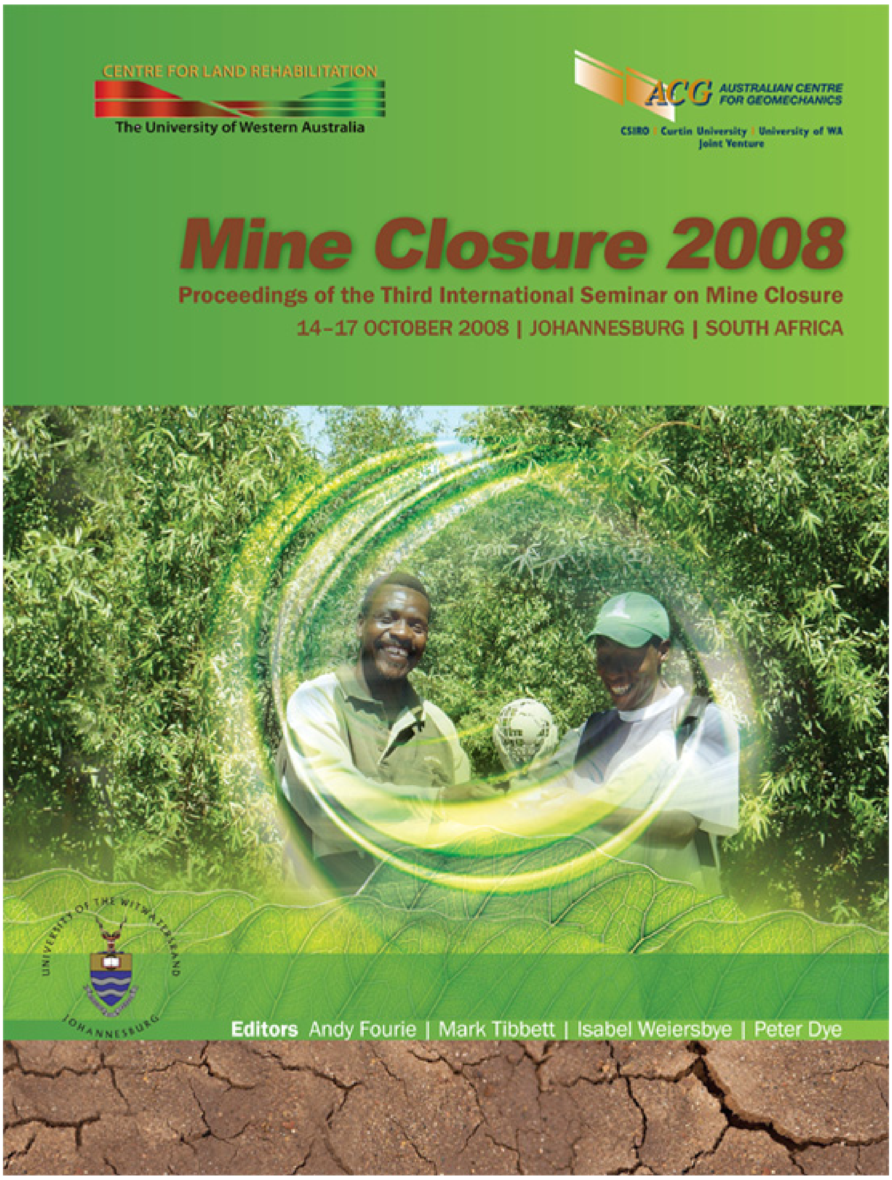
ACG AUSTRALIAN CENTRE FOR GEOMECHANICS

CSIRO | Curtin University | University of WA
Joint Venture



The following paper appeared in the Third International Seminar on Mine Closure 2008 proceedings published by the Australian Centre for Geomechanics.

© Copyright 2008. Australian Centre for Geomechanics (ACG), The University of Western Australia. All rights reserved. No part of any ACG publication may be reproduced, stored or transmitted in any form without the prior permission of the ACG.

Note to authors: This version of your work is owned by the ACG.

Authors of the papers and third parties must obtain written permission from the ACG to publish all or part of these papers in future works. Suitable acknowledgement to the original source of publication must be included.

This material may be used only on the following conditions:

- Copies of the material may be saved or printed for personal use only and must not be forwarded or sold to any third party.
- Commercial exploitation of the material is prohibited.

For further information:

Ms Rebecca Hitchings
Communications Manager

bec@acg.uwa.edu.au
Ph: +61 8 6488 3300

Australian Centre For Geomechanics
PO Box 3296
NEDLANDS WA 6008
AUSTRALIA
www.acg.uwa.edu.au

Mine Closure 2008 – A.B. Fourie, M. Tibbett, I.M. Weiersbye, P.J. Dye (eds)
© 2008 Australian Centre for Geomechanics, Perth, ISBN 978-0-9804185-6-9

Mining for Closure — Design Considerations for UraMin's Trekkopje Uranium Project

D. Limpitlaw *Turgis Consulting, South Africa*

T. Mandziak *SRK Consulting, United States of America*

I. Macpherson *UraMin, South Africa*

Abstract

The Trekkopje Uranium Project, located in the Namib Desert in Namibia, will be a large, shallow open cast mine with a production rate of 100,000 tons of ore per day, at a stripping ratio of 0.23. The scale and location of the project in the sensitive, hyper arid Namib necessitated a cost effective design that minimized impacts on the environment and facilitated closure. Restoring vegetative cover and ecosystem function in a desert setting is difficult, and minimizing the footprint of the mine to start with was adopted as a key design criterion.

The low grade ore required a cost effective means of extracting the uranium, and heap leaching was selected as the preferred approach. As a permanent, or dedicated, single lift heap leach pad (HLP) would have covered an area at least as large as the pit, an on-off heap leach pad was selected. Using this method, the crushed ore would be leached on a synthetically lined surface, with the spent ore being returned to the mine, minimizing the disturbance footprint and allowing concurrent reclamation of the mine. The final landforms arising from this approach are closer to the original land surface relative to a permanent HLP, and the total area disturbed is significantly smaller.

Other design features intended to assist the mine in meeting the main objectives of reclamation included: long-term slope stability and public safety (including radiological impact mitigation); minimizing environmental impacts; minimizing the total mining land footprint and landscape integration while complying with regulations.

In addition, plant rescue missions are mounted to remove rare and endemic plants from the path of mining, and an indigenous nursery is run to supply plants for the rehabilitated areas.

Work is ongoing for several key areas of the design, including residues management, ground water impact avoidance, the requirements of the final cover to protect against erosion, intrusion and radiological impact, and future land-use options for the site.

This paper is a report on work in progress and illustrates the benefit of integrating environmental considerations into the mine design from the initiation of the process.

1 Introduction

The shallow uranium deposits on the farms Trekkopje, Klein Trekkopje and Arandis have been extensively drilled and frequently assessed for mining potential. The Trekkopje deposit consists of the Trekkopje and the adjacent Klein Trekkopje orebodies. The former has a horizontal extent of approximately 5.5 km and the latter approximately 15 km, both extending to a maximum depth of about 30 m. The ore is hosted in ancient valleys filled millions of years ago by Namib Group sediments that have subsequently been cemented by calcite, dolomite and gypsum. The sediments overlie the schists and marbles of the Karibib Formation and are in turn covered by a 1-2 m thick gypcrete layer which thins towards the east. It is thought that uranium, originating from the erosion of the Spitzkoppe domes, was deposited into these sediments sometime after they were laid down. The dominant ore mineral at Trekkopje is carnotite – a uranium mineral that forms when uranium-rich groundwater evaporates in an extremely arid environment (AEC, 1997). Carnotite is a hydrated potassium uranium vanadate $K_2(UO_2)_2(VO_4)_2.3H_2O$.

The Trekkopje site lies 70 km north-northeast of Swakopmund, covering an area of 37,000 ha. The Rössing Uranium mine lies 35 km south of the property, and the recently developed Langer Heinrich Uranium mine lies 81 km to the south-southeast within the Namib-Naukluft Park (Figure 1). The mining tenement occurs within the //Gaingu Conservancy, communal land vested in the State by the Constitution. The State has a duty to administer such lands in trust for the benefit of traditional communities residing on them. No settlements occur on the tenement and the tenement and surrounding lands are wilderness lands which are rarely used for seasonal grazing and occasional hunting.

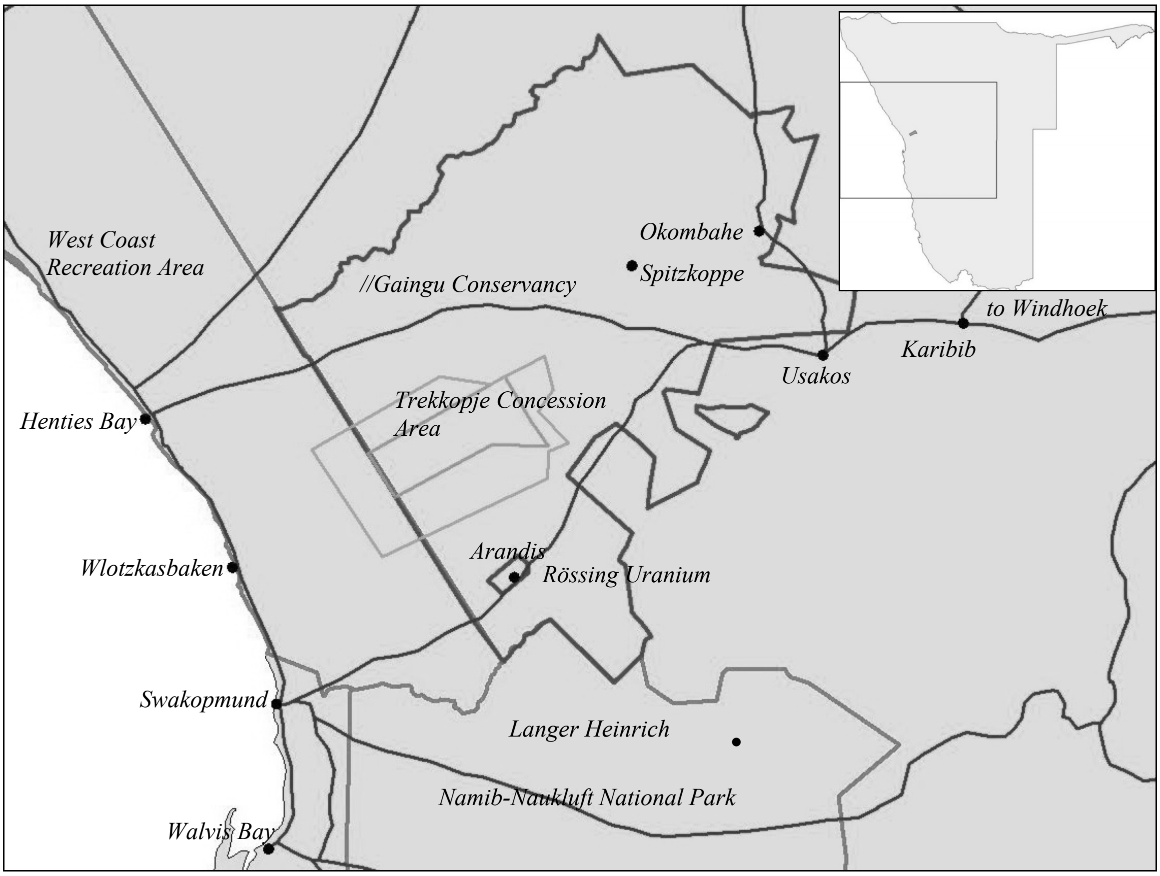


Figure 1 Regional setting of the Trekkopje Uranium Project

The Namib Desert is believed to be the world's oldest desert and it has been arid for at least 55 million years. This lengthy dry period has had a significant influence on the region's biodiversity, which has remained a relatively stable centre for the evolution of desert species. This has resulted in a unique biophysical environment, which gave rise to an array of biodiversity with high levels of endemism and numerous advanced adaptations to arid conditions.

2 Mining projects, energy and development

2.1 Uranium mining – feed for nuclear power plants

Currently available technology has allowed renewable energy generation, especially solar and wind powered systems, to be viable for small scale electricity generation. These systems are largely non-polluting and therefore very attractive, but are not currently capable of meeting base-load power requirements, largely due to low capacity factors. The high environmental costs associated with fossil fuels, especially those arising from climate forcing through greenhouse gas emissions make this traditional source of power generation unattractive. Unless society radically reduces its energy consumption, which is unlikely, alternative sources of energy will be needed. Uranium, which has its own disadvantages, can be used to bridge this gap. For example, nuclear power plants typically produce only 10% of the CO_2 emissions of a similarly sized coalfired power station (Willis, 2006), but generate small volumes of hazardous waste which remains radioactive for long periods of time. Consequently, stringent management measures are required.

2.2 Poverty and underdevelopment in Namibia

Even though Namibia is considered a middle income country (US$2371 per capita in 2004: World Bank, 2006), wealth distribution is extremely skewed. An estimated 55% of national income accrues to only 10% of the population and it is estimated that more than 35% of the population lives on less than US$1/day (World Bank, 2006).

Social indicators show high unemployment rates at 36.7% (The Namibian, 2006) and the population growth outpaces job creation as only 7000 of 20,000 annual high school graduates find jobs, and 60% of the workforce is unemployed or underemployed (USAID, 2006). Employment figures also reflect that women are still under-represented in the economy with 56.4% of males employed compared to 40.7% of females.

The proposed Trekkopje project will contribute not only towards the achievement of national development objectives, but more directly to the alleviation of poverty and unemployment in local communities. A particularly significant contribution will be the raising of low skills levels in both Arandis and Spitzkoppe in technical, conservation and management fields.

Liabilities that may be anticipated and need to be addressed through management plans include environmental impacts, including potential pollution, environmental degradation and disruption of ecosystems over large areas, increased demand for and use of natural resources, including water, potential radiation hazards, potential social dislocation, unsustainable economic development, and loss of land-use. The challenge is to provide measures that manage social impacts and growth, while minimizing long-term damage to ecosystems – the last issue is particularly important for closure planning.

3 Mining and processing

The Trekkopje deposits are well suited to extraction by surface (open pit) mining methods. At Trekkopje the mining would be similar to a strip mine given the very shallow depth of the deposit (with 80% of mineralization shallower than 20 m). The surface topsoil (growth medium) will be removed and stored for later replacement in the rehabilitation phase. Hydraulic shovels will mine the ore at a rate of 100,000 t/d and load the ore directly into off-highway trucks which will then transport the ore to a mobile primary crushing plant in the pit. The pits will be benched down only if the ore depth exceeds a single bench height (approximately 10 m). Generally, the pits will be mined to the depth of economically recoverable ore (based on the mine plans). A number of working faces will be required to achieve the required production rate. Ore will be conveyed to secondary crushers and then to the on-off heap leach pad (OOHLP). The OOHLP consists of a number of cells which are sequentially loaded using a stacker, irrigated and then reclaimed once the leaching process is complete. This is a continuous process with some cells being irrigated while others are stacked or reclaimed. The use of conveyors (and dust suppression systems) will minimize dust emissions. Spent ore will be conveyed back to the mine whenever possible, minimizing residual landscape impacts and facilitating concurrent reclamation.

The low grade of the Trekkopje orebodies has necessitated the use of heap leaching, rather than tank leaching, which is used to extract uranium elsewhere in Namibia. While tank leaching provides improved control and recoveries relative to heap leaching, the energy and water inputs required to mill and treat the ore make this approach sub-economic for the Trekkopje orebodies.

The calcitic nature of the ore renders acid leaching non-viable due to excessive consumption of acid. Thus alkaline leaching will be utilized. The gypsum present in the ore is a consumer of sodium carbonate, and selective mining will be required to minimize the concentrations of this mineral in the ore from the run-of-mine (ROM) ore. The ROM ore will be crushed in both primary and secondary crushers, agglomerated and then conveyed onto specially designed heap leach pads.

The OOHLP was designed so that ore can be stacked via conveyor in one 9 m lift with overall angle of repose sideslope. The OOHLP was designed to have an ultimate capacity to store 30 million tons (Mt) of ore, at a loading rate of about 100,000 tons per day for 300 days or storage and an average solution application rate of 10 $l/hr\text{-}m^2$. However, it will be operated utilizing a 200 to 220 day leach cycle (this is the difference in time between when ore is first loaded and then offloaded). The OOHLP will be constructed with a redundant piping network installed in a free draining granular overliner material, graded to drain to the pad edge and collect in a solution corridor which gravity drains the HLP solution pond system. A lixiviant, in this case sodium carbonate, is sprayed onto the heaps and percolates through the ore. The uranium bearing solution will be collected in a combination of overliner and piping, which is underlain by a liner system that will be used to prevent solution losses to the environment. This fluid is then recirculated in a closed loop system through the heap until it the solution has a sufficiently high uranium concentration. The fluid, now termed a pregnant leach solution (PLS), is pumped from the PLS pond to an ion exchange (IX) plant for further uranium recovery.

Modular mining areas (pits) are planned, and as best the mining sequence will allow, the mined-out pits will be used for dumping spent ore from the OOHLP (by return overland conveyor and in-pit stacking or by partial truck hauling where necessary). In the event that the mine sequence does not allow for in-pit backfilling, waste will be placed on to a dump outside of the pit.

The extensive use made of conveyors reduces dust generation at the mine site. One of the largest sources of dust in open cast mining is the loading of ore and its subsequent transport in off-highway trucks.

4 Alternatives

While a project of this scale requires assessment of a large number of alternatives, the two alternatives with the most striking differences in environmental impact are the permanent heap leach pads (HLPs) versus the OOHLP configuration. The differences in disturbed area associated with each of these options are presented below.

In heap leach operations, spent ore is commonly retained on the leach pad and recontoured on closure of the facility. The OOHLP allows most of the ore to be returned to the open pit where it is used to backfill mining voids, returning the land surface to a condition more closely resembling the pre-mining surface (Figure 3). In the current life-of-mine plan, all spent ore is returned to the pit and approximately 30% of waste (or overburden) mined can also be deposited in pit. The balance will be stacked in carefully sited and designed waste dumps adjacent to the pit limits (note: most of these are well within the maximum pit limits shown in Figures 4 and 5; those outside of the pit limits are shown in Figure 4. Due to swell of the ore in the mining process the final topography on the pit footprint will be above original elevations, but the final surface has been designed so that the maximum elevation will be 26 m above original topography. Similarly waste dumps are being designed to not exceed a height of 30 m. The OOHLP method coupled with in-pit stacking provides a unique opportunity to design the entire operation to reduce the surface footprint of the mine and improve the prospects for post mining rehabilitation.

While not all dumps will be placed within the pit, all the dumps envisaged under the OOHLP scenario are established within the maximum pit limits established during the feasibility study (Figure 3). This is in contrast to the initial design for the permanent rock dump (assuming no backfilling) that originally located outside of the pit limits and represents the worst case disturbance footprint scenario (Figure 5).

The spatial configurations for these infrastructure components are shown in Figures 4 and 5. This simplified analysis does not include roads, granite quarries and other disturbed areas and merely shows the difference between the worst case disturbance footprint (permanent pads with no backfilling) and the optimized design (OOHLP and backfilling). The difference in surface area disturbed is summarized in Table 1.

Following the active period of operation, both the heap footprint and the filled open pit will be regraded, covering soil applied, revegetated[1] and the process and recovery equipment removed. Reclamation and closure activities of the majority of the site buildings, the open pit, and the mine waste dump will be initiated starting immediately after the conclusion of mining. Annual monitoring would be conducted thereafter to ensure the successful development of vegetative communities and check the general physical stability of the reclamation measures.

[1] Revegetation is a relative term in the Namib and complete cover is not possible.

Work on this project is ongoing and optimization of processes for topsoil and subsoil prestripping, plant rescue, landform design for radiation attenuation and skilling local people for participation during the life of the project are underway. Long-term research is also planned to investigate the re-establishment of ecosystems and measures to minimize groundwater impacts.

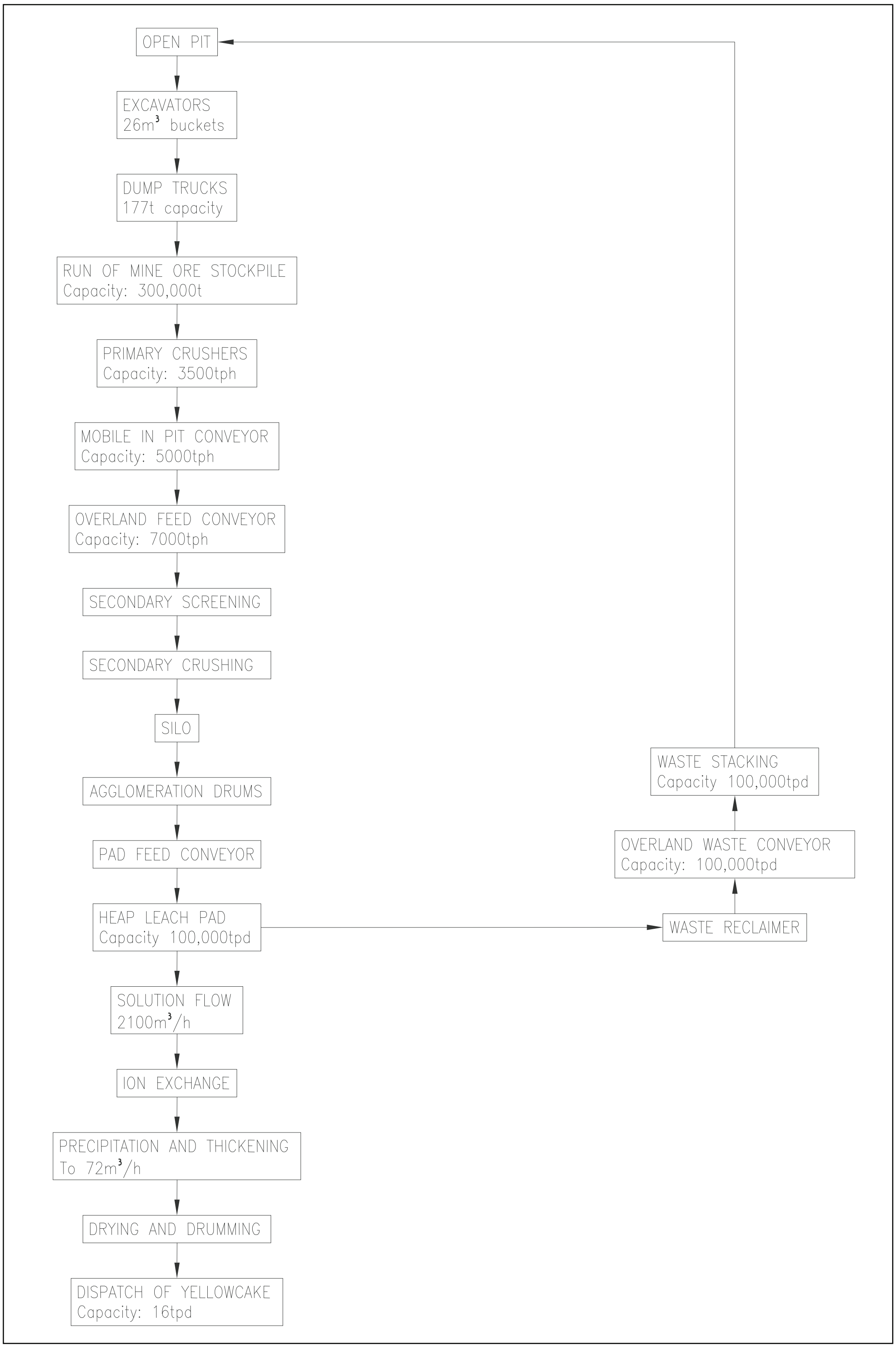


Figure 2 Mining and extraction process flow diagram (SRK, 2008)

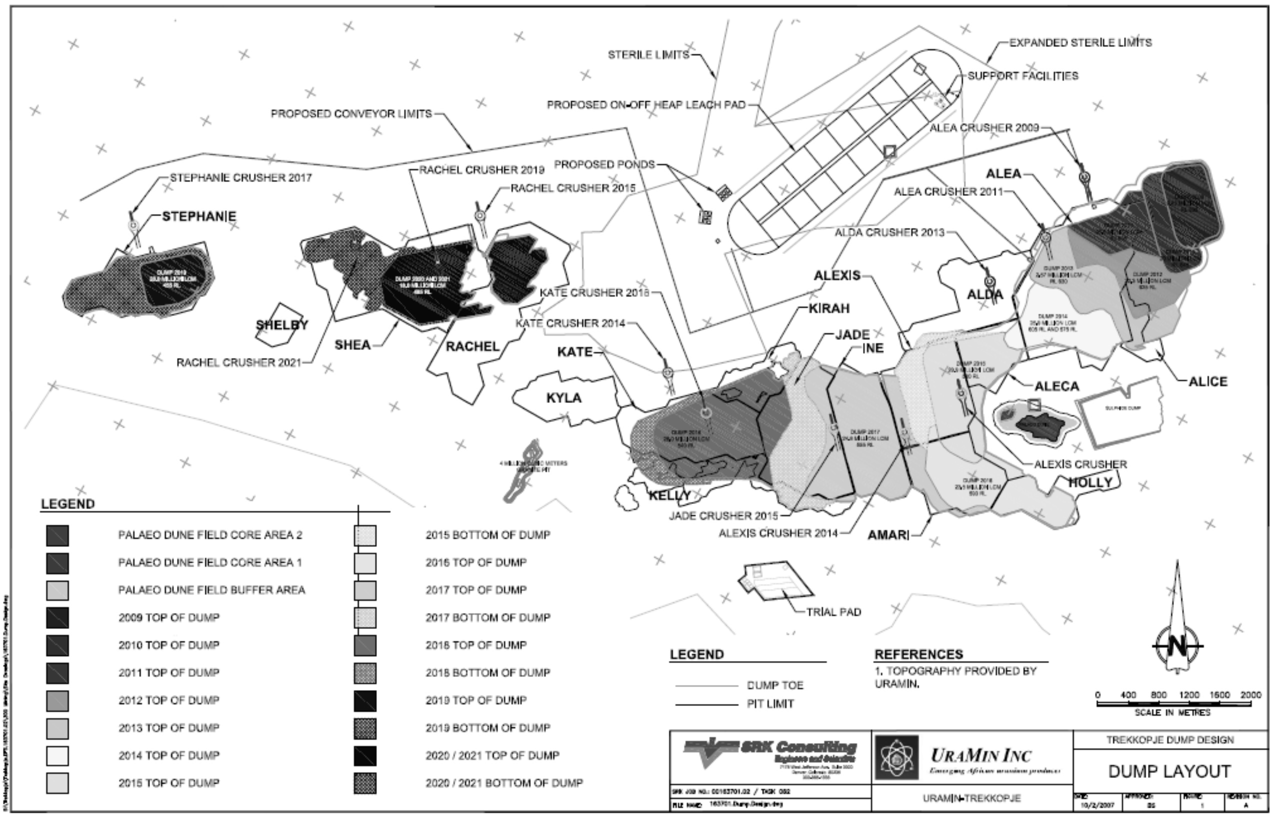


Figure 3 Mining surface infrastructure and final dump locations (SRK, 2008)

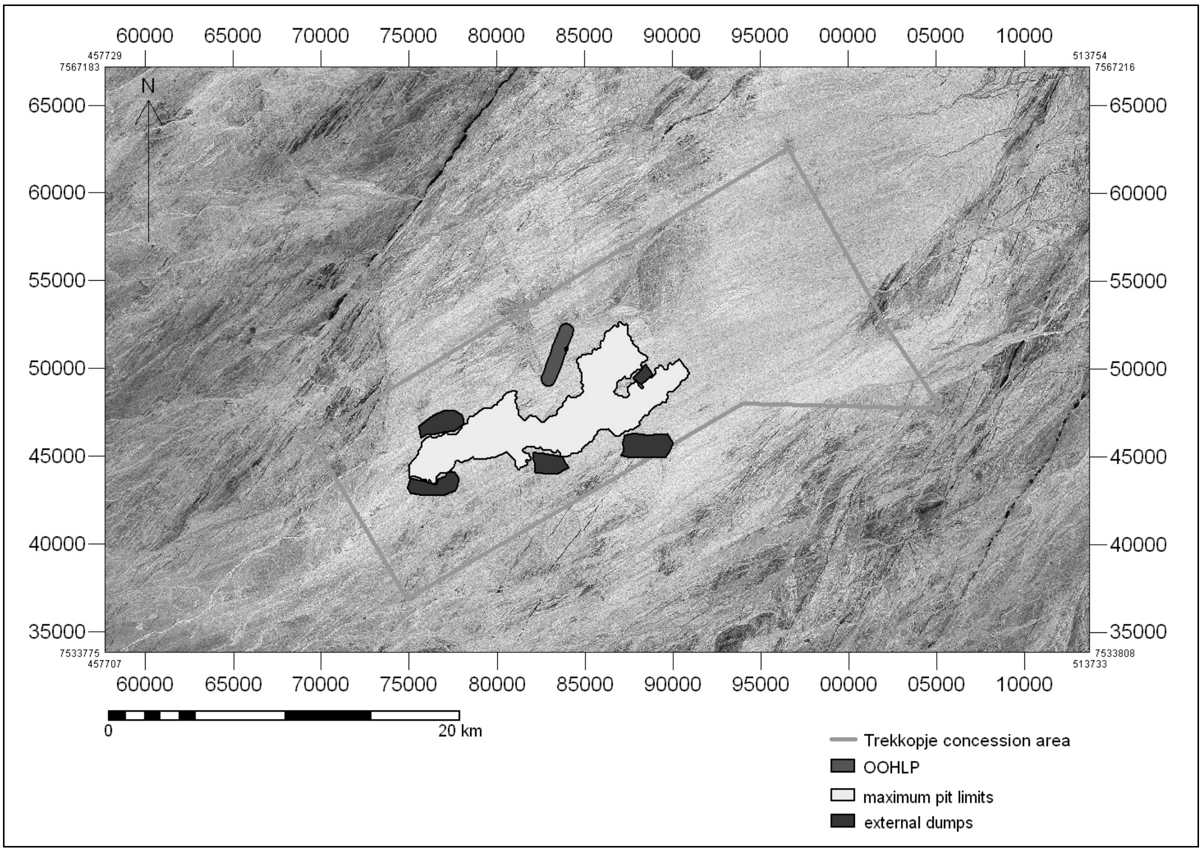


Figure 4 Spatial configuration of the OOHLP and the maximum pit extents for the Klein Trekkopje orebody

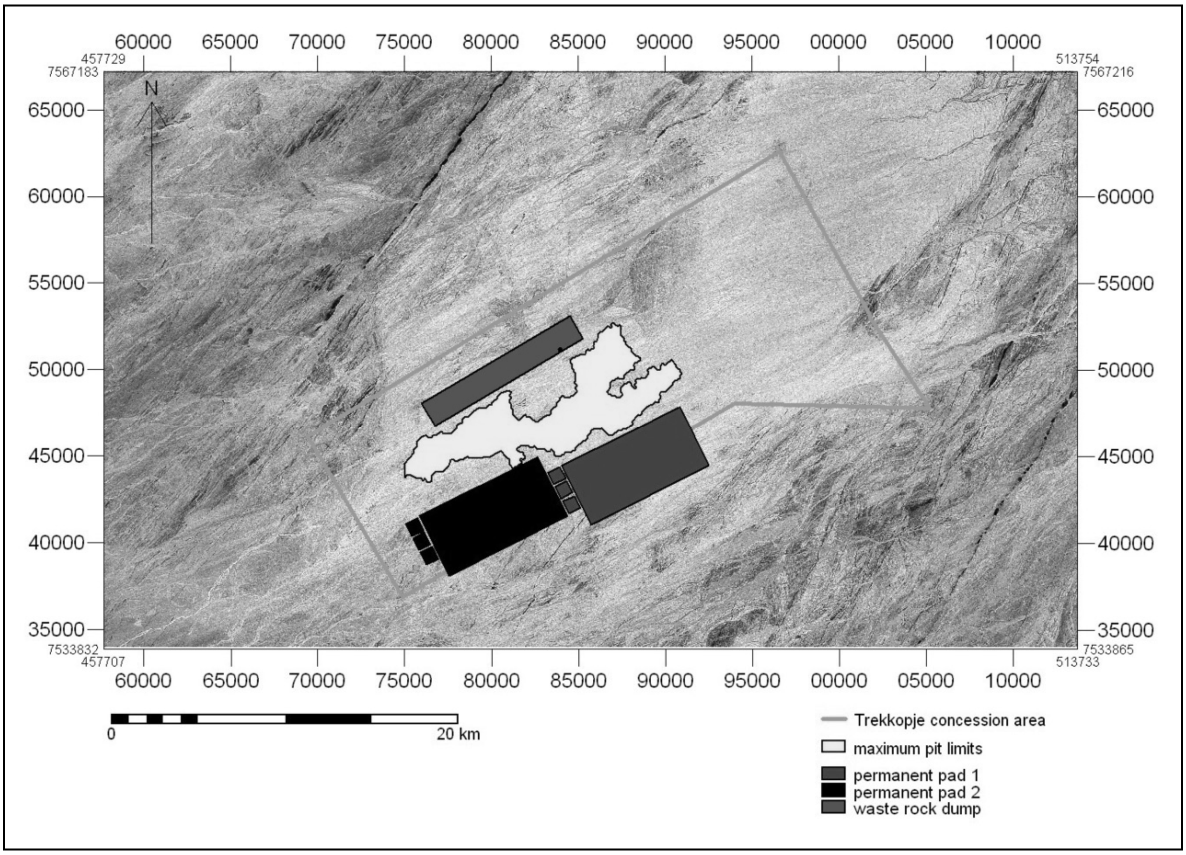


Figure 5 Spatial configuration of the permanent pads, the waste rock dump and the maximum pit extents for the Klein Trekkopje orebody

Table 1 Disturbed areas associated with each heap leach configuration considered

	Permanent Pads	OOHLP
Maximum pit area	4600 ha	4600 ha
Permanent waste rock dumps outside of maximum pit area	1500 ha	1090 ha
Area permanently disturbed by pads[2]	6100 ha	0 ha
Total	12,200 ha	5690 ha

5 Conclusion

The closure strategy for the Trekkopje project is being developed with the specific objective of minimizing disturbance and long-term environmental impacts, leaving the post mining land in a useful, safe and stable configuration capable of supporting native plant communities, wildlife habitat, watershed functions and limited livestock grazing.

The challenge in this setting is to maximize the positive impacts that accrue during the operation of the mine and to ensure that long-term negative impacts are mitigated. Local economic development and social upliftment are essential features of a modern mine. The mining methods described in this paper have been selected for their positive contribution to long-term landscape stability (as well as being economically

[2] The OOHLP occupies an area of 290 ha during the operational phase of the mine but is reclaimed and returned to the pit on closure.

viable). The selected method results in a reduction of dust and diesel emissions through use of conveyors, minimizes the disturbance footprint by using an OOHLP, and minimizes the disturbed footprint by backfilling the waste into the mine. The reduced footprint area means that there is a possibility of improved long-term prospects with wilderness use of the mine license area a possibility. This also reduces the impacts on land-uses in areas surrounding the mine lease (areas that are all part of the //Gaingu Conservancy and thus intended for community-based ecotourism and other natural resource-based activities (social interventions are discussed in more detail by Hoadley and Limpitlaw, 2008).

References

AEC (Atomic Energy Corporation of South Africa Ltd) (1997) Ore Estimation of the Trekkopje Uranium Deposit, Namibia, Report for Gulf Western Trading, 31 p.

Hoadley, E.M. and Limpitlaw, D. (2008) Preparation for closure: community engagement and readiness starting with exploration, Mine Closure 2008, In A.B. Fourie, M. Tibbett, I.M. Weiersbye and P.J., Dye (eds), Proceedings of the Third International Seminar on Mine Closure, Johannesburg, South Africa, October 14-17, 2008.

Namibian, The (2006) December 18, 2006, http://www.namibian.com.na/2006/December/national/ 06650E5C0F.html, viewed on 10 October 2007.

SRK (2008) Trekkopje Definitive Feasibility Study, SRK Consulting, Denver, 327 p.

Turgis (2008) Report of the Environmental and Social Impact Assessment: Trekkopje Uranium Project, Erongo Region, Namibia, Final Draft, Turgis Consultants, Johannesburg, 462 p.

USAID (2006) Budget, http://www.usaid.gov/policy/budget/cbj2006/afr/nm.html, viewed on 18 June 2006.

World Bank (2006) World Development Report 2006: Equity and Development, The International Bank for Reconstruction and Development, Oxford University Press, New York, 340 p.