingstone	Town	57	1,699
	Choma	Town	254	1,953
	Mazabuka	Town	130	2,083
	Mutanga	Project	189	2,272

Figure 18-3: Transport Route from Mutanga Project to Walvis Bay

Durban

The road route from Durban is well supported by efficient and effective hauliers with large fleets (Table 18-2). The route runs from Durban via Johannesburg, Messina, Harare and Chirundu to project site which is 1,938 km along a tarred road.

Table 18-2: Road Route and Distances from Durban

	Centre Name	Type of Centre	Point to Point Distance in kms	Accumulated Distance in kms
RSA	Durban	Port	0	0
	Pietermaritzburg	Province Capital	90	90
	Ladysmith	Town	170	260
	Johannesburg	Major City	340	600
	Pretoria	Admin Capital	60	660
	Polokwane*	Province Capital	265	925
	Musina	SA Border Post	235	1,160
Zimbabwe	Beit Bridge	Zim Border Post	10	1,170
	Masvingo	Town	300	1,470
	Harare	Zimbabwe Capital	310	1,480
	Karoi	Town	215	1,695
	Chirundu	Border Post	170	1,865
	Mutanga	Project	73	1,938

Dar-es-Salaam

The route runs from Dar-es-Salaam via Morogoro, Mbeya, Tunduma, Kitwe, Lusaka to Mutanga (Table 18-3).

Table 18-3: Road Route and Distances from Dar-es-Salaam

	Centre Name	Type of Centre	Point to Point Distance in kms	Accumulated Distance in kms
TANZANIA	Dar-es-Salaam	Port	0	0
	Morogoro	Town	195	195
	Iringa	Town	310	505
	Makambako	Town	176	681
	Mbeya	Town	210	891
	Tunduma	Border Post	66	957
ZAMBIA	Mpika	Town	421	1,378
	Mkushi	Town	334	1,712
	Kapiri Mposhi	Town	86	1,798
	Kitwe	Town	155	1,867
	Lusaka	Capital City	198	2,065
	Mutanga	Project	175	2,240

18.9.5 Project Road Access

The project will be accessible from Lusaka via a combination national highway and a sealed road to the site. The 32 km main access road will be from Highway M15 (Siavonga Highway) at Lusitu to the Mutanga Project, generally following the existing Zybiba Menda route but re-routed. This will be a public road. The total distance from Lusaka to the Mutanga Project site will be approximately 200 km on sealed roads with possibly 26 km requiring additional upgrade to avoid villages, rebuilt and sealed.

The main access route will be de-mined prior to the beginning of any road construction. The road will be a 6.1 m wide sealed road. There are minimal stream and no river crossings making the road an all-weather road. All of the project construction materials and equipment, and operating reagents and supplies, as well as the transportation of final product will be via this main access road.

18.10 Handling, Loading, Storage and Dispatch of Uranium Oxide

Uranium oxide will be discharged from the vacuum pan drier directly into 200l drums in a sealed environment. Drums will be half filled and weigh approximately 1,000 kg each. After filling drums will be sealed, washed down and transported by forklift to the adjacent uranium oxide storage and loading area. This area has two truck doors and loading bays. The plant has a capacity to fill two to three drums per day.

Uranium oxide will be transported from Mutanga to Walvis Bay sea port by trucks, each one towing a single trailer with a 6.3 m sea container. To load, a truck will arrive at the loading area and back into the storage and loading building where they will drop their empty trailer in one of the loading bays. They will drive out and back into the adjacent loading bay to pick up a loaded trailer. To load a container, workers will use forklifts, the number of drums loaded per container must not exceed the maximum road gross container weight. Once the drums are secured, the container will be sealed and is ready for transport. The truck will exit the building with the loaded container and stop at the vehicle washing area located immediately outside the building where wheels will be washed of any potential contaminant. The washing area will be contained and all water captured in a sump before pumping to the process water system.

It is expected there will be one truckload a week. The drum filling, storage and loading areas will all be controlled access for security and hygiene reasons.

18.11 Uranium Oxide Shipment

The ports of Dar-es-Salaam in Tanzania, Durban in South Africa, and Walvis Bay in Namibia are all accredited ports for the shipment of uranium oxide concentrate but it is currently assumed that all export will be via Walvis Bay, Namibia.

GoviEx will comply with the International Atomic Energy Agency requirements (Regulations for the Safe Transport of Radioactive Material, IAEA Safety Standard Series No TS-R-1(ST-1) 1996 Revised) for the export and transport of its uranium production and industry best practices on the packaging and transportation of the uranium oxide concentrate. Each transport truck will be equipped with GPS tracking to provide for early notification in the event the truck leaves an approved route or is stopped for a longer than acceptable period of time.

19 MARKET STUDIES AND CONTRACTS (ITEM 19)

This section aims to provide an overview of the fundamental principles of the uranium market and how the derived U_3O_8 will be sold into the market; transported; and transformed for use in nuclear reactors. As such, the following elements will be described in order to:

- understand the position and role of uranium within the nuclear fuel cycle;
- analyse U_3O_8 demand with particular reference to the U_3O_8 requirements of the world’s reactors;
- explain the transformation of U_3O_8 into UF_6 and the role of the Conversion Facilities who provide such a service;
- summarise the requirements for transportation of U_3O_8 from the Project to the Conversion Facilities;
- examine the contractual relationship between GoviEx Zambia as the Uranium Producer and the Conversion Facilities; and
- analyse the uranium market prices and pricing mechanisms.

19.1 Nuclear Fuel Cycle

The “nuclear fuel cycle” includes all nuclear operations ranging from the mining of uranium ore to the reprocessing of spent fuel and the ultimate radioactive waste disposal.

The fuel cycle is made up of a series of processes that manufacture reactor fuel, burn the fuel in a reactor to generate electricity, and manage the spent reactor fuel. These processes are grouped into three components; the front end, which includes all activities prior to placement of the fuel in the reactor; the service period, when the fuel is converted into energy in the reactor; and the back end, which covers all activities dealing with spent fuel from the reactor. If the spent fuel is sent to storage, the cycle is referred to as open. If it is reprocessed to recover useful components, it is known as closed. The United States employs an open fuel cycle, while France, Russia, China, and Japan reprocess their spent fuel.

The components of the cycle are organized as follows within this case study.

The front end

- Uranium Metallurgy, Conversion to Uranium Hexafluoride, and Fabrication of Fuel Rods.
- Uranium Enrichment.

The service period

- Nuclear Reactors.

The back end

- Reprocessing Spent Fuel.
- Nuclear Waste
- Figure 19-1 identifies the key process steps required for both the front and back end activities within the nuclear fuel cycle. (European Nuclear Society, 2003).

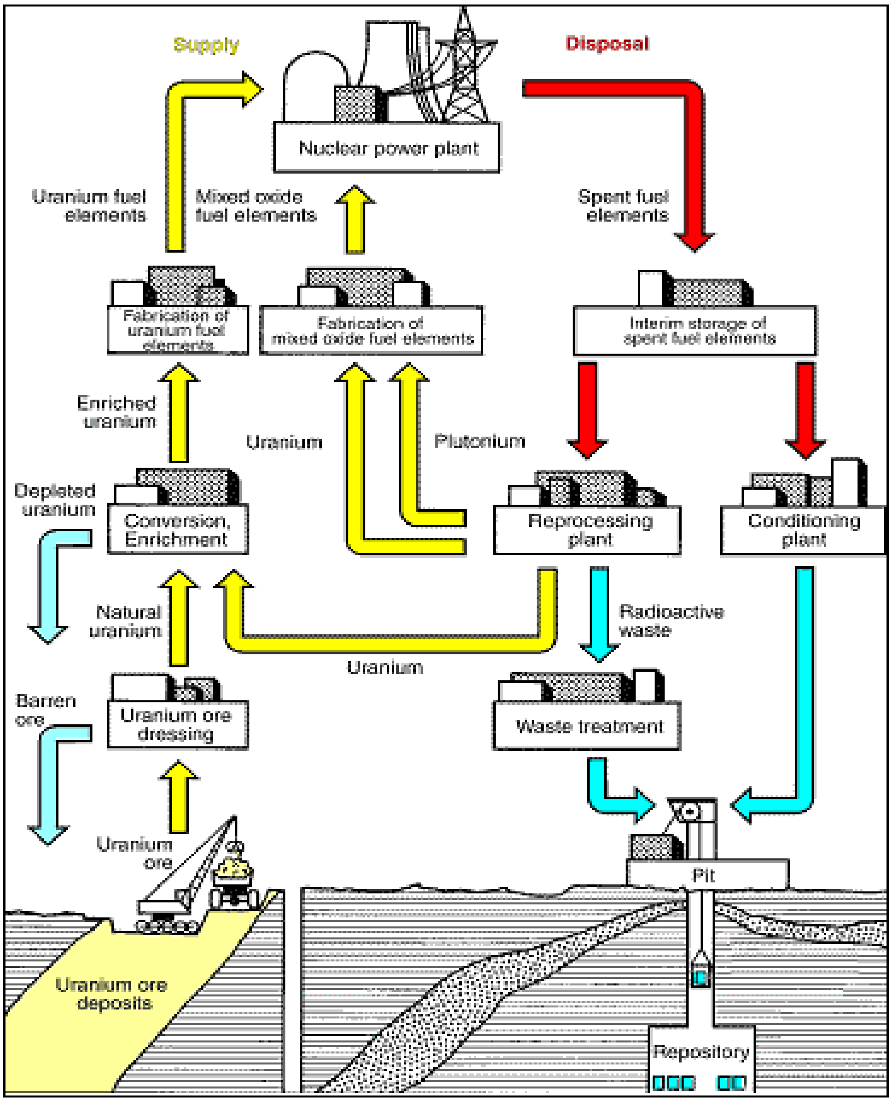


Figure 19-1: Key Process Steps Required for Front End and Back End Activities Within the Nuclear Fuel Cycle

The front end of the cycle begins with the extraction of the uranium ore by mining and then:

- It is milled to refine the material to U_3O_8. The U_3O_8 is packed in a 1000 kg drum (UN 1A2W) which are then transported from the mill to a UF_6 Conversion facility.
- Once the U_3O_8 has been converted to UF_6 at the Conversion facility, it this then transported to an Enrichment facility.
- At the Enrichment facility, the U-235 isotope is concentrated from 0.711% up to a maximum of 5%.
- Following Enrichment, EUP is produced which is transported to a Fuel Fabrication facility where the fuel that powers the Reactor is manufactured.
- The nuclear fuel is transported from the Fuel Fabrication facility to the utility site where it is loaded into the reactor to generate electricity.

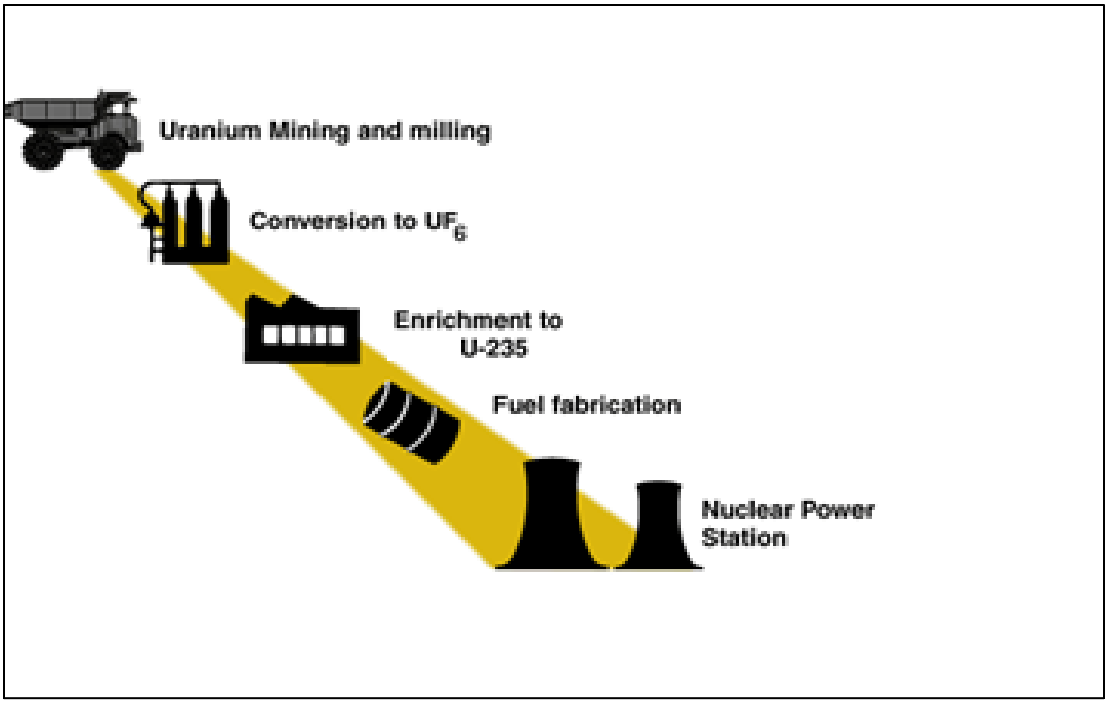


Figure 19-2: Front End Fuel Cycle

After three (3) years of electricity production, nuclear fuel is removed from the Reactor and undergoes further steps including temporary storage, reprocessing, recycling and eventually disposal. This is commonly known as the Back End of the nuclear fuel cycle.

19.2 Uranium Market

The reasons for fluctuation in mineral prices relate to demand and perceptions of scarcity. The price cannot indefinitely stay below the cost of production (see below), nor will it remain at very high levels for longer than it takes for new producers to enter the market and anxiety about supply to subside.

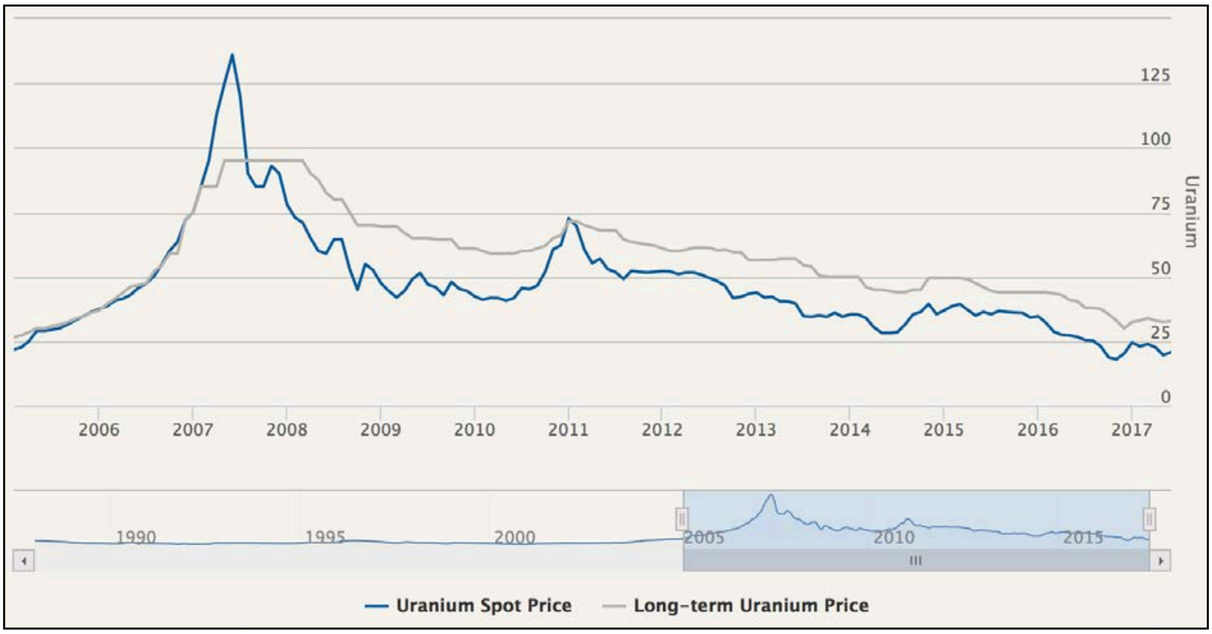


Figure 19-3: **Long Term and Spot Uranium Price (USD/lb U_3O_8) 2005-2017 (Source: Cameco)**

19.2.1 Demand

The only significant commercial use for U_3O_8 is as a fuel for nuclear power plants for the generation of electricity. Through the process of nuclear fission, the uranium isotope U 235 can undergo a nuclear reaction whereby its nucleus is split into smaller particles. Nuclear fission releases significant amounts of energy, and is the basis of power generation in the nuclear industry.

Uranium has other commercial uses in the fields of medical diagnosis and other industries, but these markets are very small in terms of volume. Uranium is also used as a feedstock for over 200 private nuclear reactors, which are operated for research purposes and for the production of isotopes for medical and industrial end uses.

The World Nuclear Association (“WNA”) reports that there are 440 nuclear reactors operable in 30 countries as of 1 March 2016. These reactors can generate 384 GWe of electricity and supply over 11% of the world's electrical requirements. As of 1 March 2016, 65 nuclear reactors are under construction in 14 countries, with the principal drivers of this expansion being China (24 reactors under construction), Russia (8), India (6), the United States (5), South Korea (3), and UAE (4). Based on the most recent statistics from the WNA, there are a total of 238 reactors that are either under construction, or planned around the world, and an additional 337 reactors that are proposed, with the potential to be operating by 2030.

According to UxC, in its "Uranium Market Outlook -- Q1 2016" (the "Q1 Outlook"), global nuclear power capacities are projected to increase by 39%, from 379.4 GWe in 2015 to 527.8 gigawatts in 2030. Of the net growth in nuclear generation capacities, China accounts for 70% while India, South Korea and Russia collectively make up a further 25%. The Q1 Outlook also estimates that uranium demand, including estimated inventory build-up, could grow by over 30% to as high as 257.0 Mlb U_3O_8 by 2025. This represents an increase of over 50% from estimated demand, excluding inventory build-up, of 168.5 Mlb U_3O_8 in 2015.

As of November 2016, 30 countries worldwide are operating 450 nuclear reactors for electricity generation and 60 new nuclear plants are under construction in 15 countries. Approximately 11% of the world's power demand or roughly 450 GWe production is directly attributable to nuclear power (https://www.nei.org/Knowledge-Center/Nuclear-Statistics/World-Statistics accessed 26 January 2017).

In addition to the restart of the reactors in Japan, the other key factor effecting uranium demand will be the rate of development in China. In 2013, China had 17 nuclear power units with a total electric capacity of 13 GWe, accounting for just 2% with further 28 under construction. By comparison, the USA is currently 20% and France 74%. China has the world's most ambitious nuclear program, with plans to provide 6% or 58 GWe of capacity by 2020, and a further increase to 16% or 200 GWe by 2030. By 2030, China is expected to consume nearly half of global uranium production. The impetus for increasing nuclear power share in China is increasingly due to air pollution from coal-fired plants. China's policy is for closed fuel cycle. China has become largely self-sufficient in reactor design and construction, as well as other aspects of the fuel cycle, but is making full use of western technology while adapting and improving it.

India's commitment to nuclear power generation is following a similar path to that of China, but a much earlier stage. The impetus for India is the same as China with a WHO 2014 survey finding that 13 of 20 most polluted cities in the world were in India.

In 2013, India had 21 reactors with installed capacity of 5,780 MWe consuming approximately 1580 TU per annum. The country is now targeting installed capacity of 63,000 MWe (equivalent to 25% total energy demand) by 2032. Ux Consulting ("UxC") forecasts that under their 2015 Base Case forecast 442 reactors (~384 GWe net), and UxC anticipates that this will grow to 478 reactors by 2020 (~425 GWe net) and 528 reactors (~485 GWe) by 2025. By 2030, UxC forecasts an increase to 591 reactors (~575 GWe net). As the figures show, the vast majority of the growth over the next two decades is anticipated to come from Asia (especially China); however, some nuclear gains are also envisioned in Eastern Europe, North America, and Africa and the Middle East.

Table 19-1: Reactor Units and Nuclear Capacities Anticipated by Country (Source UxC.com)

Units	**2015**	**2020**	**2025**	**2030**
North America	**120**	**119**	**113**	**112**
Canada	19	19	13	13
USA	99	98	98	97
Mexico	2	2	2	2
Western Europe	**117**	**109**	**101**	**87**
France	58	57	57	57
UK	16	15	13	8
Germany	9	6	0	0
Sweden	10	7	6	6
Finland	4	5	6	6
Spain	7	7	7	7
Switzerland	5	4	4	3
Belgium	7	7	5	0
Netherlands	1	1	1	1
Eastern Europe	**69**	**76**	**72**	**74**
Russia	34	38	33	31
Ukraine	15	15	15	16
Czech Republic	6	6	6	6
Other	14	17	18	21
Asia & Oceania	**125**	**131**	**167**	**214**
Japan	44	20	21	20
South Korea	24	27	31	36
China	28	49	78	111
India	20	26	26	38
Other	9	9	11	9
Africa & Middle East	**3**	**7**	**7**	**20**
South Africa	2	2	2	4
Saudi Arabia	0	0	0	2
UAE	0	4	4	6
Other	1	1	1	8
South America	**5**	**7**	**7**	**11**
Brazil	2	3	3	5
Argentina	3	4	4	6
Other	0	0	0	0
Total	**439**	**449**	**467**	**518**
Gwe	**379**	**399**	**429**	**501**

About 445 reactors with combined capacity of over 390 GWe, require some 75,000 t of uranium oxide concentrate containing 63,000 t of uranium (tU) from mines (or the equivalent from stockpiles or secondary sources) each year (http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/uranium-resources/uranium-markets.aspx accessed 17/1/17). This includes initial cores for new reactors coming online. The capacity is growing slowly, and at the same time the reactors are being run more productively, with higher capacity factors, and reactor power levels. However, these factors increasing fuel demand are offset by a trend for increased efficiencies, so demand is dampened – over the 20 years from 1970 there was a 25% reduction in uranium demand per kWh output in Europe due to such improvements, which continue today. Each GWe of increased new capacity will require about 150 tU/yr of extra mine production routinely, and about 300-450 tU for the first fuel load.

The market is expected to grow significantly over the next decade. The WNA 2015 Nuclear Fuel Report reference scenario (post Fukushima accident) shows a 26% increase in uranium demand over 2015-25 (for a 30% increase in reactor capacity; many new cores will be required). Demand thereafter will depend on new plant being built and the rate at which older plant is retired; the reference scenario has a 22% increase in uranium demand for the decade 2020 to 2030. Licensing of plant lifetime extensions and the economic attractiveness of continued operation of older reactors are critical factors in the medium-term uranium market. With electricity demand by 2040 expected (by the OECD's International Energy Agency in its World Energy Outlook 2015 report) to increase 70% from that of 2013, however, there is plenty of scope for growth in nuclear capacity in a world concerned with limiting carbon emissions.

19.2.2 Primary Supply

Uranium production is predicted to exceed 160 Mlb U_3O_8 in 2016 (http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/uranium-resources/uranium-markets.aspx accessed 17/1/17).

The issue that the industry is facing is that the Total Cost breakeven for uranium mines is estimated at between 40 and 50 USD/lb U_3O_8. The uranium price will therefore need to exceed this price range to incentivize new production and the restart of operations that have been placed on care and maintenance due to the current low price environment.

In addition, there are a number of existing mining operations that are due for closure in the next 10 to 15 years. Without higher prices to incentivise new production and restarts, mined uranium expected to decline from 160Mlb U_3O_8 to approximately 145 Mlb by 2025.

GoviEx and Houlihan Lokey have created an industry-leading dynamic supply model that covers 40 assets in 13 countries and has mapped out producing and development operations to create a model that is responsive to various price scenarios. The key issue for the industry is the substantial forecast supply deficit with the main point of contention being when it will occur.

The key themes derived from this work indicates that:

- The incentive price for large number of assets is significantly above long term forecasts and as a result, many assets will simply never be built, which means that it will be increasingly difficult to full the supply in any foreseeable price curve.
- The price needs to move higher to encourage offtake contracts to be secured, mine financing to be finalised and construction to commence at green operations.
- Many emerging assets are in geographies where there is little to no uranium experience, which is likely to significantly extend the time to production, which combined with the lacklustre price will result in difficulties for the sector.
- Limited mine development expertise exists in the market as so few assets have been brought into production over the past decade, potentially extending the time to production.
- Older, tired assets owned by the majors are likely to come offline over the coming decade, further exacerbating the supply side crisis as the industry is still reliant on a limited number of very large deposits that are hard to replace.

Figure 19-4 summarises the results of the analysis completed by GoviEx and Houlihan Lokey, and indicates that potentially new supply and restarts will not be able to provide new mined uranium production quickly enough to meet future demand of the next 15 to 20 years.

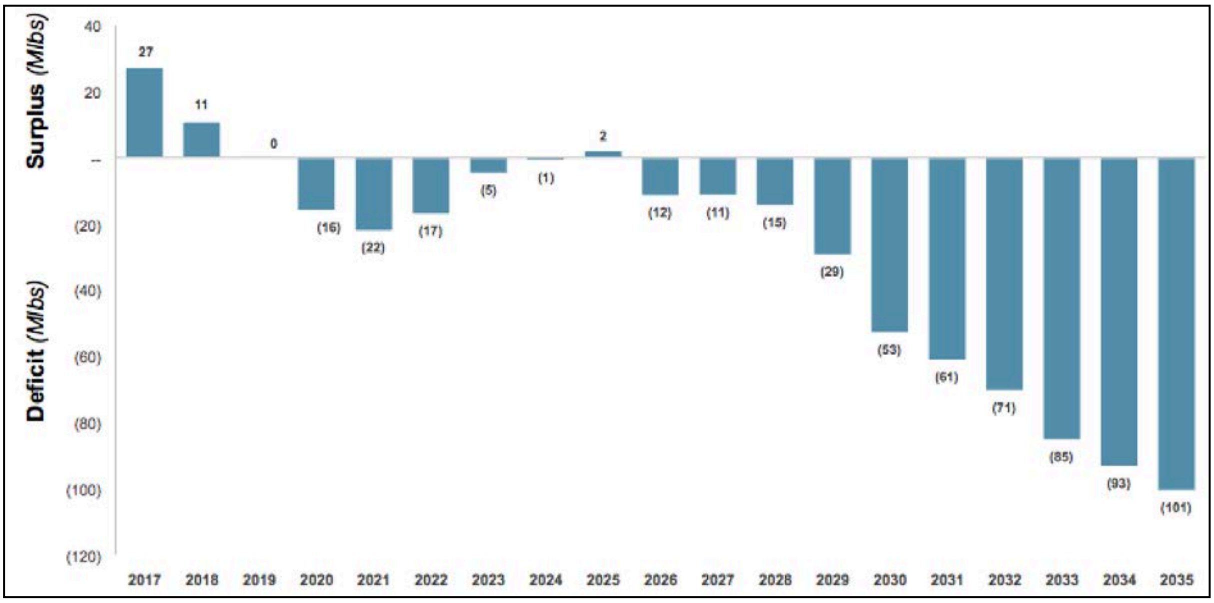


Figure 19-4: Supply Gap Analysis based on Uranium Price increasing to US$60 / lb by 2022 (Source: GoviEx and Houlihan Lokey)

Mines in 2015 supplied some 71,000 tU_3O_8 containing 60,496 tU, about 90% of utilities' annual requirements (http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/uranium-resources/uranium-markets.aspxs accessed 19 January 2017, also information paper on World Uranium Mining). Since 1985, the demand for uranium has been met by supplementing continued historical under-production by the mines with inventories accumulated before 1985.

Total inventories were in fact higher when the uranium price peaked at over USD130/lb in 2007, and again in 2011 when spot uranium went over USD70/lb, indicating that total inventories that are not the problem. According to data from the Organisation for Economic Co-operation and Development (OECD), current total inventories are about half the level of their 1991 peak (Figure 19-5 and Figure 19-6).

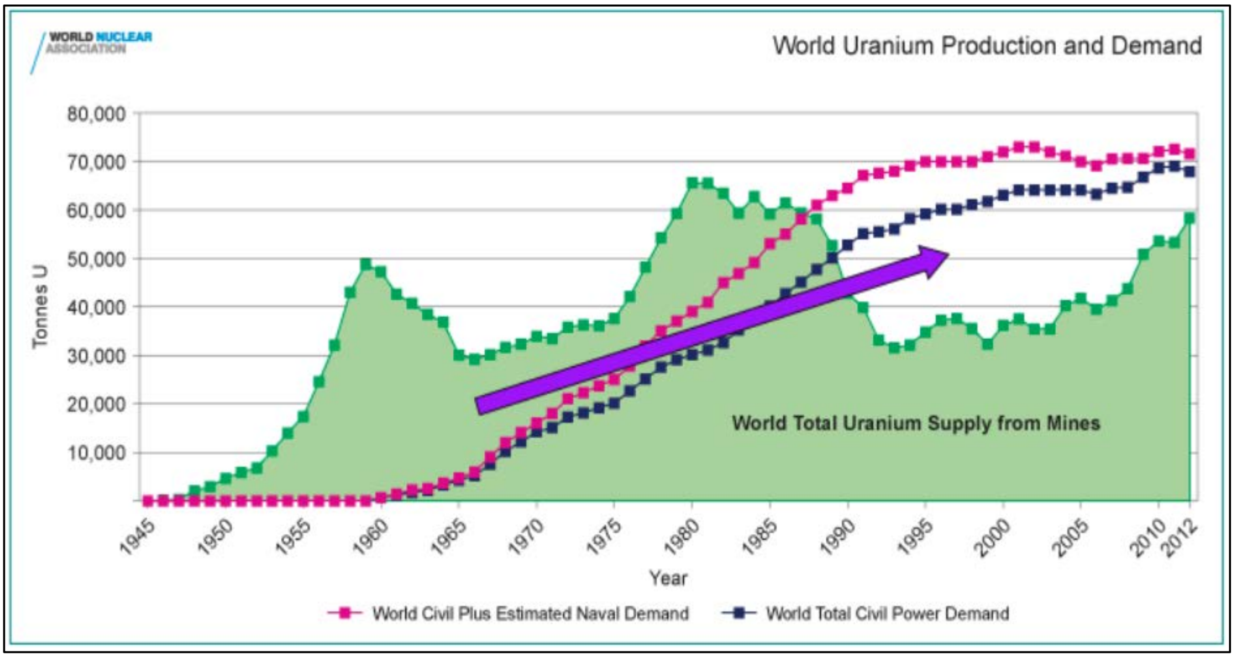


Figure 19-5: World Uranium Production and Demand

The issue that the industry is grappling with now is that most inventories are currently held with the utilities -- the main consumers of uranium. Their uranium inventories, combined with their long-term contracts, means their short-term requirements are being met.

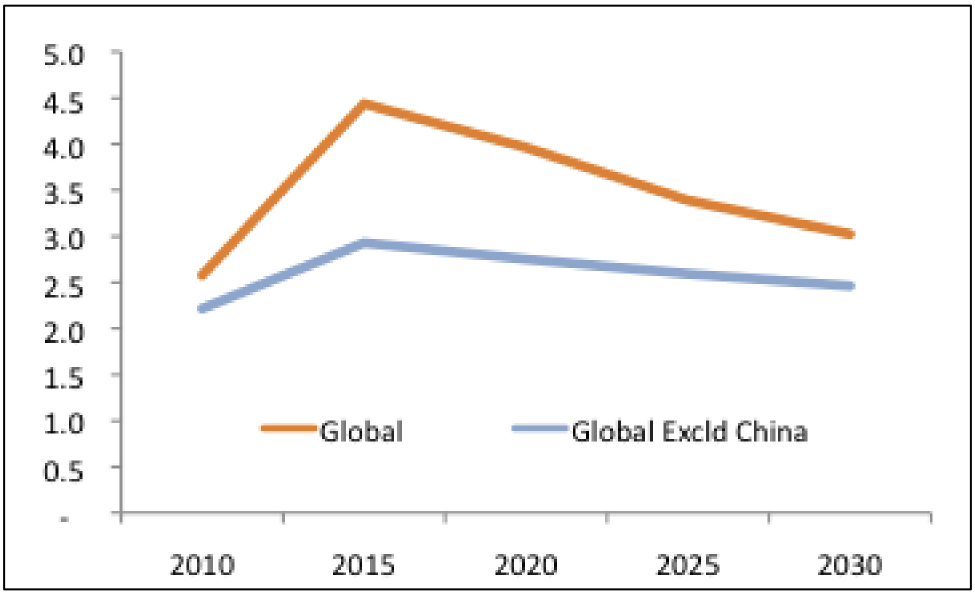


Figure 19-6: Global Utility Uranium Inventories in Terms of Annual Demand (Years (Source UxC, WNA)

Globally, utilities are reportedly holding about 770 Mlb U_3O_8, compared to current annual demand of 174 million pounds. This equates to 4.4 years of demand, of which China is estimated to hold approximately 40%. China is currently understood to be building its inventory, given that the country plans to grow its nuclear energy generation from the current 30 giga-watts of electric capacity to 130 GWe by 2030 (and 240 GWe by 2050), according to the World Nuclear Association (WNA).

Exclude China from the inventory position and the rest of the nuclear world is currently holding about 2.9 years of demand. Historically, utilities have sought to hold between 2 and 3 years in inventory, therefore current inventory levels are high, but within the historical range. Context is also important for this level of inventory; current stockpiles at utilities are not excessive, given the enrichment cycle. The utilities consume enriched uranium in their reactors. The cycle time for mining uranium out of the ground, shipping it to enrichment facilities, enriching it and then creating fuel rods from the enriched uranium is 2 – 3 years. Current stockpiles at utilities are not excessive given the enrichment cycle.

Japan is, however, expected to continue to honour its long-term contracts and buy and build inventory, even though its reactors were shut down. Japanese utilities are holding 60-80 Mlb more than needed, even if it restarts its reactors.

This is offset by India, which is reported to hold an inventory of 3 Mlb and plans to build that to 39 Mlb by 2025, providing a strategic stockpile. According to the WNA, India had 5 GWe in nuclear generation capacity in 2014, which will increase to 17 GWe in 2024, and 63 GWe in 2032.

The American and Russian governments continue to hold large inventories, but these are over 70% in the form of depleted uranium.

19.2.3 Secondary Supply

Primary mine production supplies approximately 94% of current demand, excluding inventory build-up. The balance of demand is supplied from secondary sources such as commercial inventories, reprocessing of spent fuel, sales by uranium enrichers and inventories held by governments, in particular the U.S. Department of Energy http://www.uraniumparticipation.com/s/Uranium_Market.aspx accessed 19/1/17).

Excess commercial inventories, which were once one of the major sources of secondary supplies during the period from the early 1970s to the early 2000s, have largely been consumed; however, as a result of the shutdown of the German nuclear program and the continued shut down of the majority of the Japanese nuclear fleet, commercial inventories could become a more significant factor. A large source of secondary supplies continues to be government inventories, particularly in the US and Russia. The disposition of these inventories may have a market impact over the next 10 to 20 years, although the rate and timing of this material entering the market is uncertain.

Reprocessing of spent fuel is another source of secondary supply, but is expected to satisfy roughly 6% of demand. Expansion of this secondary source would require major investments in facilities which could only be supported by a significant increase in long-term uranium prices.

UxC expects that secondary sources of supply will fall from 2016 levels of 44 Mlb U_3O_8 per year to 30 Mlb U_3O_8 per year by 2025.

19.2.4 Outlook

For purposes of assessment, SRK has utilized the proposed long term price forecasts of USD58/lb U_3O_8 as a conservative estimate well within the consensus forecast range of USD55 to 75/lb U_3O_8 (Figure 19-7, Source: CIBC Global Mining Group, Analyst Consensus Commodity Price Forecasts, April 2017).

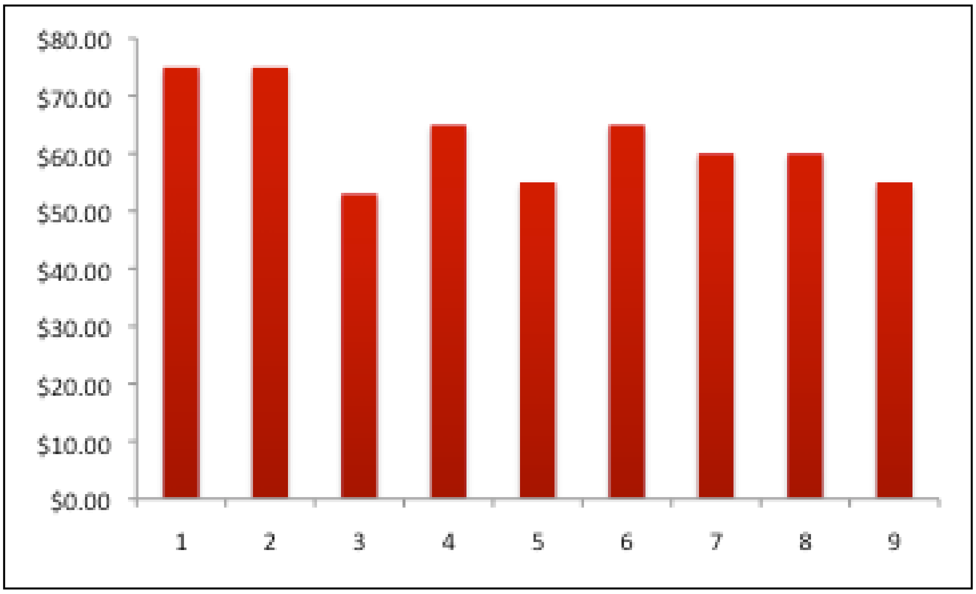


Figure 19-7: Long Term U_3O_8 Price Forecast by Broker

19.3 Weighing, Sampling, Analysis and Storage of U_3O_8

Prior to any physical delivery of U_3O_8, a Producer will be required to enter into a contract with a Conversion Facility for the weighing, sampling, analysis and storage of U_3O_8. Dependant on the particular Conversion Facility, the terms and conditions within such contract will include but not be limited to:

- The Producers obligation to provide a U_3O_8 delivery schedule each year.
- The conditions of delivery for example, packaging, loading, marking, labelling, emergency response, shipping documentation.
- The Conversion Facilities weighing and sampling process.
- The specification of the U_3O_8 that will be accepted at the Conversion Facility for Conversion without surcharges. The specification for each Conversion Facility may vary slightly but will broadly be in line with ASTM specification C967-13 Standard Specification for Uranium Ore Concentrates.
- The terms for the creation of a U_3O_8 Holding Account and the subsequent storage thereof.
- Fees and surcharges including but not limited to:
  - Weighing and sampling,
  - Surcharges for U_3O_8 relating to impurity concentration levels,
  - Storage fees; and
  - Book Transfer fees;
- U_3O_8 Title and ownership arrangements.
- Physical withdrawal conditions if allowed.
- Loss and damage insurance provisions.

19.4 Physical Delivery of U_3O_8

It is the responsibility of the party physically delivering the U_3O_8 (usually the Producer) to pay for the transportation to the Conversion Facility Figure 19-8.

A percentage quantity of the total U_3O_8 delivery quantity will be credited to the U_3O_8 Holding Account on the date of delivery. The U_3O_8 is then weighed and analysed by the Conversion Facility to confirm its acceptance. This analysis can take up to one hundred (100) days. Once completed the balance of U_3O_8 will be credited to the U_3O_8 Holding Account. A fee may be charged for this service, particularly if there are any surcharges imposed by the Conversion Facility relating to impurity concentration levels. These charges vary depending upon the terms and conditions negotiated in the contract.

Title to the U_3O_8 will remain with the U_3O_8 owner (usually the Producer) until it is sold. Risk of loss and damage will transfer to the Conversion Facility upon physical delivery of the U_3O_8 at the Conversion Facility.

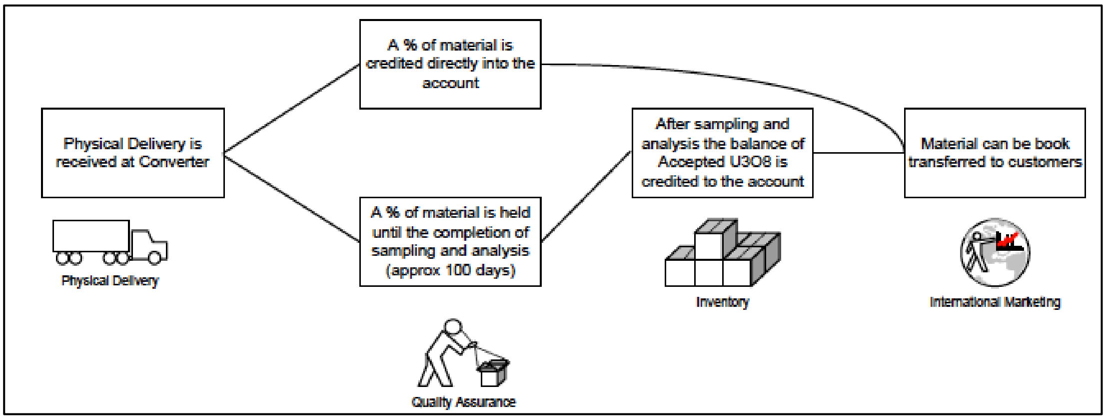


Figure 19-8: Steps Involved in a Physical Delivery of U_3O_8

19.5 Book Transfer Delivery

When a customer agrees to purchase U_3O_8 from a Producer (or other supplier), the customer will expect to receive delivery by means of Book Transfer (Figure 19-9). This transaction will appear as a credit in the customers U_3O_8 Holding Account and a debit in the Producers account at the Conversion Facility.

Title passes from the seller to the buyer on the date the U_3O_8 is Book Transferred. Risk of loss and damage remains with the Conversion Facility.

It is standard practice for a Conversion Facility to impose a charge for Book Transferring U_3O_8. The only exception is if the buyer is a Conversion customer of the Conversion Facility.

Normally the seller will provide a Book Transfer notice document around ten (10) working days prior to the required delivery date to instruct the Conversion Facility to effect the Book Transfer from one U_3O_8 Holding Account to another.

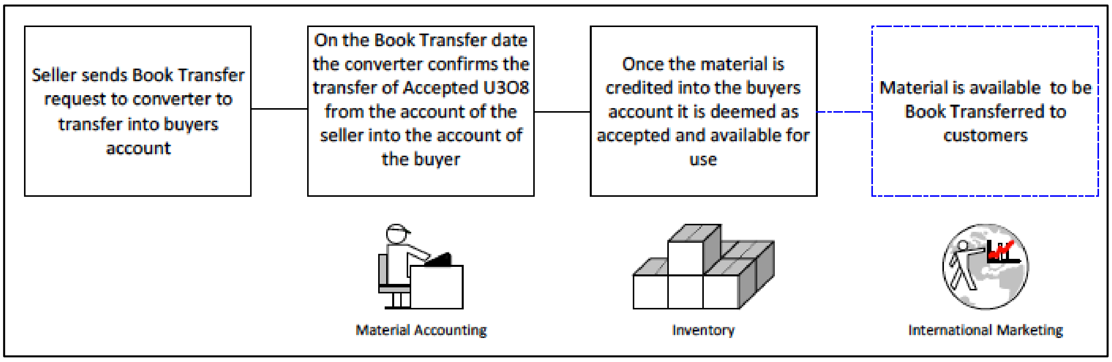


Figure 19-9: Process flow for a U_3O_8 delivery by Book Transfer

19.6 Uranium Markets

When selling a commodity dependent upon strategy and available inventory, a supplier may look to sell into the spot market or the long term market. Spot sales are those where terms and conditions are agreed for a delivery in less than three (3) months (“Spot”). A long term sale (“Term”) is one where the terms and conditions are agreed for a delivery in greater than twenty-four (24) months and a mid-term (“Mid”) sale is between the three months and two years.

19.7 Market Publications

In the uranium market, two (2) trade publications are used as price reference points in U_3O_8 sales contracts: Ux Weekly published by the Ux Consulting Company LLC; and the Nuclear Market Review published by TradeTech LLC. Both issue a weekly U_3O_8 Spot price and a Term month end price (Figure 19-10).

Figure 19-10: Spot and Term Price Since 2005 – 2014 (Source: Cameco)

19.8 Pricing Mechanisms

Various pricing mechanisms can be used when negotiating and concluding a contract for the sale of U_3O_8; in general, there are three (3) mechanisms favoured by the industry;

1) Fixed Price;
2) Market Related Price; and
3) Hybrid Price.

19.8.1 Fixed Price

Fixed pricing can also be divided into two categories:

1) Fixed price which is not subject to escalation; and
2) Based price escalated.

A fixed price contract is where the buyer and the seller agree to a specific price, which is not escalated by inflation indices. This type of pricing has been typically used for Spot or Mid sales, however more recently, buyers are now requesting fixed prices for longer term contracts.

Fixed pricing can be advantageous to the buyer and seller as both can easily forecast and measure cash flows, budgets and material inventory prices.

A base price escalated mechanism is traditionally used for longer term contracts. The base price is agreed and fixed in a contract between the buyer and seller and is escalated in line with an agreed escalation factor, the starting date of which is also agreed. A commonly used escalation factor is the US Gross Domestic Product Implicit Price Deflator (“GPDIPD”). The GPDIPD is one measure for the US annual inflation rate and is typically used in the nuclear industry.

Base price escalated approach has an element of unpredictability, but since the commonly used escalation factor or GPDIPD is used, it is unlikely that a huge variance will be seen year on year.

19.8.2 Market Related Price

Market related pricing is usually based on the Spot or Term price (as published by UxC and TradeTech or an average of both) near or at the time the delivery of U_3O_8 takes place. For Term contracts, it is not unusual for a seller to offer a buyer an agreed percentage discount against the Term price.

Market related pricing ensures that the purchase price will be more in line with the market conditions at the time of the purchase, but overall it gives a greater level of uncertainty for the buyer and the seller. This uncertainty can be mitigated somewhat by the use of price floors and ceilings, whereby the floor price protects the seller and the ceiling price protects the buyer. The level at which the floor and ceiling prices are fixed will depend on the market conditions at the time of contract negotiations.

19.8.3 Hybrid Price

In recent years, buyers have looked at ways to optimise pricing mechanisms especially for Term contracts. As a result, hybrid prices have been agreed which is a combination of both the fixed price and market price mechanisms. The percentage split between the two varies and is negotiated between buyer and seller. For example, a Term sales contract could have sixty percent (60%) of the annual quantity delivered using a fixed price mechanism and forty percent (40%) delivered using a market related price mechanism.

20 ENVIRONMENTAL STUDIES, PERMITTING AND SOCIAL OR COMMUNITY IMPACT (ITEM 20)

GoviEx currently holds Zambia Environmental Management Agency ("ZEMA") licences for management, generating and storing of hazardous waste, plus an emissions licence. These licences are listed in Section 4.3 and summarised in Table 20-1.

Table 20-1: Summary of GoviEx ZEMA Licences

Permit	Date Awarded	Duration	Expiry Date
Hazardous waste management licence	16 September 2015	3 years	15 September 2018
Licence to generate hazardous waste	16 September 2015	3 years	15 September 2018
Licence to store hazardous waste	16 September 2015	3 years	15 September 2018
Emission licence	16 September 2015	3 years	15 September 2018

The Project will be regulated through the Ministry of Mines and Minerals Development ("MMMD"), the Environmental Council of Zambia ("ECZ") and the Radiation Protection Authority ("RPA"). 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. An Environmental Impact Assessment was prepared for the Chirundu (Njame and Gwabe) operations in 2008, including an assessment of baseline conditions and identification of potential impacts to the surrounding environment (AFR, 2008). Data were collected over a nine month period from March 2007 to February 2008. Similarly, an Environmental Impact Study was prepared for the Mutanga Project in 2009 by African Mining Consultants ("AMC") for the Denison Feasibility Study (MDM, 2009). Data were collected between January 2007 and March 2009. The potential impacts described in the following sections are largely derived from these reports. The potential environmental impacts of the Project have been systematically assessed using the source-pathway receptor framework. An Environmental Management Plan ("EMP") was prepared for the Chirundu (Njame and Gwabe) operations and an EMP and Resettlement Action Plan ("RAP") were both developed for the Mutanga Project. Details the actions that will be taken during the various phases of the Project to mitigate the potential adverse environmental impacts that have been identified.

The Project will encompass air and waste water monitoring exercises that will be linked to the wider Project monitoring program, which will be implemented by the Company. The Project specific monitoring exercises are designed to support the objective of monitoring and demonstrating the human health and wider environmental benefits of the mitigation works.

The success of the Project in improving health, through relocating those villagers exposed to existing high levels of radiation to areas where the reduction of pollutants in the existing water table, within the target communities will depend on a number of factors, including the effectiveness of the monitoring programme that will be put in place.

It is expected that the most significant beneficial impact to arise as a result of the implementation of the Project will be the improved quality of life in surrounding areas of the Project site. Upgrading infrastructure will improve accessibility within the area, there will be preferential employment of Zambian people wherever possible, the economy within the Siavonga District will be expanded, the Project will contribute to national development through the remittance of taxes to the Zambian government and it will diversify the national mining industrial sector away from a reliance on individual metals and the Copperbelt.

20.1 Institutional, Legislative and Legal Framework

20.1.1 Institutional Framework

Implementation of the Mutanga Project would be governed by the following main institutions:

- Ministry of Mines (MoM);
- Geological Survey Department;
- Mines Safety Department;
- Mining Advisory Committee;
- Environmental Council of Zambia (ECZ);
- Environmental Review Board;
- Radiation Protection Authority; and
- Energy Regulation Board (ERB).

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. The applicable Zambian regulations include, but are not limited to those indicated in Table 20-2.

Table 20-2: Zambian Regulations (Source MDM, 2009)

Institution of Legislation	Act	Regulations
Mining	**The Mines and Minerals Development Act (Act No. 7 of 2008)**	The Mines and Minerals (Environmental) Regulations (SI No. 29 of 1997); The Mines and Minerals Development (Prospecting, Mining and Milling of Uranium Ores and Other Radioactive Mineral Ores) Regulations, 2008 (SI No. 7 of 2008); Mines and Minerals (Environmental Protection Fund) Regulations (SI No. 102 of 1998);
Environment	**The Environmental Protection and Pollution Control Act (SI No. 12 of 1990)**	The Environmental Protection and Pollution Control (Environmental Impact Assessment) Regulations (SI No. 28 of 1997); Waste Management (Licensing of Transporters of Wastes and Waste Disposal Sites) Regulations (SI No.71 of 1993); Hazardous Waste Management Regulations (SI No. 125 of 2001); Water Pollution Control (Effluent & Waste Water) Regulations (SI No. 72 of 1993); Pesticides and Toxic Substances Regulations (SI No. 20 of 1994); Air Pollution Control (Licensing and Emission Standards) Regulations (SI No. 141 of 1996)
Ionising Radiation	**The Ionizing Radiation Protection Act, 2005 (SI No. 16 of 2005)**	
Energy	**The Energy Regulation Act, 2003 (SI No. 23 of 2003);** **The Electricity Act, 1995 (SI No. 15 of 1995);** **The Petroleum Act, 1995 (SI No. 8 of 1995)**	
Wildlife and National Heritage	**The National Heritage Conservation Commission Act, 1989 (SI No 23 of 1989);** **The National Parks and Wildlife Act, 1991 (SI No. 10 of 1991);** **The Zambia Wildlife Act 1998 (SI No. 12 of 1998);** **The Pneumoconiosis Act (SI No. 124 of 1965 and amendments);**	
Health	**The Pneumoconiosis Act (SI No. 124 of 1965 and amendments);** **Public Health Act CAP 295**	
Employment	**The Employment Act (SI No. 57 of 1965 and all amendments);**	
Road Transport	**Roads and Road Traffic Act (Act No. 42 of 1971 and all amendments)**	
Taxes	**The Zambia Revenue Authority Act (SI No. 28 of 1993 and all amendments);** **The Customs and Excise Act (SI No. 16 of 1955 and all amendments and subsidiary legislation);** **Value Added Tax Act (SI No. 4 of 1995 and all amendments)**	

International agreements

The Republic of Zambia is a member of 44 international organisations, one of which is the International Atomic Energy Agency (IAEA). Some of the commitments made through these organisations are:

- The Rio Convention on Biological Diversity;
- The official Convention on Climate Change signed in Rio;
- The Climate Change Kyoto Protocol;
- International Convention on Desertification;
- The Ramsar Convention related to the Wetlands of International Importance and particularly recognized as habitats for wilderness;
- The International Convention for the Protection of Fauna and Flora in Africa;
- The Convention on Endangered Species;

- International Convention on the Protection of the Ozone Layer;
- The International Convention on Hazardous Wastes; and
- The Law of the Sea.

Compensation and resettlement legislation in Zambia

The main legislative and legal documents that provide for the requirements for compensation or resettlement are:

- The Fourth Republican Constitution, 1996 recognises private property and its protection by the State;
- The Lands Acquisition Act, 1994 provides that all private property affected by the development of public projects is eligible for compensation;
- The Agricultural Lands Act, 1994 identifies some property improvements that are eligible for compensation; and
- The Mines and Minerals Act, 2008.

The above legislation led AMC to develop the RAP for the Denison Feasibility Study in March 2009 (MDM, 2009), which identified the affected communities, quantified compensation and discussed compensation methods. The study was updated internally by GoviEx in 2017, and indicates that a total population of 1300 people from 19 villages will be affected. The households will be relocated to Kashundi Village, located approximately 6km southeast of Mutanga. A total of 65 fields will be affected by the mine footprint and these cover a total surface area of 116.5ha. The total estimated cost of the compensation to the local communities is USD10 million over the life of the project. The RAP will need to be updated and formalised as part of the next stage of the projects technical development

20.1.2 International Legislation and Institutions

The following international institutions have been identified as having applicable guidelines on uranium mining, handling, health, safety and the environment:

- African Development Bank (“AfDB”);
- World Bank Group (“WB”);
- International Finance Corporation (“IFC”);
- International Atomic Energy Agency (“IAEA”);
- World Health Organisation (“WHO”);
- Occupational Safety and Health Association (“OSHA”).

These organisations have provided some important international legislation and advisory documents:

- Pollution Prevention and Abatement Handbook, April 1999;
- World Bank Operational Policy 4.01 Environmental Assessment;
- World Bank Operational Policy 4.12 Involuntary Resettlement;

- “Equator Principles” developed by banking institutions around the world involved with loans for development projects;
- IFC Performance Standards;
- WHO drinking water standards; and
- occupational safety and health standards and guidelines for mining activities.

20.2 Bio-Physical Environment

20.2.1 Climate

The climate in the Project area, as described in Section 5.2, is tropical with distinct wet and dry seasons. No significant environmental impacts on climatic conditions are expected as a result of proposed Project activities.

20.2.2 Geology

The geology in the Project area, as described in Section 7, is dominated by Permian, Triassic and Cretaceous sediments of the Karoo Supergroup in a series of NE-trending, fault bounded blocks. The proposed Project is expected to have significant environmental impacts on geological conditions. This is because bulk materials will be mined in order to undertake metallurgical test work on the samples.

20.2.3 Soil

The iron- and aluminium-rich soils within the Project area are extremely weathered, nutrient deficient and have poor water retention capacity. Gleysols, sandy loams and sand soils are the predominant soil types, and lateritic horizons are common. Regional land classification based on the USDA standards indicates medium to low potential for sustainable development of these soils. Existing cultivation includes maize and a variety of green vegetables.

Potential impacts to soils as a result of Project activities include:

- site clearance leading to increased erosion potential;
- chemical and oil spillages;
- exposing of the soils with uranium as a result of the mining;
- compaction of soil from heavy machinery (resulting in potential changes to the soil matrix and moisture content); and
- poor disposal of the waste and poor disposal of waste containers.

In order to prevent soil contamination, the service, maintenance and repair of vehicles and equipment will be carried out in dedicated areas. These areas will be equipped with impermeable surfaces, containment and fire protection, and drains will be equipped with oil traps.

20.2.4 Land Use

Existing land use in the project area is a combination of Mopane or Miombo woodland, bare rock outcrops, small agricultural fields and degraded grassland with some villages. Land use within the villages is mainly cotton, sorghum, millet, and maize farming, with minimal animal husbandry in the form of pig, goat or cattle herding, and poultry. Fertile wet land adjacent to watercourses is generally cultivated to produce vegetables or fruit then abandoned during the dry season. Forestry timber cutting activities are not evident around the Mutanga Project site and there is very little charcoal activity. Exploration activities are the only major form of industrial land use in Mutanga. Housing is typically built using traditional methods and materials, with earth floors, mud brick walls and grass thatch or iron sheets roofs. No significant environmental impact on land use is expected as a result of the Project. This is because the areas where the Project will be undertaken, there are a few human activities. Approximately 65 fields will be purchased in the area.

20.2.5 Air Quality

Although no air quality data are available for the Project area, field observations indicate that the general air quality in the area is good; however, temporal deterioration in air quality does occur as a result of grassland and forest fires, charcoal burning and shifting cultivation practices during the dry season, which generate smoke and dust. 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 and 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 main threat to air quality as a result of proposed Project activities is the dispersion of uranium-bearing dust. This will take place during both the pre-construction and operational phases and will include the generation of airborne dust from blasting, ore handling, crushing and processing, in addition to vehicular emissions and dust generation from the operation of heavy plant equipment and haul trucks. To suppress dust and avoid potential air quality impacts, the haul roads, ore stockpiles and RoM ore pad will be routinely sprayed with water. Air quality control equipment will be installed in critical areas and an air quality monitoring programme will be implemented.

In addition to wind-blown dust sources, there is also the potential for radon emissions from exposed waste rock containing low concentrations of uranium. Dust concentrations will be monitored and compared to US EPA and Zambian statutory dust emission limits. Monthly radon concentration returns will be submitted to the ECZ as per the Radiation Management Plan.

20.2.6 Noise

Current noise levels in the Project area are very low owing to the remote location of the site and the absence of active industry. The Project will have some noise impacts on the environment, which will originate from blasting, vehicles and equipment operation. It is unlikely that there will be noise impacts to villages adjacent to the project area, as the open pits are situated several kilometers away from the nearest village and any noise is likely to be absorbed by the surrounding landscape.

Although blasting in the open pits may be audible, the infrequency and short duration means this will likely not be a nuisance to villagers. A complaints register will be set up to assess the impact of noise on the surrounding community.

20.2.7 Traffic

Field studies and discussions with local communities have identified that there is very little traffic travelling on the roads in the Project area. It is likely that the Project will have a significant impact on the volume of traffic in the site vicinity.

20.2.8 Radiation

Radiation surveys were conducted as part of the Denison EIS (MDM, 2009). The results indicated that terrestrial radiation levels at Mutanga ranged from 182 Cps to 420 Cps. Some individual locations sampled reported extremely high levels of radiation up to 8,129 Cps; attributed to high levels of potassium with mineralised uranium rocks. The majority of the sites assessed had an annual dose rate of less than 1 mSv/year from terrestrial radiation.

There is a potential to impact the environment through the accidental release of radioactive materials into soils, surface water, groundwater or air that may produce ionising radiation that may be harmful to health, such as dust, water, transport spills. These impacts will be managed through the implementation of the Radiation Management Plan.

20.2.9 Hydrology

Watercourses in the Project area are generally seasonal, only flowing in the rainy season and usually through flash flooding in channels. Existing surface waters are characterised by circum-neutral pH, low to moderate total dissolved solids (“TDS”) (150 - 200 mg/L) and high faecal coliform counts. Surface water samples assessed near Mutanga and Dibwe showed that concentrations of arsenic, aluminium, manganese, total chromium, selenium and barium exceeded WHO guidelines.

Although there will be no direct impacts to hydrology as a result of the Project, surface waters will be indirectly affected through discharge of effluents from the Project to the surrounding environment, resulting in potential contamination of surface water resources. Management measures will be implemented to ensure no effluents will be discharged directly into the environment without being impounded and treated.

Tests on mine wastes indicate that there is minimal potential for acid rock drainage. Runoff from dumps will be tested to confirm quality prior to release and leach pads will be lined during construction to prevent contamination. The waste rock dumps will be capped with impermeable material and re-vegetated during closure activities.

A policy of zero discharge is planned for all contaminated water and process water. All water contaminated by uranium or process residues will be recycled. Rain water runoff from potentially contaminated areas will be designated as contaminated and contained. Suspended solids from otherwise clean water will be settled prior to discharge to local water courses or used as process makeup water.

To prevent contamination of surface water caused by pumping of waters from the open pit, the sump water will be pumped to settlement ponds to allow for settlement of solids before discharge of clean water to the environment. Surface water run-off from the overburden dumps will be collected in toe drains and directed to sedimentation ponds for settlement of suspended solids. Storm water cut-off drains will be constructed around the perimeter of the RoM Pad and Plant Area to collect run-off and divert drainage to sedimentation ponds. Clear water will be returned to the plant for use as process water or discharged to the diversion system. Within the process plant, all spills and wash water from maintenance activities will be returned to the process circuit. Oil traps will be installed in the workshop drainage system to treat all effluent prior to release. Sludge from the oil traps will be treated as a hazardous substance and disposed of at an ECZ approved site.

20.2.10 Hydrogeology

Groundwater in the Project area is currently used extensively for domestic and potable water. Groundwater is circum-neutral and fresh (non-saline) with elevated TDS (typically 300 to 600 mg/L). Groundwater quality historically analysed near Mutanga and Dibwe showed generally good water quality with most parameters within WHO guidelines with the exception of iron and manganese. Certain parameters occasionally exceeded WHO guidelines including arsenic, aluminium, manganese, total chromium and selenium. Radiological analyses results showed radium, uranium and thorium concentrations in drinking water that were compliant with guideline limits. There were some WHO guideline exceedances of gross alpha concentrations in the groundwater samples. Mining operations will require aquifers in the vicinity of the pits to be drawn at a total rate of approximately 349 L/s from a series of pit perimeter wells and internal horizontally drilled boreholes when Mutanga and Dibwe are both fully operational. This will lower the water table in the vicinity of the open pits, which could impact on groundwater users in the area and shallow groundwater wells have the potential to dry up. The wells in the neighbouring villages will be regularly monitored to assess impacts on water levels. Surplus water from the dewatering programme will be released to environment after treatment for removal of solids. Aquifer water quality is very high with minimum uranium contamination.

There is also the potential to impact groundwater quality through seepage from the mine facilities. An impermeable HDPE liner in the process water, rafinate, and PLS ponds will be used to prevent impacts to groundwater. Inspection pits or monitoring boreholes will be constructed adjacent to the ponds to provide an early warning of leaks.

20.2.11 Flora and Fauna

The natural vegetation in the Project area is grassland with riparian forest along stretches of stream and rivers (Section 5.1). Near Mutanga and Dibwe an assessment of uranium bioavailability in vegetation was conducted on root, stem and leaf samples from various tree species. The highest uranium concentration occurred in the species *Burkea africana* (4.11 mg/kg) which may only have been related to concentrations in the soil.

There is a diverse and abundant number of insects in the Project area, including dragonfly, wasp, bees, caterpillars, crickets, grasshoppers, termites, mosquitoes, ants, butterflies, and moths. Mammal species are relatively low in abundance and diversity, although field surveys near Mutanga and Dibwe 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 classified as “Least Concern” on the IUCN Red List. Elephants are rarely seen, but are active in the area. The Kafue River provides a habitat to a small number of crocodiles, although there has been a decline in numbers owing to poaching and river sedimentation from anthropogenic activities. Smaller reptiles, such as terrapin, turtles, snakes and lizards, are also present. A wide variety of bird species was witnessed during surveys conducted near Mutanga and Dibwe. Paleoarctic migratory birds have been identified in the Mutulanganga Local Forest, a sensitive habitat located 20 km east of Mutanga. Site clearance and the removal of vegetative cover during the Project pre-construction phase will affect indigenous woodland areas (including rejuvenating miombo woodland and riparian forest) and part of the farming land for the local community. Despite a certain loss of terrestrial and aquatic flora and fauna, site clearance is expected to have little impact on species number or diversity in the project area. GoviEx will only conduct clearance where necessary and will implement a revegetation program as part of its environmental management plans. In order to conserve resources, the local community will be given the opportunity to use non-commercial timber free of charge for construction materials and fire wood. In addition, the mine will aim to stockpile vegetation and topsoil for use in progressive rehabilitation.

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

20.2.12 Cultural Heritage and Archaeology

Some known archaeological and palaeontological sites in the region include Ing’ombe Ilede and the Chirundu Fossil Forest. An archaeological study at Mutanga and Dibwe was conducted in October 2006. Systematic transects plus examinations of old exploration pits and ant hills revealed no existence of archaeological sites or artefacts, although a large area of precipitated iron was sampled at UTM 35 659667E 8192636N or 16º 20' 61" S 28° 29' 68" E. Two sacred cultural sites were identified: Hapepe and Malende, located 3 km north of Matuba Community School and 5-6 km north past Changa Village on the Machinga Stream. These sites are used for worship during the suspected occurrence of droughts, but they will not be affected by the Project activities.

A similar study was conducted near Njame and Gwabe during October 2007. There is a known abandoned Manyuchi village near Njame, but of a recent age and not considered to have any archaeological significance. Three burial grounds were also identified near Njame; however, these are not ancient and fall outside of heritage legislation; according to local information, no chief has ever been buried at any of the graves. No archaeological materials have yet been discovered at Gwabe.

It is still possible that Project may have significant negative impacts to archaeological heritage resulting from open pit mining methods and road construction. Mitigation measures aim to reduce the negative impacts that may threaten the integrity of heritage resources. In cases where the destruction of the archaeological resources is inevitable, rescue\salvage operation will be carried out.

20.2.13 Social Impacts

The main social impacts are:

- The relocation of 342 people and the compensation of 65 fields to 62 owners. Many of the households are anxious about the relocation and compensation activities that will be conducted. These activities will be managed through the Resettlement Action Plan process as follows:

  1. **Surface rights application:**

  - o the Company identifies the affected land within the mining lease;
  - o the Company engages government surveyors to survey the land and produce a map in an acceptable format and then superimpose the map onto an aerial photo of the surveyed area;

  - the maps are taken to the Chief/s of that area to sign off;
  - after signing off, the documents are taken to the local council for approval and filling in of forms; followed by
  - submission of the documents to the Ministry of Lands.
- Before the Surface Right application can be completed the EIA and RAP have to be approved first and the process is given below, it is worth noting that the Project personnel have experience with this process. Both the EIA and RAP will need to be updated to cover the expanded area encompassing the Dibwe East, Njame and Gwabe deposits.

2. Environmental Impact Assessment:

In addition to the EIA being carried out and an EIS being prepared, two meetings are required during the EIA process:

  - Scoping Meeting: where the stakeholders are presented with information about the project and who will be affected once the project kicks off. A report is then submitted to ZEMA by the hired consultant appointed to carry out the EIA. If ZEMA believes that the affected communities were not given enough information, then a public hearing will be held at the project site.
  - Disclosure Meeting: The appointed consultant writes a report to the Company about their findings and to ZEMA. At this stage ZEMA will now decide whether to approve or decline the application.

3. Resettlement Action Plan:

An assessment of the households to be affected is carried out, e.g. a census of all affected households, a valuation of all of their properties, fields and all ancillary structures including burial sites and other culturally important locations;

The RAP has several critical components, including:

  - a design of the proposed relocation village or villages to house the affected people
  - negotiating terms for relocation consents from the chiefs affected
  - Develop an MOU to be signed between the company and each person to be relocated
  - a documented process showing consultation between the mine and the affected peoples through relocation meetings, consulting stakeholders over the proposed relocation
  - engaging the district council through the planning committee of the council to get authorization for the proposed relocation

As the RAP is progressing the EIA will also be run concurrently, the two run side by side and are self-reinforcing, with iterations from each forming a consideration in the other. The EIA feeds into the RAP and an assessment of the people affected is required to allow the EIA to be approved.

- 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, such as HIV/Aids, tuberculosis. This will be monitored through the Company's social department activities.

20.3 Environmental and Social Management Plans

The following environmental and social management plans will be implemented for the Project and reviewed on an annual basis:

- Resettlement Action Plan – The initial RAP was developed in March 2009 to identify all of the communities that will be affected by relocation, and will be updated;
- Occupational Health and Safety Plan – This plan describes the measures to manage all aspects of employee health and safety during mining activities.
- Environmental Monitoring Plan – This plan describes measures to monitor air, soil, surface water, groundwater, vegetation that may be affected by the Project.
- Radiation Management Plan – This plan consists of a series of plans required by the Zambian government to control and manage all aspects of radiation associated with the uranium project. These plans include Radioactive Waste Management, Storage and Transport, Accidental Spills Management, Community and Worker Training, Hazard and Safety Assessments.
- Water Management Plan – This plan identifies all aspects related to water management for the Project. It focuses on identifying methods of conservation, re-use and re-cycling to minimise contamination of raw water resources by the Project.
- Handling and Storage Plan – This plan deals with management actions for handling and storage of all materials onsite as well as spills management activities.
- Waste Management Plan – The plan describes the types of waste that will be generated onsite and the management of these wastes. Waste management principles involved in the plan are minimisation, re-use or recycle.
- Emergency Response Plan – The plan identifies the original structure of the ERP which will be updated by GoviEx during construction. The plan will identify all emergencies that may occur onsite and identify measures for their management.

- Conservation and Vegetation Plan – This plan focuses on the development of conservation areas and a sustainable program with the local communities to manage their local resources.
- Preliminary Progressive Revegation and Rehabilitation Plan – The plan will identify and schedule all areas that are likely to require revegetation through the mining operations. The plan will also monitor the progress on these activities.
- Sustainable Development Plan – The plan is designed to identify social development projects that can be integrated into a schedule of activities for GoviEx to provide assistance with.
- A Mine Decommissioning and Closure Plan - This describes the activities that are foreseen to require management prior to development of the Project and the activities that GoviEx will implement.

20.4 Current Environmental Monitoring Activities

Bi-annual environmental monitoring is currently being undertaken for the Project, including surface water and groundwater quality monitoring, noise monitoring, air quality monitoring, an assessment of background radiation and ambient dosage monitoring, plus a summary of waste production and management activities, rehabilitation activities and environmental incidents.

The most recent monitoring report was for the period January to end-June 2016 and the results are summarised as follows:

- Detectable faecal coliforms were reported for the Hachibozu handpump in February 2016, which was attributed to the herding of livestock in proximity to the handpump coupled with run-off events during the wet season.
- Concentrations of zinc, iron and lead in groundwater were elevated with respect to Zambia Drinking Water Standards and World Health Organisation Guidelines for Drinking Water Quality. The elevated concentrations are attributed to natural mineralisation in the area.
- The results of personal radiation dosimeters worn by certain staff members showed dose rates of zero, as the Project is currently not operational.
- Although ^{40}K, ^{214}Bi, ^{214}Pb and ^{226}Ra were measured in the groundwater samples, gross alpha and gross beta were not determined. As such, it is not possible to provide an assessment against applicable international drinking water standards for radiation activity; however, the activity of ^{226}Ra (which ranged from below analytical detection limits to 2.66 Bq/L) was above the World Health Organisation Guideline for Drinking Water of 1 Bq/L in 6 out of 12 samples tested.

21 CAPITAL AND OPERATING COSTS (ITEM 21)

The tables below summarise the capital and operating costs for the Mutanga Uranium Project. The detailed development of these individual costs are provided in the relevant sections.

21.1 Capital Expenditure

Total capital expenditure for the life of the operation are presented in Table 21-1. A two-year construction period ahead of production is envisaged. The operation is intended to be contractor mined.

Table 21-1: Capital Expenditure

Parameter	Units	Total Amount
Project Capital		
Mine Mobilisation Fee	(USDm)	0.4
Plant	(USDm)	82.6
Camp	(USDm)	3.2
Infrastructure	(USDm)	7.5
G&A	(USDm)	2.1
EPCM	(USDm)	12.0
Contingency	(USDm)	10.7
Community	(USDm)	5.0
Total Project Capital	**(USDm)**	**123.4**
Deferred / Sustaining capital		
Plant	(USDm)	27.2
Camp	(USDm)	1.6
Infrastructure	(USDm)	4.4
G&A	(USDm)	1.6
EPCM	(USDm)	4.6
Contingency	(USDm)	3.9
Closure Cost	(USDm)	11.1
Community	(USDm)	5.0
Total Deferred / Sustaining Capital	**(USDm)**	**59.5**
Total Capital Expenditure	**(USDm)**	**182.9**

21.2 Operating Costs

Life of mine operating costs are presented in Table 21-2.

Table 21-2: LoM Operating Costs

Operating Cost Item	Total Amount (USDm)	Unit Cost (USD/t ore)	Unit Cost (USD/lb U_3O_8)
Mining	452.5	11.1	17.1
Ore Transport	20.4	0.5	0.8
Processing	288.9	7.1	10.9
G&A	39.7	1.0	1.5
Transport U_3O_8	3.0	0.1	0.1
Environmental	18.0	0.4	0.7
Subtotal Operating Costs	**822.5**	**20.2**	**31.1**

22 ECONOMIC ANALYSIS (ITEM 22)

GoviEx and SRK completed a preliminary economic analysis on the Project. The various assumptions and inputs are described in the following section, followed by the results.

22.1 Inputs

The following assumptions have been applied to the life-of-mine plans and the economic analysis:

- Mineral Resources as defined in line with the CIM guidelines;
- maximum processing feed of 4 Mtpa;
- average U_3O_8 recovery of 88%.
- a total project life of 13 years (2 of construction, 11 of production);
- a flat long term U_3O_8 price of USD58/lb, in line with the median of consensus market forecasts;
- operating costs and capital expenditures as defined in Section 18;
- a 30% income tax rate;
- royalty rate of 9% as in Zambian regulation for open pit mining;
- a base case 8 % discount rate; and
- no provision for salvage value at closure is assumed in the analysis. Cost of closure of USD11.1M is included in sustaining capital.

Total ore tonnages and grades for the three different deposits are presented in Table 22-1. Figure 22-1 presents the mining production schedule (which equals the plant feed schedule), per source of material.

Table 22-1: Technical Mining Inputs

Parameter	Units	Base Case
Strip Ratio	$(t_{waste}:t_{ore})$	3.4
Dibwe East	$(t_{waste}:t_{ore})$	4.2
Dibwe	$(t_{waste}:t_{ore})$	2.9
Gwabe	$(t_{waste}:t_{ore})$	1.9
Mutanga	$(t_{waste}:t_{ore})$	1.4
Njame	$(t_{waste}:t_{ore})$	6.0
RoM	(kt)	40.8
Dibwe East	(kt)	21.4
Dibwe	(kt)	4.1
Gwabe	(kt)	3.1
Mutanga	(kt)	9.4
Njame	(kt)	2.7
RoM U_3O_8 Grade	(ppm)	333
Dibwe East	(ppm)	339
Dibwe	(ppm)	250
Gwabe	(ppm)	345
Mutanga	(ppm)	346
Njame	(ppm)	360
U_3O_8 Content	(t)	13,612
Dibwe East	(t)	7,263
Dibwe	(t)	1,028
Gwabe	(t)	1,066
Mutanga	(t)	3,266
Njame	(t)	989

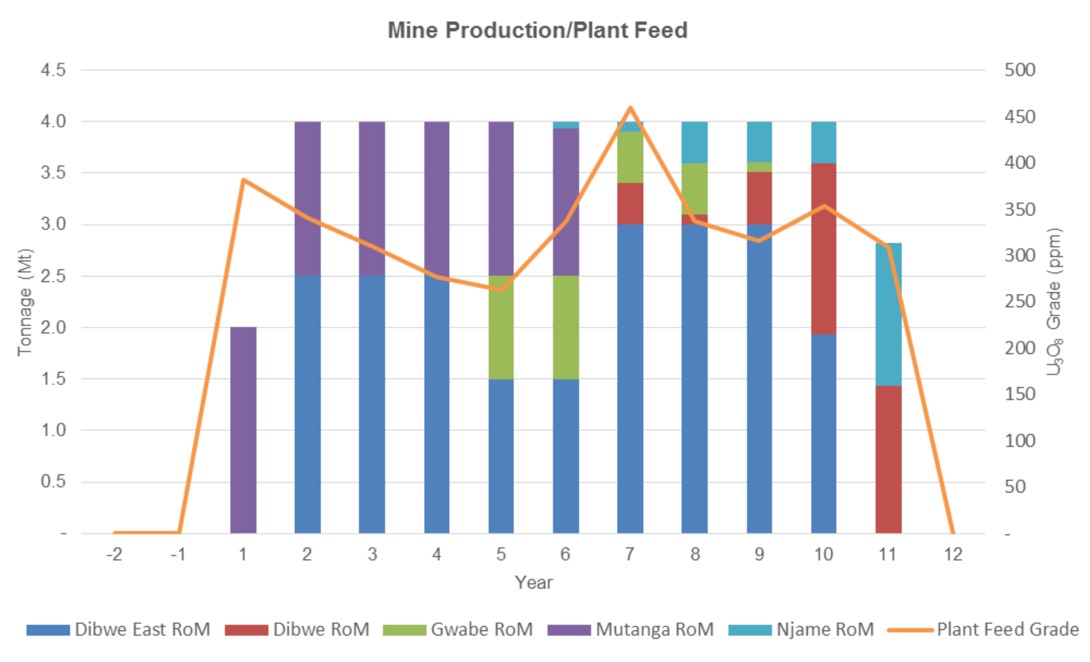


Figure 22-1: RoM Production Profile

22.2 Results

The base case preliminary economic analysis (at a Uranium price of \$50/lb U_3O_8) results in a post-tax pre-finance net present value ("NPV") of USD114M (at 8% discount rate), with an internal rate of return ("IRR") of 25%. Undiscounted payback will be in production year 3. Total LoM statistics are presented in Table 22-2. A year by year summary is presented in the technical economic model summary, Table 22-4.

Table 22-2: Technical Economic Model Summary and Results

Parameter	Units	Base Case
Mining	(USD/t ore)	11.1
	(USD/t mined)	2.5
Ore Transport	(USD/t ore)	0.5
Processing	(USD/t ore)	7.1
G&A	(USD/t ore)	1.0
Transport U_3O_8	(USD/t U_3O_8)	250.0
Environmental	(USD/t ore)	0.4
Subtotal operating costs	**(USD/t ore)**	20.2
	(USD/lb U_3O_8)	31.1
Royalty	(USD/t ore)	3.4
Total Operating Costs	**(USD/t ore)**	23.5
	(USD/lb U_3O_8)	36.4
Operating Profit - EBITDA	**(USDm)**	**571**
Corporate Profit Tax	**(USDm)**	**(119)**
Capital Expenditure		
Project Capital		
Mine Mob Fee	(USDm)	0.4
Plant	(USDm)	82.6
Camp	(USDm)	3.2
Infrastructure	(USDm)	7.5
G&A	(USDm)	2.1
EPCM	(USDm)	12.0
Contingency	(USDm)	10.7
Community	(USDm)	5.0
Project Capital Expenditure	**(USDm)**	**123.4**
Deferred/Sustaining capital		
Plant	(USDm)	27.2
Camp	(USDm)	1.6
Infrastructure	(USDm)	4.4
G&A	(USDm)	1.6
EPCM	(USDm)	4.6
Contingency	(USDm)	3.9
Closure Cost	(USDm)	11.1
Community	(USDm)	5.0
Sustaining Capital Expenditure	**(USDm)**	**59.5**
Total Capital Expenditure	**(USDm)**	**182.9**
Net Free Cash	**(USDm)**	**269**
NPV @ 8.00%	**(USDm)**	**112**
IRR	(%)	25

22.3 Sensitivity

Table 22-3 presents a twin parameter NPV sensitivity for changes in price and discount rate, and Figure 22-2 graphically presents the NPV sensitivity to commodity price, operating costs and capital expenditures.

Table 22-3: Twin Parameter NPV Sensitivity: Sales Price vs Discount Rate

NPV Twin Parameter Sensitivity		Sales Price		
		50 USD/lb	58 USD/lb (base case)	65 USD/lb
Discount Rate	6%	54.1	140.3	215.0
	8%	36.6	111.9	176.8
	10%	22.3	88.3	145.1
	12%	10.5	68.8	118.7

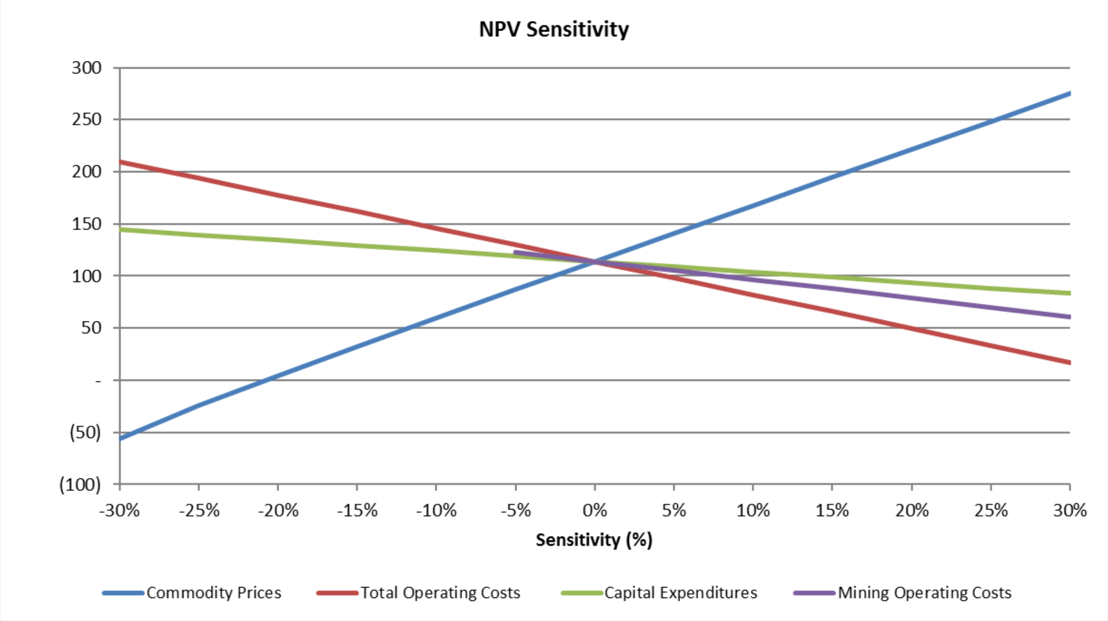


Figure 22-2: NPV$_{8\%}$ Sensitivity to Uranium Price, Operating Costs and Capital Expenditure

Table 22-4: Preliminary Technical Economic Model, November 2017

Calendar Year		Units	Totals	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Year				-2	-1	1	2	3	4	5	6	7	8	9	10	11
Mining																
Dibwe East																
Waste		(Mt)	91	-	-	-	11	14	12	8	12	12	11	9	1	-
RoM Ore		(Mt)	21	-	-	-	3	2	3	2	1	3	3	3	2	-
Grade		(ppm U_3O_8)	339	-	-	-	287	264	270	286	343	500	317	314	455	-
Content		(t U_3O_8)	7,263	-	-	-	718	659	676	429	514	1,500	950	941	876	-
Total Material Mined		(Mt)	112	-	-	-	14	16	15	10	14	15	14	12	3	-
Strip ratio		(t_{waste}:t_{ore})	4.2	-	-	-	4.6	5.5	5.0	5.5	8.0	4.0	3.5	3.1	0.4	-
Dibwe																
Waste		(Mt)	12	-	-	-	-	-	-	-	-	2	0	3	5	1
RoM Ore		(Mt)	4	-	-	-	-	-	-	-	-	0	0	1	2	1
Grade		(ppm U_3O_8)	250	-	-	-	-	-	-	-	-	249	243	263	242	256
Content		(t U_3O_8)	1,028	-	-	-	-	-	-	-	-	100	24	134	405	366
Total Material Mined		(Mt)	16	-	-	-	-	-	-	-	-	2	0	4	7	3
Strip ratio		(t_{waste}:t_{ore})	2.9	-	-	-	-	-	-	-	-	4.9	3.7	5.9	3.3	0.9
Gwabe																
Waste		(Mt)	6	-	-	-	-	-	-	5	1	0	0	0	-	-
RoM Ore		(Mt)	3	-	-	-	-	-	-	1	1	0	0	0	-	-
Grade		(ppm U_3O_8)	345	-	-	-	-	-	-	239	364	436	437	286	-	-
Content		(t U_3O_8)	1,066	-	-	-	-	-	-	240	364	217	218	26	-	-
Total Material Mined		(Mt)	9	-	-	-	-	-	-	6	2	1	1	0	-	-
Strip ratio		(t_{waste}:t_{ore})	1.9	-	-	-	-	-	-	4.7	0.7	0.2	0.2	2.8	-	-
Mutanga																
Waste		(Mt)	13	-	-	3	2	2	2	2	1	-	-	-	-	-
RoM Ore		(Mt)	9	-	-	2	2	2	1	1	1	-	-	-	-	-
Grade		(ppm U_3O_8)	346	-	-	381	431	388	289	256	318	-	-	-	-	-
Content		(t U_3O_8)	3,266	-	-	764	647	582	433	383	457	-	-	-	-	-
Total Material Mined		(Mt)	22	-	-	5	4	4	4	4	2	-	-	-	-	-
Strip ratio		(t_{waste}:t_{ore})	1.4	-	-	1.5	1.6	1.6	1.5	1.5	0.6	-	-	-	-	-
Njame																
Waste		(Mt)	16	-	-	-	-	-	-	-	1	2	4	1	3	6
RoM Ore		(Mt)	3	-	-	-	-	-	-	-	0	0	0	0	0	1
Grade		(ppm U_3O_8)	360	-	-	-	-	-	-	-	183	207	387	409	336	364
Content		(t U_3O_8)	989	-	-	-	-	-	-	-	11	21	156	163	134	504
Total Material Mined		(Mt)	19	-	-	-	-	-	-	-	1	2	4	2	3	7
Strip ratio		(t_{waste}:t_{ore})	6.0	-	-	-	-	-	-	-	18.7	16.9	9.5	3.3	6.3	4.3
Total Mining																
Waste		(Mt)	138	-	-	3	14	16	15	15	15	16	15	14	9	7
RoM Ore		(Mt)	41	-	-	2	4	4	4	4	4	4	4	4	4	3
Grade		(ppm U_3O_8)	333	-	-	381	341	310	277	263	337	459	337	316	354	309
Content		(t U_3O_8)	13,612	-	-	764	1,364	1,241	1,109	1,052	1,346	1,837	1,348	1,264	1,416	870
Total Material Mined		(Mt)	179	-	-	5	18	20	19	19	19	20	19	18	13	10
Strip ratio		(t_{waste}:t_{ore})	3.4	-	-	1.5	3.4	4.0	3.7	3.8	3.7	3.9	3.7	3.5	2.2	2.6
Processing																
Feed		(Mt)	41	-	-	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	2.8
	Dibwe East	(Mt)	21	-	-	-	2.5	2.5	2.5	1.5	1.5	3.0	3.0	3.0	1.9	-
	Dibwe	(Mt)	4	-	-	-	-	-	-	-	-	0.4	0.1	0.5	1.7	1.4
	Gwabe	(Mt)	3	-	-	-	-	-	-	1.0	1.0	0.5	0.5	0.1	-	-
	Mutanga	(Mt)	9	-	-	2.0	1.5	1.5	1.5	1.5	1.4	-	-	-	-	-
	Njame	(Mt)	3	-	-	-	-	-	-	-	0.1	0.1	0.4	0.4	0.4	1.4
Grade		(ppm U_3O_8)	333	-	-	381	341	310	277	263	337	459	337	316	354	309
Content		(t U_3O_8)	13,612	-	-	764	1,364	1,241	1,109	1,052	1,346	1,837	1,348	1,264	1,416	870
		(lb U_3O_8)	30,009,560	-	-	1,683,373	3,007,457	2,736,210	2,445,442	2,319,503	2,967,108	4,050,882	2,972,843	2,787,649	3,120,701	1,918,392
Recovery		(% U_3O_8)	88%	0%	0%	85%	90%	90%	90%	86%	86%	89%	90%	90%	85%	80%
	Dibwe East	(% U_3O_8)	93%	0%	0%	0%	93%	93%	93%	93%	93%	93%	93%	93%	93%	0%
	Dibwe	(% U_3O_8)	75%	0%	0%	0%	0%	0%	0%	0%	0%	75%	75%	75%	75%	75%
	Gwabe	(% U_3O_8)	75%	0%	0%	0%	0%	0%	0%	75%	75%	75%	75%	75%	0%	0%
	Mutanga	(% U_3O_8)	85%	0%	0%	85%	85%	85%	85%	85%	85%	0%	0%	0%	0%	0%
	Njame	(% U_3O_8)	85%	0%	0%	0%	0%	0%	0%	0%	85%	85%	85%	85%	85%	85%
Recovered U_3O_8		(t U_3O_8)	11,978	-	-	652	1,222	1,112	1,001	908	1,154	1,655	1,202	1,137	1,234	702
		(lb U_3O_8)	26,406,740	-	-	1,437,601	2,693,351	2,451,532	2,206,111	2,002,773	2,543,035	3,648,773	2,649,410	2,505,817	2,720,475	1,547,862
Sales Summary																
U_3O_8		(lb U_3O_8)	26,406,740	-	-	1,437,600.7	2,693,350.6	2,451,532.0	2,206,111.2	2,002,773.3	2,543,035.1	3,648,773.0	2,649,409.9	2,505,817.1	2,720,475.5	1,547,862.2
Product Prices																
U_3O_8		(USD/lb)	58.00	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0
Revenue																
U_3O_8		(USDm)	1,532	-	-	83.4	156.2	142.2	128.0	116.2	147.5	211.6	153.7	145.3	157.8	89.8

Calendar Year	**Units**	**Totals**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**
Year			**-2**	**-1**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Mining															
Unit Costs															
Mining (rehandle included in total cost, but not in unit ra	(USD/t mined)	2.53	-	-	4.3	2.4	2.3	2.4	2.5	2.3	2.4	2.3	2.5	3.1	3.0
Ore Transport	(USD/t feed)		-	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Processing															
Dibwe East	(USD/t feed)		-	-	-	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	-
Dibwe	(USD/t feed)		-	-	-	-	-	-	-	-	7.3	7.3	7.3	7.3	7.3
Gwabe	(USD/t feed)		-	-	-	-	-	-	8.0	8.0	8.0	8.0	8.0	-	-
Mutanga	(USD/t feed)		-	-	6.9	6.9	6.9	6.9	6.9	6.9	-	-	-	-	-
Njame	(USD/t feed)		-	-	-	-	-	-	-	6.8	6.8	6.8	6.8	6.8	6.8
G&A	(USDm pa)		-	-	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6
Transport U3O8	(USD/t U3O8)		-	-	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0	250.0
Environmental	(USDm pa)		-	-	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Operating Expenditure															
Mining	(USDm)	(453)	-	-	(21.7)	(42.0)	(47.0)	(44.0)	(48.3)	(43.5)	(47.1)	(43.8)	(45.5)	(39.4)	(30.4)
Ore Transport	(USDm)	(20)	-	-	(1.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(1.4)
Processing	(USDm)	(289)	-	-	(13.7)	(27.9)	(27.9)	(27.9)	(28.8)	(28.8)	(28.7)	(28.6)	(28.3)	(28.5)	(19.8)
Dibwe East	(USDm)	(151)	-	-	-	(17.6)	(17.6)	(17.6)	(10.6)	(10.6)	(21.2)	(21.1)	(21.1)	(13.6)	-
Dibwe	(USDm)	(30)	-	-	-	-	-	-	-	-	(2.9)	(0.7)	(3.7)	(12.2)	(10.4)
Gwabe	(USDm)	(25)	-	-	-	-	-	-	(8.0)	(8.0)	(4.0)	(4.0)	(0.7)	-	-
Mutanga	(USDm)	(65)	-	-	(13.7)	(10.3)	(10.3)	(10.3)	(10.3)	(9.9)	-	-	-	-	-
Njame	(USDm)	(19)	-	-	-	-	-	-	-	(0.4)	(0.7)	(2.7)	(2.7)	(2.7)	(9.4)
G&A	(USDm)	(40)	-	-	(3.6)	(3.6)	(3.6)	(3.6)	(3.6)	(3.6)	(3.6)	(3.6)	(3.6)	(3.6)	(3.6)
Transport U3O8	(USDm)	(3)	-	-	(0.2)	(0.3)	(0.3)	(0.3)	(0.2)	(0.3)	(0.4)	(0.3)	(0.3)	(0.3)	(0.2)
Environmental	(USDm)	(18)	-	-	(1.6)	(1.6)	(1.6)	(1.6)	(1.6)	(1.6)	(1.6)	(1.6)	(1.6)	(1.6)	(1.6)
Contingency	(USDm)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Subtotal operating costs	**(USDm)**	**(822.5)**	**-**	**-**	**(41.8)**	**(77.4)**	**(82.4)**	**(79.4)**	**(84.5)**	**(79.9)**	**(83.5)**	**(79.9)**	**(81.3)**	**(75.4)**	**(57.0)**
Royalty	(USDm)	(138)	-	-	(7.5)	(14.1)	(12.8)	(11.5)	(10.5)	(13.3)	(19.0)	(13.8)	(13.1)	(14.2)	(8.1)
Total operating costs	**(USDm)**	**(960)**	**-**	**-**	**(49.3)**	**(91.5)**	**(95.2)**	**(90.9)**	**(95.0)**	**(93.1)**	**(102.6)**	**(93.7)**	**(94.4)**	**(89.6)**	**(65.1)**
Operating Profit - EBITDA	**(USDm)**	**571**	**-**	**-**	**34.1**	**64.7**	**47.0**	**37.1**	**21.2**	**54.4**	**109.1**	**60.0**	**51.0**	**68.2**	**24.7**
Corporate Income Tax															
Profit tax	(USDm)	(119)	-	-	-	-	(6.8)	(9.1)	(4.3)	(12.7)	(29.1)	(16.4)	(13.7)	(20.4)	(6.6)
Net Profit	(USDm)	452	-	-	34.1	64.7	40.1	28.0	16.9	41.7	80.0	43.5	37.2	47.7	18.1
Capital Expenditure															
Project															
Mine Equipment	(USDm)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mine Mob Fee	(USDm)	(0)	-	(0.4)	-	-	-	-	-	-	-	-	-	-	-
Plant	(USDm)	(83)	(33.0)	(49.6)	-	-	-	-	-	-	-	-	-	-	-
Camp	(USDm)	(3)	(1.3)	(1.9)	-	-	-	-	-	-	-	-	-	-	-
Infrastructure	(USDm)	(8)	(3.0)	(4.5)	-	-	-	-	-	-	-	-	-	-	-
G&A	(USDm)	(2)	(0.8)	(1.3)	-	-	-	-	-	-	-	-	-	-	-
EPCM	(USDm)	(12)	(4.8)	(7.2)	-	-	-	-	-	-	-	-	-	-	-
Contingency	(USDm)	(11)	(4.3)	(6.4)	-	-	-	-	-	-	-	-	-	-	-
Community	(USDm)	(5)	(2.0)	(3.0)	-	-	-	-	-	-	-	-	-	-	-
Subtotal	**(USDm)**	**(123)**	**(49.2)**	**(74.2)**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Deferred/Sustaining															
Mine	(USDm)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Plant	(USDm)	(27)	-	-	-	-	-	(13.6)	-	(13.6)	-	-	-	-	-
Camp	(USDm)	(2)	-	-	-	-	-	(1.6)	-	-	-	-	-	-	-
Infrastructure	(USDm)	(4)	-	-	-	-	-	(2.2)	-	(2.2)	-	-	-	-	-
G&A	(USDm)	(2)	-	-	-	-	-	(0.8)	-	(0.8)	-	-	-	-	-
EPCM	(USDm)	(5)	-	-	-	-	-	(2.3)	-	(2.3)	-	-	-	-	-
Contingency	(USDm)	(4)	-	-	-	-	-	(2.0)	-	(1.9)	-	-	-	-	-
Closure cost	(USDm)	(11)	-	-	-	-	-	-	-	-	-	-	-	-	(11.1)
Community	(USDm)	(5)	-	-	-	-	-	(5.0)	-	-	-	-	-	-	-
Subtotal	**(USDm)**	**(59)**	**-**	**-**	**-**	**-**	**-**	**(27.5)**	**-**	**(20.8)**	**-**	**-**	**-**	**-**	**(11.1)**
Total Capital Expenditure	**(USDm)**	**(183)**	**(49.2)**	**(74.2)**	**-**	**-**	**-**	**(27.5)**	**-**	**(20.8)**	**-**	**-**	**-**	**-**	**(11.1)**
Net Free Cash	**(USDm)**	**269**	**(49.2)**	**(74.2)**	**34.1**	**64.7**	**40.1**	**0.5**	**16.9**	**20.9**	**80.0**	**43.5**	**37.2**	**47.7**	**7.0**
Cumulative NFC	**(USDm)**	**-**	**(49.2)**	**(123.4)**	**(89.3)**	**(24.6)**	**15.5**	**16.0**	**32.9**	**53.8**	**133.7**	**177.3**	**214.5**	**262.2**	**269.2**
Reporting Statistics - Real															
Cash Costs (ex. royalty)	(USD/lb)	31.15	-	-	29.1	28.7	33.6	36.0	42.2	31.4	22.9	30.1	32.4	27.7	36.8
Cash Costs	(USD/lb)	36.37	-	-	34.3	34.0	38.8	41.2	47.4	36.6	28.1	35.4	37.7	32.9	42.0
Total Cash Costs	(USD/lb)	36.37	-	-	34.3	34.0	38.8	41.2	47.4	36.6	28.1	35.4	37.7	32.9	42.0
Total Working Costs	(USD/lb)	40.88	-	-	34.3	34.0	41.6	45.3	49.6	41.6	36.1	41.6	43.1	40.5	46.3

23 ADJACENT PROPERTIES (ITEM 23)

Multiple uranium deposits are found across the Karoo basin in southern Africa and in the Proterozoic of Zambia as shown in Figure 8-1 in Section 8. The subsections below summarise properties in Zambia and also in neighbouring southern African countries.

23.1 Lumwana, Zambia

Although not in Karoo rocks, Barrick Gold Corp is operating the Lumwana project located in North West Zambia. This is primarily a large copper mine, with two open pits (Malundwe and Chimiwungo) from which uranium is being extracted as a significant potential by-product, although currently it is not sold or processed. Lumwana produced 287 Mlb copper in 2015 (Barrick Gold Corporation, 2017). The indicated and inferred uranium resources for the two pits are outlined in Table 23-1. Uranium occurs within the Malundwe and Chimiwungo deposits as discrete uranium-enriched zones that will be selectively mined and stockpiled during the copper mining operation. An environmental impact assessment of the uranium project was approved in December 2008. To the end of December 2010, 4.6 Mt of this material at an average grade of 900 ppm uranium and 0.86% copper was mined and stockpiled (Equinox Minerals Ltd, 2011).

Table 23-1: Lumwana Uranium Resource Estimate, 0.01% Cut-off Grade (Equinox Minerals Ltd., 2011)

	Tonnes (Mt)	Grade U_3O_8%	Contained Metal U_3O_8 lbs
Malundwe			
Indicated	4.7	0.095	9,920,000
Inferred	3.9	0.047	4,009,000
Chimiwungo			
Inferred	2.2	0.056	2,660,000

23.2 Mkuju River, Tanzania

Uranium One is undertaking a definitive feasibility study for its Mkuju River project in the Namtumbo district of southern Tanzania. The project incorporates the Nyota deposit, located approximately 470 km southwest of Dar es Salaam. Current activity at the Mkuju River Project is focused on licensing and permitting. Additional exploration work is also being conducted in the expected special mining license area, and a definitive project feasibility study is being prepared (Uranium One Inc, 2017). Resources are 58,534 tU, including measured and indicated resources of 47,927 tU and inferred resources of 10,562 tU with an average grade 0.026%U at 100 ppm cut-off.

Table 23-2: Mkuju River Project as of June 2013 (Uranium One Inc., 2017)

	Measured	Indicated	Inferred
Size	31,579 tU	16,348 tU	10,562 tU
Grade	0.028 %U	0.022 %U	0.019 %U

23.3 Letlhakane, Botswana

A-Cap Resources' Letlhakane project in the northeast of the country comprises Gojwane and Serule deposits. This includes 29,000 tU at 0.013% U as JORC-compliant indicated resource in Gojwane deposit (WNA, 2016). Serule contributed two thirds of the 72,000 tU inferred resource in mid-2012. In July 2013, the global total was upgraded to 22,160 tU at 0.017%U indicated and 96,750 tU inferred at 0.018%U, all at 100 ppm cut-off (WNA, 2016). The ore is carnotite in calcrete and amenable to alkaline or acid heap leaching. A-Cap Resources applied for a mining licence in September 2015, and in May 2016 the Department of Environmental Affairs approved the EIS.

23.4 Kayelekera, Malawi

Paladin Energy, of Perth, Australia, has developed the Kayelekera uranium mine in northern Malawi, west of Karonga. As of April 2011, Kayelekera had reserves of 11,265 tU at 0.04% cut-off, within 15,000 tU Measured and Indicated Resources in average 0.08% ore (JORC and NI 43-101 compliant) (WNA, 2016). Inferred resources add 2900 tU. The orebody remains open to the west and exploration is proceeding here and on nearby leases, including Mpata to the east and Juma to the south.

23.5 Ryst Kuil, South Africa

Australian-based Peninsula Energy has reported a JORC-compliant resource of 21,930 tU at its Karoo project straddling the East and West Cape provinces. This includes indicated resource of 8440 tU grading 0.089%U in sandstone. Drilling continues to convert historical resource information from 1970s to JORC-compliant. Uranium and molybdenum mineralisation is hosted in fluvial channel sandstone deposits chiefly in the western and central parts of the Main Karoo basin. The occurrences are epigenetic, tabular and sandstone-hosted, and the thickest sandstone bodies tend to contain the highest proportion of mineralisation. The company’s further exploration target is up to 110,000 tU. The Ryst Kuil part of the Karoo project was held by Uramin Inc, which was then taken over by Areva to become Areva Resources Southern Africa. The deposit had been discovered by Esso in the 1970s. Some 16,000 tU resources were estimated on historic basis at 0.1% grade. Areva suspended the project at the end of 2011, and in April 2014 it was acquired by Peninsula Energy to form part of the Karoo project.

24 OTHER RELEVANT DATA AND INFORMATION (ITEM 24)

24.1 Hydrogeology

24.1.1 Mutanga, Dibwe and Dibwe East

Knight Piesold conducted a hydrogeological study on behalf of Denison Mines in November 2008. This section summarises the key findings from that study:

- The Mutanga hydrogeology is characterised by semi-confined aquifers, although there is most likely a combination of semi-confined and unconfined conditions. There is a poor correlation (30%) between topography and static groundwater elevation. The sedimentary rocks (mainly sandstone) act as a less permeable primary matrix, while the fault zones act as the main aquifer, resulting in semi-confined/unconfined conditions.
- The aquifers are classified as dual porosity aquifers with groundwater stored mainly in the primary porosity and, to a lesser degree, in the faults and microfissures in the surrounding

country rock. The larger fractures/faults act as preferential pathways and are the main conduits for groundwater movement. The porosity of the rock matrix is greatly increased by the interconnected system of faults and microfissures.

- The average static groundwater level in the study area is approximately 20 mbgl, with a standard deviation of 8.05 m. The general direction of groundwater flow in the Mutanga domain is from south to north and north-east, while in the Dibwe domain it is from north to south-west; however, the flow direction may vary from this generalised description based on the orientations of the faults and other structures that control water flow.
- Mean annual precipitation in the Project area was reported as 529 mm/annum. Based on mass balance and model calibration, the groundwater recharge was reported as 3.2% in the aquifer matrix and 5.6% in the fault zones. This value is within the acceptable ranges of the recharge in the Karoo aquifers.

Hydrology

Drainage within the area follows three distinct patterns as the Mutanga area straddles the watershed between three different catchments. The Dibwe area lies within the Lufua catchment, while the Mutanga area drains either into the Lusitu or Mbendele and Mutulanganga catchments (Bäumle, Nkhoma, Silembo, & Neukum, 2007). In the Mutanga area, the drainage can locally be to the east-south-east into the Mbendele and Mutulanganga Catchment, or to the north-north-west into the Lusitu Catchment

This drainage pattern takes runoff from the area and channels it toward the Lusitu River in the north-west or the Mutulanganga River in the east, and then to the Zambezi River. The drainage pattern itself is characterised by a roughly dendritic arrangement of relatively deeply incised, steep sided gullies, although in places they appear to trace linear structural features, such as faults and geological contacts.

The Dibwe area is separated from the Mutanga area by a watershed, with the result that the surface water flow direction runs in the diagrammatically opposite direction to Mutanga into the greater Lufua Catchment

Locally and regionally, the drainage is almost directly to the south-west towards the Lufua River and Lake Kariba with a more dendritic pattern. A relatively large, linear valley containing the Lufua River is, however, present in the southern part of the Dibwe area, which flows to the south-east before joining the regional drainage pattern. Drainage within the Dibwe area is similar to the Mutanga area on a smaller scale with steeply incised drainage gullies and ditches, which appear to follow structural and geological features.

Hydrocensus

A hydrocensus was conducted on more than 70 boreholes in the vicinity of Mutanga and Dibwe with samples taken from hand-pumps serving the local community or surface water bodies likely to be used as watering points for livestock. Results showed a relatively poor correlation between surface topography and static water level elevation in the area, indicating that the aquifers are most likely semi-confined to leaky, and are therefore relatively insensitive to atmospheric pressure conditions. Groundwater levels were highly variable, with an average of 19.94 mbgl, a minimum of 0.54 mbgl and a maximum of 59.14 mbgl as determined from the hydrocensus results (although holes were encountered with water levels at depths greater than the maximum extent of the water level meter (60 m)).

The hydrocensus revealed that local communities rely almost solely on groundwater from hand-pumps within the Mutanga area, especially during the dry season. Numerous small seeps and wetlands were found throughout the area, with evidence that they are used for livestock watering. Standing water was also found within otherwise dry river beds at the height of the dry season, most likely indicating a significant contribution of groundwater to baseflow. A number of wells were also found within the area usually in sandy river beds, which appear to be used for very minor crop watering by means of buckets. The relatively sparse population of the area and wide spacing of the water abstraction points mean that current aquifer utilisation is very low.

Geophysical Surveys / Borehole Siting and Drilling

Borehole siting was based upon a combination of magnetometer survey and LUND electrical resistivity survey conducted by Knight Piesold in May 2008, as well as raw radiometric and magnetic data from an airborne geophysical survey conducted by GeoServices Group in 2006. Some 36 boreholes were drilled with the aim of characterising aquifers within the project area, determining water supply capacity of the aquifers and establishment of long term monitoring boreholes.

Aquifer Testing & Analysis

Aquifer testing was conducted by means of step- and constant discharge tests on 22 of the boreholes and yielded aquifer parameters for the Mutanga and Dibwe areas. 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 determined to be 4.51 L/s and 2.67 L/s for the Mutanga and Dibwe sites respectively, 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/s and 3.54 L/s for the Mutanga and Dibwe areas respectively. These results showed that there were three types of boreholes: 1) those drilled in the fault zones, characterised by high sustainable yield; 2) those with intermediate sustainable yields, sited in the matrix aquifer that intersects small fractures; and 3) those boreholes sited in the aquifer matrix, characterised by low sustainable yields. This variation in the yields is primarily due to the heterogeneity of the fault aperture, connectivity and density. All these boreholes in the fault zones are recommended to be used for the dewatering of the Mutanga and Dibwe Pits (Section 16.8).

Estimation of aquifer sustainable yield is highly dependent on the groundwater recharge. Model calibration was used to determine recharge at 3.2% of the mean annual precipitation (529 mm/annum). This is an average value for the aquifer matrix, but, in reality, will vary depending upon thickness of topsoil cover and vegetation distribution. Where a fractured aquifer is exposed to the atmosphere, recharge is higher than those areas composed of matrix only. Recharge was higher in the fault zones at 5.6% of the mean annual precipitation.

Hydrogeological Setting

As the Mutanga site is undeveloped and classified as a “greenfields” exploration project, the aquifers on site are expected to be in a near pristine state with very little or no anthropogenic impacts present.

Regional 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 area of the province (Bäumle, Nkhoma, Silembo, & Neukum, 2007). The majority of the aquifers in the area are in the form of fractured and faulted hard-rock systems, and this is particularly evident in the Mutanga area (Bäumle, Nkhoma, Silembo, & Neukum, 2007).

- The geological formations mainly comprise compact sedimentary rocks.
- The saturated interstice type(s) or storage medium is indicated as fractures within fresh rock, as well as within the intergranular porosity of the host rocks itself, most notably coarse to very coarse grained clean sandstones. This is described as a dual-porosity system.
- Average values for transmissivity for the Karoo in the Southern Province are given as 39.3 m^2/day and mean yield as 2.23 L/s (Bäumle, Nkhoma, Silembo, & Neukum, 2007).
- Ground water is indicated to occur in fractures which may be open, weathered or fractured due to being an unconformity, or fractured due to movement along the contact, or fractured due to proximity with larger faults or faults systems.
- The Karoo rocks within Southern Province are classified as D-E (moderate to limited groundwater potential (Bäumle, Neukum, Nkhoma, & Silembo, 2007a).
- Groundwater in the area is typically classified as continental groundwater of primarily meteoric origin (Bäumle, Nkhoma, Silembo, & Neukum, 2007).

Local Aquifer Description:

The aquifer types in the Mutanga and Dibwe areas are described as semi-confined, heterogeneous dual-porosity aquifers. Lateral aquifer interconnections are expected to be high. As a result, groundwater is expected to flow relatively easily across the project area. Two aquifer host rock types are present in the Mutanga area; the sandstones and conglomerates of the Escarpment Grit Formation in the Mutanga deposit area, and the interbedded sandstones and mudstones of the Dibwe deposit area. The highest blow-yield (22.9 L/s) was encountered within a fresh, coarse to very coarse grained, clean sandstone with a fining upward tendency which overlay grey mudstones of the Madumabisa formation. This unit is important in that although fresh and reasonably hard, it tends to be friable and exhibits significant matrix porosity suggesting that it may act as a significant contributor to the storage of the aquifer. The sandstones in the Mutanga area also appear to be relatively highly fractured with the highest yielding boreholes situated in close proximity to interpreted fault positions. Abundant water strikes were encountered at or near the contacts between distinctly different sandstone beds and it is assumed that the bedding plane contacts and bedding plane fractures act as preferential flow paths.

The water strikes in the Dibwe area were significantly lower than the greater Mutanga area with little to no thick sandstone beds intersected during drilling. In general, the rocks of the Dibwe area exhibit lower effective porosity as they are generally fine grained and the vast majority of water strikes occurred on the bedding planes between units.

The Madumabisa Mudstones are found in the area to the north-east of Mutanga and to the south-west of the Dibwe area. Where intersected, the yields were either very low or completely dry. These mudstones are interpreted as having very low effective porosity and hydraulic conductivity and are described as aquiclude.

Flood Hydrology Assessment

A hydrological investigation of the flood hydrology and floodlines of the rivers and natural water courses that flow through the Mutanga Project area was conducted. The deterministic method was chosen to determine the flood peak discharges is the Rational Method with the 1:50 year and 1:100 year flood inundation lines prepared using the HEC-RAS software. Floodlines indicate that the area to the south of the proposed Mutanga Pit lie within the flood inundation area. The Dibwe open pit is located on the natural water course and will be affected by the 1:50 and 1:100 year floods, before mitigation using water course-diversions.

Numerical Hydrogeological Model

Knight Piesold generated two hydrogeological models for the Mutanga and Dibwe pits (MDM, 2009) using Visual MODFLOW (VMOD) Version 4.3. The aim of the model was to:

- Generate pre-operational groundwater levels and flow directions in the project area.
- Determine the inflow values towards the proposed Mutanga and Dibwe pits at various stages of their depths.
- Propose dewatering design based on the hydrogeological conditions and environmental impact assessments.
- Determine the shape and depth of the cone of depression due to the dewatering processes.
- Assess the environmental impact of the dewatering on the groundwater environment.
- Propose strategies to mitigate any impact due to the dewatering.
- Evaluate the post-closure groundwater recession rate and decanting potential.
- Investigate the operation and post-closure mass transport patterns of potential contaminants (if any).

Groundwater Impact Assessment

The numerical model was used to assess the impacts that the process plants, heap leach pads, storage ponds, Mutanga and Dibwe pits and waste rock dumps could have on groundwater pre-construction phase, operation phase and closure phase. The main conclusions were as follows:

- The groundwater quantity in the Project area and the vicinity is expected to decrease due to the dewatering process. Throughout the LoM, however, the cone of depression is not expected to extend out of the concession area.

- After the decommissioning of dewatering at the mine closure phase, the groundwater is expected to fully recover after 65 years in the Mutanga Pit and 82 years in the Dibwe Pit. The groundwater will be restored through recharge of the aquifers by precipitation as well as regional groundwater ingress flowing towards the pits.
- During the LoM, potential contaminant movement is primarily due to dewatering induced groundwater flow. As a result, the plume will be drawn towards the open pits during the LoM. After the decommissioning of the dewatering process, however, the contaminants are expected to migrate further from the source.

Potential seepage from the HLP was modelled using SEEP/W software (version 7.03) (MDM, 2008). The seepage potential is limited; however, a worst-case scenario for the contaminant model was simulated assuming complete failure of the liner system for the heap leach and at a higher seepage rate than the value estimated using the Seep/W model. Since the proposed heap leach pads in both domains are in a close proximity to the pits they are under the influence of the radius of influence due to dewatering during the LoM. The movement of the contaminants will therefore be impacted by the drawdown; hence the contaminant plume will migrate toward the pits from the footprints of the heap leach facilities. Assuming the leak is not repaired, the plume will slowly expand and 200 years after mine closure, it will be a maximum distance of 2400 m from the base of the heap leach in the Mutanga domain towards the north and 1566 m towards the south-west in the Dibwe domain.

Proposed Mitigation Methods

The recommended mitigation strategy for prevention of contaminant seepage from the heap leach pad is the application of appropriate liner, drainage and leak detection systems. The recommended mitigation strategy for prevention of contaminant seepage from the waste rock dumps (WRD) during the operational phase is the profiling of the dumps in order to limit rainfall infiltration, the proper management of all run-off and, depending on the results of the additional kinetic testing, the addition of lime/carbonate as a neutralising agent during deposition of the waste rock, should it be necessary.

Proposed Ongoing Monitoring

A groundwater and surface water monitoring system will be established for the mine. The groundwater qualities will be sampled quarterly, while the groundwater levels will be monitored monthly for the LoM. During post-closure, the groundwater levels and qualities will continue to be monitored quarterly for the first two years, and, based on the results, the monitoring frequency will be adjusted.

CAPEX and OPEX

The implementation and operation of the required dewatering programme is detailed below. It should be noted that all costs are given in US dollars (USD) and have been calculated at an exchange rate of USD 1: ZAR 9.50.

Table 24-1: Summary of Capital Expenditure Costs for the Dewatering Programme

Item	Sub Total (USD)
Drilling and aquifer testing	460,994.00
Pumps	192,439.90
Water level loggers (divers)	11,240.40

24.1.2 Njame, Njame South and Gwabe

Key points relating to the hydrogeology in and around Njame, Njame South and Gwabe are as follows:

- The Project area is dominated by sedimentary rocks consisting of sandstones, grits, conglomerates and siltstones (Escarpment Grit Formation) which a high effective porosity (in particular sandstones – approximately 10%) indicating that the primary porosity has a significant role in the groundwater flow and contaminant migration patterns.
- The average annual precipitation is 737 mm. There is a distinct wet and dry season, with 90% of the rainy days occurring from November to March. Although the annual evapo-transpiration exceeds the average annual precipitation by 1263 mm, recharge to the underlying aquifers will occur during high intensity rainfall events during the summer months. The recharge can be determined with the use of chemical analyses of groundwater samples.
- The Njame prospect is transected by a number of generally east-west trending faults. The Gwabe prospect also contains faults, but very little data are available. The faults are suspected of acting as preferential pathways for groundwater movement and will have a significant influence on the groundwater in terms of quantity present, aquifer parameters and the direction of groundwater movement.
- It is suspected that the aquifers in both the Njame and Gwabe prospects are comprised of a poorly developed weathered, unconsolidated aquifer and a deeper, consolidated fractured aquifer. Drilling indicated the presence of a perched aquifer in the low lying areas with a deeper, better developed aquifer on the contact between consolidated and unconsolidated material and in fractures within the consolidated material. Boreholes drilled on the rocky ridges have not indicated an upper perched aquifer and water was only encountered in small quantities in fractures within fresh rock. It is believed that the perched aquifer observed in the low lying areas, which are deeply weathered, are a primary, unconfined aquifer while the deeper aquifers observed in both the low lying areas and rocky ridge areas are a combination of a primary and secondary aquifer which is confined.
- From historical drilling results, it is believed that groundwater is concentrated in areas which are deeper weathered and form ‘basin’ like aquifers where groundwater accumulates. Fault zones are also believed to act as preferential pathways for groundwater. Deeper weathered areas and fault zones are thus the well-developed aquifers in the region.
- Static groundwater levels vary significantly across the site and is quite deep in boreholes drilled on rocky ridges and shallow in flat flood plain areas.
- Regionally, the depth to the different aquifer types as determined by the lithology, weathering distribution of the sediments, and water level distribution, varies as follows:
  - weathered zone aquifer: 19 m to 54 m; and
  - deeper fractured aquifer: 54 m to 70 m;
  - the thickness of the weathered zone and deeper fractured aquifer is highly variable:
    - weathered zone aquifer: 0 m to 35 m; and
    - deeper fractured aquifer: 5 m to 15 m.

- Historic slug tests indicated hydraulic conductivity (K) values of 2.998 m/day for a borehole which is situated on a fault and 0.602 m/day for a borehole situated in the matrix rock.
- There is a lack of hydrogeological data at Gwabe but the geological environment at Gwabe and Njame is generally similar, therefore, it is assumed that both prospects will have generally the same hydrogeological characteristics. This assumption will have to be verified by a more detailed investigation at Gwabe.

Hydrology

Watercourses in the region of the Njame area tend to drain towards the Lusitu River, which then flows into the Zambezi River to the south of the permit. Drainage from Njame flows to the southeast and lies within the catchment area of the Lusitu River. The drainage from Gwabe flows to the northeast into the Kafue River, which later flows into the Zambezi River.

Apart from the Zambezi and Kafue Rivers, watercourses in the area are generally seasonal, only flowing in the rainy season and usually flow through flash flooding in channels. The area is not densely populated however where settlements do occur water is very scarce and in high demand by people and animals. Surface water in these areas is likely to be highly contaminated. For Njame, there are about five covered hand pump wells in the area that are used by the villagers for domestic use and also for the animals. Surface water is used mostly for domestic use by local people around Gwabe Project site. The water from the Kafue is also used for irrigation of banana plantations which are situated along the Kafue River.

Nominal grading and ditching will be adequate to maintain a well-drained site. Finish grade on the plant site will be constructed to provide positive drainage away from structures. A system of ditches will route runoff around the plant site and the leach pad.

Water Sources

Sources of water supply have been identified for Njame and Gwabe and consist of the following:

- Process water could be locally sourced through a small bore-field (although the quality of this water needs to be assessed for leaching).
- Kafue River (17 km from site) or Zambezi River (17 km from site) are possible sources of river water supply for the Njame site. Kafue River (0.5 km to 1 km from site) is the only river source that is possible for the Gwabe site.
- Potable water will need to be trucked in or supplied and pumped from a remote well suitable for human consumption or river water will need to be treated by RO and chlorination water treatment plant.

Hydrocensus

A hydrocensus conducted in December 2007 revealed that there were 11 community boreholes equipped with handpumps at Njame; each supplies water to between 200 and 700 dependents. No groundwater users were identified within the 2 km radius from the Gwabe prospect as the local residents collect their potable water from the nearby Kafue River.

Static water levels in Njame exploration boreholes ranged from 11.20 mbgl in the low lying areas, to 44.97 mbgl along sandstone ridges. Generally, there was a good correlation between surface elevation and measured static water levels. This relatively good correlation suggests that an unconfined aquifer is present at the site; however, it is suspected that a combination of confined and unconfined conditions exists; potentially an upper unconfined aquifer exists in the unconsolidated weathered material with a confined aquifer situated in fractures in fresher consolidated rock. General groundwater flow is in a north-easterly to easterly direction, with an average groundwater gradient of 1:41 (0.02). This is, however, only for a specific area, near the proposed Pit1 and Pit2 at Njame, where sufficient data was available, little to no data exist on the groundwater in areas such as the proposed waste rock dump and the heap leach pad at Njame and very little data for Gwabe.

Drilling

A limited number of historical tests have been conducted on boreholes in the vicinity of Njame and Gwabe to determine aquifer parameters such as hydraulic conductivity (K), transmissivity (T) and storativity (S), aquifer characterisation. At Njame, drilling and consultation with the on-site geologist and geological logs generally revealed that boreholes drilled on the ridge did not intersect significant quantities of groundwater. This may be due to the generally shallow weathering in the area and groundwater only occurring in fractures within the fresher, consolidated rock; however, there is a possibility that faults may contain significant quantities of groundwater even though the depth of weathering is quite shallow and this should be investigated further. Some boreholes drilled towards the eastern part of the prospect area, in the flat low lying areas, did indicate significant groundwater yields. Drilling in these low lying areas indicated that a greater depth of weathering and water strikes were encountered in shallow unconsolidated material as well as on the contact between fresher and weathered material and within fractures within the fresh, consolidated rock. Some boreholes drilled in these low lying areas, however, did not indicate high yields during drilling, despite the deeper weathering.

A number of faults exist in the prospect areas and in particular, in the open pit areas which require further investigation. These faults may have a significant influence on the local groundwater in terms of quantity and will greatly influence the amount of groundwater which may flow into the open pits. They may also form an ideal target when identifying areas for water supply purposes.

Aquifer Testing

Slug tests and pump tests were historically performed on two boreholes at Njame and one at Gwabe. Results showed a general lack of water towards the hilly west-north-western part of the Njame prospect, indicating that groundwater is more concentrated in the zones of deeper weathering as is found towards the eastern part of the Njame prospect in the relatively topographically flat areas. It is also suspected that faults act as preferential pathways for groundwater.

Yields of boreholes are highly variable across the study area. Relatively high yields for this geological environment (approximately 2 L/s) were encountered in areas which are deeper weathered and in an inferred fault zone. Very low yields (<0.1 L/s) were observed in boreholes drilled on the rocky ridges with very shallow weathering. The pump test results are summarised Table 24-2.

Table 24-2: Calculated Transmissivity and Sustainable Yields of Pump Tested Boreholes (Source: AFR, March 2008)

Borehole	Transmissivity (m^2/day)				Sustainable Yield (l/sec)			
	Recovery	Calibration	Cooper -Jacob	Hantush	FC	Calibration	Inflection	Barker
NJE003 (north of Njame proposed Pit 2)	22.4	25.0	32.0	22.8	0.92	0.86	0.90	1.32
NJN210 (on proposed fault in vicinity of the eastern boundary of proposed Pit 1)	21.2	44.0	47.0	50.0	2.18	1.27		3.34
GWN186 (Gwabe prospect)	12.8	6.0	21.3	20.8	0.60	1.14	1.02	0.91

The slug test results were not all reliable due to very small changes in the groundwater level but generally the heights of displaced water were relatively small. The average hydraulic conductivity of the boreholes slug tested was 0.23 m/day.

Limitations on the current study are:

- There is a lack of information regarding the structural features at both Njame and Gwabe.
- Hydrogeological investigation conducted to date is limited, areas of importance, such as the proposed waste rock dump and heap leach pad, will have to be investigated to determine factors such as depth to the static water level and aquifer parameters.
- A geo-referenced image of the inferred faults as determined by the resource drilling will help with the planning. Geophysical methods that would be applicable to the project include resistivity and frequency domain electro magnetics (“FDEM”) with resistivity being the preferred method. Zones of deeper weathering, which is indicative of faults, fault zones or paleo-channels will be identified with resistivity and to a lesser degree by FDEM. Resistivity surveys are expensive and time consuming. FDEM surveys are less expensive and less time consuming Future drilling contractors must be prepared to collect v-notch measurements every six meters drilled and install or uninstall steel casing as and when required. There have been historical issues with sand entering boreholes therefore future constructions should be revised to minimize this.

25 INTERPRETATION AND CONCLUSIONS (ITEM 25)

This PEA considers the economic and technical viability of the Mutanga uranium Project in the Southern Province of the Republic of Zambia near the town of Siavonga. GoviEx holds three mining licences for Mutanga, Dibwe and Chirundu ML (Gwabe and Njame). Two additional prospecting licences for Chirundu PL and Kariba Valley are pending (Section 4.2).

The Mutanga Project contains a Measured and Indicated Mineral Resource of 21.6 million tonnes at an average grade of 318 ppm U_3O_8, containing 15 million pounds of U_3O_8, and an Inferred Mineral Resource of 74.6 million tonnes at an average grade of 273 ppm U_3O_8, containing 45 million pounds of U_3O_8 in in six deposits (Mutanga, Dibwe East, Dibwe, Gwabe, Njame and Njame South), located over 65 km strike. The mineral resource estimate determined by SRK based on information provided in previous studies is shown below.

Table 25-1: Mineral Resource Estimate[1], Mutanga Uranium Project, Namibia, SRK Consulting (UK) Ltd, November 20, 2017

Deposit	Category	Tonnes (Mt)	U_3O_8 Grade (ppm)	U_3O_8 Mlb
Mutanga[2]	Measured	1.9	481	2.0
	Indicated	8.4	314	5.8
	Inferred	7.2	206	3.3
Dibwe[2]	Inferred	17.0	239	9.0
Dibwe East[2]	Inferred	43.1	304	28.9
Gwabe[3]	Measured	1.3	237	0.7
	Indicated	3.6	313	2.5
	Inferred	0.7	178	0.3
Njame[3]	Measured	2.7	350	2.1
	Indicated	3.7	252	2.1
	Inferred	2.1	225	1.1
Njame South[3]	Inferred	4.4	250	2.4
Sub-total Measured		5.9	366	4.8
Sub-total Indicated		15.7	299	10.4
Measured and Indicated		21.6	317.5	15.1
Inferred		74.6	273.0	44.9

[1] Mineral Resources have not been constrained by pit shells, however, almost all of the mineralisation occurs within 125 m of surface with uranium grades which are, in general, considered to have reasonable prospects for eventual economic extraction by open pit mining.

[2] The cut-off grade used for reporting the Mineral Resource is 100 ppm U_3O_8, which is applied directly to block model cells.

[3] No U_3O_8 ppm cut-off is applied to block model cells for reporting the Mineral Resource. However, the outer limits block model was constrained within a 100 ppm U_3O_8 wireframe used for geological modelling.

No Mineral Reserve has yet been determined for this Project.

The deposits are amenable to conventional, shallow open cast mining methods utilising excavators and trucks with relatively low stripping ratios. The preliminary mining plan has been developed assuming open pit extraction and conventional truck and shovel mining method. Pit optimisations were run for considered deposits to determine pit limits and pushback development. Subsequently, production schedule has been prepared for all deposits assuming the same cut-off grade for all of them and a plant feed rate of 4.0 Mtpa. Using metal price of 50 USD/lb U_3O_8 for pit optimisation it gave enough RoM inventory to cover 11 years of production from the six considered deposits.

Mining losses and dilution were applied as 10% and 90% global values, diluting grade was at 0.0 ppm U_3O_8. The total pit inventory for mineralized material is around 40.8 Mt at 333 ppm U_3O_8 and the overall strip ratio for the project is 3.4 (t:t) but varies from 1.4 to 6.0 (t:t), depending on the deposit.

Currently, no pit design has been made, but pit wire frames were developed and appropriate sensitivity to some parameters was assessed. A mining production schedule has been developed at a feed rate of 2.0 Mtpa in 2019 and 4.0 Mtpa thereafter.

Two process options have been investigated: alkaline leach and acid leach. Acid heap leaching was selected on the basis of giving slightly better overall recovery for all six deposits is more rapid and has lower operating and capital cost. Test work has confirmed heap permeability would be good and that acid consumption would be relatively low at 8-12 kg/t. The process is considered by SRK to be robust, simple and to have a low environmental profile. The main facilities for recovery of uranium oxide will be located close to Mutanga and Dibwe East pits.

At the CPF, uranium will be purified then stripped from the leach solution and loaded onto a resin. The process is reliable and has been proven at other locations. The barren leach solution will be returned to the barren pond to be used for leach solution make up. The process plant will produce uranium oxide in the form of a dry powder that will be loaded directly into drums and immediately sealed. The drums will be washed, transported to an adjacent storage area and then loaded into 6.3 m sea containers for transport to port. The plant has the capacity to produce sufficient uranium to fill two or three barrels a day, each drum weighing about 1,000 kg. Uranium recovery is expected to be 80% to produce an average of 2.4 Mlb per annum of uranium contained in uranium oxide.

For Mutanga and Dibwe East leach pads, PLS will be pumped to the adjacent CPF for stripping and concentrating uranium. For the other deposits, PLS will be pumped to an adsorption plant where uranium will be stripped of uranium and loaded onto resin.

Tests on mine wastes indicate that there is minimal potential for acid rock drainage. Runoff from dumps will be tested to confirm quality.

Total capital expenditure for the life of the operation are presented in Table 25-2. A two-year construction period ahead of production is envisaged. The operation is intended to be contractor mined. Life of mine operating costs are presented in Table 21-2.

Table 25-2: Capital Expenditure

Parameter	Units	Total amount
Project Capital		
Mine Mobilisation Fee	(USDm)	0.4
Plant	(USDm)	82.6
Camp	(USDm)	3.2
Infrastructure	(USDm)	7.5
G&A	(USDm)	2.1
EPCM	(USDm)	12.0
Contingency	(USDm)	10.7
Community	(USDm)	5.0
Total Project Capital	**(USDm)**	**123.4**
Deferred / Sustaining capital		
Plant	(USDm)	27.2
Camp	(USDm)	1.6
Infrastructure	(USDm)	4.4
G&A	(USDm)	1.6
EPCM	(USDm)	4.6
Contingency	(USDm)	3.9
Closure Cost	(USDm)	11.1
Community	(USDm)	5.0
Total Deferred / Sustaining Capital	**(USDm)**	**59.5**
Total Capital Expenditure	**(USDm)**	**182.9**

Table 25-3: LoM Operating Costs

Operating Cost Item	Total amount (USDm)	Unit Cost (USD/t ore)	Unit Cost (USD/lb U_3O_8)
Mining	452.5	11.1	17.1
RoM Transport	20.4	0.5	0.8
Processing	288.9	7.1	10.9
G&A	39.7	1.0	1.5
Transport U_3O_8	3.0	0.1	0.1
Environmental	18.0	0.4	0.7
Subtotal Operating Costs	**822.5**	**20.2**	**31.1**

25.1 Implementation

Provisional major milestones, subject to financing are summarised in Table 25-4. The summary statistics for the Mutanga project are shown in Table 25-5.

Table 25-4: Proposed Summary of Project Milestones

Milestone	Date
Submit mining license application	awarded
Begin detailed feasibility study	2019
Begin design, procurement and construction	2020-2021
Begin commissioning	2022
Full production	2022 / 2023

Table 25-5: Technical Economic Model Summary and Results

Parameter	Units	Base Case
Mining		
RoM	(Mt)	40.8
U_3O_8 Grade	(ppm)	333
U_3O_8 Content	(t)	13,612
Processing		
U_3O_8 Recovery	(%)	88%
U_3O_8 Recovered/Sold	(lb)	26,406,740
Revenue		
U_3O_8 Price	(USD/lb)	58
U_3O_8 Revenue	(USDm)	1,532
Operating Expenditure		
Direct Operating Costs	(USDm)	823
Royalty	(USDm)	138
Total Operating Costs	**(USDm)**	**960**
Unit Operating Costs		
Subtotal Operating Costs	(USD/t ore)	0.2
	(USD/lb U_3O_8)	31.1
Royalty	(USD/t ore)	3.4
Total Operating Costs	(USD/t ore)	23.5
	(USD/lb U_3O_8)	36.4
Operating Profit – EBITDA	**(USDm)**	**571**
Corporate Profit Tax	**(USDm)**	**119**
Capital Expenditure		
Project	(USDm)	123
Deferred/Sustaining	(USDm)	59
Total Capital Expenditure	**(USDm)**	**182**
Net Free Cash	**(USDm)**	**269**
NPV @ 8.00%	**(USDm)**	**112**
IRR	(%)	25%

26 RECOMMENDATIONS (ITEM 26)

26.1 Geology and Resources (Item 9, 14)

In order to advance the project towards a prefeasibility study, the majority of the deposit will need further drilling to increase confidence to Indicated Mineral Resource or better to allow the derivation of Mineral Reserves; namely:

- Additional exploration in Chirundu area and test continuity between the Mutanga and Njame deposits.
- Drilling to upgrade Mineral Resource classifications and additional drilling on trenched targets.

26.2 Mineral Processing and Metallurgical Testing (Item 13)

In order to further improve the understanding of the flowsheet finalisation, the following recommendations are provided:

- Continue the optimisation of leach conditions, to provide those to be used in the continuous testing part of the feasibility study that will be employed to prepare capital and operating cost estimates.
- Investigate options for enhanced oxidation to enhance recovery from Gwabe and Njame.
- Complete testwork to demonstrate potentially higher consistent recovery.
- Continue the refinement of uranium recovery from the enriched liquors post-ion exchange to demonstrate acceptable product quality can be consistently achieved.
- Develop innovative ways of heat recovery and heating of the liquor streams to provide the environment required to support fast uranium dissolution.

26.3 Mining Methods (Item 16)

Further work will be required in a number of areas affecting mine planning to address the modifying factors in sufficient detail to allow the estimation of Mineral Reserves in a prefeasibility study including;

- Review approach to mining losses and dilution. SRK recommends using local as opposed to global application of these two factors in future.
- Conduct a geotechnical analysis for the deposits to confirm the slope angles of 50° and assess if potential to increase the angle
- Develop a study defining optimum location for the plant and material handling method together to define the cost.

26.4 Hydrogeology

Following review and analysis of the data gathered during this investigation, the following recommendations are made:

- As the cone of depression due to the dewatering process expands to a large extent, but within the concession area, it is recommended that the topographical elevation be surveyed within a 5 km radius of the proposed pits.

- It is also recommended that groundwater quantity and quality be monitored within this radius. A groundwater and surface water monitoring programme will be established.

27 REFERENCES (ITEM 27)

African Energy Resources Limited (AFR), 2007, Annual Report 2007

African Energy Resources Limited (AFR), 2008, Annual Report 2008

African Energy Resources Limited (AFR), 2008, Environmental Impact Statement Draft as Submitted to the Environmental Council of Zambia

African Energy Resources Limited (AFR), March 2008, Chirundu Uranium Joint Venture Pre-Feasibility Report, Document Number AFR001, including Appendix 1 - 25

African Energy Resources Limited (AFR), 10 November 2008, Chirundu Uranium Project, Environmental Monitoring Programme (Memorandum).

African Energy Resources Limited (AFR), 2009, Annual Report 2009

African Energy Resources Limited (AFR), March 2009, Mineral Resource Report for the Njame and Gwabe Uranium Deposits, Chirundu Project, Zambia.

African Energy Resources Limited (AFR), 2010, Annual Report 2010

African Energy Resources Limited (AFR), February 2011, Quarterly Report on Exploration Activities for the Period: October 1st to December 31st 2010, Prospecting Licence No: 8302-HQ-LPL

African Energy Resources Limited (AFR), June 2013, Zambian Uranium Projects Information Memorandum, including Appendix 1 - 8

ALS Minerals May 2011 QEMScan mineralogy report.

Barrick Gold, 2017. Operations – Lumwana. Available at:
http://www.barrick.com/operations/lumwana/default.aspx Accessed on: 25/01/2017

Chirundu Joint Ventures Zambia Ltd, April 2010 – June 2016, 22 x Quarterly Reports on Exploration Activities on Tenement No: 8264-HQ-LPL (Formerly 13262-HQ-LPL, PLLS 250), January 2010 to December 2013 and March 2014 to April 2014 and April 2015 to June 2016

CSA Global (UK) Ltd (CSA), 12 September 2013, NI43-101 Technical Report, Mineral Resource Estimates for the Mutanga Uranium Project for Denison Mines Corp., Report Number R305.2013.

Denison Mines (USA) Corp & Roscoe Postle Associates, Inc, 27 March 2012, The Dibwe East Project, Southern Province, Republic of Zambia, National Instrument 43-101 Technical Report

European Nuclear Society (ENS) (2003), 7th International Topical Meeting on Research Reactor Fuel Management, March 9 to 12, 2003, Aix-en-Provence, France

Equinox Mineral Limited, 2011. Annual Information Form for the year ended December 31, 2010. Available at:

https://www.sec.gov/Archives/edgar/data/1377085/000119312511068861/dex217.htm Accessed on: 25/01/2017

Geoquest Ltd, 10 May 2012, AERL Ltd Chirundu Project Environmental Monitoring Database, Status Report

Knight Piesold, January 2008, Chirundu Joint Venture Project, Zambia – Hydrogeological Pre-Feasibility Study, Report Number 5319/01

MDM Engineering Kariba Uranium Project Scoping Study, 2006, Report Reference 0697/DD/001, including Appendix 3, 4, 6, 7 and 9

MDM Engineering Mutanga Project Feasibility Study, May 2009, Sections: 2, 3, 8, 9, 10, 11, 12 and 13

Mintek, 20 January 2010, Determination of Uranium Heap Leach Process Design Criteria for the Chirundu Project in Zambia, Report 5456

SGS Lakefield Oretest Pty Ltd (SGS), 26 July 2006, Qemscan Analysis of 12 U-Ore Samples for U Classification, Project Code: BAMF00017a

Sound Mining Solution Central Africa (PTY) Ltd (SMS), March 2009, Trade Off Study Chirundu Uranium Project, Report No. SMS-CA/008/09.

World Nuclear Association (WNA), 2016. Uranium in Africa. Available at: http://www.world-nuclear.org/information-library/country-profiles/others/uranium-in-africa.aspx Accessed on: 25/01/2017

Uranium One Inc., 2017. Mkuju River Project. Available at: http://www.uranium1.com/index.php/en/development/mkuju-river-tanzania Accessed on: 25/01/2017

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GLOSSARY, ABBREVIATIONS, UNITS

Glossary

Term	Definition
Assay:	The chemical analysis of mineral samples to determine the metal content.
Capital Expenditure:	All other expenditures not classified as operating costs.
Composite:	Combining more than one sample result to give an average result over a larger distance.
Concentrate:	A metal-rich product resulting from a mineral enrichment process such as gravity concentration or flotation, in which most of the desired mineral has been separated from the waste material in the ore.
Crushing:	Initial process of reducing ore particle size to render it more amenable for further processing.
Cut-off Grade (“CoG”):	The grade of mineralized rock, which determines as to whether or not it is economic to recover its metal content by further concentration.
Dilution:	Waste, which is unavoidably mined with ore.
Dip:	Angle of inclination of a geological feature/rock from the horizontal.
Fault:	The surface of a fracture along which movement has occurred.
Footwall:	The underlying side of an orebody or stope.
Gangue:	Non-valuable components of the ore.
Grade (“G”):	The measure of concentration of uranium within mineralized rock.
Hangingwall:	The overlying side of an orebody or slope.
Haulage:	A horizontal underground excavation which is used to transport mined ore.
ICP-MS	Inductively coupled plasma – mass spectrometer; standard analytical technique
ICO-OES	Inductively coupled plasma – atomic emission spectroscopy
Kriging:	An interpolation method of assigning values from samples to blocks that minimizes the estimation error.
Level:	Horizontal tunnel the primary purpose is the transportation of personnel and materials.
Lithological:	Geological description pertaining to different rock types.
LoM Plans:	Life-of-Mine plans.
Material Properties:	Mine properties.
Milling:	A general term used to describe the process in which the ore is crushed and ground and subjected to physical or chemical treatment to extract the valuable metals to a concentrate or finished product.
Mineral/Mining Lease:	A lease area for which mineral rights are held.
Mining Assets:	The Material Properties and Significant Exploration Properties.
Ore Reserve:	See Mineral Reserve.
RoM:	Run-of-Mine.
Sedimentary:	Pertaining to rocks formed by the accumulation of sediments, formed by the erosion of other rocks.
Stratigraphy:	The study of stratified rocks in terms of time and space.
Strike:	Direction of line formed by the intersection of strata surfaces with the horizontal plane, always perpendicular to the dip direction.
Sulfide:	A sulfur bearing mineral.
Tailings:	Finely ground waste rock from which valuable minerals or metals have been extracted.
Thickening:	The process of concentrating solid particles in suspension.
Uranium units	1.0 per mil = 1000 ppm = 0.10 % eU. And 0.1000 % eU = 0.1179 % eU_3O_8
Variogram:	A statistical representation of the characteristics (usually grade).

Abbreviations and Units

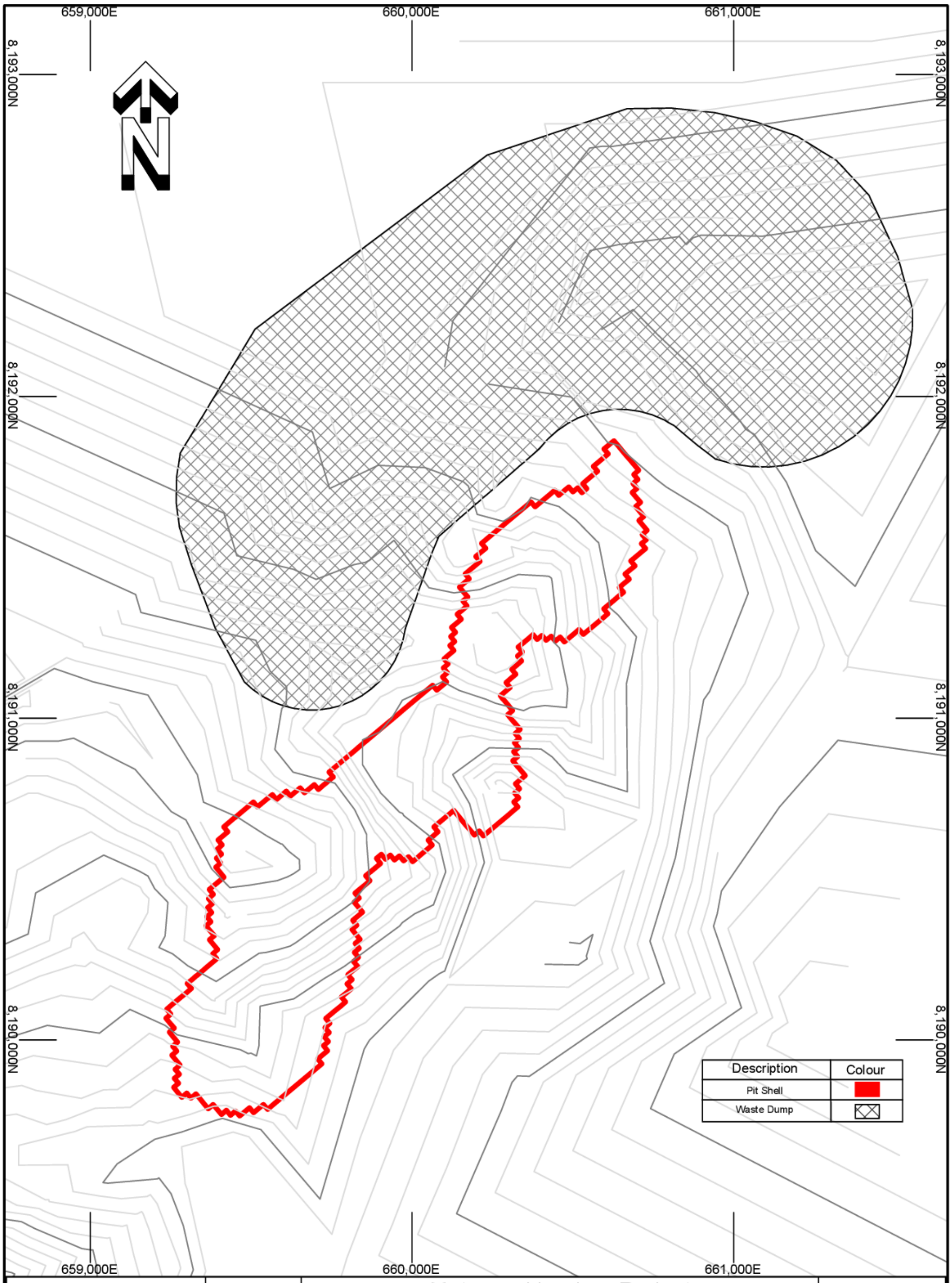
Abbreviation / Unit	Unit or Term
%	percent
AA	atomic absorption
ANFO	ammonium nitrate fuel oil
Au	gold
AuEq	gold equivalent grade
°C	degrees Centigrade
CCD	counter-current decantation
cfm	cubic feet per minute
CIL	carbon-in-leach
CIX	Continuous ion exchange circuit
CoG	cut-off-Grade
cm	centimeter
cm^2	square centimeter
cm^3	cubic centimeter
cfm	cubic feet per minute
ConfC	confidence code
Crec	core recovery
CSS	closed-side setting
CPS	counts per second
CTW	calculated true width
°	degree (degrees)
dia.	Diameter
€	Euro
eU	Equivalent uranium assay value; determined radiometrically
eU_3O_8	Equivalent U_3O_8; determined radiometrically
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
ft	foot (feet)
ft^2	square foot (feet)
ft^3	cubic foot (feet)
G&A	General and administrative project costs
g	gram
gal	gallon
g-mol	gram-mole
gpm	gallons per minute
gpt	grams per tonne
GWe	giga Watts electricity
ha	hectares
HDPE	Height Density Polyethylene
hPa	hectopascals
HPS floodlights	High pressure sodium floodlights
ICP	induced couple plasma

Abbreviation / Unit	**Unit or Term**
ID^2	inverse-distance squared
ID^3	inverse-distance cubed
IFC	International Finance Corporation
ILS	intermediate leach solution
IX	Ion exchange
JORC	Joint Ore Reserves Committee of the Australasian Institute of Mining and Metallurgy, Australian Institute of Geoscientists and Mineral Council of Australia
kg	kilograms
kg/m^3	kilograms per cubic meter
kg/t eU	kilograms per tonne of equivalent uranium metal
km	kilometer
km^2	square kilometer
koz	thousand troy ounce
kt	thousand tonnes
ktpa	Kilotonnes per annum
ktpd	thousand tonnes per day
ktpy	thousand tonnes per year
kV	kilovolt
kW	kilowatt
kWh	kilowatt-hour
kWh/t	kilowatt-hour per metric tonne
L	litre
Lps	liters per second
lb	pound
LLDDP	Linear Low Density Polyethylene Plastic
LOI	Loss On Ignition
LoM	Life-of-Mine
m	meter
m^2	square meter
m^3	cubic meter
M lcm	Million loose cubic meters
m/month	Meters per month
masl	meters above sea level
MDA	Mine Development Associates
mg/l	milligrams/litre
Mlb	million pounds
mm	millimeter
mm^2	square millimeter
mm^3	cubic millimeter
MME	Mine & Mill Engineering
MMMD	Ministry of Mines and Minerals Development
MoM	Ministry of Mines
Mt	million tonnes
MTW	measured true width
m_{vert}/m_{hor}	Vertical meters per horizontal meter

Abbreviation / Unit	Unit or Term
m.y.	million years
MWe	Mega Watts electricity
NGO	non-governmental organization
NI 43-101	Canadian National Instrument 43-101
oz	troy ounce
%	percent
PLC	programmable logic controller
PLS	pregnant liquor solution
PMF	probable maximum flood
ppm	parts per million
QA/QC	Quality Assurance/Quality Control
RC	rotary circulation drilling
RO	Reverse osmosis
RoM	Run-of-Mine
SCADA	Supervisory control and data acquisition
s	second
SG	specific gravity
st	short ton (2,000 pounds)
t	tonne (metric ton) (2,204.6 pounds)
t eU	Tonnes of equivalent uranium metal
t/doh	Tonnes per direct operating hour
tph	tonnes per hour
tpd	tonnes per day
tpy	tonnes per year
$t_{waste}:t_{RoM}$	Tonnes of waste per tonne of run-of-mine
µ	micron or microns
U	uranium
U_3O_8	Uranium expressed as an oxide; common units by which uranium is sold
USD/kg	US dollars per kilogram
USD/kg U	US dollars per kilogram of equivalent uranium
USD/lb U_3O_8	US dollars per pound of U_3O_8
USD/t	US dollars per tonne
USD/t_{metal}	US dollars per tonne of uranium metal
USD/t_{RoM}	US dollars per tonne of run-of-mine
USDk	Thousand US dollars
USDm	Million US dollars
eU_3O_8	Equivalent Uranium as determined by gamma log derivations
V	vanadium
V_2O_5	Vanadium expressed as an oxide; common units by which vanadium is sold
W	watt
XRD	x-ray diffraction
yr	year

APPENDIX

A PITS AND WASTE DUMPS LOCATIONS



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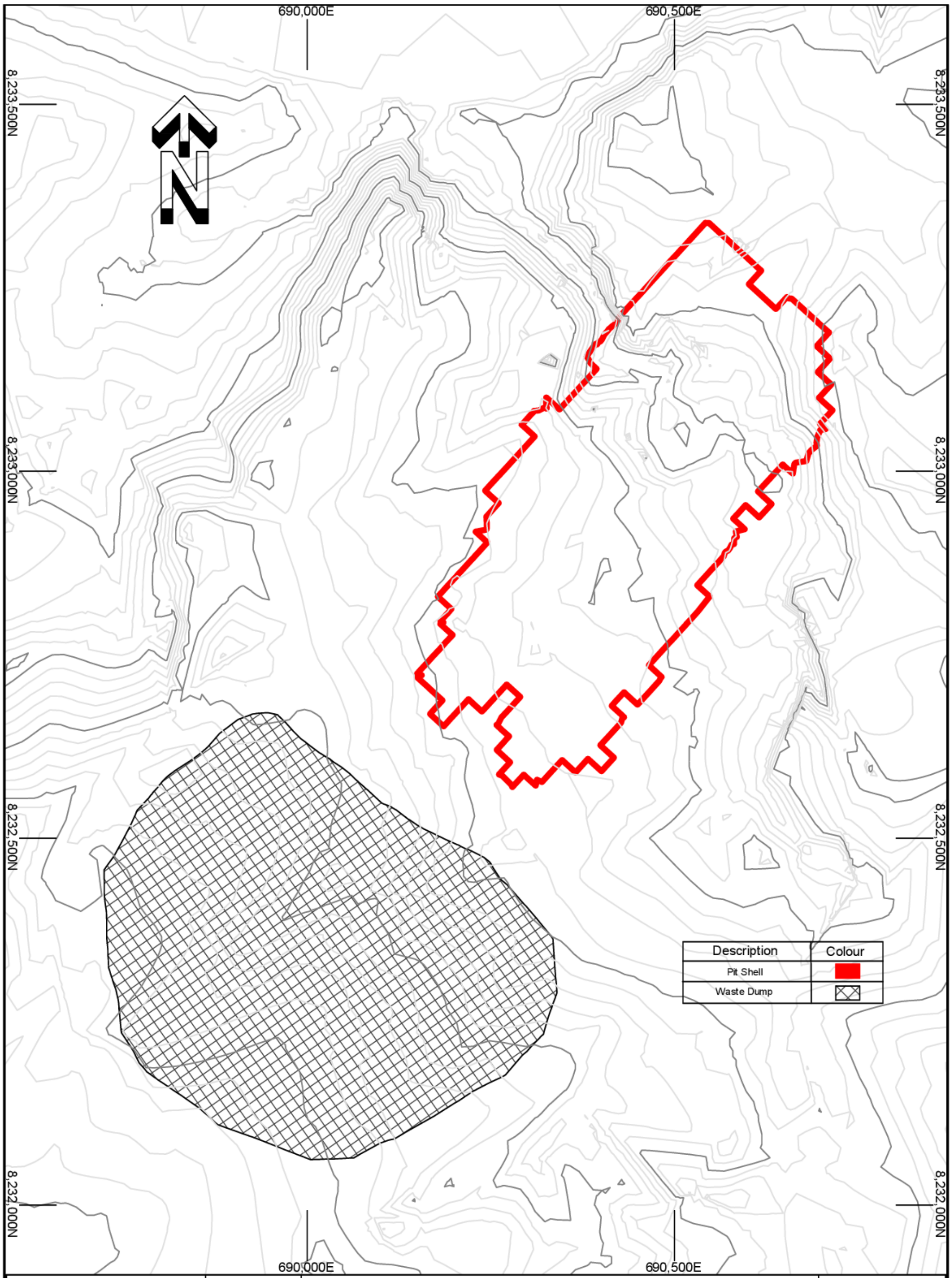
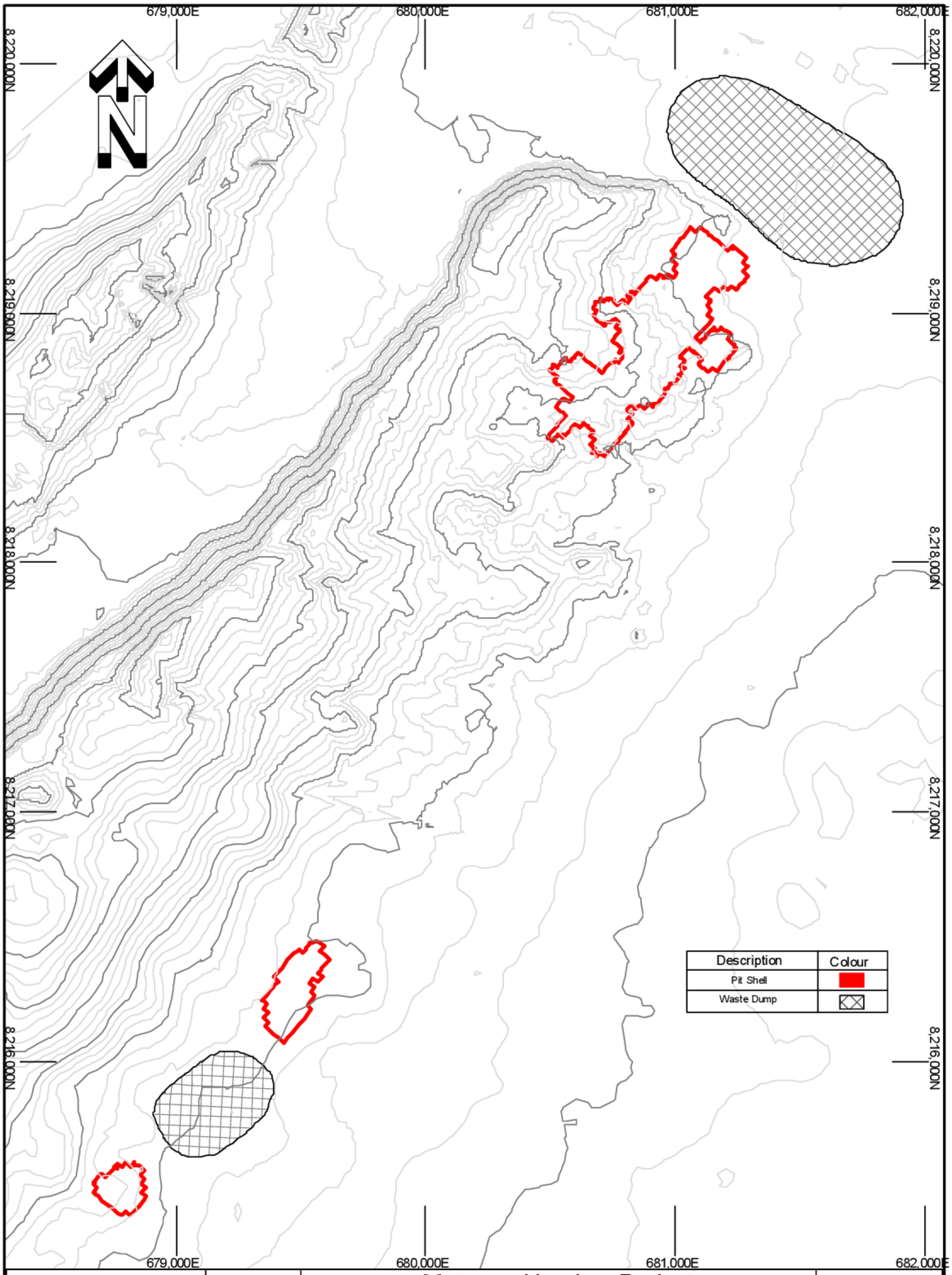
Dibwe East Pit Shells



09/12/2016	U6913	Mutanga Uranium Project
srk consulting		Gwabe Shell Limits



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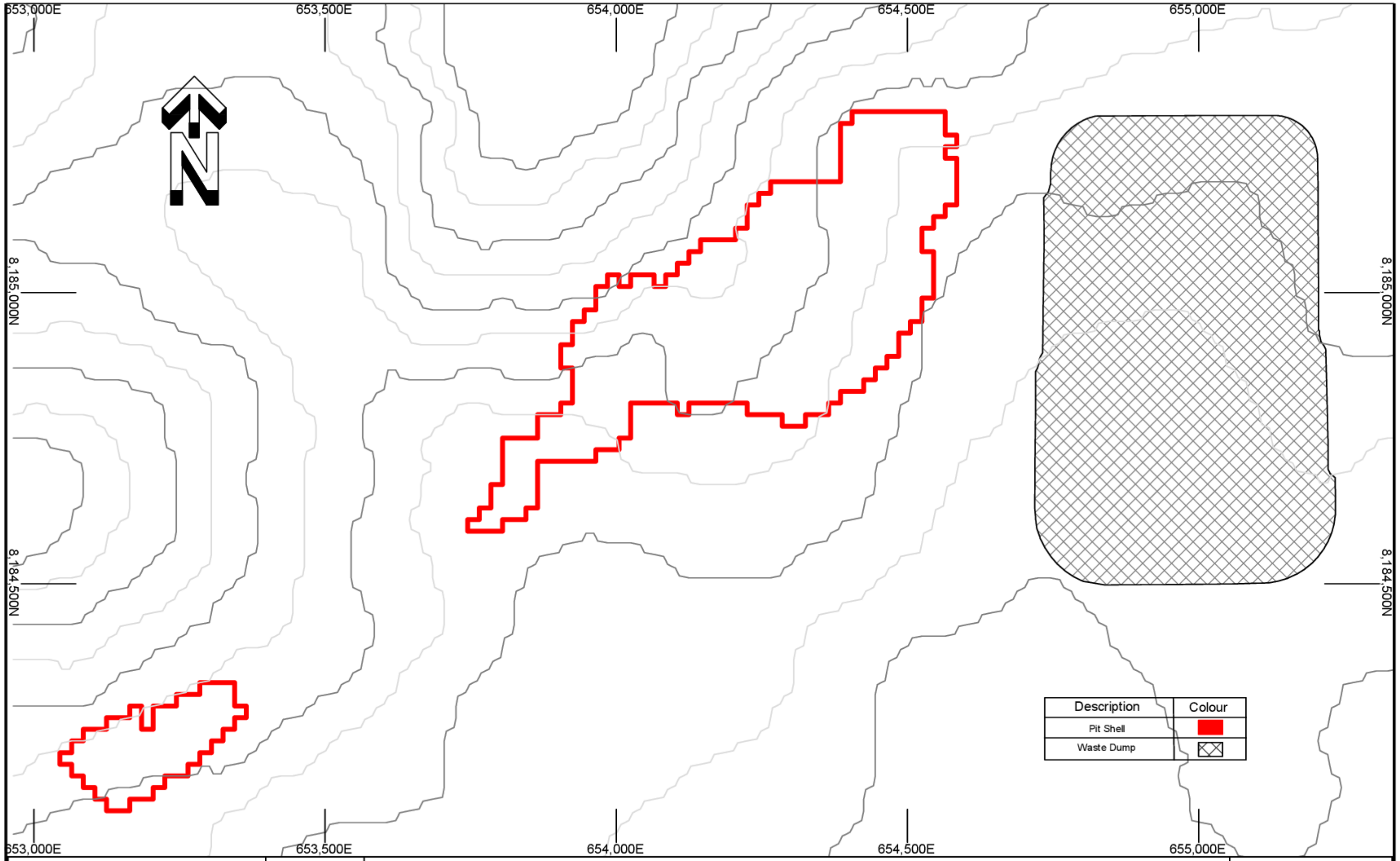
Mutanga Uranium Project

srk consulting

Njame Shell Limits



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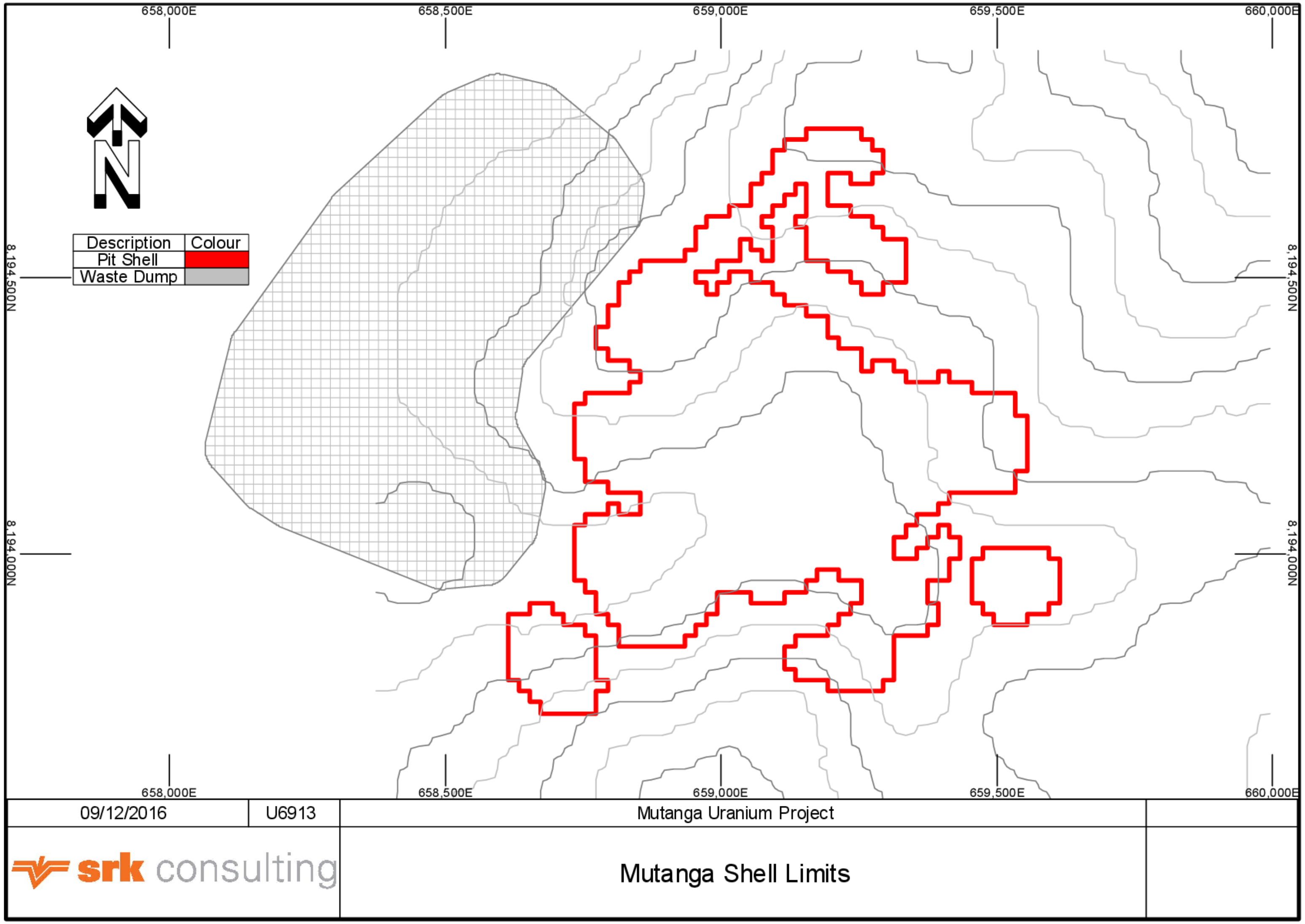
Dibwe Pit Shells



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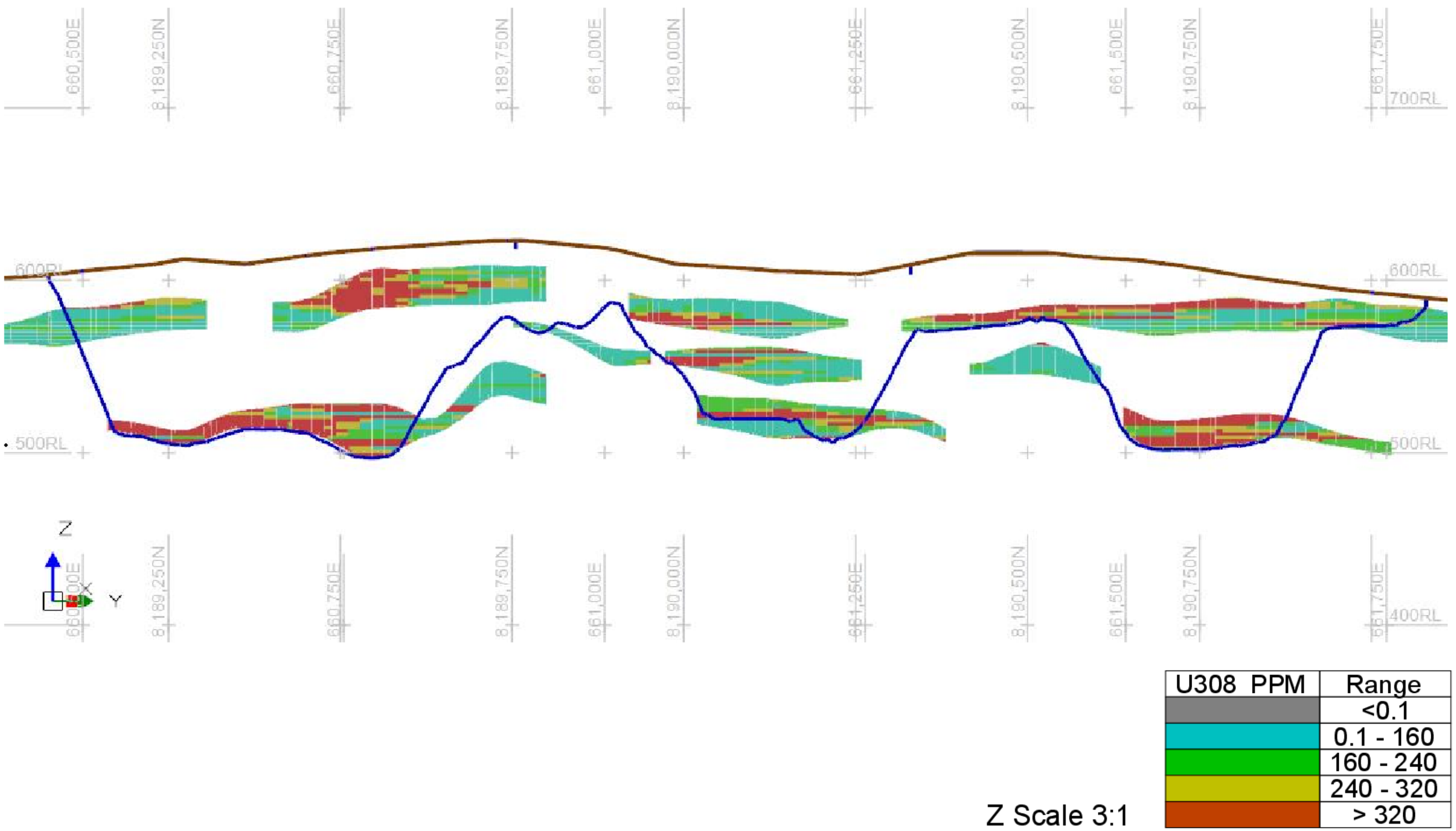
Mutanga Shell Limits

APPENDIX

B PIT CROSS - SECTIONS



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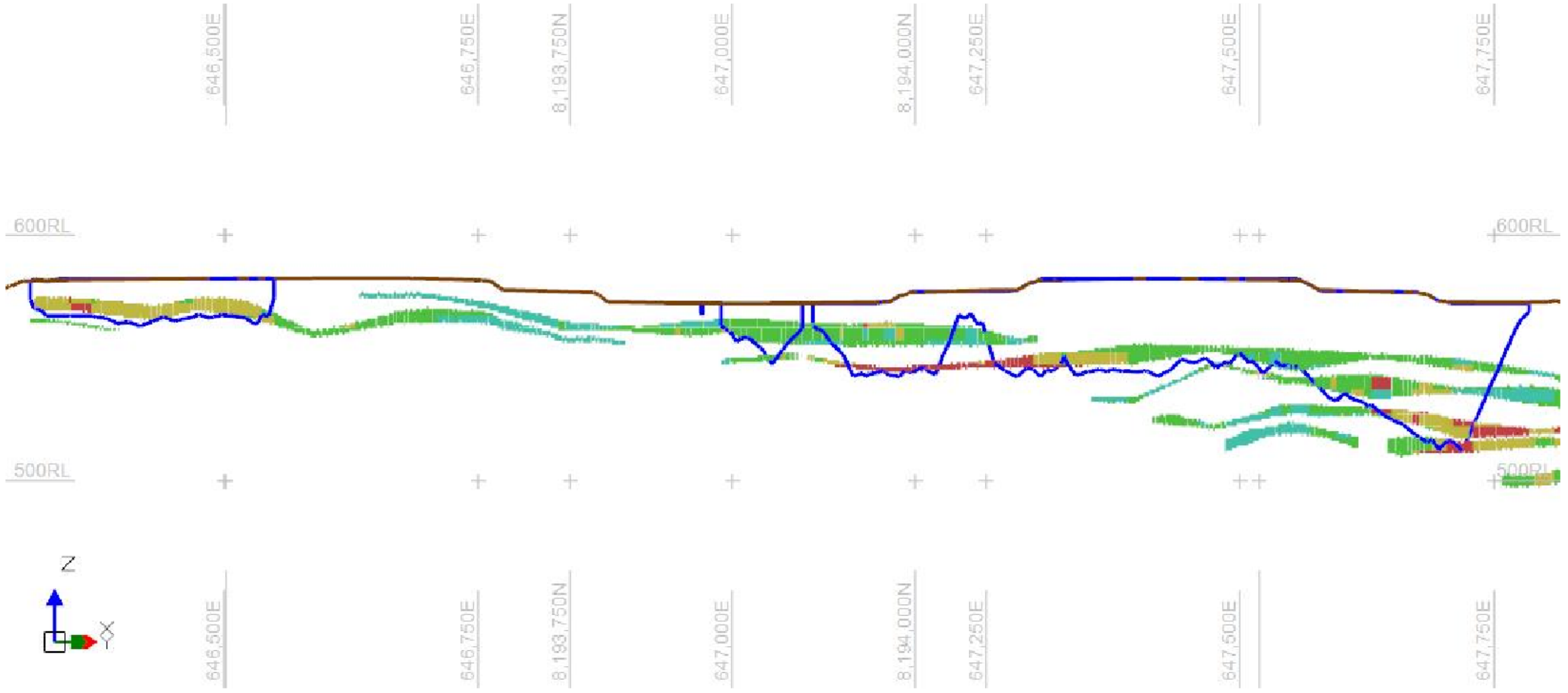
Dibwe East Pit Cross Section



U308 PPM	Range
⬛	<0.1
🟦	0.1 - 160
🟩	160 - 240
🟨	240 - 320
🟥	> 320

Z Scale 3:1

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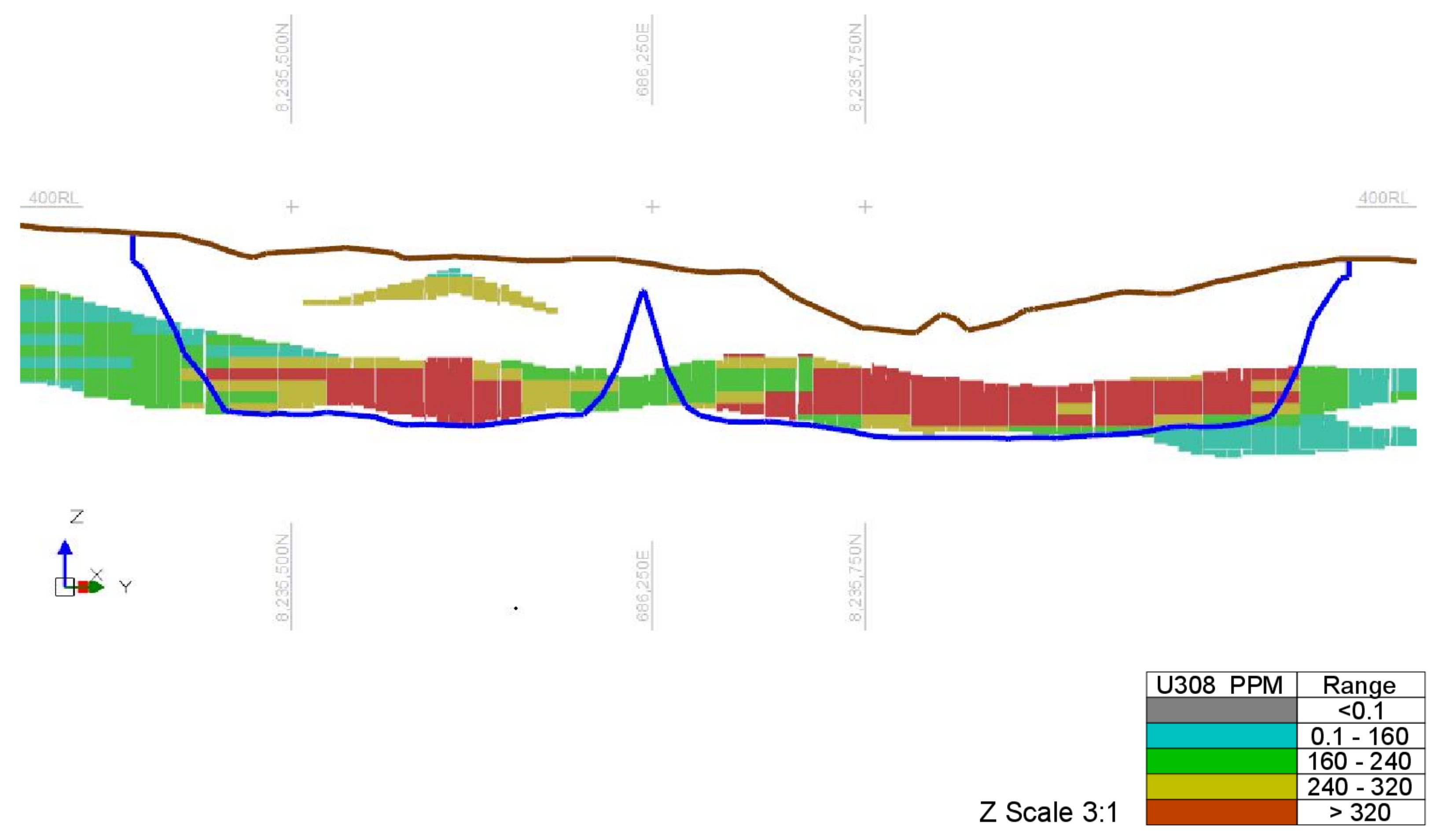
Dibwe Pit Cross Section



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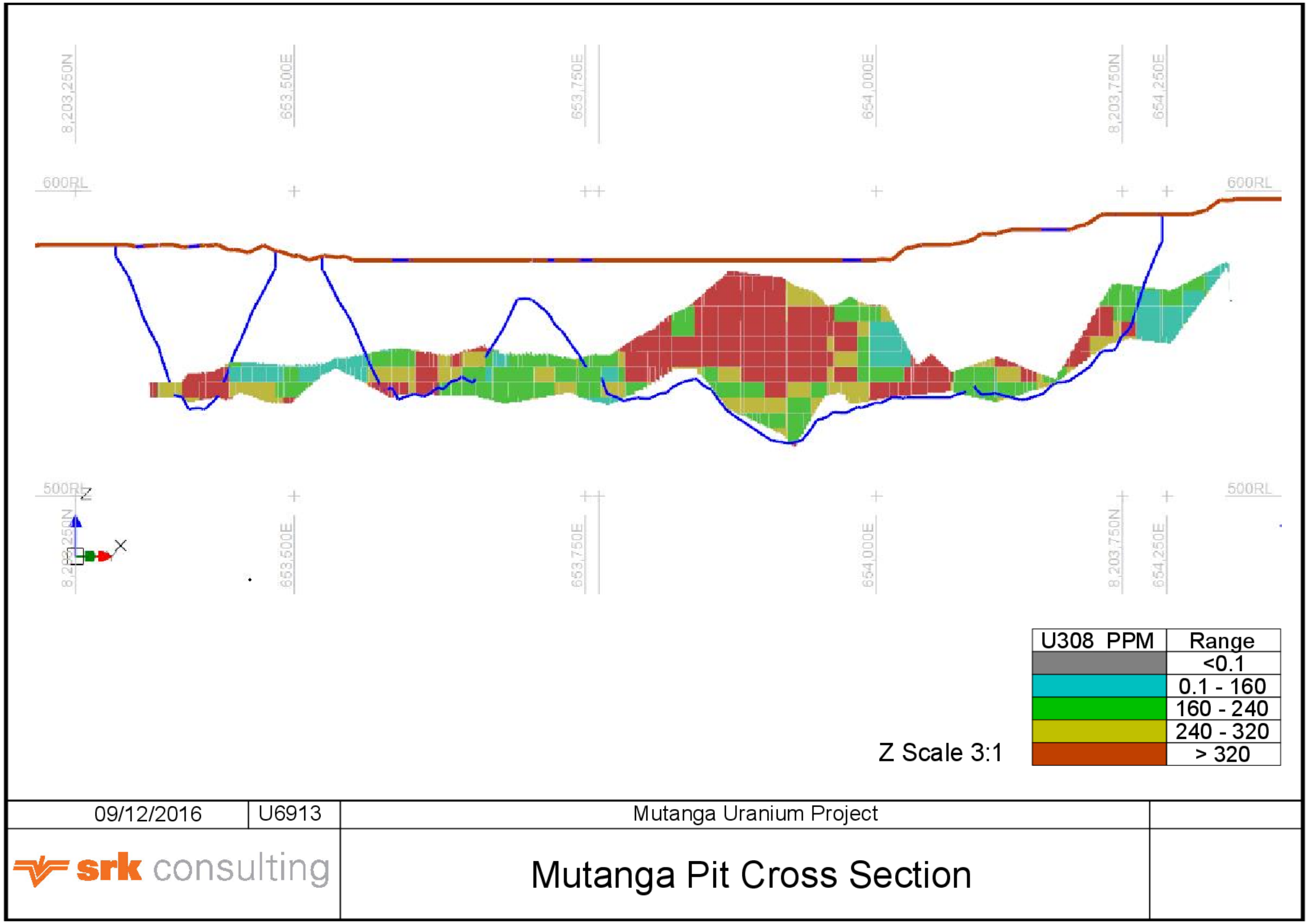
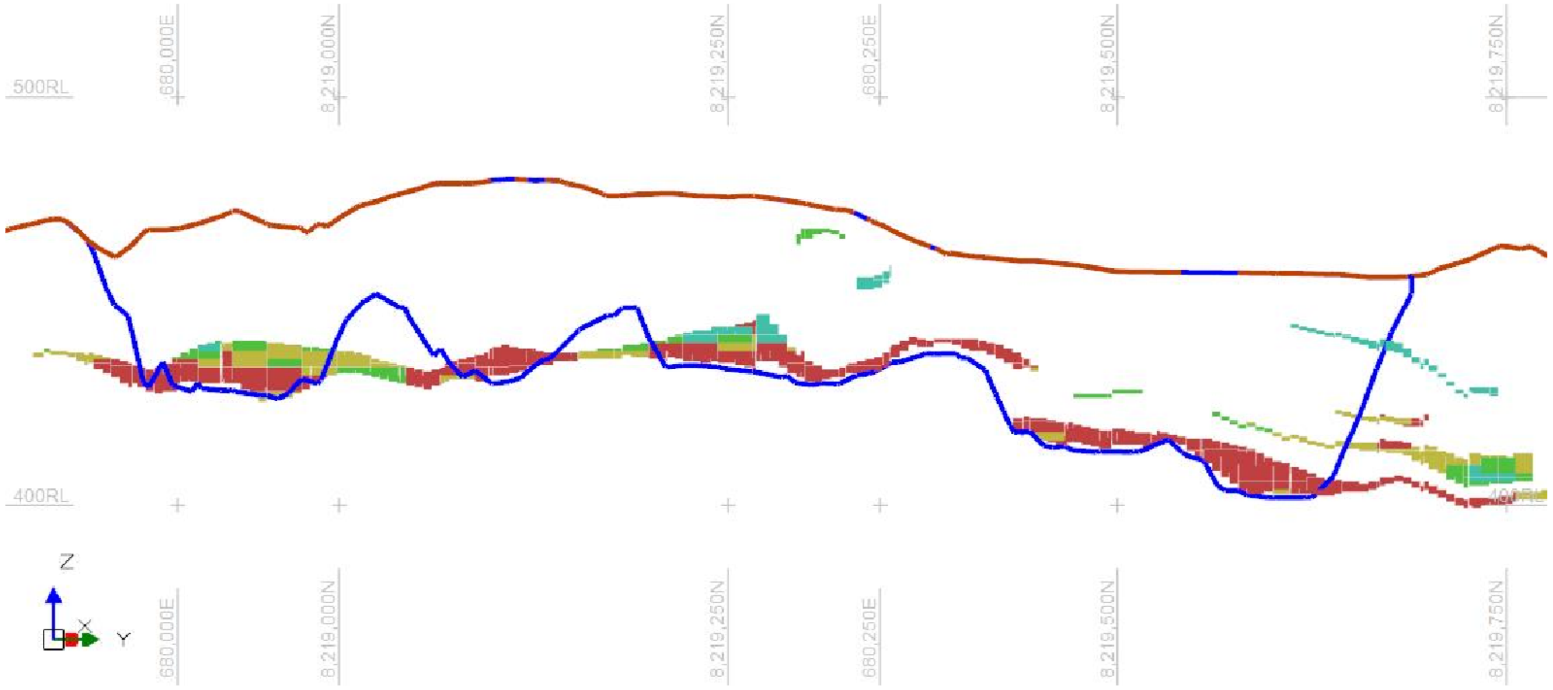
Gwabe Pit Cross Section


8,203,250N
653,500E
653,750E
654,000E
8,203,750N
654,250E
600RL
600RL
500RL
500RL
Z
X
U308 PPM | Range
<0.1
0.1 - 160
160 - 240
240 - 320
> 320
Z Scale 3:1
09/12/2016
U6913
Mutanga Uranium Project
srk consulting
Mutanga Pit Cross Section



Z Scale 3:1

U308 PPM	Range
⬛	<0.1
🟦	0.1 - 160
🟩	160 - 240
🟨	240 - 320
🟥	> 320

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srk consulting		Njame Pit Cross Section	

APPENDIX

C PIT OPTIMISATION SENSITIVITIES

Pit Optimisation Sensitivities

Optimisation Results	Units	40	50	60	70
		US$/lb U_3O_8			
Dibwe East					
Insitu					
Inventory	(Mt)	11.5	21.6	29.1	32.3
	(ppm U_3O_8)	397.38	372.86	354.63	348.97
	(t U_3O_8)	4,583	8,070	10,317	11,281
Diluted					
Inventory	(Mt)	11.4	21.4	28.8	32.0
	(ppm U_3O_8)	361.25	338.96	322.39	317.24
	(t U_3O_8)	4,125	7,263	9,285	10,153
Quantities					
Total Rock	(Mt)	49.0	112.0	165.9	197.0
Mineral Inventory	(Mt)	11.4	21.4	28.8	32.0
Waste + OM	(Mt)	37.6	90.546	137.1	165.0
Stripping Ratio	(t:t)	3.3	4.2	4.7	5.1
Product					
Recovered Metal	(t U_3O_8)	3,300	5,810	7,428	8,122
Dibwe					
Insitu					
Inventory	(Mt)	0.9	4.2	7.6	10.1
	(ppm U_3O_8)	323.20	274.87	260.32	260.54
	(t U_3O_8)	276	1,143	1,968	2,619
Diluted					
Inventory	(Mt)	0.8	4.1	7.5	10.0
	(ppm U_3O_8)	293.82	249.88	236.66	236.85
	(t U_3O_8)	248	1,028	1,772	2,357
Quantities					
Total Rock	(Mt)	2.2	16.2	31.9	51.7
Mineral Inventory	(Mt)	0.8	4.1	7.5	10.0
Waste + OM	(Mt)	1.3	12.1	24.4	41.7
Stripping Ratio	(t:t)	1.6	2.9	3.2	4.2
Product					
Recovered Metal	(t U_3O_8)	199	823	1,417	1,886
Gwabe					
Insitu					
Inventory	(Mt)	2.2	3.1	3.6	3.8
	(ppm U_3O_8)	441.66	379.09	353.41	345.80
	(t U_3O_8)	961	1,184	1,287	1,322
Diluted					
Inventory	(Mt)	2.2	3.1	3.6	3.8
	(ppm U_3O_8)	401.51	344.63	321.28	314.36
	(t U_3O_8)	865	1,066	1,158	1,189

Optimisation Results	Units	40	50	60	70
		US$/lb U_3O_8			
Quantities					
Total Rock	(Mt)	6.6	9.0	10.5	11.3
Mineral Inventory	(Mt)	2.2	3.1	3.6	3.8
Waste + OM	(Mt)	4.5	5.9	6.9	7.5
Stripping Ratio	(t:t)	2.1	1.9	1.9	2.0
Product					
Recovered Metal	(t U_3O_8)	692	853	927	951
Mutanga					
Insitu					
Inventory	(Mt)	7.0	9.5	11.6	12.8
	(ppm U_3O_8)	432.1	380.7	351.6	335.8
	(t U_3O_8)	3,013	3,629	4,070	4,297
Diluted					
Inventory	(Mt)	6.9	9.4	11.5	12.7
	(ppm U_3O_8)	392.8	346.1	319.7	305.3
	(t U_3O_8)	2,712	3,266	3,663	3,867
Quantities					
Total Rock	(Mt)	15.3	22.4	29.8	34.6
Mineral Inventory	(Mt)	6.9	9.4	11.5	12.7
Waste + OM	(Mt)	8.4	13.0	18.4	21.9
Stripping Ratio	(t:t)	1.2	1.4	1.6	1.7
Product					
Recovered Metal	(t U_3O_8)	2,170	2,613	2,931	3,094
Njame					
Insitu					
Inventory	(Mt)	1.0	2.8	3.9	5.2
	(ppm U_3O_8)	456.97	396.24	368.08	343.36
	(t U_3O_8)	458	1,099	1,451	1,802
Diluted					
Inventory	(Mt)	1.0	2.7	3.9	5.2
	(ppm U_3O_8)	415.42	360.21	334.61	312.15
	(t U_3O_8)	412	989	1,306	1,622
Quantities					
Total Rock	(Mt)	6.4	19.2	27.8	38.6
Mineral Inventory	(Mt)	1.0	2.7	3.9	5.2
Waste + OM	(Mt)	5.4	16.4	23.9	33.4
Stripping Ratio	(t:t)	5.4	6.0	6.1	6.4
Product					
Recovered Metal	(t U_3O_8)	330	791	1,045	1,297