ANNEXURE N6:
HAZARDOUS WASTE STUDY BY PASCO WASTE & ENVIRONMENTAL CONSULTING CC

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For aurecon

RÖSSING URANIUM HAZARDOUS WASTE LANDFILL: Conceptual Design and Costing

July 2010

RIO TINTO RöSSING URANIUM

HAZARDOUS WASTE LANDFILL

CONCEPTUAL DESIGN AND COSTING

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List of Abbreviations

B^-	Water deficit climate, resulting in only sporadic leachate generation
B^+	Water surplus climate, resulting in significant leachate generation
BATNEEC	Best Available Technology Not Entailing Excessive Cost
Bq	Becquerel
BPEO	Best Practicable Environmental Option
CA	Competent Authority
CBO	Community Based Organisation
CQA	Construction Quality Assurance
CQC	Construction Quality Control
CR	Co-disposal Ratio
EIA	Environmental Impact Assessment
EIAR	Environmental Impact Assessment Regulations
FML	Flexible Membrane Liner
GCL	Geomembrane Clay Liner
H	Hazardous Waste or Landfill for Hazardous Waste
H:h	Hazardous Waste Landfill that can receive wastes with hazard ratings of 3 and 4
H:H	Hazardous Waste Landfill that can receive wastes with hazard ratings of 1 and 2
HELP	Hydrological Evaluation of Landfill Performance
IAP	Interest and Affected Parties
IDSA	Integrated Disposal Site Authorisation
IEM	Integrated Environmental Management
Inactive Radioactive waste	A specific activity less than 100 becquerels per g (Bq/g) and total activity less than 4 kBq (0.1uCi)
IRD	Initial Rate of Deposition
LDO	Land Development Objective
LEL	Lower Explosive Limit
MRD	Maximum Rate of Deposition
m/s	Metre per Second
NGO	Non Governmental Organisation
PI	Plasticity Index
PCB	Polychlorinated biphenyl
Radioactive	A specific activity greater than 100 becquerels per g (Bq/g) and total activity greater than 4 kBq (0.1uCi)
RBDM	Risk-Based Decision Making
RoD	Record of Decision
STP	Standard Temperature and Pressure
VOC	Volatile Organic Carbon

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CONCEPTUAL DESIGN AND COSTING

1 INTRODUCTION

1.1 Project Background

Rössing Uranium is planning an expansion of its operations to increase production from the current 14 million tonnes of ore processed per annum to a proposed maximum of 19 million tonnes per annum, and to extend the projected life of the mine by 10 years to 2026, to benefit from the general upward trend in uranium prices on the international market in recent years. This is a direct result of rapidly growing international energy demands and associated projected increased reliance on nuclear energy in future.

The proposed expansion project will comprise the following new facilities, or expansions to the existing facilities, which have the potential to significantly change the land use profile of the mine, given the total footprint extension implications:

- An acid heap leach pad of approximately 2 km by 600 m wide, totaling approximately 110 ha to increase production from the current tank leach process;
- An area for heap leach waste (ripios) disposal of approximately 460 ha;
- Extension of the existing waste rock dump areas to allow for an approximate 200 million m^3 of additional waste rock disposal; and
- A new area for high density tailings disposal of approximately 570 ha.

The social and environmental impact assessment (SEIA) for the proposed expansion project was initiated by Rössing Uranium in 2008. The current second phase of this EIA focuses specifically on these expansion project components, or facilities, which have associated long term spatial planning implications, amongst others. Phase 2 of the Social and Environmental Impact Assessment for Rössing Uranium's Expansion Project involves the following specialist studies:

- Noise Assessment
- Vibration Assessment
- Air Quality Assessment

- Public Dose Assessment
- Solid Waste Assessment
- Traffic Study
- Visual Assessment
- Archaeological Assessment
- Water Balance Study
- Cumulative Impact Assessment and Internal Review
- Public Participation and Social Impact Assessment

The solid waste assessment addresses the disposal of general waste at the existing landfill on the mine, and non mineral hazardous waste at a separate new disposal facility on the mine property. Specifically the solid waste assessment involves the following:

- Compilation of an Operations and Maintenance Manual for the existing General Waste landfill site including the rehabilitation and closure plan.
- Identification of a feasible and acceptable site for the disposal of non mineral Hazardous Waste.

This report covers the identification of a site for the disposal of non mineral Hazardous waste (including "inactive" radioactive waste), as well as the conceptual design and costing of the proposed hazardous waste disposal facility. Radioactive material is not included in the hazardous waste, waste stream.

1.2 Terms of Reference

Aurecon South Africa (Pty) Ltd (formerly Ninham Shand (Pty) Ltd) has been appointed by Rössing Uranium Limited as the Lead Consultant for Phase 2 of the Social and Environmental Impact Assessment for Rössing Uranium's Expansion Project. Aurecon has, in turn, appointed PASCO Waste & Environmental Consulting to carry out the solid waste assessment aspects of the project.

1.3 Objectives

The overall objective of the project is to establish a cost effective hazardous waste disposal facility within the Rössing Uranium Operational Area, to serve the long term hazardous waste disposal needs of the mine. The proposed facility must be both publicly and environmentally acceptable, and according to best practice as determined by the Directorate of Environmental Affairs of the Namibian Ministry of Environment and Tourism.

More specifically, the objectives of this conceptual design phase are as follows:

- To classify the hazardous waste disposal facility in terms of waste types (including the "inactive" radioactive waste as hazardous waste), size of waste stream and the potential for leachate generation.
- To identify a suitable site for the new hazardous waste facility within the Rössing Uranium Operational Area through a process of site selection and ranking.
- To develop a conceptual design for the hazardous waste facility that meets the disposal needs and that incorporates the necessary precautionary measures to mitigate any environmental impacts and critical factors.
- To estimate the capital cost of development of the hazardous waste facility.

The purpose of this Conceptual Design Report is to document the design criteria, assumptions, conceptual details and estimated cost of the proposed hazardous waste facility, for the purpose of submission to the Rössing Uranium management for approval of the selected site and conceptual design, prior to development of detailed design, tender documentation and construction of the facility.

1.4 Scope

The scope of the Conceptual Design relates to the design of a hazardous waste management facility that addresses the non mineral hazardous waste disposal needs of the Rössing Uranium Mine, and that mitigates the potential impacts the facility could have on the environment, including the socio-economic and biophysical environments.

In the absence of any specific Namibian legislation concerning the classification and design of waste disposal sites, the "precautionary principle" approach is to be followed in the development of the new Rössing Uranium hazardous waste facility. To this end, the design is generally based on the "Waste Management Series" documents of the South African Department of Water Affairs & Forestry. These include:

- Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste(1).
- Minimum Requirements for Waste Disposal by Landfill(2).
- Minimum Requirements for Monitoring at Waste Management Facilities(3).

The Minimum Requirements for Waste Disposal by Landfill addresses landfill classification, site selection, investigation, design, operation and monitoring of landfill sites. In the landfill classification system, a landfill is classified in terms of waste class, size of operation, and potential for significant leachate generation, all of which influence the risk it poses to the environment. Graded requirements are then set for all aspects of landfill design and operation, including public participation.

Where applicable, the US EPA Minimum Technology Guidance documents (4) are to be used in conjunction with the South African Minimum Requirements, particularly regarding the design of the landfill liner systems.

The scope of this report therefore includes the following:

- Determination of the waste disposal need in terms of the types and quantities of waste to be disposed of at the site, and hence the airspace and leachate management requirements.
- Identification, evaluation and ranking of alternative candidate sites according to a scientific model[1].
- A brief description of the biophysical conditions relating to the preferred site, based on a brief visit to the sites and existing information.
- Conceptual design of the facility which includes site access, drainage, facilities and infrastructure, cell development and sequencing, hazardous waste containment, leachate management, rehabilitation measures and monitoring systems.
- Costing of the development of the facility to enable Rössing Uranium to budget and plan accordingly.

In accordance with the terms of reference, the design of the hazardous waste management facility is to be based on the current design life of the mine, which is 20 years.

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[1] An analytical hierarchy process multi criteria decision-making (MCDM) model was used in the process.

2 WASTE DISPOSAL NEEDS AND SITE CLASSIFICATION

2.1 Introduction

In order to design a hazardous waste facility that would meet the hazardous waste disposal needs of the Rössing Uranium Mine for a period of 20 years, it is necessary to qualify and quantify the current and future waste streams. An estimate of current waste generation volumes is necessary to forecast future waste generation volumes, and hence landfill airspace utilisation. Forecasting is done by evaluating and extrapolating existing or historic data.

As the design of the waste disposal facility is to be based on the Minimum Requirements(1,2), the site needs to be classified in terms of the Minimum Requirements, so as to determine the technical and operational standards to which the facility has to comply.

The Minimum Requirements' landfill classification system defines the disposal situation or needs according to the:

- Waste type;
- Size of the waste stream and landfill operation; and
- Potential for significant leachate generation, and the need for leachate management.

These factors will determine the potential impact of the waste facility on the receiving environment and public health. The Rössing Uranium hazardous waste management facility has been classified on the current and projected waste stream, and on conditions at the proposed site.

2.2 Waste Types and Origin

There are two generic categories of waste, General and Hazardous, according to the risk that each type poses. These are defined as follows:

General waste is normally solid waste, comprising rubble, garden, domestic, commercial and general dry industrial waste. It may also contain small quantities of hazardous substances dispersed within it, such as batteries, insecticides, weed killers, fluorescent tubes and household medical waste such as used plasters and bandages, not to be confused with medical waste generated at clinics, sickbays or even hospitals which have to be disposed at a special facility. General waste referred to above would typically originate from offices, workshops and office gardens and will be disposed on the general waste landfill.

Hazardous waste is waste which, on account of its inherent properties such as toxicity, corrosivity, ignitability or carcinogenicity, has the potential to have a significant adverse effect on public health.

Since the design of a waste disposal facility relates to the risk posed by the wastes disposed, design specifications for a general waste facility would be considerably less stringent than those for a hazardous waste facility.

A Hazardous Waste is thus defined as:

> "an inorganic or organic element or compound that, because of its toxicological, physical, chemical or persistency properties[2], may exercise detrimental acute or chronic impacts on human health and the environment. It can be generated from a wide range of commercial, industrial, agricultural and domestic activities and may take the form of liquid, sludge or solid. These characteristics contribute not only to degree of hazard, but are also of great importance in the ultimate choice of a safe and environmentally acceptable method of disposal."

Further to this, a Hazardous Waste can be defined as a waste that directly or indirectly represents a threat to human health or the environment, if not correctly managed, by introducing one or more of the following risks:

- explosion or fire;
- infections, pathogens, parasites or their vectors;
- chemical instability, reactions or corrosion;
- acute or chronic toxicity;
- cancer, mutations or birth defects;
- toxicity, or damage to the ecosystems or natural resources;
- accumulation in biological food chains, persistence in the environment, or multiple effects to the extent that it requires special attention and cannot be released into the environment or be added to sewage or be stored in a situation which is either open to air or from which aqueous leachate could emanate.

The following types of waste should be regarded as potentially hazardous:

Inorganic waste

- Acids and alkalis
- Cyanide waste
- Heavy metal sludges and solutions
- Waste containing appreciable proportions of fibrous asbestos.

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[2] The South African definition of Hazardous Waste complies with the UNEP definition, primarily because of its content and scope, but also in order to obtain international acceptance for South African Waste Management Legislation Practice (see Section 1.7 and Appendix 2).

Oily waste

- Wastes primarily from the processing, storage and use of mineral oils.

Organic waste

- Halogenated solvent residues
- Non-halogenated solvent residues
- Phenolic waste
- PCB waste
- Paint and resin waste
- Biocide waste
- Organic chemical residues.

Putrescible organic waste

- Waste from the production of edible animal and vegetable oils, slaughterhouses, tanneries, and other animal and vegetable based products.

Apart from the two main generic categories of general and hazardous waste, medical waste should also be considered as a <u>separate category</u>, because of the particular risks it poses and the special precautions necessary in the handling, storage and disposal thereof.

Radioactive waste

As per RSA Minimum Requirements the disposal of radioactive wastes in a landfill is PROHIBITED.

Only those radioactive wastes defined as "inactive", i.e., with a specific activity less than 100 becquerels per g (Bq/g) and total activity less than 4 kBq (0.1uCi), may be disposed as waste.

In terms of Rössing procedures on disposal of contaminated items, JK65/PRD/003, no contaminated waste shall be disposed or dumped on the domestic waste disposal site (Landfill Site). This would then include items such as radioactive waste. As stated this procedure deals with the redundant items that are contaminated and are to be disposed of at the Tailings Impoundment according to the following contamination criteria.

Total of fixed and non-fixed radioactivity	> 0.4 Bq/cm^2 (averaged over 300 cm^2)	Tailings Impoundment

In summary therefore:

- Contaminated waste less than 100 becquerels per g (Bq/g) and total activity less than 4 kBq (0.1uCi), may be disposed as waste in a hazardous waste landfill; and
- Contaminated waste more than 100 becquerels per g (Bq/g) or > 0.4 Bq/cm2 (averaged over 300 cm2) may have to be disposed in the tailings impoundment for now and as such may not be disposed in any landfill.

Industrial waste produced as part of the mining and processing operations could fall into either the general waste or hazardous waste categories, depending on the hazard rating of each particular waste. Unless specific industrial wastes are known to be non-hazardous, and would therefore be treated as general waste, the industrial wastes generated at Rössing Uranium mine should be considered as potentially hazardous and treated appropriately. This approach is in line with the "precautionary principle".

In 1998, as part of the development of a waste management strategy for Rössing Uranium mine carried out by Metago Environmental Engineers(5), a waste characterization study was performed to classify all non-mineral waste being generated at the mine according to:

- The types and quantities of waste being disposed of at the general waste landfill site;
- The origin of the wastes and their method of transportation to the site; and
- The quantities of hazardous and recyclable wastes being deposited on the waste site.

Classification of waste according to origin was required in order to facilitate the minimisation of waste at source as well as to assist in the optimisation of waste collection and transportation procedures. Classification according to method of collection and transportation was required in order to assess the magnitude of the resources being employed in the collection and transportation of waste and hence the costs incurred in those activities. Classification according to waste type was required in order to identify those materials being deposited on the site which could:

- Be recycled;
- Be returned to supplier (e.g. reagent containers);
- Pose a threat to the safety of personnel frequenting the waste site; or
- Pose a threat to the environment.

A record of the quantities of waste being disposed of at the waste site was required both in order to determine the remaining life of the site as well as to enable the formulation of an appropriate waste management strategy.

Table 1 below gives a summary of the results of the 1998 waste characterization study. Using an assumed average density of 0,25 t/m^3 for uncompacted waste, this translates to an average total waste stream of approximately 220 t/month, of which 24% was general waste, 15% was hazardous waste, and 61% was recyclable waste.

Table 1: Summary of Waste by Class and Origin (1998 waste characterization study$^{(5)}$)

Department	General waste	Hazardous waste *	Recyclable waste	Totals (m^3/month)
Administration	9.70	1.20	34.04	44.94
Contractors	21.54	0.56	20.44	42.54
Engineering	67.92	14.77	97.03	179.72
Metallurgy	51.04	11.42	173.52	235.98
Mining	61.87	105.60	209.14	376.61
			Total (m^3/month)	**879.79**

* It is assumed in this study that the hazardous waste is either “inactive” radioactive waste or includes “inactive” radioactive waste materials that could be defined as waste.

2.2.1 General Waste

The Mine’s general waste is currently disposed of on the general household waste landfill site, located in a cross valley between Boulder Gorge and Dome Gorge within the mine license area north of the open pit. The site is located in a high biodiversity area just off the water shed in the cross valley which eventually leads to Dome Gorge.

The general waste stream was investigated again in 2007 when a further waste characterization and risk assessment was carried out by BECO$^{(6)}$. This updated information on the general waste stream has been used in the recent assessment of the general waste landfill at Rössing Uranium mine, and in the compilation of an Operations and Maintenance Manual for the General Waste Landfill$^{(7)}$.

2.2.2 Non-mineral Hazardous Waste

Since the 1998 waste characterization study$^{(5)}$, Rössing Uranium has been keeping some records of hazardous waste generated and where it is sent for treatment or disposal. There are a number of different types of non-mineral wastes generated as a result of the mining and processing operations. These include pipes, rubber liners, scrap metals, pumps, radioactive nuclides, empty drums, samples, shot blasting grit, batteries, fluorescent tubes, used oil, grease, reagent bags, and solid laboratory waste. Many of these items can be returned to suppliers or recycled. However, because of the remote location of the Rössing Uranium mine and the high cost of transportation, only limited recycling is practised. Many of the waste materials will therefore have to be compacted and stored until there is a sufficiently large load to warrant a recycler to travel to the mine to fetch the materials.

Currently a substantial quantity of used oil is used in blasting operations and the remainder is sent to Wesco Salvage in Walvis Bay for recovery. Grease is currently being sent to the Walvis Bay hazardous waste facility for disposal. This facility however appears to be full and may not be able to accommodate additional waste discharges in future.

Whilst many of the above materials may well be non-hazardous, they are to be treated as hazardous unless proven otherwise by means of formal hazard rating procedures. All such procedures should also include scanning for radioactive contamination.

2.3 Size of hazardous waste stream and landfill airspace requirements

In the absence of more definitive information on the types and quantities of hazardous waste requiring disposal, Rössing Uranium has indicated that the 1998 hazardous waste generation rate (134 m^3 per month based on production rates) increased by 25% should be used. Based on this assumption, it is seen that Rössing Uranium mine requires to dispose of approximately 2 010 m^3 of hazardous waste (which may include "inactive" radioactive waste) per annum (with an uncompacted density of 250 kg/m^3). For a design period of 20 years, the total quantity of waste requiring disposal will be approximately 40 000 m^3 (uncompacted). Assuming an average landfill density of approximately 800 kg/m^3 and allowing 20% for cover material or blending material such as ash or similar material, the total required hazardous waste landfill airspace for the next 20 years is approximately 15 000 m^3.

In terms of the South African Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste, some of the wastes listed in Table 1 fall into Hazard Groups 1 or 2 (Extreme and High hazard), requiring an H:H landfill, while other wastes would fall into Hazard Groups 3 or 4 (Moderate and Low hazard), requiring an H:h landfill. However, because of the relatively small quantities of waste requiring disposal, and because of the small difference in design standards between an H:H and an H:h landfill, it is recommended to develop a single landfill to H:H standards. This recommendation is considered prudent and in line with the "precautionary principle", especially in view of the relative uncertainty regarding the hazard ratings of the waste streams.

On account of both the uncertainty of the hazardous waste generation figures and the high cost of constructing a modern state-of-the-art hazardous waste disposal facility, it is proposed to initially develop a hazardous waste landfill with a disposal capacity of approximately 7 500 m^3. This would give approximately 10 years of hazardous waste disposal site life.

2.4 Potential for leachate generation

The potential for significant leachate generation depends on the water balance associated with a waste disposal site. This is dictated by ambient climatic conditions or by other site specific factors such as the moisture content of the incoming waste and/or ingress of either ground water or surface water run-off from high ground into the waste body.

2.4.1 Climatic water balance

Although the detailed climatic water balance for Rössing Uranium Mine has not been calculated, it is clearly evident that, with a mean annual rainfall of only 27 mm (max approximately 100 mm) and a mean annual evaporation rate of approximately 4 400 mm, the climatic water balance is negative, i.e. evapotranspiration greatly exceeds precipitation. This means that any moisture retained in the waste body from rainfall will escape through evapotranspiration at a faster rate than recharge by further rainfall. There would therefore be no generation of leachate as a result of rain water percolating through the waste body.

2.4.2 Other factors affecting the water balance

Other factors that could affect the water balance of a waste site include the moisture content of the incoming waste, and the ingress of groundwater and/or surface water into the waste body due to poor siting, design and maintenance of the site.

With the exception of certain hazardous and liquid wastes, no significant volumes of high moisture content wastes would be disposed of at the facility. There should therefore be no significant leachate generation as a result of liquid waste disposal.

With appropriate drainage design there should no leachate generation resulting from surface run-off, on account of the extremely low rainfall. In addition, there should be no groundwater infiltration as the site would be located much higher than the groundwater level in the area.

2.4.3 Considering the above factors, it is therefore considered highly unlikely that leachate would be generated at the waste disposal facility, provided that excessive quantities of liquid wastes are not disposed of on the landfill. Nonetheless, the hazardous waste landfill has to be classified as an H:H facility, implying that leachate management is mandatory.

3 SITE CONDITIONS

3.1 Location

The proposed hazardous waste disposal site for Rössing Uranium Mine will be located on the mine which is in the Erongo Region of Namibia and has been operating since 1976.

3.2 Climatic conditions

The site is approximately 540 m above sea level. Shade temperatures can range between 5.3ºC in the winter and 38.3ºC in the summer. Monthly temperature and rainfall statistics are given in Tables 2and 3.

Table 2: Monthly climatic statistics for Rössing Uranium Mine

Month	***Max Daily Temp °C***	***Min Daily Temp °C***	***Mean Temp °C***
January	34.6	14.3	21.9
February	38.3	14.7	22.6
March	35.5	11.4	25.4
April	36.6	12.0	25.5
May	33.6	10.5	20.4
June	33.0	10.1	21.6
July	32.0	5.3	18.3
August	33.7	7.3	18.7
September	36.8	8.0	20.5
October	38.3	8.6	21.8
November	38.3	11.2	21.8
December	33.5	12.0	20.1

Table 3: Annual climatic statistics for Rössing Uranium Mine

Years	***Mean Annual Precipitation (mm)***	***Mean Annual Evaporation (mm)***	***No. of Rain Days***
1986	22.7	4401	6
1987	20.7	4401	5
1988	17.1	3964	8
1989	28.5	4818	9
1990	28.1	3150	12
1991	32.8	5572	15
1992	4.8	4502	1
1993	44.2	4401	18
1994	32.1	4401	14
1995	45.6	4401	17
1996	12.5	4401	6
Average	27.20	4401	10

(Source: Rössing Environmental Services)
(In line with Walvis Bay 1997 month-on-month figures with annual average of 4209mm)

Typical figures used by the mine for planning purposes are:

Annual figure used by the mine are:	Total rainfall: **30mm/a**	Total evaporation: **2700mm/a**

On an annual basis the evaporation significantly exceeds the rainfall. It is thus not likely that leachate will be generated in significant quantities, during any month of the year.

A typical wind direction figure for the Mine is shown in Figure 1. The prevailing wind direction at Rössing for the last 2 year period is from the west (14% of the time), the west-southwest (13%) and the east-northeast (13%). This wind direction also dominates daytime and nighttime wind patterns. These wind components are characterized by low to moderate strong wind speeds. Wind speeds exceeding 5 m/s occurred for 5.4% of the time with the maximum recorded at 8.5 m/s. During the day the westerly and west-southwesterly winds were more dominant with a distinct decrease during nighttime from this direction. This information is of specific importance when controlling windblown litter.

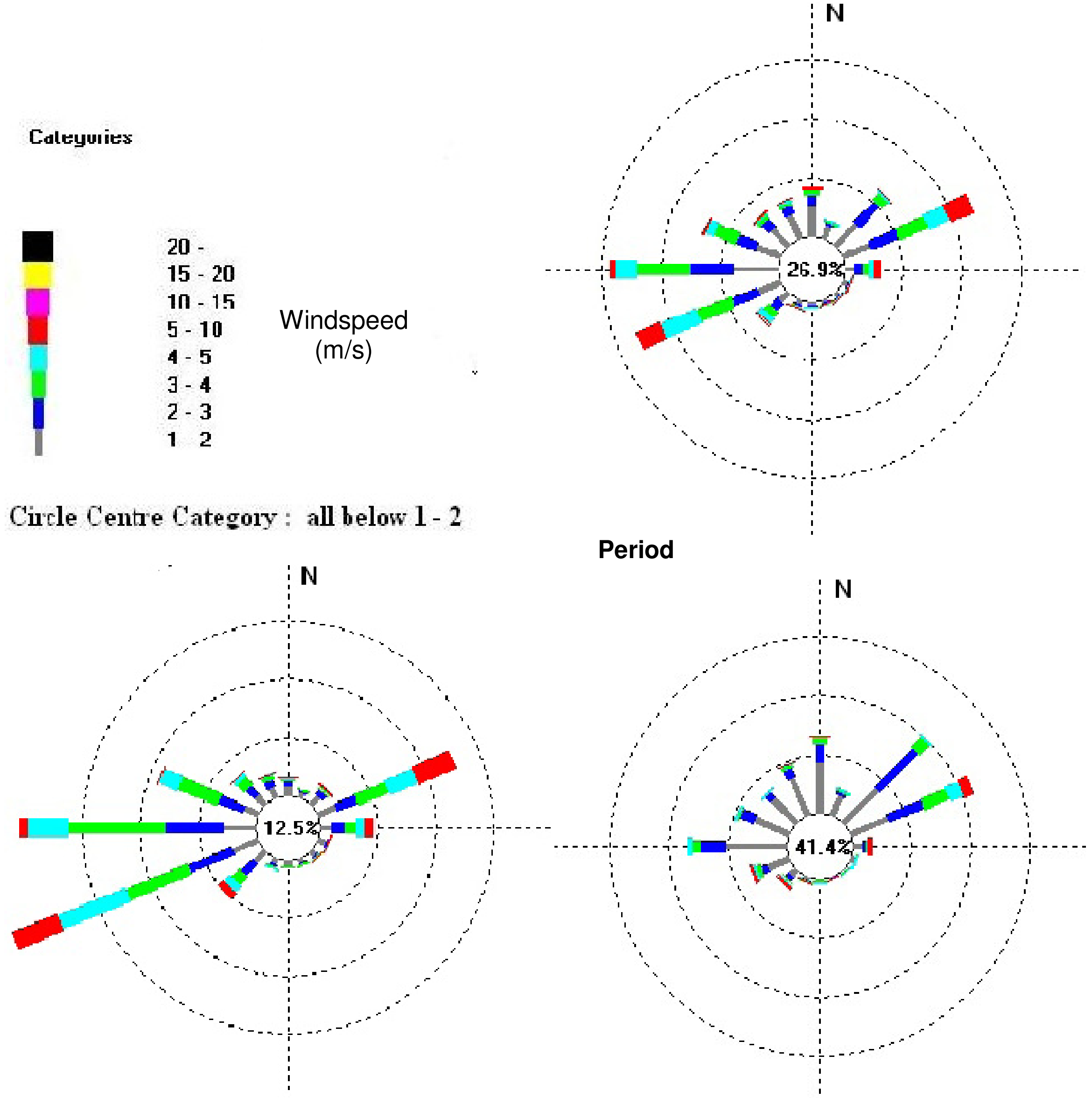
Climatic conditions are of significance when dealing with the waste especially when it comes to the management of surface water and litter and dust. With virtually no rainfall, water management as part of the operations would therefore not be an issue. However the lack thereof would require additional measures to be able to carry out dust suppression and additional water will have to be carted to site for this purpose.

On the other hand cognisance has to be taken of the wind direction and strengths to enable the curbing of windblown litter, possibly by means of litter screens, and the control of odours emanating from site.

3.3 Soil Formation

The site is covered by Alluvial material and underlain by Alaskite, Karibib and Chuos formations. Further geological information can be obtained from the Geohydrological Reports.

In general the proposed sites are excavatable but to limited depth with hard rock formation across the entire area.



Period

Day-time

Night-time

* Source: Airshed Planning Professionals (Pty) Ltd - Air quality impact assessment for the proposed expansion project for Rössing Uranium mine in Namibia: Phase 1, December 2007

Figure 1: Typical Wind Rose for Rössing Mine.

4 SITE SELECTION

4.1 Selected process

Six alternative sites were identified as shown in Figure 2 and were selected based on the site selection criteria below. The identified sites do not have specific locations but represent a potential site within a given area. The sites are:

1 - On top of the tailings near the ridge;
2 - Near the acid plant;
3a - North of the SK4 haul road;
3b - South of the SK4 haul road;
4a - North of the ore sorter; and
4b - South of the ore sorter.

All the sites are in close proximity to an access road.

4.2 Site selection criteria

In terms of the Minimum Requirement landfill regulations, no landfill shall be developed in areas with an inherent fatal flaw. The following situations may represent fatal flaws in that they may prohibit the development of an environmentally or publicly acceptable waste disposal facility except at excessive cost:

- Sterilizing production areas;
- Areas within 3000m from an airport runway;
- In geological unstable areas due to seismic activity, presence of dolomites and geological fault zones;
- Areas within a floodplain;
- Catchment areas of important water resources ;
- Shallow groundwater - depth to groundwater less than 2m;
- Steep sloped areas; and
- Potential conflict areas such as servitudes.

Sites were thus selected based on them not being associated with negative aspects or not being fatally flawed.

4.3 Ranking of the Selected Sites

Once identified the sites were ranked based on the following criteria:

- Economic criteria;
- Public acceptability criteria; and

- Environmental criteria.

The different criteria stated above consisted of a set of parameters upon which the sites were evaluated. The various parameters are thus as follows:

4.3.1 Economic Criteria

Economic criteria relate to the cost of obtaining, developing and operating a site. The criteria include the following considerations:

- Sterilising production areas;
- Distance to the source which would have an effect on: risk of spillage; illegal dumping; running costs;
- Size of site available (Economic operating size);
- Access to site (in terms of internal users and external conveyors);
- Waste processing and treatment of emissions;
- Excavatable cover material;
- Displacement of facilities including infrastructure;and
- Infrastructure needs for the facility.

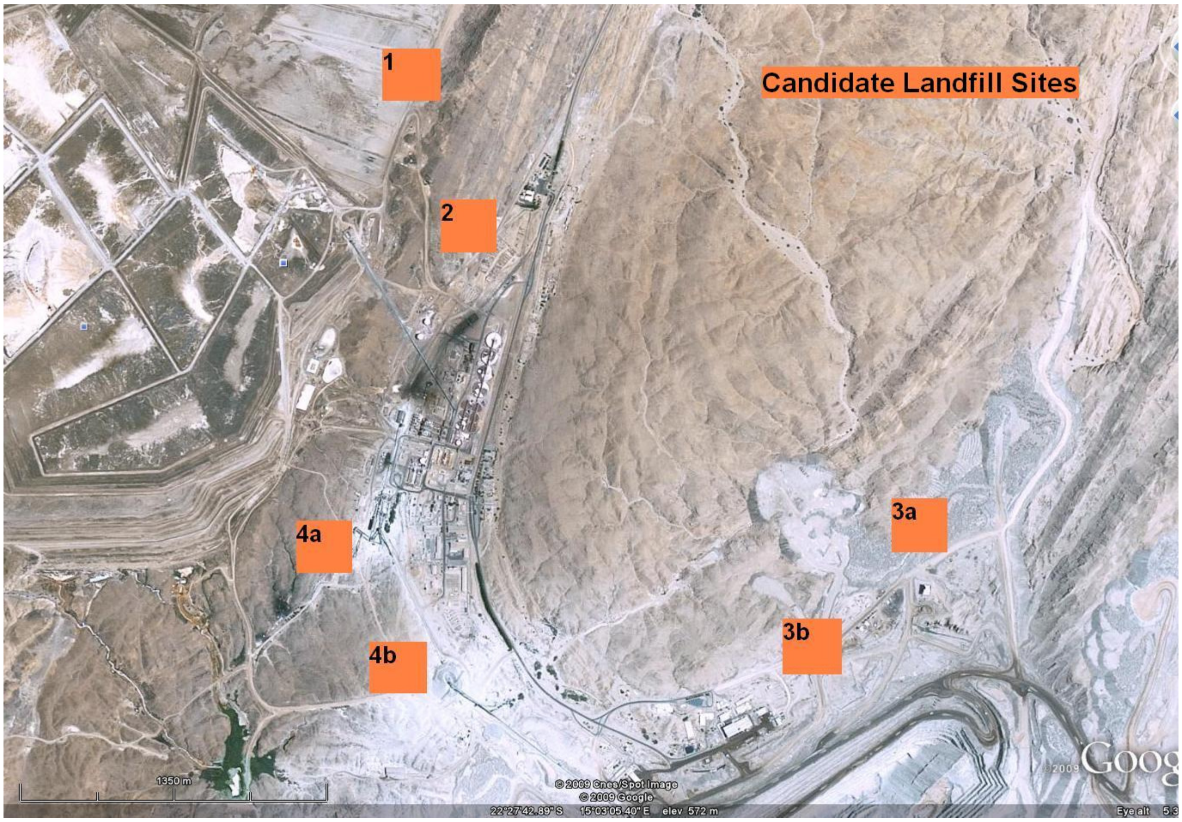


Figure 2: Location of the Candidate Landfill Sites

4.3.2 Public acceptability

Environmental criteria relate to such issues as the possible adverse impact on public health, quality of life, and local land and property values. They also relate to potential public resistance to the development of a landfill site. The criteria include the following considerations:

- Visibility;
- Wind – odours; and
- Psychological impact.

4.3.3 Environmental Criteria

Environmental criteria relate to the potential threat to the biotic and abiotic environment, particularly to water resources. They include the following considerations:

- Distance to surface water – seepage;
- Distance to ground water – seepage;
- Migration of gas through the soil and rock formation; and
- Sensitive biodiversity areas.

Under the three sets of criteria some items of consideration were grouped where they were considered to be similar to form the following list which was used in the ranking process:

- Distance to the source;
- Access to site;
- Waste processing and treatment of emissions;
- Excavatability and cover material;
- Displacement of / need for infrastructure;
- Staff / public acceptability;
- Seepage into surface / ground water; and
- Migration of gas.

A Multicriteria Decision-Making (MCDM) Model approach using the analytic hierarchy process (AHP) was then used to rank the candidate sites to determine the most preferred site for the development of the hazardous waste landfill.

The AHP is a MCDM approach introduced by Saaty (1977), and is structured using sets of pair wise comparisons in a matrix to derive both the relative weights of the individual decision criterion (if required) and the rating of options in terms of each of the criteria. This ideal mode AHP is widely considered to be the most reliable MCDM methodology. It has increased in popularity amongst other MCDM tools and methodologies, mainly as a result of its simple mathematical structure and ease of use, typically in a matrix structure such as a spreadsheet.

A technical methodological overview of the model is provided in **Appendix C** along with the results of the process.

With the aid therefore of the MCDM with inputs from a group of interested and affected parties (I&AP's) the various parameters (options and criteria) were combined to determine a ranking order. Sensitivity analyses were performed and the most preferred sites were identified as indicated in the figures below. The IAP group was represented by people from the following departments or companies:

Rainer Schneeweiss:	Principal Advisor-Land Use Management
Aina Kadhila Amoomo:	Environmental Technical Support – Air Quality
Frans Goaseb:	Radiation specialist
Ann-August Shikongo:	Hazardous materials - Storage & Handling
Aina Mutota:	Hydrogeologist
Rabanus Shoopala:	Environmental Coordinator
John Clarke:	Environmental Coordinator
Anneke Du Plessis:	Superintendent Environmental Management
Andries van der Merwe:	Aurecon – Environmental Consultant
Pieter Smuts:	PASCO – Waste Management Consultant

Based on the importance (weight) placed on certain considerations of the different criteria as per the group of I&AP sites 1, 3a, 3b and 4b were considered as most likely candidates. A sensitivity analysis varying the importance of the various considerations emphasized the preference to sites 1, 3a and 4b. Further detailed information of the sites would be required to narrow the options down to a single preferred site.

RANKING RESULTS IDEAL MODE AHP	Distance to source	Access to site	Excavatability and cover material	Displacement of / need for infrastructure	Staff / public acceptability	Seepage into surface / groundwater	Migration of gas
RELATIVE WEIGHT	5.2%	3.5%	7.2%	4.2%	22.4%	37.2%	20.3%

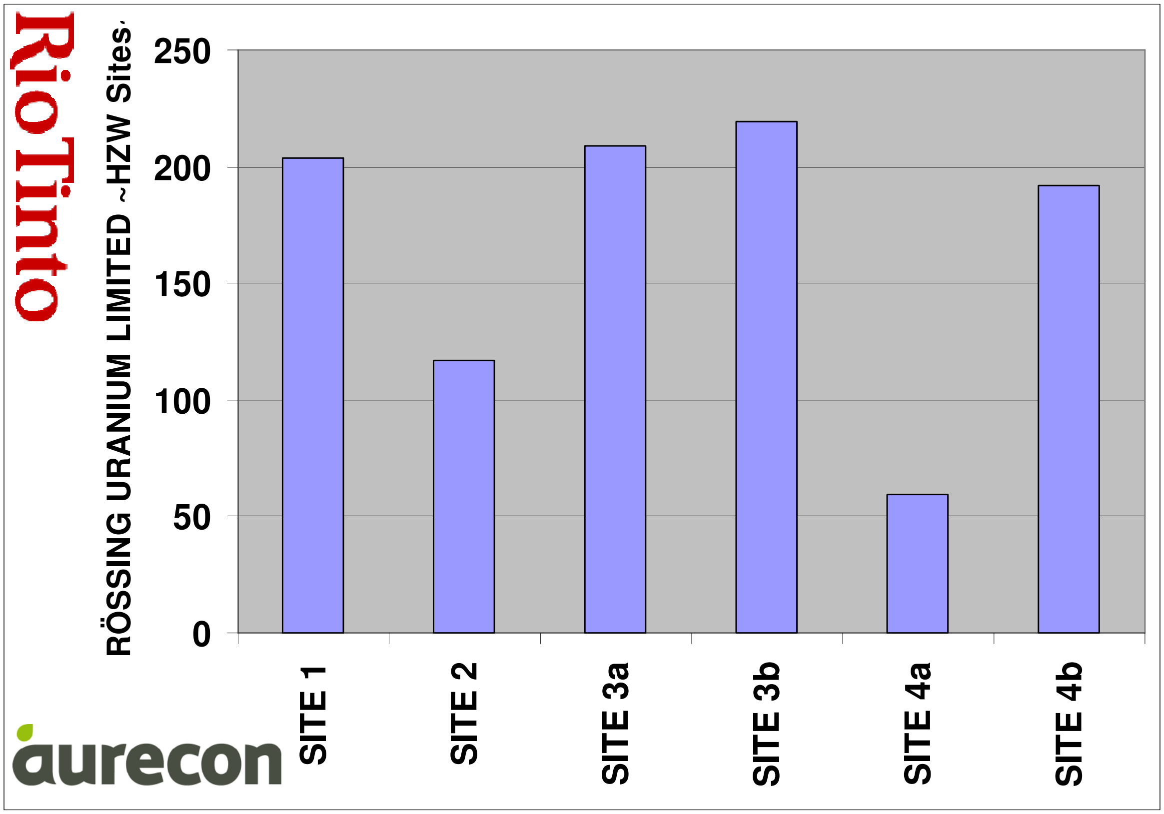


Figure 3: Outcome of the MCDM model

Additional information of the results and the modeling and sensitivity analysis is shown in **Appendix C**

5 ENVIRONMENTAL EVALUATION

An environmental assessment of the proposed hazardous waste facility was carried out based on the assessment methodology as described in **Appendix E.** The following is thus the assessment of the environmental impacts of the facility during the construction and operational phases.

The candidate sites are in close proximity to one another (on mine land) and as such the impacts are considered very similar irrespective of the specific site chosen. Minor site specific issues may be addressed and mitigated when the preferred site is identified. A final assessment may thus be required once the final site is identified.

5.1 Summary of Impacts and mitigation

Recommendations listed below incorporate the management actions identified in this report. The aim is to mitigate potential negative impacts arising from the construction and operational phases and, where possible, optimise the benefits. The management and monitoring plan that will form part of the future design and documentation will need to take the recommended mitigation measures further by adding specific actions and suggested targets and guidelines for their implementation. The salient impacts that will take place during the operations are stated in the table below. Impacts during the construction phase are negligent to none specifically in this mining environment. The full table is shown in the **Appendix F**

DURING OPERATIONAL PHASE

IMPACTS	IMPACT WITH NO MITIGATION	IMPACT WITH MITIGAITON	MITIGATION MEASURE
Impact on Water: Pollution of ground water			Construction of liner and well drained site
Significance	Low(-)	Very low(-)	
Impact on Water: Siltation of streams due to exposed surfaces			Ensure flat slopes in well drained areas – engineered design drainage system required.
Significance	Low(-)	Very low(-)	
Impact on Air: Odours from landfill			Waste to be covered regularly and operations monitored
Significance	High(-)	Low(-)	
Socio-economic impact: Accidents due to increased traffic			Although access road to be improved volumes are small thus low traffic levels
Significance	Low(-)	Very low(-)	
Socio-economic impact: Job creation			Recruit local labour as far as possible especially on recycling of materials where possible
Significance	Neutral	Very low (+)	
Socio-economic impact: Danger to health & safety of workers.			Workers to be properly trained and access control to be enforced.
Significance	High(-)	Low(-)	

5.2 Discussion:

Due to the waste volumes being relatively small and the climatic condition of the site being very dry few impacts other than "wind-blown" emissions (odours) would emanate from the site.

Most of the impacts would be mitigated if the waste is covered with material (soil) and compacted with the final surfaces and water courses or drainage pathways sloped away from the waste body.

A comprehensive operating plan will cover all the potential impacts and measures to mitigate the negative impacts or methods to optimise the positive impacts.

5.3 Recommendations relating to Construction and Operation

The following mitigation measures could be initiated during the construction and operational stages to minimise negative impacts:

- In order to prevent habitat destruction, the area of construction and operation should be confined to the smallest possible space and well-defined access roads established;
- To prevent unauthorised access, a security fence with a lockup gate must be erected around the operating area of the site; 24-hour broad security established based on the mining conditions;
- Waste material should be separated at source thereby facilitating the effective management of smaller volumes of materials at site;
- Implement management actions to mitigate the visual impact of windblown materials carried from the proposed waste disposal site
- Implement management actions to mitigate odours generated by waste materials;
- Implement management actions to reduce occupational health and safety risks at the waste disposal site;
- Manage and control vectors of disease through compaction and application of daily cover; and
- Regularly monitor the new system to ensure that it is working efficiently.

6 CONCEPTUAL LANDFILL DESIGN

6.1 Introduction

The design presented in this document is a conceptual design. It is presented with a view to providing the broad concept of what is intended, rather than giving details and specifications. It is to be regarded as preliminary and almost generic in nature, until such time as a specific site is chosen and topographic and geotechnical information is made available. Regarding implementation, it is noted that a full detailed design, including drawings, specifications and bills of quantities, will need to be drawn up on the basis of the site specific preliminary design.

The general objective of the conceptual design is to provide a cost effective, sustainable, environmentally acceptable hazardous waste disposal facility. More specifically, the design presented is aimed at addressing and mitigating the negative impacts, as identified in the SEIA.

The design should make provision for the phased development of the site, as determined by the waste disposal need. The intention would be to monitor the operation of the facility closely for the first few years, particularly regarding the size and nature of the hazardous waste stream and the operation of the hazardous waste cell. On the basis of this monitoring, the design may then be modified and refined for the subsequent phases of the development.

The generic layout and liner details of the conceptual design proposed for the Rössing Uranium mine hazardous waste facility are shown on the sketch drawings included at the back of this report.

6.2 Constraints and factors affecting design

Based on the terms of reference, the waste disposal need, and general site conditions at the Rössing Uranium mine, there are several constraints or factors that affect the design philosophy adopted:

- The Rössing hazardous waste facility design needs to comply with the Minimum Requirements for an H:H landfill;
- The design of the hazardous waste cell needs to cater for the disposal of approximately 330 tonnes of hazardous waste per annum;
- The first cell development should have a capacity for at least 10 years of hazardous waste (7 500 m^3 including cover material);
- Hazardous waste will not be co-disposed with general waste;
- The hazardous waste cell is to be designed as a “zero effluent” containment facility;

- There is no source of good clay in the vicinity of the site that could be used effectively in the landfill liner construction. The liner design is therefore based on a geocomposite landfill barrier system;
- On account of the extremely arid climate, leachate generation is highly unlikely, so that a separate leachate pond and treatment system is not necessary;
- There is a need to provide temporary storage for a number of the industrial and hazardous waste streams until they can be sent back to suppliers for re-use or to recycling companies.

6.3 Site layout

Because of the high cost of lining a hazardous waste landfill, and because the majority of the general waste stream would not require lining on account of the arid climate, it was decided to develop a stand-alone hazardous waste facility, separate from the general landfill area. To control access to the hazardous waste facility, a separate entrance facility is to be established and the site is to be fenced.

Incoming vehicles would be checked at the gate of the facility and, after checking the type of waste in the vehicles, they would be directed either to the temporary storage area or to the hazardous waste cell.

6.4 Services and infrastructure

6.4.1 Access

Access to the hazardous waste facility would be by means of a new gravel road off an existing mine road. Appropriate sign posting is to be installed.

6.4.2 Weighbridge

Due to the small quantities of waste expected, it does not justify the installation of a weighbridge. In exceptional circumstances where vehicle weighing is necessary, this can be arranged at the plant weighbridge.

6.4.3 Laboratory

Due to the close proximity of the hazardous waste to the Rössing Uranium process plant, and because the facility will only be used for the disposal of Rössing wastes, a laboratory will not be established at the waste site. Instead the plant laboratory will be used when necessary for analysing wastes.

6.4.4 Fencing

The entire perimeter of the site is to be fenced with a 1.8 m high security fence to prevent unauthorised access. Lockable vehicle access gates are to be provided at the entrance to the site.

6.4.5 Water

Potable water is to be piped to the facility from the mine's water main supply for drinking and ablution purposes. It may also be used for occasional washing of waste delivery vehicles before they leave the site.

6.4.6 Electricity

At this stage it is not envisaged to provide a power supply to the facility.

6.4.7 Staff facilities

A single building for the site operational staff is to be located near the site entrance. This building will include a site office / mess room, change room and ablution facility. A buried septic tank will be installed with effluent discharged into the landfill cell.

6.4.8 Plant maintenance facilities

Due to the site's close proximity to the mine's process plant, there is no need to establish a plant and equipment maintenance facility on the site, as the plant and equipment would be sent to the main workshop for maintenance.

6.4.9 Temporary Waste Storage Facility

For the temporary storage and possible treatment of various industrial and hazardous waste materials, a temporary storage facility should be established on site (see Appendix F - drawings HAZ-03). The types and quantities of the waste brought to this storage facility will have to be well monitored to determine whether to pretreat and dispose these waste types at the facility, or whether they have to be treated elsewhere and what kind of pretreatment (for instance oil separation, acid treatment, incineration) would be required.

In addition, where arrangements can be made for the return of materials to the suppliers or to recyclers, e.g. bulk bags, batteries, drums, etc, these materials could be stored in this facility until such time as there is sufficient quantity for a full truck load.

It is intended to construct a single roofed waste holding shed with a number of compartmentalised bays. Each bay would be large enough to hold a skip container or drums of waste on pallets. The floor of each bay would be sloped to a sump in the corner for removal of leakage/spillage that might occur. The concrete floors are to be suitably protected from chemical attack by means of an epoxy or similar screed. The bays for storage of inflammable wastes are to be partitioned off from the other bays by means of brick firewalls. Provision for firefighting equipment must be taken into account.

One of the bays is to be used for the storage of used lubricants. The used lubricants will either be stored in 200 l drums, or in a bulk steel tank installed within the bay. The tank will have a valve outlet for discharge into the tankers sent by the oil recycling company.

Adjacent to the waste holding shed, a concrete bunded area is to be constructed to ensure that any spillage occurring during unloading and packaging is contained and collected for treatment and safe disposal on the landfill.

6.5 Hazardous waste disposal facility

6.5.1 Design approach

The industrial and hazardous waste generated mainly by the Rössing Uranium plant and mining operations is to be either stored for return or recycling, or it must be treated and/or disposed of in an H:H hazardous class landfill. Regardless of the climatic conditions, the landfill must comply with the most stringent environmental protection requirements. It must have a leachate management system, including a double geocomposite liner, leachate drainage and leakage detection systems and a leachate storage facility.

Despite the uncertainties regarding the amounts of hazardous waste requiring final disposal by landfill, the hazardous waste landfill will have to be developed with a total airspace capacity of at least 15 000 m^3. Although a design life of 20 years is required only the first phase development with 50% capacity is to be constructed initially (7 500 m^3).

Due to the extremely low rainfall and high evaporation of the area, no significant leachate generation is expected, except possibly as a result of liquid waste disposal. It is therefore proposed not to have a separate leachate pond but rather to use the landfill cell itself to store leachate if it is generated.

During operation, the types and quantities of hazardous waste disposed at the new facility must be carefully monitored and recorded. In addition, the performance of the facility must be closely monitored to facilitate design refinements in subsequent extensions of the facility.

6.5.2 Landfill layout and cell construction

The hazardous waste facility to be located at the final approved site will either be on the natural or reworked ground. The initial development is to comprise of a lined hazardous waste cell with a capacity of at least 7 500 m^3.

For an airspace volume of 7 500 m^3 (50% of total required), a landfill cell footprint with plan dimensions of 40 m x 40 m is proposed. The cell will be excavated to an average of 2 m deep and landfilling will be taken up to a height of about 4 m above the crest of the outer berm or bund. The height is determined by the limited footprint area as stated above and acceptable side slopes of 1:3 of the final landfill shape. The excavation depth is furthermore determined by the volume of cover material required for the volume of waste to be landfilled. The inner slopes of the excavated cell will be in the order of 1:2.

The following cell would be developed adjacent to this initial cell and the void between the two cells would also be landfilled with waste, giving a total airspace volume in excess of 20 000 m^3.

A starter berm or bund approximately 1 m high and 3 m wide is to be constructed around the perimeter of the cell. The cell is to be developed with a cross fall of about 5% diagonally across the floor of the cell towards a leachate collector manhole made of penstock rings. Industrial and hazardous waste will be delivered to the facility by various types of vehicles. A haul road is to be constructed to enable the waste trucks to enter the waste tipping area in the landfill cell.

Based on the Minimum Requirements design for an H:H hazardous facility, and because suitable clay for lining is not available in the vicinity of the site, a multi-layered geocomposite lining system is proposed, as detailed on the conceptual design sketches (see Appendix F - drawings HAZ-01 and HAZ-02). Working from the top downwards, the components of the hazardous cell liner are as follows:

- Woven polypropylene geofabric filter (approximately 145g/m^2);
- Drainage layer of 19 mm stone, 250 mm thick;
- Protection layer of non woven geofabric (approximately 500 g/m^2);
- Primary liner of 2 mm thick HDPE geomembrane;
- Leakage detection layer of cuspated HDPE drainage sheet;
- Secondary liner of 1.5 mm thick HDPE geomembrane;
- Geosynthetic clay liner (GCL);
- Base preparation layer of fine soil, at least 150 mm thick.

The liner system is to be extended up the sides of the bund walls and anchored in a trench on top of the walls.

The base of the cell is to be sloped towards a leachate collection sump at the lowest corner of the cell (see Figure 4). A herring bone system of perforated leachate collector pipes is to be placed within the stone drainage layer, to discharge into the leachate collection sump. An inclined HDPE pipe (200mm diameter) sleeve is to be installed from the leachate sump up the side of the cell wall, to provide a sleeve for insertion of a submersible borehole type pump to pump out leachate if required. In this event, leachate would be pumped back over the landfilled waste to evaporate off excess liquid and contain contaminants within the lined cell. The leachate sump is to be designed as a decant tower using precast concrete rings, to facilitate removal of surface water from the cell if it is found to be necessary.

The cuspated drainage layer between the primary and secondary liners represents a leakage detection system should the primary liner fail in any way. Within this layer are three perforated HDPE collector pipes, which also drain towards the lower corner of the cell, from where they would drain via a solid walled pipe into a leakage detection manhole.

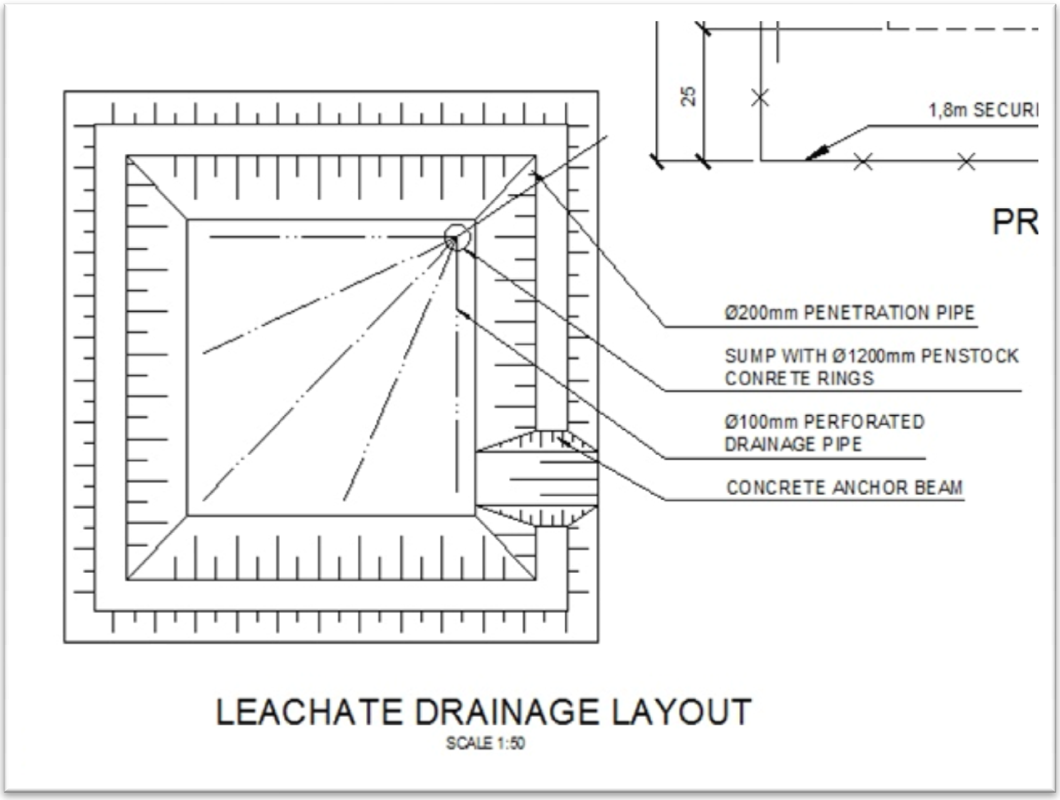


Figure 4: Leachate drainage layout and detail

Before any liquid waste is discharged into the hazardous cell, and before any vehicles or equipment enter the cell, a pioneering layer of 0,5m thick of domestic waste or sandblasting grit must be placed over the stone drainage layer to prevent any mechanical drainage to the liner.

6.5.3 Construction Quality Assurance

The main risk to the performance of a geomembrane liner is mechanical/physical damage, during and after installation. For this reason, it is imperative that the liner is supplied and installed by a competent and reputable contractor, and in accordance with a strict quality assurance programme. In particular, extreme care must be taken when placing the stone leachate collection layer over the installed liner system so as not to damage the liner. Strict supervision is required.

6.6 Rehabilitation and end-use design

The objectives of the end-use design of the hazardous waste disposal facility are as follows:

- To create an aesthetically acceptable landform with gentle slopes (not exceeding 1:3) that, as far as possible blends in with the surrounding terrain;
- To maximise the landfill airspace available for waste disposal and hence the site life.

6.6.1 Final landform and end-use

At this stage, the proposed final shape of the landfill would be determined according to the surrounding terrain, and to maximise the airspace from the available footprint. It would also be designed to meet drainage and end-use requirements. It is recommended that the end-use of the landfill be considered as restricted open space, on account of the hazardous nature of the waste disposed on it.

Based on the surrounding topography and land use, the maximum height of the landfill would be about 6 m above the original natural ground level. The upper surfaces of the landfill must have general slopes of at least 1:20 to promote rapid drainage of the landfill surface.

6.6.2 Closure and rehabilitation

As the different sections of the landfill are completed to final height, they are to be appropriately shaped, graded and capped in accordance with the Minimum Requirements. The capping for the landfill would include as a minimum, the following components, working from the top of the waste body upwards:

- 150 mm foundation and gas drainage layer, comprising of coarse aggregate;
- Geotextile separation layer;
- 200 mm soil support layer;
- Geosynthetic clay liner (GCL);
- 400 mm (minimum) topsoil layer.

Normally vegetation of completed areas would commence as soon as possible after capping. However, because of the extremely arid climate, capping the completed cover with a layer of rock fill would be more appropriate.

6.7 Gas Management

Depending on the mixture of wastes disposed of in the hazardous waste cell, it is likely that landfill gas could be generated. This must be monitored and if landfill gas is detected in significant quantities or concentrations, an appropriate level of gas management should be determined on the basis of a risk assessment. The following features could be incorporated in such a system:

- a containment system to retain gas within the site and prevent off-site migration
- a system for landfill gas collection, utilisation or flaring with adequate back-up facilities
- a separate system to control gas migration at the site perimeter, operating separately of gas collection from within the waste body
- use of gas monitoring boreholes (probes) outside the waste boundary as safe practices to avoid hazardous concentrations of gases at temporary or permanent working area of the site

6.8 Water quality monitoring system

In terms of the Minimum Requirements and to ensure adequate environmental protection, a long term water quality monitoring programme for the site is required. This would involve background analyses, routine detection monitoring, investigative monitoring and post closure monitoring.

6.9 Discussion

In formulating the conceptual design for the Rössing Uranium hazardous waste facility, every effort has been made to meet the objectives of landfill design, i.e. to provide a cost effective, environmentally and socially acceptable facility. In addition, the requirements of the Minimum Requirements have been followed and the "Precautionary Principle" has been implemented throughout.

7 COSTING

7.1 Introduction

This section includes an estimate of the capital cost of the development of the proposed Rössing hazardous waste facility. The purpose of the costing is to enable Rössing Uranium management to determine the financial feasibility of developing the facility and, if so, to budget for the development and operation of the facility.

7.2 Costing basis

The capital costing has been based on quantities estimated for the conceptual design, and applying unit rates typical for this type of construction in the Rössing Uranium area. In the case of the lining system, budget prices were obtained from a reputable lining contractor.

7.3 Capital cost estimate

The capital cost estimate for the development of the Rössing Uranium hazardous waste facility with a disposal capacity of 10 years, determined within an accuracy level of approximately 25% is given in Table 4. The total capital cost of development is approximately N$ 3 678 000 excluding value added tax (VAT).

Table 4: Hazardous waste facility - capital cost estimate

Item	Description	Unit	Quantity	Rate(N$)	Amount(N$)
1.1	Bulk earthworks to form cell (including berms)	m^3	2100	60.00	126 000.00
1.2	Restricted excavation to leachate drains and sump	m^3	12	90.00	1 080.00
1.3	Restricted excavation and backfill to liner anchor trench	m^3	26	90.00	2 340.00
1.4	Paving blocks over anchor trench	m^2	100	150.00	15 000.00
1.5	Place 150mm sand protection layer for liner	m^2	360	150.00	54 000.00
1.6	1.5mm HDPE Geomembrane secondary liner	m^3	2400	70.00	168 000.00
1.7	GCL Liner (Bentomat ST or similar)	m^2	2400	70.00	168 000.00
1.8	Cuspated HDPE leakage detection layer (HiDrain 750 or similar)	m^2	2400	25.00	60 000.00
1.9	2mm HDPE Geomembrane primary liner	m^2	2400	85.00	204 000.00
1.10	500g/m^2 non woven geofabric (Bidim A10 or similar)	m^2	2400	35.00	84 000.00
1.11	Stone drainage layer, 19mm agg, 250mm thick	m^3	600	300.00	180 000.00
1.12	200g/m^2 woven tape geotextile (Kaytape S120 or similar)	m^2	2400	20.00	48 000.00
1.13	Wastex DN110mm leachate drainage pipes	m	164	50.00	8 200.00
1.14	Drainex DN75 leakage detection pipes	m	96	40.00	3 840.00
1.15	200mm HDPE Class 6 pipe installed as leachate pump sleeve	m	15	300.00	4 500.00
1.16	1200mm dia Penstock Rings to leachate sump	No	40	150.00	6 000.00
1.17	Construct 300mm thick hardstanding with gypsum gravel	m^2	200	100.00	20 000.00
1.18	Temporary Storage building	m^2	160	2 500.00	400 000.00

1.19	Guard house and ablution facility	m^2	160	3 000.00	480 000.00
1.20	Blending facility (concrete enclosure)	m^3	35	3 500.00	122 500.00
1.21	Security fencing to hazardous facility (1.8m high)	m	510	180.00	91 800.00
1.22	Security gates (2 x 3m wide)	No	1	16 000.00	16 000.00
					0.00
	Sub-total measured work				**$2 263 260.00**
	Preliminary & General Costs (30%) *				**$678 978.00**
	Contingency allowance (25%)				**$735 559.50**
	Total Capital Cost Estimate				**$3 677 797.50**

* Preliminary and general costs are to cover the contractor's risks, costs and obligations in terms of the GCC, running and overhead costs (head office, field office, workshops, etc.), insurances, profit and financing costs not built into the rates, services such as water, sewer and electricity and cleaning services.

Further allowance has to be made for the operating cost of the facility. These costs have not been included in the cost estimate. However, the section below provides an indication of what would be required to operate the facility.

7.4 Number of Site Personnel

The proposed minimum number of site personnel to run the site is five as detailed in Table 5. Due to the size of operations the site does not have to be manned 24 hours per day. Communications however is vital between the supervisor and the operators of the plant to ensure the planned sequence filling is followed.

Table 5: Site Personnel

Position	Nr.
Site supervisor	1
TLB/FEL operator	1
Water tanker operator	1
Labourers / Litter pickers	2
TOTAL	5
Medium term	
Bull dozer	1

7.5 Equipment Provided

The equipment provided to operate the site is listed below. Some of the equipment and facilities don't necessary have to be available on site but be close-by as is typical with operations on the mine.

7.5.1 Personnel Equipment Required

- Ear muffs
- Dust masks
- Head protection

- Eye Protection
- Safety boots/Wellington boots
- Overalls
- Shower equipment
- Reasonable shelters (as described in 5.2 below)
- Safety gloves.

7.5.2 Mobile Equipment

- Tractor-loader-backhoe (TLB)
- Water cart and spray bar (bowser)
- Tipper truck
- Utility vehicle for landfill management

As the volume of hazardous waste increases a bulldozer suited for waste management will have to be made available more regularly to assist in the landfill operations.

8 CONCLUSIONS

Based on the results of the investigations undertaken and the content of this report, the following conclusions are drawn regarding the Rössing Uranium hazardous waste facility.

In line with the objectives of this study and report it can thus be stated that a hazardous waste disposal facility would be required in terms of the classified waste stream, the size of the waste stream and the potential for leachate generation.

The waste stream as presented is either fully classified hazardous waste or includes radioactive wastes defined as "inactive", i.e., with a specific activity less than 100 becquerels per g (Bq/g) and total activity less than 4 kBq (0.1uCi), which may be disposed as waste.

In terms of Rössing's procedures on disposal of contaminated items, JK65/PRD/003, no contaminated waste shall be disposed or dumped on the domestic waste disposal site (Landfill Site). Furthermore no contaminated waste more than 100 becquerels per g (Bq/g) or > 0.4 Bq/cm2 (averaged over 300 cm2) may be disposed in the hazardous waste landfill and will have to be disposed in the tailings impoundment until required otherwise.

With the assistance of the MCDM model candidate landfill sites within the Rössing Uranium Mining Area were ranked and the most preferred landfill site needs to be identified after more information regarding the top ranked sites have been obtained.

This report describes the conceptual design for the hazardous waste facility that meets the disposal need and that incorporates the necessary precautionary measures to mitigate any environmental impacts and critical factors.

To develop a hazardous waste facility at Rössing Uranium Mine would thus require approximately N$ 3 678 000 capital investment excluding operational costs.

9 RECOMMENDATIONS

Based on the aforementioned conclusions, it is recommended that:

- The site selection process be finalized by investigating the top ranked sites in more detail and then go through another round of ranking of the remaining sites by making use of the MCDM model possibly incorporating other members of the I&AP groups;

- The cost estimate for the development of the facility be revisited based on the final site that is selected;

- That the Rössing Uranium Mine budget for the development of the hazardous waste disposal facility at the mine for hazardous and "inactive" radioactive waste and at the same time consider the future operational requirements of such as facility especially as the Walvis Bay facility may soon run out of capacity; and

- A study be conducted on the level of radioactive contamination of hazardous waste materials to determine the size of waste stream classified as "inactive" and what management options are available for the upper limits of contaminated material as defined in the Rossing Uranium JK65/PRD/003 procedures code.

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APPENDIX A

WASTE QUANTITIES

Appendix A

TABLE 1 : CHARACTERISATION OF WASTE BY ORIGIN AND METHOD OF TRANSPORTATION (SEPTEMBER 1997)

		LUGGER BINS				OTHER VEHICLES			
		General	Hazardous	Recyclable		General	Hazardous	Recyclable	
ADMINISTRATION	Central Stores	7.9		22.6					
SERVICES	Plant Store	1.8	1.2	9.2					
	Central Recieving							2.24	
		9.7	1.2	31.8	**42.7**	0	0	2.24	**2.24**
CONTRACTORS	Arandis Services					11.2	0.56	8.4	
	NEC							2.24	
	Neumayer					4.48		7.84	
	R J Southey					5.865		1.955	
		0	0	0	**0**	21.545	0.56	20.435	**42.54**
ENGINEERING	Plate Shop	6.3	2.4	15.7					
	Gritblasting Yard	1.8	2.4	7.9					
	Instrumentation	3.7		2.4				4.48	
	Joiner Shop			6.1					
	Machine Shop	6.1	4.3	20.2			0.56	0.56	
	Sodexho Buffeteria	7.3		4.9					
	Vehicle Maintenance	3.7	1.2	7.3		8.4		8.38	
	Mobile Equipment W/Shop					3.91		11.73	
	Outside Services					22.804		7.376	
	SATEC Sewage Plant					3.91	3.91		
		28.9	10.3	64.5	**103.7**	39.024	4.47	32.526	**76.02**
METALLURGY	Acid Plant	4.6		13.7					
	CCD / Thickeners	2.4		9.8				5.03	
	Continuous Ion Exchange	11.6	0.6	20.8					
	Fine Crushing Plant	1.2	1.2	22				16.76	
	Leaching	2.5		15.8		4.692	3.519	23.069	
	Manganese Plant		0.6	11.6					
	Plant Offices	0.9		5.2					
	Recovery Maintenance	3.7	0.6	1.8				5.03	
	Rod Mills	5.6		6.6					
	Rotoscoop Maintenance	3.7	1.2	1.2					
	Rubber Lining	1.2	3.7	7.3				5.03	
	Plant Electrical					3.36		2.24	
	Tailings Impoundment					5.59		0.56	
		37.4	7.9	115.8	**161.1**	13.642	3.519	57.719	**74.88**
MINING	Auxiliary Workshop		1.2	11					
	Cat Shop	14.1	4.9	17.7					
	Haul Truck Mechanical	3.7	2.4	12.2					
	Haul Truck Electrical							1.12	
	HEF Plant			12.2					
	Lube Bay	1.7	89.2	6.8					
	Planning	1.2	4.9						
	Mine Stores	6.1		24.4					
	Open Pit Operations	7.9		10.4					
	Pit Electrical	12.2	1.2	4.9		2.24		1.12	

Pit Mechanical	6.1	1.2	29.3		4.23		50.5	
Primary Crushers	2.4		22					
Tyre Bay		0.6	5.5					
	55.4	105.6	156.4	**317.4**	6.47	0	52.74	**59.21**
	G	**H**	**R**		**G**	**H**	**R**	
WASTE TOTALS BY CATEGORY	**131.4**	**125**	**368.5**	**624.9**	**80.681**	**8.549**	**165.66**	**254.89**
Category as Percentage of Total	**21%**	**20%**	**59%**		**32%**	**3%**	**65%**	
					G	**H**	**R**	
					212.08	**133.55**	**534.16**	**879.79**
					24%	**15%**	**61%**	

TABLE 3 : SUMMARY OF WASTE STREAM BY ORIGIN AND METHOD OF TRANSPOSRTATION

DEPARTMENT	% of Tot	LUGGER BINS	VEHICLES
ADMINISTRATION SERVICE	5.1	42.77	2.24
ENGINEERING	20.4	103.87	76.02
METALLURGY	26.8	161.3	74.88
MINING	42.8	317.72	59.22
CONTRACTORS	4.8		42.54
	100.0	**625.7**	**254.9**

TABLE 4 : SUMMARY OF WASTE STREAM BY TYPE AND QUANTITY

		QUANTITIES (m^3/mnth Uncompacted)	
		METHOD OF DELIVERY TO SITE	
WASTE CLASSIFICATION	**% of Tot**	**LUGGER BINS**	**OTHER VEHICLES**
BUILDING RUBBLE	1.5		12.87
CARDBOARD	10.0	76.33	11.45
CHEMICAL CONTAINERS	2.5	21.39	0.56
DOMESTIC WASTE	15.9	99.62	39.95
FIBRE GLASS	0.1		1.12
GARDEN REFUSE	4.3	25.87	12.2
IRON GRID	1.0		8.39
OIL SLUDGE	12.1	98.98	7.99
PAPER STATIONARY	2.0	14.84	2.68
PLASTIC / PVC	4.2	34.39	2.74
PLASTIC CONTAINERS	0.4	2.44	1.51
20 l PLASTIC DRUMS	0.5	2.44	2.35
ROAD SWEEPER SLUDGE	0.3		2.24
RUBBER	2.4	20.77	0.12
SEWAGE SLUDGE	1.1	6.11	3.91
STEEL / METAL	30.5	147.44	120.76
20 l STEEL DRUMS	1.4	9.43	3.08
WOOD	9.8	65.62	20.97
	TOTAL	**625.7**	**254.9**

APPENDIX B

Geotechnical Information and Perimeter Bund Specification

Appendix B

Some general notes are highlighted here under.

Soil Stability

Cut Slopes

Due to the high density, the insitu residual soils in the vicinity of the proposed landfill site it is expected to remain stable when cut to angles of up to 1 vertical to 2 horizontal, provided the cuts are situated above the water table.

To reduce slope erosion by surface waters, it is considered expedient to place cut-off drains at the top of permanent cut slopes, so that rain water can be channelled away from them. For slopes maintained for short periods of time, the drain may be considered unnecessary.

Embankments

Although no specific testing was conducted to ascertain stability of recompacted material, it is anticipated that insitu material used to form embankments will be stable if compacted in layers of maximum thickness 150 mm to 93% mod. AASHTO density. Embankments slopes constructed at slopes of 1 vertical to 2 horizontal are considered reasonable. However final slopes on the landfill should be in the order of 1 vertical to 3 horizontal.

It is considered likely that embankments will be susceptible to erosion, and consequently will need to be periodically maintained. Compaction of the insitu material will reduce permeabilities, depending on compaction achieved.

Perimeter Bund Construction

B1 The perimeter bunds should be constructed from engineered fill selected for uniformity from the stockpile. The bunds are required to stand until either the next phase of development or the construction of the final cover, soon after the next phase is commenced. The profile of the bund has been chosen as 1 vertical to 3 horizontal on the outside face and 1 vertical to 2 horizontal on the inside face. A steeper slope on the inside face is acceptable as the waste supports this slope.

B2 The portion of the bund will be set out using pegs. The base area will first be pegged out in the correct position as shown on the layout drawings of the landform. Simple triangular planks set up at 1 in 3 and 1 in 2 can assist in forming the battered slope.

B3 It is anticipated that the perimeter bunds will be constructed by using the track type loader. It will excavate material from the stockpile and spread it out in layer about 150 mm thick. To compact the layer the track type loader should run over the material 8 times, making sure that the whole surface has been given the compaction treatment.

B4 The next layer will follow, and so on until the 2 metre height of the bund has been reached. The addition of water may be desirable to aid compaction. The water bowser for damping down the site roads may be used for this purpose. Compaction density tests can be carried out to determine the optimum moisture content and to experiment with the number of passes of the track loader to achieve the best results.

B5 It may be that the track loader is fully occupied in the daily covering of the waste, in which case the perimeter bunds may be constructed by the public works section or by private contractor.

APPENDIX C

Site Selection Process Using the MCDM Approach

Appendix C

OVERVIEW OF THE IDEAL MODE ANALYTICAL HIERARCHY PROCESS MULTICRITERIA DECISION-MAKING MODEL[3]

Historical Development

The analytic hierarchy process (AHP) is a MCDM approach introduced by Saaty (1977), and is structured using sets of pairwise comparisons in a matrix to derive both the relative weights of the individual decision criterion (if required) and the rating of options in terms of each of the criteria. The pairwise comparison approach itself dates back to the eighteenth century and the mathematician and philosopher Marie Jean Antoine Nicolas Cariat, the Marquis de Condorcet, after which the Condorcet Method of voting using pairwise comparisons was named, is primarily credited for its development. The original AHP pairwise comparison model was later proven to be mathematically unstable by Belton and Gear (1983), based on the finding that it may influence the relative ranking of options with the introduction of an option that is similar or identical to one of the existing options. They then developed the ideal mode AHP as a variant of the original AHP, which proved to address this deficiency by adding an additional mathematical normalisation process to the calculation. This ideal mode AHP was later accepted by Saaty (1994) and according to Triantaphyllou and Mann (1995) is widely considered to be the most reliable MCDM methodology. It has increased in popularity amongst other MCDM tools and methodologies, mainly as a result of its simple mathematical structure and ease of use, typically in a matrix structure such as a spreadsheet.

Model Description

A technical methodological overview of the model is provided in subsequent paragraphs. When comparing options in a pairwise comparison using this model, as would be done for each of the criterion, the following scale of rating introduced by Saaty (1980) is used:

RATING SCALE TABLE	
Rating (R)	**Description of Relative Rating**
1	Equal preference
3	Weak preference
5	Essential or strong preference
7	Demonstrated preference
9	Absolute preference

When applying this scale, it is useful to first consider whether an option is better or worse than the option it is being compared to in respect of the criterion under consideration. This will then indicate whether the relative rating should be an integer value (when it is better) or a fraction (when it is worse), using the principle of reciprocal rating. The significance or severity of this preference is then expressed through the application of the numerical values in the scale, unless it is equal in which case a rating of 1 is used. Intermediate values (the equal numbers) could be used if required to indicate slight differences in rating. To create the pairwise comparison matrices, the first step would be to define the number of options and the number of criteria. To simplify the example, let us assume four options (A, B, C and D) and four criteria (C_1, C_2, C_3 and C_4), resulting in the following

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[3] Adapted from a paper presented at the IAIAsa National Conference in Wilderness, South Africa in August 2009: *The Application of the Ideal Mode Analytical Hierarchy Process Multicriteria Decision-Making Model in Strategic Project Planning and Environmental Impact Assessments* by Mellerson Pillay, Andries van der Merwe and Ashwin West of Aurecon South Africa (Pty) Ltd.

pairwise comparison matrix for the first criterion, where R_{1AB} represents the rating of option A compared to option B for criterion 1 (or answering the questions "is A better or worse than B?" and "what is the significance or severity of this preference?"):

OPTIONS MATRIX FOR CRITERION 1				
Options	**A**	**B**	**C**	**D**
A	R_{1AA}	***R_{1AB}***	***R_{1AC}***	***R_{1AD}***
B	R_{1BA}	R_{1BB}	***R_{1BC}***	***R_{1BD}***
C	R_{1CA}	R_{1CB}	R_{1CC}	***R_{1CD}***
D	R_{1DA}	R_{1DB}	R_{1DC}	R_{1DD}

Note that since $R_{1AA} = R_{1BB} = R_{1CC} = R_{1DD} = 1$ per definition as it represents the rating of an option compared to itself and $R_{1BA} = 1 / R_{1AB}$ etc. per definition as the one is the reciprocal of the other, only the cells indicated in bold italics in the top half of the matrix need to be rated. For the chosen example, similar matrices would be created for criteria C_2, C_3 and C_4. The same methodology could be used to determine the relative weighting of the criteria in relation to each other (P_{C1} , P_{C2} , P_{C3} and P_{C4}) that would later be applied to arrive at the overall ranking of options. To calculate the relative priorities, the geometric mean is first calculated per row, as shown below, where M_1A represents the geometric mean of rating results of option A for criterion 1, where 4 options are evaluated:

$$\boxed{M_1A = (1 \text{ x } R_{1AB} \text{ x } R_{1AC} \text{ x } R_{1AD})^{1/4}}$$

The relative priority of each option is then calculated per criterion by normalising the values, with the resultant formula for the calculation of the relative priority of option A for criterion 1 (P_1A) for the given example:

$$\boxed{P_1A = M_{1A} / (M_{1A} + M_{1B} + M_{1C} + M_{1D})}$$

These steps are easily completed by adding columns to the options matrix and the Original AHP decision matrix is then produced by copying the respective priority vector columns from the options priority matrices into a single matrix, with the criterion priorities from the criterion priority matrix in the top row. This matrix is then used to produce the ideal mode AHP decision matrix, by adjusting the relative options priority values through a second normalisation:

$$\boxed{IP_{1A} = P_{1A} / (\text{maximum of } P_{1A}\ ;\ P_{1B}\ ;\ P_{1C}\ ;\ P_{1D})}$$

Similarly, these relative priority values are normalised for the other options and criterion, resulting in the ideal mode AHP decision matrix below, with the maximum IP value per criterion column having the value of 1:

IDEAL MODE AHP DECISION MATRIX				
Criteria	**C_1**	**C_2**	**C_3**	**C_4**
Priority	P_{C1}	P_{C2}	P_{C3}	P_{C4}
A	IP_{1A}	IP_{2A}	IP_{3A}	IP_{4A}
B	IP_{1B}	IP_{2B}	IP_{3B}	IP_{4B}
C	IP_{1C}	IP_{2C}	IP_{3C}	IP_{4C}
D	IP_{1D}	IP_{2D}	IP_{3D}	IP_{4D}

The final option priority is then calculated by using the formula below:

$$P_A = (IP_{1A} \times P_{C1}) + (IP_{2A} \times P_{C2}) + (IP_{3A} \times P_{C3}) + (IP_{4A} \times P_{C4})$$

As stated previously, these final option relative priorities are usually again normalised by dividing each through the total of all and is often also represented in a graph for ease of use. The numerical values of the results should not be interpreted directly, other than for the purposes of indicating relative importance.

In addition, this model allows for the testing or confirmation of the consistency of the rating through calculation of a consistency ratio (CR) and Saaty (1980) concluded that a CR of less than 0.10 (or 10%) is considered acceptable. To determine the consistency of ranking in any options matrix (or criterion priority matrix), the consistency index (CI) value is calculated first using the formula below for the example of 4 options, where E_{max} denotes the approximation of the maximum eigenvalue:

$$CI = (E_{max} - 4) / (4-1)$$

In this formula, the approximation of the maximum eigenvalue is calculated by adding each column in the priority matrix and multiplying the resultant vector by the priority vector, as shown below, where R_1A represents the numerical total of the ratings in column A for criterion 1, and then multiplying this resultant vector with the priority vector:

$$R_1A = R_{1AA} + R_{1BA} + R_{1CA} + R_{1DA}$$

A row could be added to the options matrix to indicate these totals. The calculation of the E_{max} is then done by multiplication of the resultant vector of totals with the priority vector, using:

$$E_{max} = (R_1A \times P_1A) + (R_1B \times P_1B) + (R_1C \times P_1C) + (R_1D \times P_1D)$$

The consistency ratio (CR) is then calculated by dividing the CI value by the random consistency index (RCI) value, given in the table below for different numbers of options (Saaty (1980)):

RANDOM CONSISTENCY INDEX TABLE	
Number of Options	**RCI**
1	0
2	0
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45

The consistency ratio (CR) is given by:

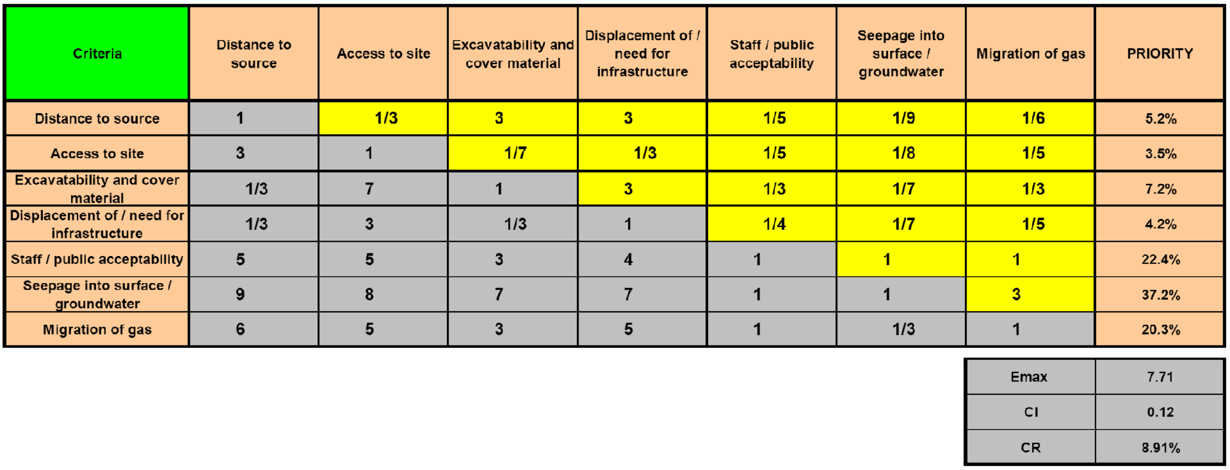
$$CR = CI / RCI$$

Resultant CR values higher than 0.10 (or 10%) warrants a re-evaluation of the pairwise comparisons in the particular matrix.

Input parameters and results of the model:

Option 1	SITE 1	**Criterion 1**	Distance to source
Option 2	SITE 2	**Criterion 2**	Access to site
Option 3	SITE 3a	**Criterion 3**	Excavatability and cover material
Option 4	SITE 3b	**Criterion 4**	Displacement of / need for infrastructure
Option 5	SITE 4a	**Criterion 5**	Staff / public acceptability
Option 6	SITE 4b	**Criterion 6**	Seepage into surface / groundwater
Option 7		**Criterion 7**	Migration of gas
Option 8		**Criterion 8**	

Comparing the criteria with one another to determine the highest priority:



RÖSSING URANIUM LIMITED ~HZW Sites~

Criteria	Distance to source	Access to site	Excavatability and cover material	Displacement of / need for infrastructure	Staff / public acceptability	Seepage into surface / groundwater	Migration of gas	PRIORITY
Distance to source	1	1/3	3	3	1/5	1/9	1/6	5.2%
Access to site	3	1	1/7	1/3	1/5	1/8	1/5	3.5%
Excavatability and cover material	1/3	7	1	3	1/3	1/7	1/3	7.2%
Displacement of / need for infrastructure	1/3	3	1/3	1	1/4	1/7	1/5	4.2%
Staff / public acceptability	5	5	3	4	1	1	1	22.4%
Seepage into surface / groundwater	9	8	7	7	1	1	3	37.2%
Migration of gas	6	5	3	5	1	1/3	1	20.3%

Emax	7.71
CI	0.12
CR	8.91%

Accessing the criteria per site

RÖSSING URANIUM LIMITED ~HZW Sites~

Distance to source	SITE 1	SITE 2	SITE 3a	SITE 3b	SITE 4a	SITE 4b	PRIORITY
SITE 1	1	1/3	1	1/3	1/7	1/9	0.035
SITE 2	3	1	3	1	1/5	1/7	0.080
SITE 3a	1	1/3	1	1/3	1/5	1/9	0.037
SITE 3b	3	1	3	1	1/5	1/8	0.078
SITE 4a	7	5	5	5	1	1/5	0.237
SITE 4b	9	7	9	8	5	1	0.533

Emax	6.54
CI	0.11
CR	8.75%

RÖSSING URANIUM LIMITED ~HZW Sites~

Access to site	SITE 1	SITE 2	SITE 3a	SITE 3b	SITE 4a	SITE 4b	PRIORITY
SITE 1	1	3	5	4	7	4	0.392
SITE 2	1/3	1	6	5	9	3	0.289
SITE 3a	1/5	1/6	1	1/3	1	1/5	0.041
SITE 3b	1/4	1/5	3	1	3	1/4	0.079
SITE 4a	1/7	1/9	1	1/3	1	1/5	0.036
SITE 4b	1/4	1/3	5	4	5	1	0.162

Emax	6.61
CI	0.12
CR	9.89%

RÖSSING URANIUM LIMITED ~HZW Sites~

Excavatability and cover material	SITE 1	SITE 2	SITE 3a	SITE 3b	SITE 4a	SITE 4b	PRIORITY
SITE 1	1	3	5	6	8	9	0.466
SITE 2	1/3	1	3	3	5	6	0.228
SITE 3a	1/5	1/3	1	1/3	4	5	0.094
SITE 3b	1/6	1/3	3	1	5	7	0.145
SITE 4a	1/8	1/5	1/4	1/5	1	1/3	0.029
SITE 4b	1/9	1/6	1/5	1/7	3	1	0.037

Emax	6.58
CI	0.12
CR	9.42%

RÖSSING URANIUM LIMITED ~HZW Sites~

Displacement of / need for infrastructure	SITE 1	SITE 2	SITE 3a	SITE 3b	SITE 4a	SITE 4b	PRIORITY
SITE 1	1	5	7	6	9	5	0.496
SITE 2	1/5	1	5	3	7	3	0.215
SITE 3a	1/7	1/5	1	1/3	2	1/3	0.046
SITE 3b	1/6	1/3	3	1	4	1/3	0.084
SITE 4a	1/9	1/7	1/2	1/4	1	1/5	0.029
SITE 4b	1/5	1/3	3	3	5	1	0.130

Emax	6.55
CI	0.11
CR	8.90%

RÖSSING URANIUM LIMITED ~HZW Sites~

Staff / public acceptability	SITE 1	SITE 2	SITE 3a	SITE 3b	SITE 4a	SITE 4b	PRIORITY
SITE 1	1	7	1	5	3	5	0.350
SITE 2	1/7	1	1/5	2	1	1/3	0.064
SITE 3a	1	5	1	5	4	3	0.319
SITE 3b	1/5	1/2	1/5	1	1/4	1/4	0.040
SITE 4a	1/3	1	1/4	4	1	1/3	0.085
SITE 4b	1/5	3	1/3	4	3	1	0.142

Emax	6.38
CI	0.08
CR	6.06%

RÖSSING URANIUM LIMITED ~HZW Sites~

Seepage into surface / groundwater	SITE 1	SITE 2	SITE 3a	SITE 3b	SITE 4a	SITE 4b	PRIORITY
SITE 1	1	1/4	1/3	1/7	4	1/5	0.050
SITE 2	4	1	5	1/5	5	1/4	0.143
SITE 3a	3	1/5	1	1/7	1	1/3	0.061
SITE 3b	7	5	7	1	9	3	0.475
SITE 4a	1/4	1/5	1	1/9	1	1/5	0.035
SITE 4b	5	4	3	1/3	5	1	0.236

Emax	6.57
CI	0.11
CR	9.18%

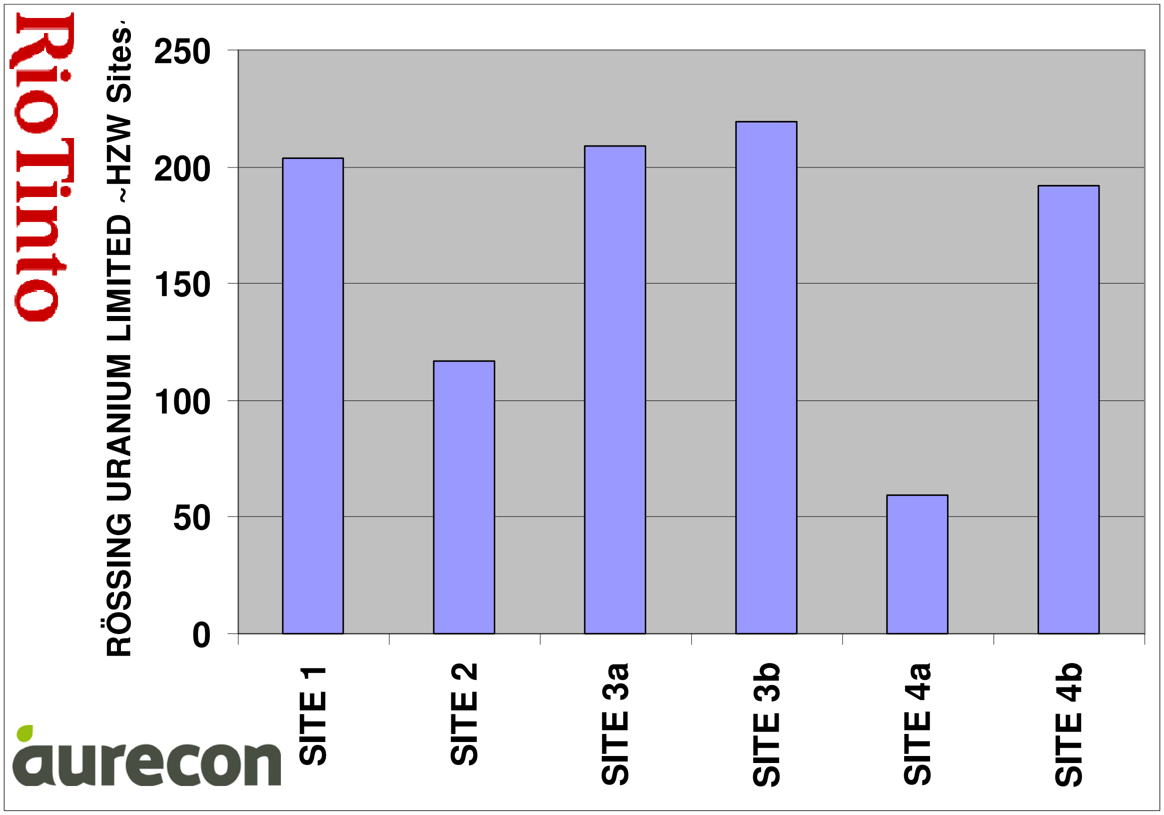
RÖSSING URANIUM LIMITED ~HZW Sites~

Migration of gas	SITE 1	SITE 2	SITE 3a	SITE 3b	SITE 4a	SITE 4b	PRIORITY
SITE 1	1	3	1/5	1/3	3	1	0.116
SITE 2	1/3	1	1/7	1/3	3	1/3	0.063
SITE 3a	5	7	1	5	4	3	0.452
SITE 3b	3	3	1/5	1	3	1/3	0.139
SITE 4a	1/3	1/3	1/4	1/3	1	1/3	0.048
SITE 4b	1	3	1/3	3	3	1	0.182

Emax	6.59
CI	0.12
CR	9.59%

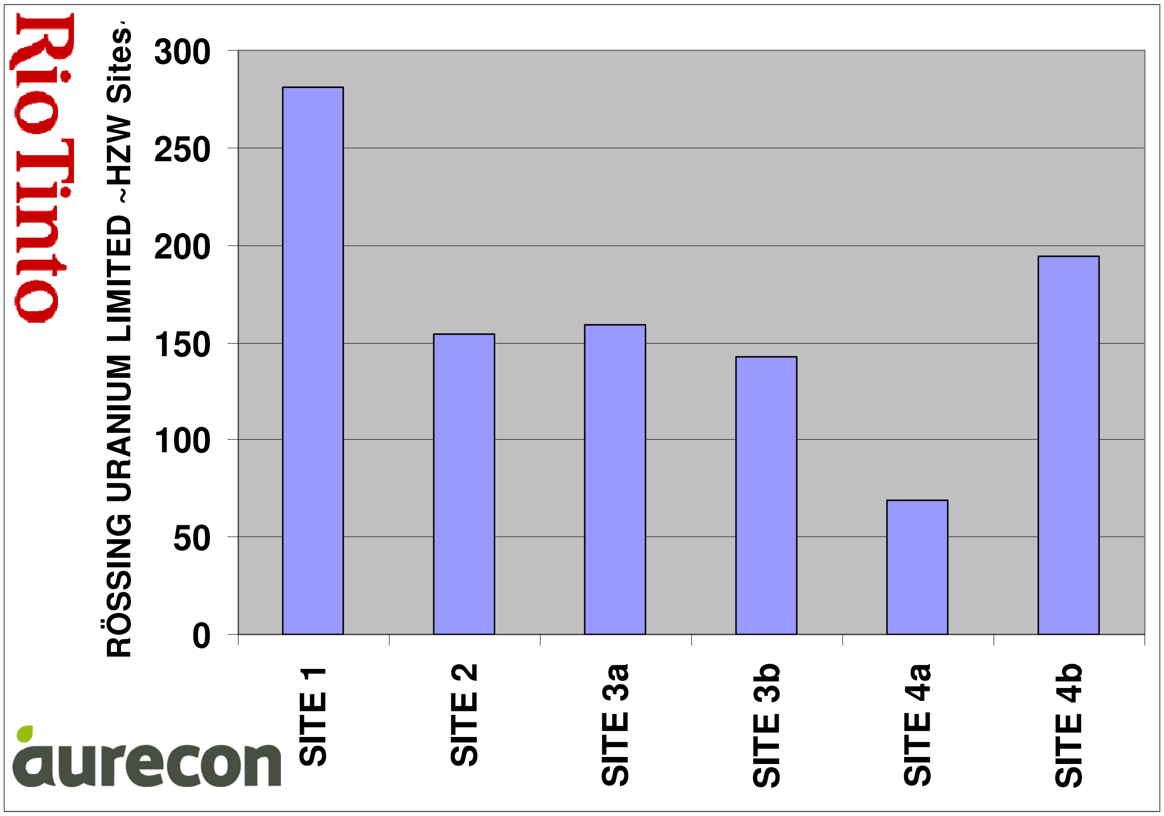
Results based on the criteria priority awarded during assessment:

RANKING RESULTS IDEAL MODE AHP	Distance to source	Access to site	Excavatability and cover material	Displacement of / need for infrastructure	Staff / public acceptability	Seepage into surface / groundwater	Migration of gas
RELATIVE WEIGHT	5.2%	3.5%	7.2%	4.2%	22.4%	37.2%	20.3%



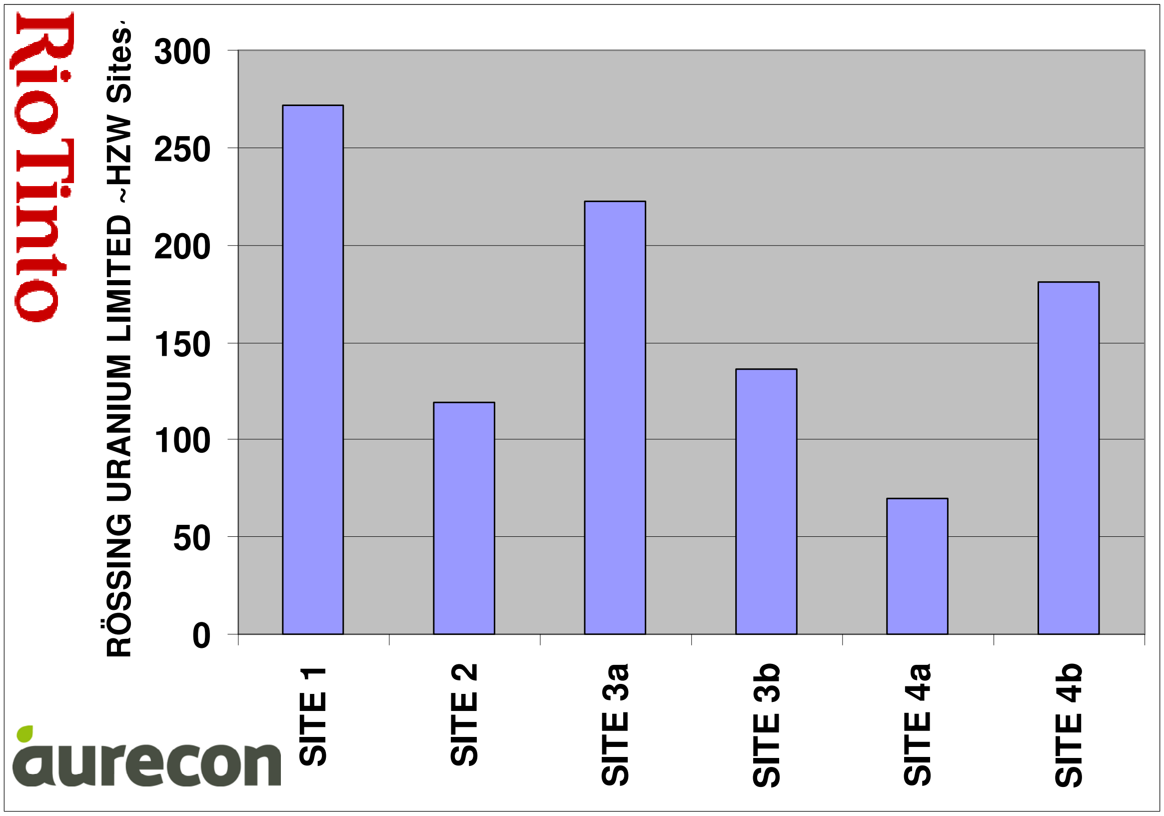
Results of model based on equal weighted criteria

RANKING RESULTS IDEAL MODE AHP	Distance to source	Access to site	Excavatability and cover material	Displacement of / need for infrastructure	Staff / public acceptability	Seepage into surface / groundwater	Migration of gas
RELATIVE WEIGHT	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%	14.3%



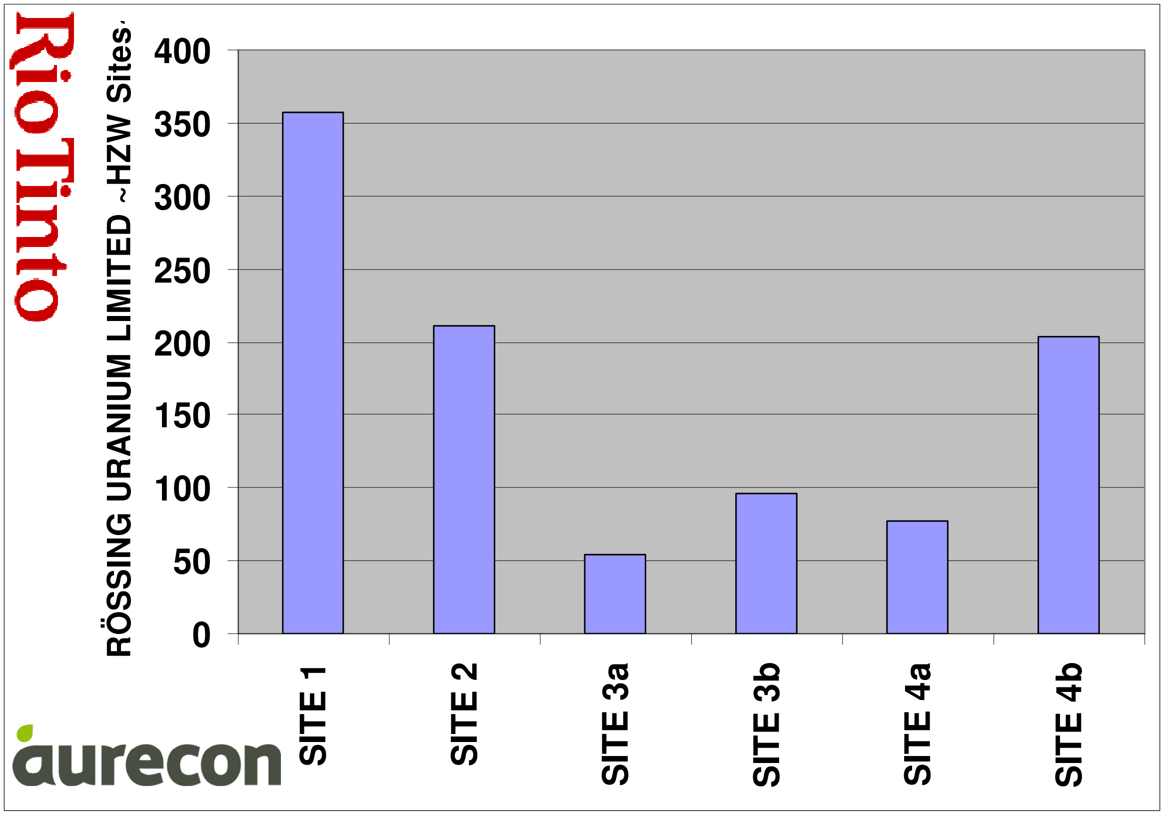
Results of model based on weighted public acceptance criteria only

RANKING RESULTS IDEAL MODE AHP	Distance to source	Access to site	Excavatability and cover material	Displacement of / need for infrastructure	Staff / public acceptability	Seepage into surface / groundwater	Migration of gas
RELATIVE WEIGHT	8.3%	8.3%	8.3%	8.3%	33.4%	16.7%	16.7%



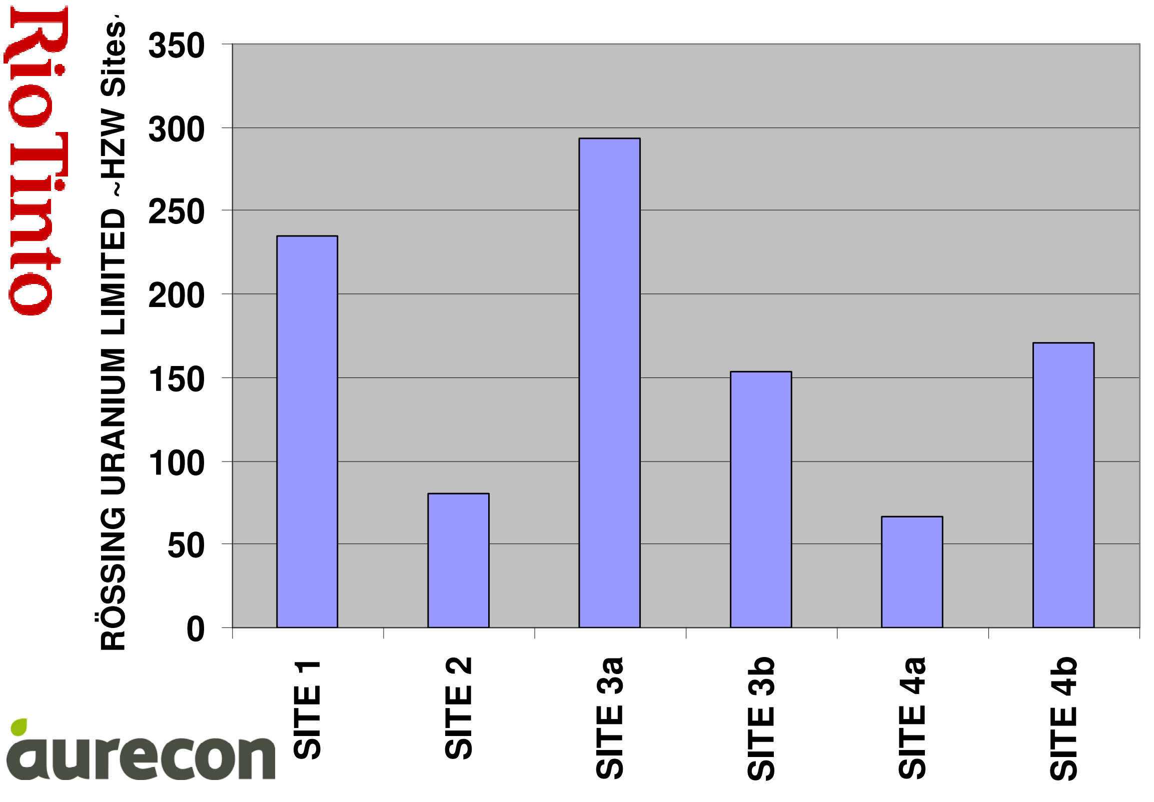
Results of model based on weighted economic criteria only

RANKING RESULTS IDEAL MODE AHP	Distance to source	Access to site	Excavatability and cover material	Displacement of / need for infrastructure	Staff / public acceptability	Seepage into surface / groundwater	Migration of gas
RELATIVE WEIGHT	25.0%	25.0%	25.0%	25.0%	0.0%	0.0%	0.0%



Results of model based on weighted environmental criteria only

RANKING RESULTS IDEAL MODE AHP	Distance to source	Access to site	Excavatability and cover material	Displacement of / need for infrastructure	Staff / public acceptability	Seepage into surface / groundwater	Migration of gas
RELATIVE WEIGHT	0.0%	0.0%	0.0%	0.0%	50.0%	25.0%	25.0%



APPENDIX D

Wastes that should not be Landfilled

Appendix D

Government Gazette RSA, 7 September 2001

LIST OF HAZARDOUS OR TOXIC MATERIAL WHICH MAY NOT BE DISPOSED OF ON A GENERAL DISPOSAL SITE.

1. Waste where specific control has been established in terms of the Nuclear Energy Act, 1993 (Act 131 of 1993).
2. Waste types controlled in terms of the Minerals Act, 1991 (act 50 of 1991) and the Electricity Act, 1987 (Act 41 of 1987), unless written permission has been obtained from the Regional Director.
3. Waste which is defined, according to the Minimum Requirements, as an extreme hazard or Hazard Group 1 (HG1); High hazard or Hazard Group 2 (HG2); moderate hazard or Hazard Group 3 (HG3) and low hazard or Hazard Group 4 (HG4), unless an application for delisting has been successfully submitted to the regional Director and written approval was obtained from the Regional Director for the disposal of the waste on the Site.
4. Flammable wastes, with a closed cup flash point less than 61°C.
5. Corrosive substances, as defined and described in the Minimum Requirements as Class 8 (1998 edition: page 6-8, Diagram III).
6. Oxidising substances and organic peroxides, as defined and described in the Minimum Requirements as Class 5 (1998 edition: page 6-8, Diagram III)
7. Any waste with a substance which is a Group A and /or Group B carcinogen/mutagen. Group A carcinogens/mutagens have been proven in humans, both clinical and epidemiological. Group B carcinogens/mutagens have been proven without a doubt in laboratory animals.
8. Any waste with a substance at a concentration greater than 1% where the substance is a Group C and/or Group D carcinogen/mutagen. Group C carcinogens/mutagens have shown limited evidence in animals. Group D carcinogen/mutagen – the available data is inadequate and doubtful.
9. Any infectious waste, unless it has been incinerated in 800°C or higher for at least 1 second. Infectious waste is waste which is generated during the diagnosis, treatment or immunisation of humans or animals; in the research pertaining to this; in the manufacturing or testing of biological agents including blood, blood products and contaminated blood products, cultures, pathological wastes, sharps, human and animal anatomical waste and isolation waste that contain or may contain infectious substances.
10. All materials which falls in Class 1 (explosives), Class 2 (compressed gasses) and Class 7 (radioactive materials), as defined and described in the Minimum Requirements.
11. Any waste with a pH less than 6 or greater than 12.
12. Any waste which is difficult to analyse and classify.
13. Any complexes of heavy metal cations, paint and paint sludge, or laboratory chemicals.

As a general guide the wastes described as follows should not be landfilled:

- Waste with high percentages of volatile organic content;

- Waste with high percentages of aromatic, halogenated and nonhalogenated compounds;

- Wastes with high percentages of metals, especially arsenic, cadmium, lead, mercury and selenium;

- Wastes with a high percentage of cyanide and sulphide;

- Powdery hazardous waste that may cause dust problems in and around the landfill;

- Large amounts of waste with very low shear strength that may preclude settlement particularly on the final lifts, near the surface (for example sewage sludge with a high moisture content);

- Waste with high percentages of liquid that may generate too much leachate (for example tankers of liquid waste).

It should be understood that any recommendation of specific acceptable concentration levels of hazardous materials is not viable because of the fairly unregulated manner in which waste enters a landfill and in which a landfill is operated. The wastes mentioned above are permissible on the landfill site but in amounts which are not potentially harmful. In this regard, it will be necessary for a Hazard Rating System, perhaps according to the United States EPA's methodology, to be drawn up. The South African Minimum Requirements series could also act as an excellent guideline.

Wastes, which should, under no circumstances, be allowed onto the site in any form, are:

- Strong Acids and Alkalis (these should be diluted to a pH of 8-9);
- PCB's;
- Explosive materials;
- Compressed gases;
- Radioactive material.

As per RSA Minimum Requirements Class 7, Radioactive wastes, are covered by the Atomic Energy Act, 1967, (Act 90 of 1967) and the Hazardous Substances Act, 1973 (Act 15 of 1973); their disposal in a landfill is PROHIBITED.

Only those radioactive wastes defined as "inactive", i.e., with a specific activity less than 100 becquerels per g (Bq/g) and total activity less than 4 kBq (0.1uCi), may be disposed as waste in terms of the RSA regulations. Becquerel is a measurement of decay and measures all radioactivity (alpha, beta and gamma rays) of a waste body.

In terms of Rossing's procedures on disposal of contaminated items, JK65/PRD/003, no contaminated waste shall be disposed or dumped on the domestic waste disposal site (Landfill Site). This would then include items such as radioactive waste. As stated this procedure deals with the redundant items that are contaminated and are to be disposed of at the Tailings Impoundment according to the following contamination criteria;

Total of fixed and non-fixed radioactivity	> 0.4 Bq/cm^2 (averaged over 300 cm^2)	Tailings Impoundment

The latter would then be in line with the RSA Dept Minerals and Energy (Radioactive waste management policy (draft)) to dispose of such waste in deep impoundments or deep earth burial and covering.

In summary therefore:

- Contaminated waste less than 100 becquerels per g (Bq/g) and total activity less than 4 kBq (0.1uCi), may be disposed as waste in a hazardous waste landfill;
- Contaminated waste more than 100 becquerels per g (Bq/g) or > 0.4 Bq/cm2 (averaged over 300 cm2) will have to be disposed in the tailings impoundment for now and as such may not be disposed in any landfill.

APPENDIX E

Environmental Impact Assessment Methodology

Appendix E

Impact Assessment Methodology

For each impact, the EXTENT (spatial scale), MAGNITUDE (size or degree scale) and DURATION (time scale) will be described. These criteria are used to ascertain the SIGNIFICANCE of the impact, firstly in the case of no mitigation and then with the most effective mitigation measure(s) in place. The mitigation described in the SEIA Report will represent the full range of plausible and pragmatic measures but does not necessarily imply that they should or will all be implemented. The decision as to which combination of alternatives and mitigation measures to apply for will lie with RU as the proponent, and their acceptance and approval ultimately with MET:DEA and MME. The SEIA Report will explicitly describe RU's commitments in this regard. The tables on the following pages show the scales used to assess these variables and define each of the rating categories.

Table 1: Assessment criteria for the evaluation of impacts

CRITERIA	CATEGORY	DESCRIPTION
Extent or spatial influence of impact	**National**	Within Namibia
	Regional	Within the Erongo Region
	Local	Mine Licence Area and Mine Accessory Works Area
*** Magnitude of impact (at the indicated spatial scale)**	**High**	Social and/or natural functions and/ or processes are *severely* altered
	Medium	Social and/or natural functions and/ or processes are *notably* altered
	Low	Social and/or natural functions and/ or processes are *slightly* altered
	Very Low	Social and/or natural functions and/ or processes are *negligibly* altered
	Zero	Social and/or natural functions and/ or processes remain *unaltered*
Duration of impact	**Short term** (construction period)	Up to 3 years
	Medium Term	Between 3 and 10 years
	Long Term	More than 10 years after construction

The SIGNIFICANCE of an impact is derived by taking into account the temporal and spatial scales and magnitude. The means of arriving at the different significance ratings is explained in the following table, developed by Ninham Shand in 1995 as a means of minimising subjectivity in such evaluations, i.e. to allow for standardisation in the determination of significance.

Table 2: Definition of significance ratings

SIGNIFICANCE RATINGS	LEVEL OF CRITERIA REQUIRED
High	High magnitude with a regional extent and long term duration High magnitude with either a regional extent and medium term duration or a local extent and long term duration Medium magnitude with a regional extent and long term duration

Medium	High magnitude with a local extent and medium term duration High magnitude with a regional extent and construction period or a site specific extent and long term duration High magnitude with either a local extent and construction period duration or a site specific extent and medium term duration Medium magnitude with any combination of extent and duration except site specific and construction period or regional and long term Low magnitude with a regional extent and long term duration
Low	High magnitude with a site specific extent and construction period duration Medium magnitude with a site specific extent and construction period duration Low magnitude with any combination of extent and duration except site specific and construction period or regional and long term Very low magnitude with a regional extent and long term duration
Very low	Low magnitude with a site specific extent and construction period duration Very low magnitude with any combination of extent and duration except regional and long term
Neutral	Zero magnitude with any combination of extent and duration

Once the significance of an impact has been determined, the PROBABILITY of this impact occurring as well as the CONFIDENCE in the assessment of the impact would be determined using the rating systems outlined in the following two tables. It is important to note that the significance of an impact should always be considered in concert with the probability of that impact occurring.

Table 3: Definition of probability ratings

PROBABILITY RATINGS	CRITERIA
Definite	Estimated greater than 95% chance of the impact occurring.
Probable	Estimated 5 to 95% chance of the impact occurring.
Unlikely	Estimated less than 5% chance of the impact occurring.

Table 4: Definition of confidence ratings

CONFIDENCE RATINGS	CRITERIA
Certain	Wealth of information on and sound understanding of the environmental factors potentially influencing the impact.
Sure	Reasonable amount of useful information on and relatively sound understanding of the environmental factors potentially influencing the impact.
Unsure	Limited useful information on and understanding of the environmental factors potentially influencing this impact.

Lastly, the REVERSIBILITY of the impact is estimated using the rating system outlined in the following table.

Table 5: Definition of reversibility ratings

REVERSIBILITY RATINGS	CRITERIA
Irreversible	The activity will lead to an impact that is permanent.
Reversible	The impact is reversible, within a period of 10 years.

APPENDIX F

Environmental Impacts and Mitigation

IMPACTS DURING CONSTRUCTION PHASE

IMPACTS	IMPACT WITH NO MITIGATION	IMPACT WITH MITIGATON	MITIGATION MEASURE
Socio-Economic Impacts: Visual Impact: Change in landform			**Excavations of channels and road ways will alter the lower landform temporarily during construction.**
Extent	Local	NA	
Magnitude	Very low	NA	
Duration	Short term	NA	
Significance	**Very low(-)**	NA	
Probability	Probable	NA	
Confidence	Certain	NA	
Reversibility	Reversible	NA	
Impact on Soil: Contamination by oil, fuel, etc.			**Preventative measures to be put in place by the contractor such as drip pans, etc. when refueling**
Extent	Local	Local	
Magnitude	Very low	Very low	
Duration	Short term	Short term	
Significance	**Very low(-)**	**Very low(-)**	
Probability	Definite	Definite	
Confidence	Certain	Certain	
Reversibility	Reversible	Reversible	
Impact on Soil: Alteration & compaction of original soil			**Compacted soil to be ripped and fertility improved where necessary**
Extent	Local	Local	
Magnitude	Very low	Zero	
Duration	Short term	Short term	
Significance	**Very low(-)**	**Neutral**	
Probability	Definite	Unlikely	
Confidence	Certain	Certain	
Reversibility	Reversible	Reversible	
Impact on Soil: Increased rate of erosion			**Preventative measures to be taken through the design and construction.**
Extent	Local	Local	
Magnitude	Very low	Very low	
Duration	Short term	Short term	

Significance	**Very low(-)**	**Very low(-)**	
Probability	Definite	Definite	
Confidence	Certain	Certain	
Reversibility	Reversible	Reversible	
Impact on Soil: Loss of cover			**Impact is temporary – cover material to be replaced where required**
Extent	Local	Local	
Magnitude	Very low	Zero	
Duration	Short term	Short term	
Significance	**Very low(-)**	**Neutral**	
Probability	Definite	Definite	
Confidence	Certain	Certain	
Reversibility	Irreversible	Reversible	
Impact on Water: Changes to drainage system			**Engineered drainage pathways to blend in with surrounding system.**
Extent	Local	Local	
Magnitude	Low	Very low	
Duration	Short term	Short term	
Significance	**Very low(-)**	**Very low(-)**	
Probability	Definite	Definite	
Confidence	Certain	Certain	
Reversibility	Reversible	Reversible	
Impact on Water: Surface water contamination			**Preventative control measures to be put in place.**
Extent	Local	Local	
Magnitude	Very low	Very low	
Duration	Short term	Short term	
Significance	**Very low(-)**	**Very low(-)**	
Probability	Definite	Definite	
Confidence	Certain	Certain	
Reversibility	Reversible	Reversible	
Impact on Water: Possible ground water contamination			**Preventative measures to be taken in design.**
Extent	Local	Local	
Magnitude	Very low	Zero	
Duration	Short term	Short term	
Significance	**Very low (-)**	**Neutral**	
Probability	Definite	Definite	
Confidence	Certain	Certain	
Reversibility	Reversible	Reversible	

Impact on Air: Pollution due to construction dust, smoke and odours			**The impact is during construction and operations. Dust suppression to be initiated and control over construction plant**
Extent	Local	Local	
Magnitude	Very low	Very low	
Duration	Short term	Short term	
Significance	**Very low(-)**	**Very low(-)**	
Probability	Definite	Definite	
Confidence	Certain	Certain	
Reversibility	Reversible	Reversible	
Impact on Air: Noise pollution from vehicle operation			**Preventative measures to be taken on limited number of vehicles /machinery used to prepare the site. Vehicles to be road worthy**
Extent	Local	Local	
Magnitude	Very low	Very low	
Duration	Short term	Short term	
Significance	**Very low(-)**	**Very low(-)**	
Probability	Definite	Definite	
Confidence	Certain	Certain	
Reversibility	Reversible	Reversible	
Impact on Bio-diversity: Destruction of wildlife habitat			**Destruction area during construction very limited. Site most likely to be place on reworked area**
Extent	Local	NA	
Magnitude	Very low	NA	
Duration	Short term	NA	
Significance	**Very low(-)**	NA	
Probability	Definite	NA	
Confidence	Certain	NA	
Reversibility	Irreversible	NA	
Socio-Economic Impacts: Perceptions	**No impact**	**No impact**	**Set up participation programme where required**
Extent	Local	Local	
Magnitude	Very low	Very low	
Duration	Short term	Short term	
Significance	**Very low(-)**	**Very low(-)**	
Probability	Definite	Definite	
Confidence	Certain	Certain	

Reversibility	Reversible	Reversible	
Socio-Economic Impacts: Increased traffic and potential for accidents			**Provide temporary access or deviations**
Extent	Local	Local	
Magnitude	Very low	Very low	
Duration	Short term	Short term	
Significance	**Very low(-)**	**Neutral**	
Probability	Probable	Probable	
Confidence	Certain	Certain	
Reversibility	Reversible	Reversible	
Socio-Economic Impacts: Noise and vibrations			**Impact is short term. Limit offices or accommodation close to the site.**
Extent	Local	Local	
Magnitude	Very low	Very low	
Duration	Short term	Short term	
Significance	**Very low(-)**	**Very low(-)**	
Probability	Definite	Definite	
Confidence	Certain	Certain	
Reversibility	Reversible	Reversible	
Socio-Economic Impacts: Influx of temporary workers	**No impact**	**No impact**	**Only as part of the construction team – well controlled system on mine.**
Extent	Local	Local	
Magnitude	Very low	Zero	
Duration	Short term	Short term	
Significance	**Very low(-)**	**Neutral**	
Probability	Probable	Definite	
Confidence	Certain	Certain	
Reversibility	Reversible	Reversible	

DURING OPERATIONAL PHASE

IMPACTS	**IMPACT WITH NO MITIGATION**	**IMPACT WITH MITIGAITON**	**MITIGATION MEASURE**
Impact on Water: Pollution of ground water			**Construction of liner and well drained site with no waste disposed in water**
Extent	Local	Local	
Magnitude	High	Very low	
Duration	Long term	Long term	
Significance	**Low(-)**	**Very low(-)**	
Probability	Probable	Probable	

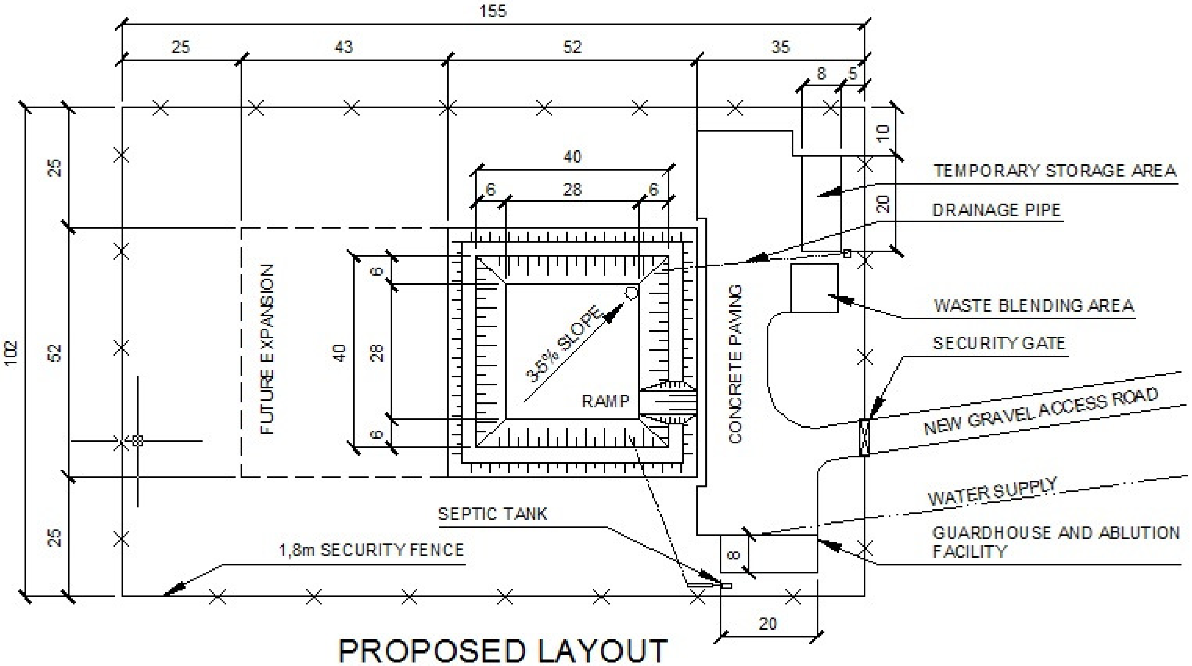
Confidence	Certain	Certain	
Reversibility	Irreversible	Reversible	
Impact on Water: Siltation of streams due to exposed surfaces			**Ensure flat slopes in well drained areas – engineered design drainage system required.**
Extent	Local	Local	
Magnitude	Low	Very low	
Duration	Long term	Long term	
Significance	**Low(-)**	**Very low(-)**	
Probability	Probable	Probable	
Confidence	Certain	Certain	
Reversibility	Reversible	Reversible	
Impact on Water: Pollution of surface water			**Surface water to be kept out of the waste body – to be drained away from waste**
Extent	Local	Local	
Magnitude	High	Very low	
Duration	Long term	Long term	
Significance	**Very low(-)**	**Very low(-)**	
Probability	Probable	Probable	
Confidence	Certain	Certain	
Reversibility	Irreversible	Reversible	
Impact on Air: Incidence of fires			**Waste to be covered regularly with no smoking on site and operations monitored**
Extent	Local	Local	
Magnitude	Very low	Zero	
Duration	Long term	Long term	
Significance	**Very low(-)**	**Very low(-)**	
Probability	Probable	Unlikely	
Confidence	Certain	Certain	
Reversibility	Reversible	Reversible	
Impact on Air: Odours from landfill			**Waste to be covered regularly and operations monitored**
Extent	Local	Local	
Magnitude	High	Very low	
Duration	Long term	Long term	
Significance	**High(-)**	**Low(-)**	
Probability	Definite	Probable	
Confidence	Certain	Certain	
Reversibility	Reversible	Reversible	

Impact on Bio-diversity: Invader plant introduction			**Remove weeds/invader plants at landfill with no outside soil for cover**
Extent	Local	Local	
Magnitude	Very low	Very low	
Duration	Long term	Long term	
Significance	**Very low(-)**	**Very low(-)**	
Probability	Probable	Probable	
Confidence	Sure	Sure	
Reversibility	Reversible	Reversible	
Socio-economic impact: Accidents due to increased traffic			**Volume of waste is still small but access road to be improved**
Extent	Local	Local	
Magnitude	Low	Very low	
Duration	Long term	Long term	
Significance	**Low(-)**	**Very low(-)**	
Probability	Probable	Probable	
Confidence	Sure	Sure	
Reversibility	Irreversible	Irreversible	
Socio-economic impact: Job creation			**Recruit local labour as far as possible especially on recycling of materials**
Extent	Local	Local	
Magnitude	Low	Very low	
Duration	Long term	Long term	
Significance	**Neutral**	**Very low (+)**	
Probability	Probable	Probable	
Confidence	Certain	Certain	
Reversibility	Reversible	Reversible	
Socio-economic impact: Land use conflicts			**After-use will return land to original use. To inform communities**
Extent	Local	NA	
Magnitude	Very low	NA	
Duration	Long term	NA	
Significance	**Very low(-)**	NA	
Probability	Definite	NA	
Confidence	Certain	NA	
Reversibility	Reversible	NA	
Socio-economic impact: Danger to health & safety of workers.			**Workers to be properly trained and access control to be enforced.**
Extent	Local	Local	
Magnitude	High	Low	

Duration	Long term	Long term	
Significance	**High(-)**	**Low(-)**	
Probability	Probable	Probable	
Confidence	Certain	Certain	
Reversibility	Irreversible	Irreversible	

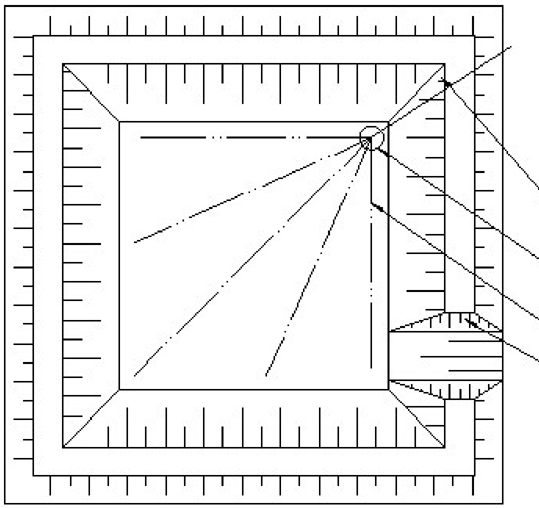
APPENDIX G

Conceptual Design Drawings



PROPOSED LAYOUT

SCALE 1:100



LEACHATE DRAINAGE LAYOUT

SCALE 1:50

CLIENT

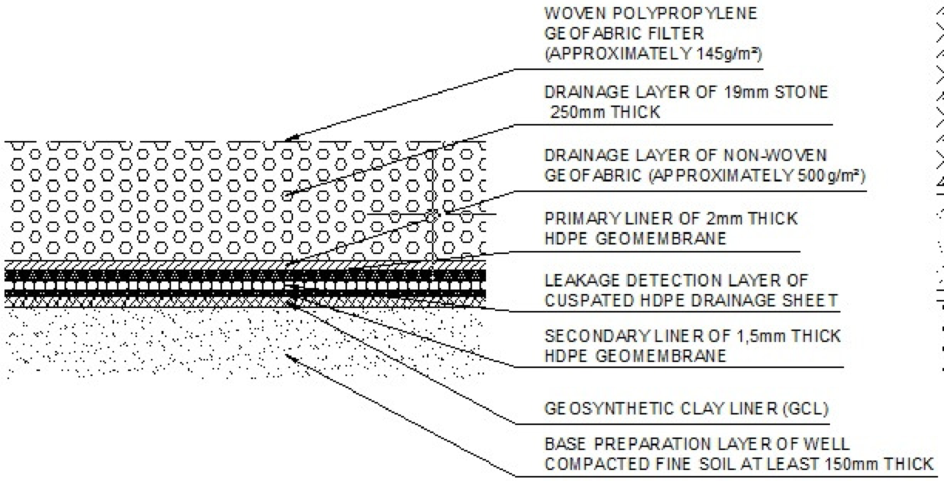
PASCO
WASTE & ENVIRONMENTAL
CONSULTING

PROJECT
ROSSING URANIUM
MINE - HAZARDOUS
WASTE LANDFILL

DRAWING TITLE
PROPOSED LANDFILL
LAYOUT

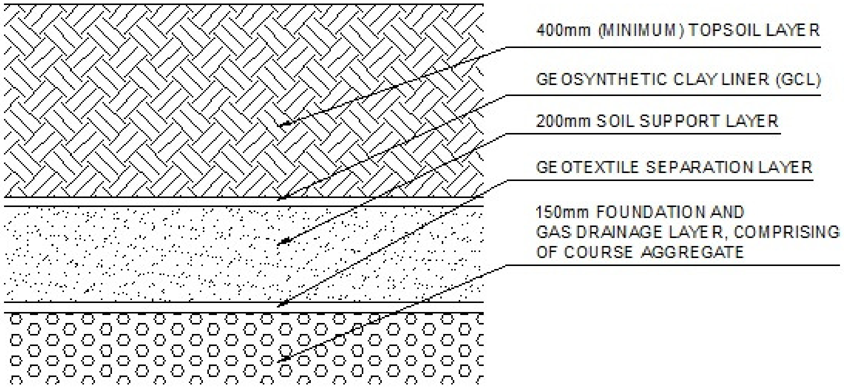
DATE
10.12.2009

DRAWING NO.
1070-HAZ-01



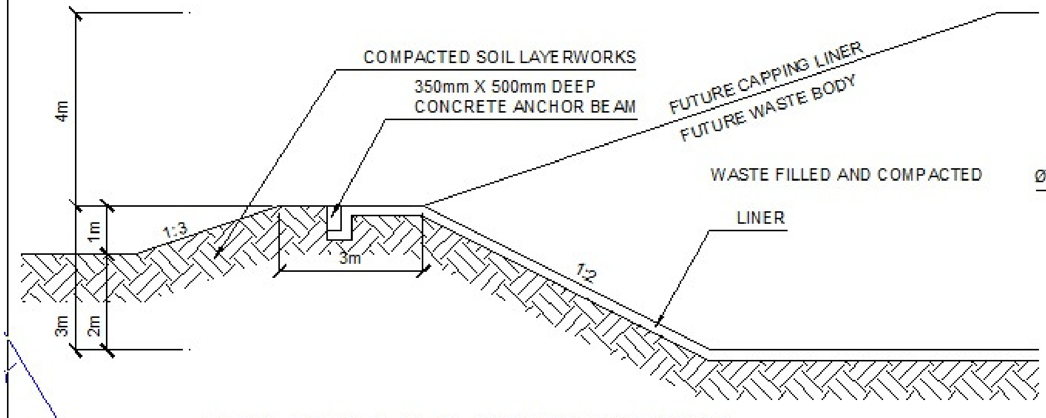
HAZARDOUS WASTE LINER DETAIL

NTS



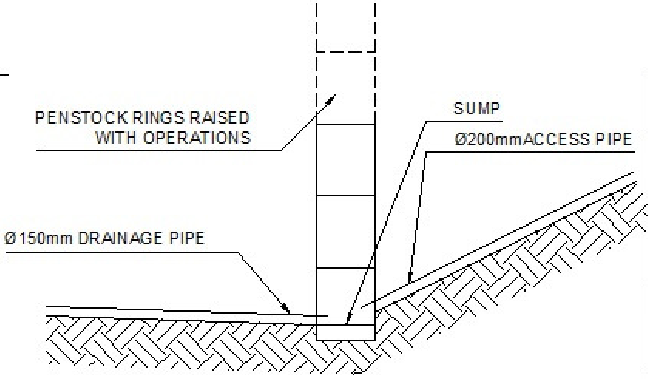
CAPPING LINER DETAIL

NTS



SECTION THROUGH BUND WALL

NTS



DRAINAGE SYSTEM

NTS

CLIENT

RioTinto

Rössing Uranium

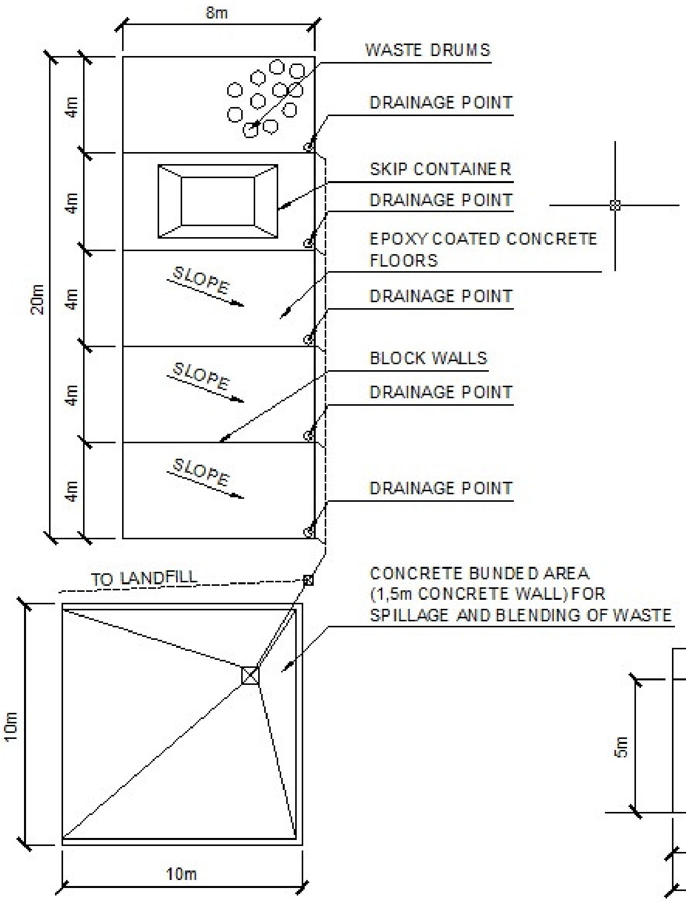
PASCO
WASTE & ENVIRONMENTAL CONSULTING

PROJECT
ROSSING URANIUM MINE - HAZARDOUS WASTE LANDFILL

DRAWING TITLE
PROPOSED LANDFILL DETAILS

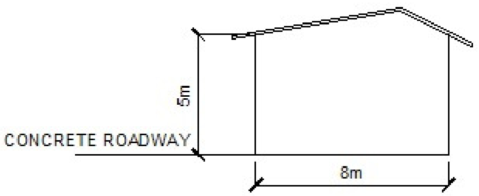
DATE
10.12.2009

DRAWING NO.
1070-HAZ-02



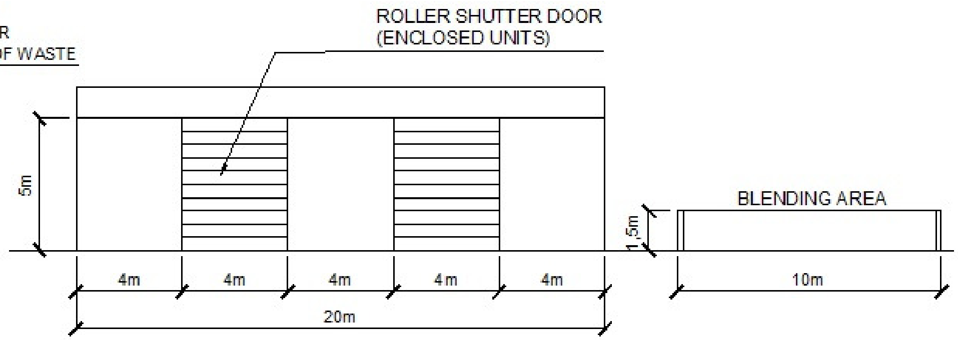
TEMPORARY STORAGE AND SPILLAGE CONTAINMENT AREA LAYOUT

NTS



TEMPORARY STORAGE FACILITY SIDE ELEVATION

NTS



TEMPORARY STORAGE FACILITY FRONT ELEVATION

NTS

CLIENT
RioTinto
Rössing Uranium

PASCO
WASTE & ENVIRONMENTAL CONSULTING

PROJECT
ROSSING URANIUM MINE - HAZARDOUS WASTE LANDFILL

DRAWING TITLE
TEMPORARY STORAGE AREA

DATE
10.12.2009

DRAWING NO.
1070-HAZ-03