

Decommissioning and Closure Plan for Aughinish Alumina Plant

SRK Consulting recently submitted a fully-costed decommissioning and closure plan (DCP), for Aughinish alumina refinery on the west coast of Ireland.

The DCP included criteria defining the successful, environmentally responsible decommissioning of the refinery, and included a programme to demonstrate the successful implementation of the DCP.

“Plans included costs for several different closure options”

SRK’s Glenn Freak notes: “Main focuses of the work were the processing residuals management areas, wharf, mudstack, and

peripheral drains and ponds. Minor areas such as a seawall, adjacent bird sanctuary, and non-operational lands were also considered.”

The DCP also introduced the possibility of the operations being suspended for a prolonged period.

Further proposals included closure of the red mudstack, and implementation of a rehabilitation plan including synthetic liners to restrict rainfall infiltration; revegetation of the mudstack surface, and control of surface runoff water.

“Management of contaminated surface runoff water and groundwater will continue for five years,” Glenn concludes. “Thereafter, the water quality is expected to be acceptable.”



Aughinish posed challenges such as the protection of the adjacent bird sanctuary

Recovering 'Locked-up' Gold During Closure

Natural gravitation of gold to the lowest points in a gold processing plant may result in significant concentrations over a period of time. This, coupled to the process inventory, yields precious metal (lock-up) value during the closure phase of a gold processing plant.

"Locked-up" gold typically becomes available during initial decommissioning, covering the final cleaning operations; and post-demolition, when the foundation material can be reclaimed.

The actual amount recovered depends on historical criteria including plant design, integrity of operations, housekeeping and head grade. However, the actual processing of the gold-bearing materials may pose their own challenges.

Steve Hordley, Principal Process Engineer comments: "The financial benefits of recovery may be augmented by the managed disposal of assets. As with many other processes, maximisation of recovery and disposal requires effective planning and implementation in well-designed, systematic, safe and cost-effective closure."

"Recovery of gold from final closure is a highly inexact science, and there are no guarantees about the quantity of material recovered," concludes Steve. "What is certain is that closure must be undertaken and that recovered gold, together with the managed disposal of assets, could go some distance towards funding the final site rehabilitation."

Closing the East German Uranium Mining Industry



Estimates of closure and reclamation costs are in the billions

Wismut GmbH, formerly a joint Russian-East German uranium producer and now owner of the world's largest mine closure project, has been a beneficiary of SRK consulting expertise since 1992.

With remediation of mining and processing facilities a top environmental priority of the unified German government, Wismut estimates the total costs of closing and reclaiming its operations in the billions of dollars.

SRK's involvement began with a 1992-93 study of the options for controlling groundwater flow through underground workings in the Ronneburg area. SRK subsequently was retained to investigate options for remediating waste rock. The associated environmental concerns include acid generation, leaching of uranium, sulphate and metals, and radon emission. SRK recommended a program of selective relocation of rock to the Lichtenberg open pit.

In 1995-96, SRK helped Wismut set up a laboratory testing facility, develop field methods for waste rock 'grade control', and recommend methods for block modeling and scheduling of the waste rock relocation. SRK also assisted Wismut's decision-making about remediation measures for the remaining fourteen waste rock piles in the Ronneburg district.

In 1996 and 1997, attention shifted to the Nordhalde, the second largest remaining waste rock pile at the Ronneburg site. SRK assisted in the design of a borehole gas and temperature monitoring system, and carried out detailed analysis of the data to estimate oxidation rates. SRK also provided conceptual designs and cost estimates for remediation measures.

SRK's recent work in the Ronneburg area has included an audit of the ongoing waste rock relocation, and assistance with testing of cover designs for the backfilled Lichtenberg pit.

SRK's Daryl Hockley and John Chapman have led SRK's contribution to the Wismut project.

Says Daryl: "Our work has been equal parts consulting and technology transfer. Initially the transfer was unidirectional, but the scale of the project is such that we now learn as much as we teach. Some of the precedents set by Wismut will be the standard for mine closure activities in the 21st century."



Daryl Hockley



Design and Operation for Closure at Kennecott Ridgeway

SRK, through its long-standing ties with the Kennecott Ridgeway Mine in South Carolina, has helped make this mine a prime example of successful design and operation for closure.

“From the prefeasibility stage of design, strong emphasis was given to the need to minimise the actual and contingent liability associated with operations and closure,” explains Rob Dorey, SRK Corporate Consultant. “Closure planning has been periodically updated throughout the mine life, with the detail of the plan increasing as closure approached.”

“The potentially acid generating (PAG) nature of the host rock of this epithermal deposit required the adoption of proactive waste rock management. Use of the waste rock in construction of the tailings impoundment, with compaction

and encapsulation of PAG waste rock, was incorporated in the design. The phased development of the two pits also allowed the partial backfilling of one pit during mining of the other.”

As part of the closure planning, SRK has performed a number of studies. These include a surface water mixing and water quality model, project-wide groundwater and contaminant transport model and tailings cover model. A detailed evaluation of the methods and viability of achieving long-term closure was also completed.

The presence of PAG material in the pit walls required the management of both backfill material and water used to flood the pit. “Lime softening has been used, with a target alkalinity of the pit water to buffer acid generated by the pit walls and backfill and contact runoff water from

the site,” Rob expands. “To close the tailings impoundment, a modification of the deposition system to regrade the impoundment surface to create positive drainage was adopted.”

“With a net positive water balance at closure, the need to rapidly cover the tailings was accommodated by placing the cover as a slurry, using the existing tailings deposition system. To date all indications are that performance criteria for the closure are being met.”



Rob Dorey

Framework for Coal Mine Closure in Bulgaria

SRK Consulting recently completed its contribution to new guidelines for closure of underground coal mines in Bulgaria, a European Commission-funded PHARE project covering socio-economic, technical, safety and environmental issues.

Pilot closure programmes were developed for two mines in contrasting socio-economic and environmental settings: Pernik, in a heavily industrialised city, and Pirin in a remote mountain location.

Piers Sadler remarks: “The approach taken to environmental aspects was through risk assessment and risk control carried out in parallel with staged site investigation.”

“Complex issues included restitution of state-owned land to its pre-communist owners, and reconciling existing Bulgarian legislation with EC environmental requirements.”



Abandoned surface facilities at the Pirin Mine

SRK Consultant Profile: Julie Glavin



Julie Glavin

Julie Glavin joined the SRK Tucson office in early 1999. Julie brings over 10 years of mining and civil/construction experience, primarily in environmental engineering and compliance. As a senior engineer in the Tucson office, she is currently engaged in the development of a comprehensive closure program for an existing mining client.

This particular project features contributions from SRK technical specialists from around the world. Julie also provides specialized consulting services related to the Clean Water Act, National Environmental Policy Act and wetlands mitigation work.

Proactive Operating Procedures Reduce Future Closure Liability

An extensive SRK project to manage oxidation-prone residual sulfides in the tailings impoundment at Thompson Creek Mine in central Idaho is set to pay future dividends in the form of significantly reduced costs and liability.

Situated in the Salmon River drainage, Thompson Creek processes up to 32 000 tpd of molybdenum ore. The tailings impoundment at the project uses a centerline construction technique employing cycloned sand to construct the embankment.

The impoundment, designed by SRK in the early 1980s, is planned to reach an ultimate height of 720 ft from toe to crest.

In 1990, residual sulfides in the tailings product were identified as having a potential to oxidize. Of the options considered to alleviate the impact of this

oxidation, use of a secondary flotation process to produce a pyrite concentrate was selected. In this process, the sulfide content of the tailings is reduced to a level at which oxidation is not predicted to significantly impact drainage water quality.

To dispose of the pyrite concentrate, a separate delivery system was designed to allow placement of the material within the saturated slimes zone of the impoundment. This 'subaqueous' environment alleviates the potential of oxidation of the pyrite.

SRK's Rob Dorey remarks: "This proactive step by Thompson Creek has reduced the contingent liability of closure of the impoundment by the adoption of operating procedures to facilitate ultimate closure."

Mine Closure Workshop Advances the State of the Art

In October 1998, eighteen of SRK's senior engineers and scientists met in Vancouver for a mine closure workshop.

The objectives were to crystallize and synthesize SRK's experience in closure projects, and map out areas of relevant expertise.

Participants came from SRK offices in South America, Africa and the UK, as well as Denver, Reno, Elko, Tucson and Vancouver.

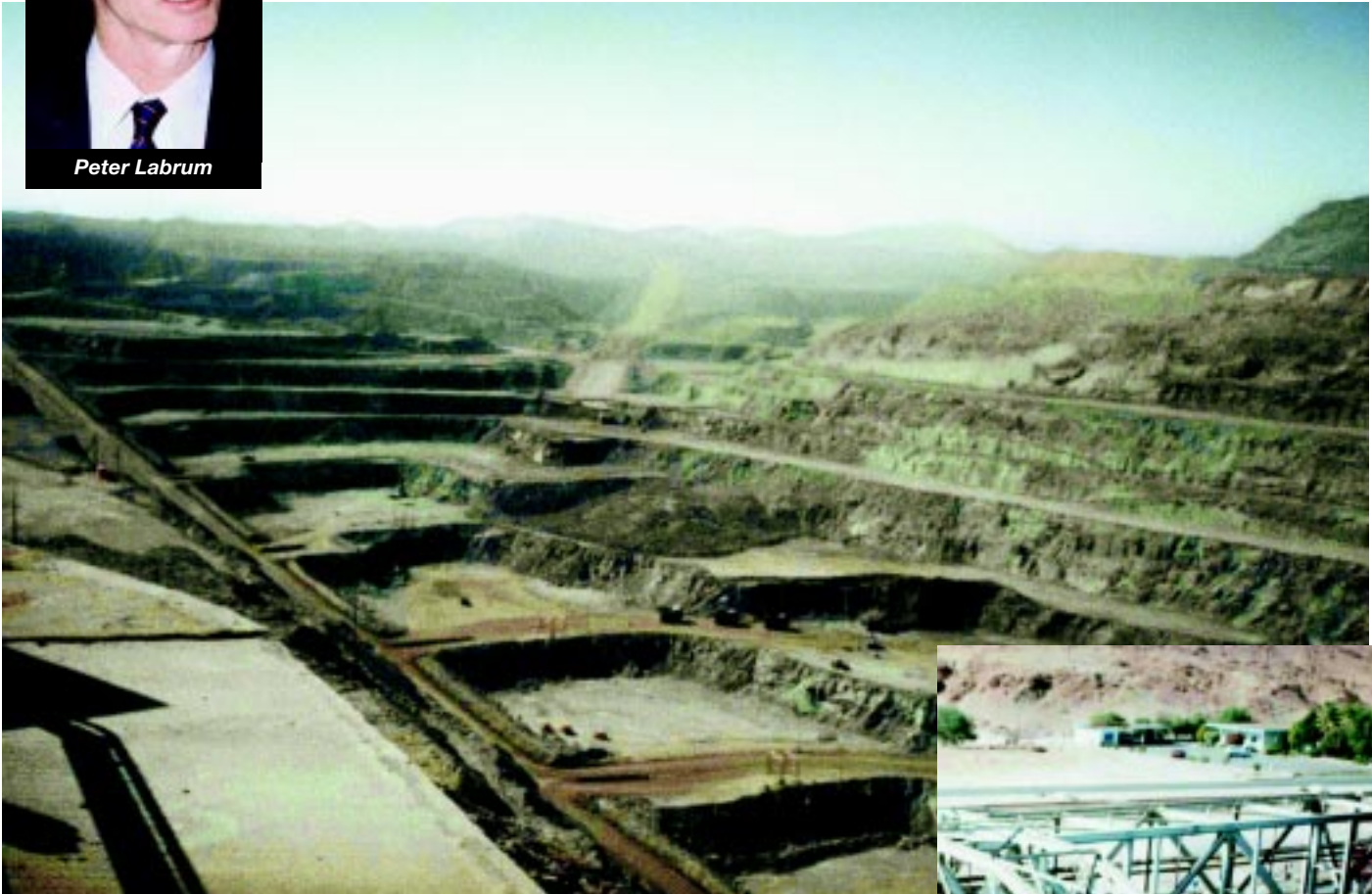
Products of the workshop include several papers on various areas of expertise, and a website featuring a 'knowledge map' that charts the relationships between technical disciplines and project objectives.

Workshop organiser Daryl Hockley elaborates: "Most of our clients do not have a lot of mine closure experience. But in SRK we have over 20 people who have each worked on at least a dozen closure projects."

"We thought that if we could get most of those people together, we could significantly advance the state of the art. The challenge is to create a systematic approach, while at the same time respecting the variety of project needs."



Digital Database Eases Closure Costing & Surface Assets Evaluation at Rossing Mine



Rossing Mine showing part of the open pit



Thorough groundwork done by an SRK team at Rossing mine in Namibia in July 1995 has allowed mine personnel to carry out in-house updates of probable closure costs and, as of 1996, maintain accurate records of surface asset replacement costs for insurance and other purposes.

During the initial visit SRK staff spent time with all relevant mine personnel to ensure that a comprehensive database of closure costs was compiled. Extensive use was made of surface layout plans of the mine, and the database was cross-referenced to the plans.

“A rates build-up was supplied for most items,” recalls Peter Labrum, Principal Engineer. “This was linked to the main database, enabling the costing to be updated by simply changing key parameters in the rates. The final product was supplied to the mine in digital form, enabling them to carry out the updates in-house.”

In December 1996 SRK completed a detailed schedule of surface asset replacement costs to enable the mine to check its insurance portfolio.

“Due to the detailed schedules produced during the closure costing study, the replacement cost schedules could be quickly and efficiently produced in a similar updatable digital format,” says Peter.

UN Taps SRK for Omai Gold Mine Closure Review



Geoff Ricks

In the wake of the failure of Tailings Dam #1 at Omai Gold Mine, Dr. Geoff Ricks of SRK Consulting was recently appointed through the United Nations Development Programme (UNDP) to independently review the mine closure plans and implementation.

As the Specialist International Consultant on behalf of the Government of Guyana Environmental Protection Agency (EPA), Geoff's brief was to technically review the plans, and define a structure within which EPA and Omai Gold Mines could implement the closure plans. In addition recommendations were to be made to strengthen the EPA's effectiveness in regulating the mining operations.

Geoff comments: "The final report included a programme of environmental monitoring, equipment and training of officers who will be involved in monitoring and evaluating environmental impacts."

"Other key aspects included recommendations on environmental obligations to be imposed on the company, provisions for minimising environmental damage during closure implementation and methods of providing financial sureties".

Edmondsley & Fender Minewater Discharge Remediation

**"treatment
remediates
one of the
most polluting
sites in
England"**



The Edmondsley wetland uses reeds to filter metals which precipitate from the water

The British Coal Authority commissioned SRK Consulting to undertake feasibility studies and detailed designs for minewater remediation at the Edmondsley & Fender former colliery sites, ranked among the most polluting in England.

Piers Sadler, responsible for discharge characterisation and wetland designs, comments: "The Edmondsley scheme involves pumping minewater at 4 l/sec to



Piers Sadler

a 0.4 ha wetland treatment area, within a wildlife conservation zone providing educational and recreational facilities."

"The Fender scheme involves a pipeline river crossing and a wetland of about 0.6 ha area."

SRK was subsequently awarded a third feasibility study and detailed design study for the treatment of minewater discharge at Blaenavon in South Wales.

Combined Closure Plan and EIA Report for Copper Project

SRK recently completed a fully-costed closure plan and EIA report for a confidential client seeking mining approval for a proposed underground copper mine in Western Europe.

The deposit, consists of 14.3 Mt of high-grade massive sulphide ore located within a sensitive rural environment. Key closure issues included tailings disposal, re-instatement of agricultural land and treatment of post-mining metal and acid-contaminated mine water.

Glenn Freak, Senior Environmental Scientist, comments: "In response to the strict environmental legislation in Europe and the environmental concerns at the project site, tailings disposal centred on a

paste backfill plant to return tailings underground, operating in tandem with an engineered repository to store dewatered tailings on surface."

"The design minimises the reduced surface area required for disposal, restricts pyrite oxidation and allows progressive rehabilitation."

Land use will revert to agriculture once all site infrastructure is decommissioned, dismantled and removed. Pre-stripped topsoil, from stockpiles, will be spread on the re-contoured ground at closure. To protect the low permeability membrane cover on the repository, low-intensity grazing is proposed.



Glenn Freak

"Mine water investigations indicated that backfilled workings should be flooded as quickly as possible after mining by active water injection," Glenn continues. "This creates an inward hydraulic gradient allowing water quality to

be stabilised by re-circulation and treatment over two to three years."

Closure and rehabilitation cost estimate calculations for decommissioning, demolition, rehabilitation, after-care and monitoring were made including provisions should premature closure occur.

Don't Underestimate Closure Liabilities When Valuing Mining Properties

Clients involved in mergers, acquisitions, share offerings and other transactions often underestimate the importance of closure costs in the overall valuation of mining properties.

Examples of closure liabilities recently assessed by SRK's Vancouver office range from US\$750 000 for an advanced exploration site with minimal water quality impacts to US\$30-million net present value for a mine site with a requirement to collect and treat acidic water.

"The process of estimating closure liabilities starts with a closure plan," says Kelly Sexsmith of SRK Consulting's GeoEnvironmental Engineering group.

"We usually find that people at the mine site have clear ideas about closure issues and possible closure measures. But they often haven't had the time needed to pull those ideas together."



Kelly Sexsmith

"Further, the quality of plans prepared to meet regulatory requirements is quite variable. Our job in a liability estimate is to quickly review closure issues and then focus on estimates for the most costly items. Given the limited time available for

these projects, our ability to quickly compare costs with experience elsewhere is critical."

What Goes Up...

Must Come Down!



Steve Hordley of SRK Consulting was involved in the decommissioning of the President Brand Metallurgical Scheme, part of Freegold, in South Africa's Free State.

The plant re-treated gold tailings material, yielding sulphuric acid, uranium and gold. Uranium production ceased in 1990, the flotation, acid and gold operations continued until 1995.

Decommissioning activities included inventory removal and radiological decontamination, asset removal and final demolition, including demolition of the sulphuric acid pyrite roasters and stack, pictured here. The site is currently undergoing rehabilitation.



Steve Hordley

Steve Hordley

Experienced mine closure specialist Steve Hordley, joined SRK Consulting's UK office in 1998 after some 18 years' work in metallurgical operations in South Africa involving production, closure planning and demolition activities. Steve has participated in numerous projects, including closure planning and management of operations such as flotation, uranium, gold and sulphuric acid. He also has considerable expertise encompassing radiological decontamination, decommissioning, precious metal recovery and all aspects of related health and safety issues.



Black Pine Mine Heap Leach Closure

Black Pine Mining, Inc. (BPMI) contracted in 1995 with WESTEC, Inc. (whose operations were merged with SRK Consulting in 1998) to prepare a closure plan for their 34-million ton heap leach facility located in the south-eastern corner of Idaho, USA. The heap, a valley fill design, had 50 million gallons of solution in process containing cyanide and other constituents in concentrations greater than safe drinking water standards.

Background data was collected to characterize the physical, geochemical, and other environmental aspects of the heap. Solution treatment methodologies were researched and their respective costs evaluated. The results of this work were used to develop a risk assessment to address the potential impacts that the spent ore-solution system could have on

the local environment. Black Pine Mining, Inc., stopped adding cyanide to the heap in January 1998 and began recirculating solution. Evaporation proved to be so effective that land application of spent solution was not utilized. Further, the weak-acid dissociable (WAD) cyanide level has been consistently declining and was projected to meet the 0.2 mg/l standard in March 1999. Other constituents previously occurring at concentrations greater than safe drinking water standards have also declined.

“All in all,” said BPMI’s General Manager Crellin Scott, “closure activities at the mine proceeded at or better than projections. Advanced planning allowed us to proceed with a minimum of capital and operating outlay. This project demonstrates, among other things, that intensive solution

management can shorten the pad closure time requirements, enhance gold recovery, reduce solution treatment costs and control the solution balance.”

“We interacted closely with BPMI to identify the most effective means of providing the best quality service while keeping costs down”, said Val Sawyer, SRK Principal Consultant. “We were able to work directly with BPMI technical and operating staff to collect samples, conduct metallurgical testing, analyze results, and then form a long-term strategy.”



Val Sawyer

SRK's 'Reverse Mining' Experts



John Chapman

SRK's John Chapman and Daryl Hockley are becoming experts in what they smilingly refer to as 'reverse mining'. Together, they have completed two major projects involving the return of waste rock to

mined-out pits. Kennecott's Flambeau Mine in Wisconsin is now backfilled and reclaimed, and backfilling of Wismut's Lichtenberg pit in Germany is about half completed.

Pit backfilling raises a number of very practical questions. In both projects, the objective was to put the most acid-generating material near the bottom of the pit, where it would subsequently be inundated with groundwater.

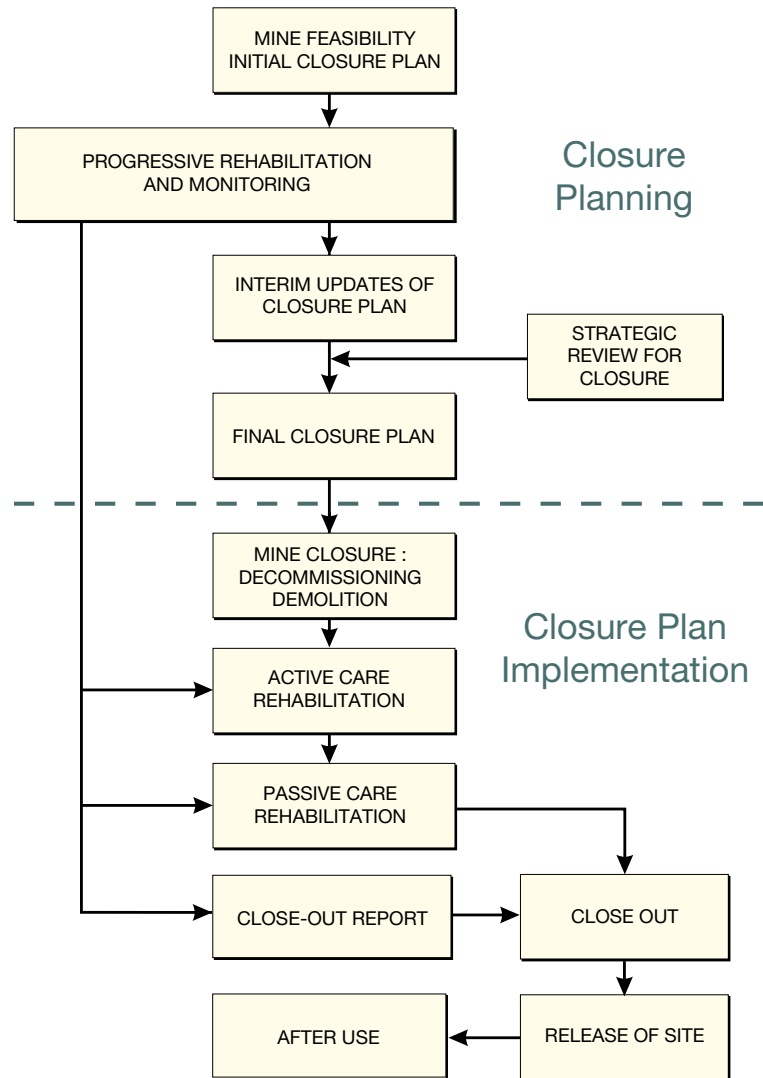
The groundwater will prevent long term oxidation and acid generation, but will also release any acidity that has accumulated in the rock during its time on surface.

SRK, as part of the 120 000-tpd earth-moving operation at Lichtenberg, and 80 000-tpd project at Flambeau, designed programs to sample waste rock during the relocation, measure both its current acidity and its future acid generation potential, and add appropriate amounts of alkalinity.

"The resulting system of long-term planning, sampling, analysis, data review and short term planning was very similar to the procedures used to control open-pit mining," says John.

"Open pit mining engineers from SRK's Vancouver mining group provided much of the required mining technology."

Closure Sequence



This diagram, which outlines the phases of the closure sequence, is part of a proactive initiative by SRK Consulting to promote successful and effective mine closure planning and decision-making within a European context.

Integral to the programme is a report, *A Technical Framework for Mine Closure Planning - Technical Review Series No. 20*, published by the British Mineral Industry Research Organisation (MIRO). Targeted mainly at the mining and mineral

processing industries and regulatory bodies, the framework is designed to assist in the preparation and evaluation of mine closure plans, providing an overview of mine closure practices.

This invaluable reference is available for purchase through MIRO for GBP 200 and can be ordered by contacting Hazel Pexton, Secretary, MIRO, telephone: +44 (0) 1543 262957, fax: +44 (0) 1543 262183 email: hsp@mirolich.demon.co.uk

Departure With Dignity – Ten Years Later

SRK recently returned to the scene of a highly successful mine closure from the previous decade – the Beaverlodge uranium mine in Northern Saskatchewan.

Beaverlodge was one of the first operations of its sort in the very productive Athabasca Basin. Its closure in 1986 was the subject of considerable investigation and careful design, later described in the book *Departure with Dignity*.

“Ten years later, SRK returned to the site to investigate ‘boils’ of radioactive tailings through a cover that had been applied during the reclamation” says Cam Scott of SRK Vancouver. “The cause was found to be a combination of hydraulic pressures and winter freezing of the cover and upper tailings.”

SRK carried out design calculations and field investigations to determine the cause

A decade after closure, reclamation and remediation are exemplary

of the problems, and recommended a number of remediation measures. SRK was awarded the contract to supervise construction of the remediation measures during the summer of 1997. Follow up inspections in 1998 demonstrated the success of the work.

Escondida Shows It’s Never Too Early to Plan Closure



Estimates of closing and reclamation are in the billions



Cam Scott

Though the Escondida deposit has reserves sufficient for an additional 40 to 50 years of mining, Minera Escondida Limitada (MEL) is making plans now to regularly set aside funds for closing the mine and related facilities – an approach expected to pay significant dividends later.

The Escondida deposit is 3 100 m above sea level in the Atacama desert of northern Chile. Mining started in late 1990. Recent estimates put reserves at about 1 800-million tons of ore, with an average 1.59% copper. The current mining rate is about 127 000 tpd.

SRK’s Cam Scott says: “In March 1997, we were contracted to develop a

decommissioning plan and cost estimate in association with the environmental department of MEL.”

“The objectives were to provide a comprehensive list of mine facilities to be addressed at closure and, to the extent possible, identify the appropriate closure measure for each of these facilities.”

“Where further information or action was required to define the appropriate closure measure with a reasonable degree of confidence, we were tasked with specifying action(s) necessary to reduce the uncertainty to an acceptable level.”

The study indicated that the tailings facilities are likely to dominate the total closure cost, and that this cost could be significant.

The closure plan will be periodically updated to reflect changes in the mine facilities, technology and the legal aspects of mine closure.

“However, for now, MEL will use the plan as the basis for establishing regular funding allocations in preparation for closure,” Cam reveals. “In the long term, this approach is expected to have highly positive implications for MEL in terms of closure quality and minimising eventual closure expenditures.”

Closing Abandoned Mines in the Canadian North



Abandoned tailings facility near Carcross, Yukon Territory

SRK's Vancouver office recently assisted Public Works & Government Services Canada (PWGSC) in implementing closure measures at four abandoned mines in the Canadian North.

The Rayrock Mine in the Northwest Territories was reclaimed by PWGSC in 1996. Daryl Hockley and Rod Olason inspected the site in June 1998 and recommended minor upgrades and maintenance.

The same team reviewed plans for Phase I reclamation at the Discovery Mine, also in the Northwest Territories (NWT), in the winter of 1997-98. After his return from Santiago, Cam Scott joined the team, and is currently leading SRK's review of the Phase II reclamation plans for Discovery.

Because of their remote location, heavy equipment can only reach Discovery and Rayrock by ice roads, a common feature in the NWT. Constructed over frozen lakes and streams, ice roads often are associated with very high costs owing to requirements for winter mobilization, operation and demobilization before the spring thaw.

The neighboring Yukon Territory is the site of two other SRK-PWGSC mine closure projects. The Venus Mine tailings facility was reclaimed in 1996, using a 'Waterloo Barrier', i.e. a grouted sheet pile wall used to cut off seepage. SRK reviewed the work in 1998 and recommended upgrades to ensure dam stability and improve water cover.

SRK inspected the Arctic Gold & Silver (AGS) tailings facility site in June 1998, and has since carried out a complete investigation and submitted recommendations for the closure work.

Construction specifications are now being drawn up by PWGSC.

"AGS is a good example of the challenges posed by abandoned mine closures in the Yukon," Daryl points out. "Issues that needed to be assessed included re-processing of the tailings, which might provide employment for the local First Nation and, on a completely different tack, the long term stability of a water retaining structure constructed by a beaver (Cam calculated the factor of safety to be just a little over one!)"

Closure Study for Cerro Do Lobo Tailings Impoundment



The tailings is placed sub-aqueously behind a rockfill embankment

Neves Corvo Copper Mine in Portugal is owned by Somincor, the state mining company, with Rio Tinto a minority shareholder. The pyritic tailings are deposited under water, to prevent acid generation.

SRK was appointed to revise the tailings impoundment closure plan.

Five different methods of operation and closure were considered, including combinations of disposal as a slurry or paste, deposition by sub-aqueous or sub-aerial methods, and closure under a water cover or beneath a low-permeability cover.



Ian Brackley

The assessment of the preferred option was influenced by the desire to apply tried and trusted technology, by the need to prevent oxidation of the tailings, and by the need for an environmentally-acceptable solution which minimised the long-term maintenance after closure.

The closure study was followed by a risk analysis to determine the probability and consequences of tailings dam failure followed by a catastrophic flow slide, and to identify changes required to reduce the risk to an acceptable level.

Mine Closure Services 'Down Under'



John Chapman

In 1998, SRK transferred some of its North American mine closure expertise to Australia.

Prior to moving to Australia, John Chapman, a chemical engineer, spent 10 years working on mine closures in Canada, the U. S. and Europe.

"Although mine closure regulations in many states of Australia are not as stringent as those of North America, many clients appreciate the perspective that comes from working with stricter environmental regulations," says John. Most recently, Normandy Mining Company has been taking advantage of John's experience by having him review final closure plans for their Mt. Leyshon Mine in Queensland and the Woodcutters Mine in the Northern Territory.

Palabora's Closure Database Saves Cost and Manpower



Peter Labrum

Some of the infrastructure at Palabora Mine

Early development of a database of probable closure costs for South Africa's Palabora open pit mine provided a payback in subsequent years in the form of reduced cost and manpower needed to update this key information.

The initial cost-estimate was completed in 1993 by a multi-disciplinary SRK team led

by Peter Labrum and Ritchie Stuart.

They spent a week at the minesite in the north-eastern part of the country, assessing and quantifying all closure aspects with the help of surface layout plans. These were cross-referenced to detailed schedules of cost items prepared by the team.

In 1998 Peter Labrum, accompanied by SRK colleague Brian Read, returned to update the costing.

"Due to the experience of the team and the nature of the 1993 database it was possible to complete the review fairly quickly using a very small team," Labrum reports.

Environmental Quality Assessments Help Mines Avoid Future Problems

SRK Consulting has considerable experience in assessment of background or historic environmental quality standards, and using this information to provide practical guidelines for the assessment of potential degradation.

"Many mining operations, on closure, are faced with meeting stringent guidelines for soil, sediment and water quality," explains Rob Bowell, Principal Geochemist. "In many cases these guidelines are based on drinking water guidelines which may not only be unsuitable for a mining district, but unobtainable due to geology and natural background."

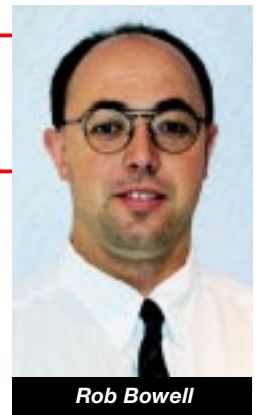
A survey by SRK prior to site development of the Ashanti Goldfields Geita project in Tanzania, demonstrated that historic mining has had less impact, than current artisan mining.

In some cases, little data and several episodes of mining overprint each other, complicating environmental assessment such as at the Getchell Mine Nevada, where gold is associated with high levels of arsenic sulfides, and environmental release of arsenic is a major concern.

As part of the closure plan for the open pits and assessment of pit lakes, the SRK detailed hydrogeochemical study revealed, groundwater is strongly

compartmentalised at Getchell.

"For many of these compartments, bedrock groundwater quality is poor when compared to water quality guidelines," Bowell continues. "However, SRK's study indicated that little connection occurred between the deep bedrock aquifers and the shallow alluvium aquifers that are the main source of water in the area. This information is being used to propose modifications to the water quality guidelines for the site to account for natural variations in background water quality."

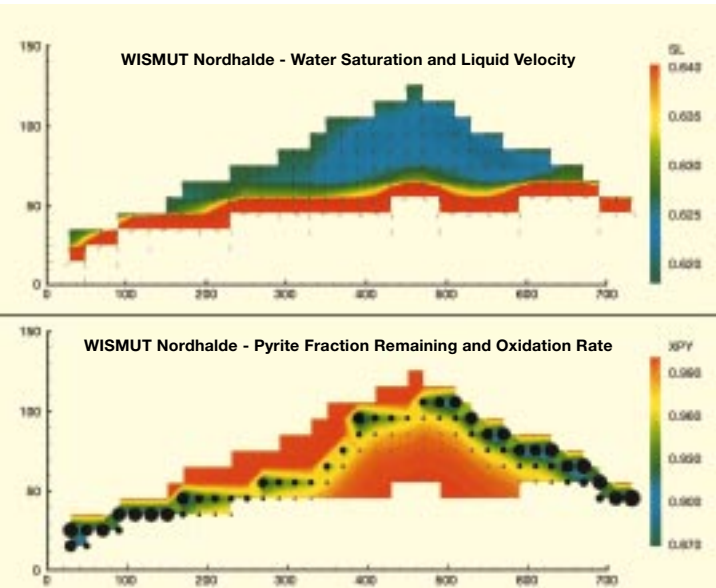


Rob Bowell

Modeling O₂ and Thermal Transport Processes for Waste Rock Closure



Jason Smolensky



Modelling Results – Convective Case – Conditions at year 30

Over the past few years SRK has been developing computer models to simulate acid generation and leaching processes in waste rock piles as a means to better assess rehabilitation options.

Acidity generation is the result of a series of heat-producing chemical reactions between sulfide minerals, oxygen and water. Because oxygen supply is often the limiting control on oxidation rate within a pile, accounting for the processes of oxygen transport has been a fundamental component of these models.

One important aspect of this modelling has been calibration to field data. For example, SRK laid out an installation and monitoring program for Wismut's Nordhalde. Eight boreholes were installed with instrumentation equipped to monitor oxygen concentration and temperature at intervals throughout the thickness of the waste pile.

Under SRK's recommendations, Wismut collected a year's worth of data, resulting in one of the most comprehensive databases of its kind.

SRK undertook subsequent calibration and modelling using the code TOUGH-AMD. Results of the modelling showed the future acidity-generating potential of the dump.

Other clients of SRK that have benefited from this type of modelling include Nicolet Minerals (formerly the Crandon Mining Corporation), Kennecott's Flambeau Mine and Cominco's Red Dog Mine in Alaska.

SRK's Jason Smolensky says: "This technology gives us a unique insight into the significant processes that lead to acidity generation within a waste pile and allows prediction of future rates and duration of oxidation."

"Modelling also allows us to assess various rehabilitation measures at a relatively low cost."

New SRK Office in Yellowknife



Stephen Schultz

SRK now has a full-time presence, and a major closure project, in Yellowknife NWT.

As well as being the capital of Canada's Northwest Territories, Yellowknife is the main staging point for mining operations throughout the area, including the new Ekati and Diavik diamond mines. SRK welcomes Stephen Schultz to the team as our man in Yellowknife. Stephen and several of our Vancouver staff are busy assessing alternatives for managing 280,000 tonnes of arsenic-rich dust that was left underground when the nearby Giant Mine declared bankruptcy. SRK was awarded this high profile, multi-disciplinary project after a Canada-wide competitive bid.

SRK is cooperating with the Department of Indian Affairs and Northern Development and the new site owners, Miramar Giant Mines Ltd, to assess alternatives for in situ stabilization, extraction and/or re-processing of the dust.

It's Not as Simple as Open and Close

Discourse on mine closure is becoming increasingly topical, as existing mines move towards the end of their operations and greenfields projects are subject to the 'do not open if you cannot close' philosophy.

Simultaneously, discussion is broadening from biophysical, engineering and rehabilitation aspects to the more nebulous socio-economic impacts of closure.

It is not difficult to conjure up a comprehensive list of socio-economic impacts related to mine closure, the challenge is rather in untangling the web of socio-economic impacts so as to devise and



Allison Burger-Pinter

apply workable management measures.

Workable management measures require that, among others:

- Parties responsible for mitigation of impacts participate from the very beginning of the process. This can be difficult when impacts and responsibility cannot be clearly defined and responsible parties are unaware of, or unable/unwilling to assume responsibility.
- Sufficient financial resources are set aside, in advance, for the management of closure planning and closure related impacts. Generally socio-economic

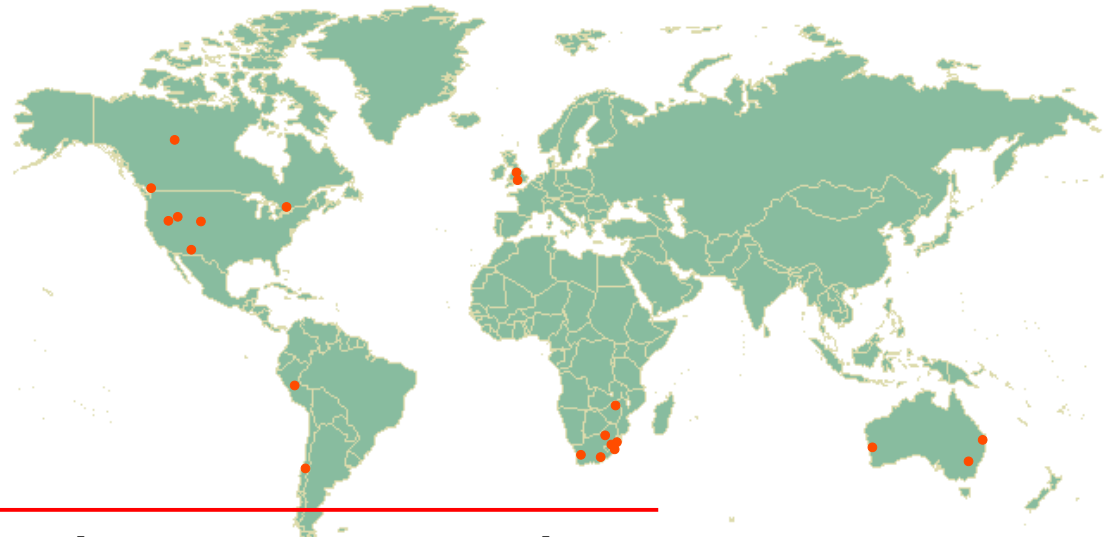


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impacts require management years in advance of closure.

- Tensions between what is acceptable closure for biophysical and engineering impacts, and that of socio-economic impacts, be defined and resolved.

SRK recognises that mining is not a simple case of 'open and close'. We continue to partner clients to resolve the myriad of challenges, associated with mine closure, as part of the planning of greenfields projects and for existing operations pending closure.



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