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The "smoking gun" of detailed mine closure cost over-run – a review using case studies of the real costs associated with the demolition and removal of infrastructure in mine closure

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Abstract

Mine and facility closure planning is a dynamic and rapidly evolving landscape. In this landscape, mining companies and industry consultants are generally good at estimating the associated earthworks and rehabilitation costs because it is core business. Through our extensive work in mine closure we have found that the safe and cost effective demolition of mining related infrastructure is often grossly under estimated; or it is simply assumed that the returns on scrap steel and sale of re-usable plant will cover the related costs. With fluctuating steel prices and no guaranteed buyer for the assets, the estimated monetary return is often unreliable, and in many cases unrealistic. On this basis this logic is fundamentally flawed, and we have found that on most occasions this has meant that closure costs estimates fall well short of what the actual costs are to close the mine.

GSS Environmental and Liberty Industrial have worked on over 60 mine closure projects in Australia and overseas of varying scales and across a range of commodity types. An evaluation of these projects has shown that costs associated with the safe demolition and removal of a mining related infrastructure is in the order of 20–30% of the total cost at closure. We believe it is one of the top three risk areas associated with mine closure planning and cost estimation, alongside bulk earthworks, and the capping of tailings and waste rock storage facilities.

Our paper uses examples from recent projects to demonstrate all aspects outlined above. We have also endeavoured to address the following key points related to the demolition and removal of mining related infrastructure:

- *If companies fail to plan appropriately, complicating factors such as contamination, hazardous materials, mobilisation/de-mobilisation, geographical location, decommissioning standards, site constraints and weather can add considerable costs to the project and result in variations for the demolition contractor.*
- *Closure planning often assumes infrastructure that is no longer required can be utilised by a third party and/or the new land holder. We intend to show that unless adequate consultation and planning is undertaken, this is not beneficial to the mining company, the environment, or the local community.*

1 Introduction

Mining globally has experienced steady growth in recent times primarily due to the demand for natural resources by industrialising economies in Asia, South America, and Africa. This has led to the expansion of existing mining operations to augment production, and the fast tracking of many greenfield projects including mining related infrastructure, i.e. processing facilities, ports, power stations etc., to meet demand. With the industry so focussed on expanding, it may seem incongruous to stress the importance of decommissioning and closure at the end of facility life; however failure to do so may have serious financial implications upon execution of the facility closure strategy.

Most companies and their stakeholders appreciate the detailed engineering and design work required for mine infrastructure to ensure maximum equipment availability and product yield. They also understand that mine planning involves countless model iterations to determine an optimal mining sequence and waste, i.e. overburden, coarse rejects and tailings, management strategy that avoids rehandling, will achieve the approved post mining landform, and ensures that rehabilitation objectives can be met at minimum cost. Many companies however, are yet to appreciate the complexities associated with infrastructure demolition and removal; and that the absence of a detailed and fully costed decommissioning and demolition program will most likely lead to a significant cost over-run at the end of the project lifecycle.

2 Closure cost estimation

Closure cost estimates within the mining industry typically fall into one of the following categories:

- Security deposits/bonds – a guarantee for the anticipated costs of decommissioning, rehabilitation and closure within a defined operational period (short term, approximately 1–5 years).
- Financial assurance cost estimates – a guarantee for the anticipated costs of decommissioning, rehabilitation and closure at the point of greatest disturbance (highest cost) within the operations phase of the project.
- Life of mine closure cost estimate – an estimate of the residual cost for decommissioning, rehabilitation and closure once the life of mine plan has run to completion (assumes progressive rehabilitation is completed).

It is noticeable just from these descriptions that the inputs required to determine these cost estimates may be very different, and in-turn the values are likely to vary significantly. Failure to appreciate the difference can result in confusion and inadequate provisioning. It is also apparent that each of these calculations is largely dependent on the operational status of the mine, the mine plan or schedule, and an ongoing commitment to progressive rehabilitation. While mine plans have a propensity for constant variation, the net impact of these changes on the closure cost estimate is often minimal as cost reduction is usually the driver for the changes.

Table 1 provides a breakdown of estimated end of mine life closure costs for a range of Australian operations. It shows, on average, three activities account for approximately 80% of mine closure cost estimates. These are:

- Bulk earthworks and rehabilitation (includes high walls and voids).
- Capping tailings and waste rock facilities.
- Infrastructure demolition and removal.

Table 1 End of mine life closure cost estimates for a range of Australian operations

Site	Infrastructure Demolition (%)	Rehabilitation Works (%)	Tailings/Waste Rock Capping (%)	Indirect (%)
Small underground	**56.9**	12.7	2.2	28.2
Large open cut	**18.8**	45.2	13.5	22.4
Small open cut	**8.0**	14.2	50.2	27.7
Large open cut	**24.1**	32.7	19.8	23.4
Large open cut	**15.4**	43.5	17.1	24.0
Coal handling and preparation plant	**47.4**	30.3	17.6	4.8
Large open cut	**16.4**	33.5	48.9	1.2
Small open cut	**16.1**	59.7	0.0	24.2
Medium open cut	**29.2**	38.6	0.0	32.2
Large open cut and underground	**18.9**	42.4	14.6	24.1
Average	**25.1%**	**35.3%**	**18.4%**	**21.2%**

The remaining 20% is indirect costs associated with administration, environmental monitoring, engineering, mobilisation/demobilisation of equipment and closure project management. Figure 1 provides the data from Table 1 displayed in chart form.

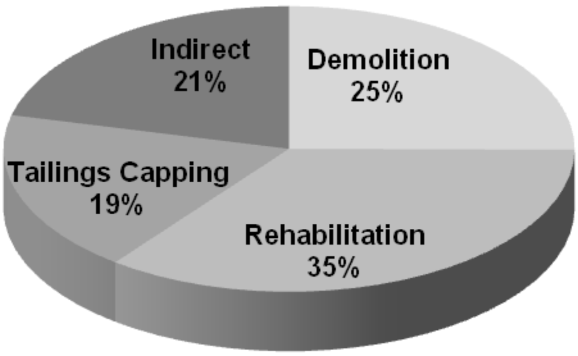

Figure 1 General break down of key elements in closure cost estimates

Typically the basis for calculating the rehabilitation and capping, i.e. blasting, bulk pushing, capping, topsoiling, revegetation etc., or core-business components of the closure cost estimate is, when available, from surveyed areas or volumes (i.e. m^2, m^3, ha) recorded as part of the mine planning/scheduling activities or alternately estimates of areas and volumes from a site assessment and/or aerial/site photos. These values are then multiplied by a generic flat rate for each of the associated works which is provided by the operation, company, regulator, or third party mining industry personnel. Actual costs are sometimes used however this is the exception, not the rule. A “sanity check” of these totals is usually conducted by the company/operation prior to sign-off.

A similar process is used for the decommissioning, demolition and removal of infrastructure. The footprint, i.e. building, conveyor, processing plant etc., is multiplied by a generic flat rate. However demolition is not core business and technically very different from mining. Mining companies and their stakeholders typically do not have the appropriate in-house skills or experience to conduct an accurate assessment of the decommissioning and demolition requirements and costs, due to limited understanding of the following:

- The planning and management required for decommissioning and demolition.
- That demolition presents different challenges regarding safety and engineering.
- The requirement to engage suitably qualified structural engineers and appropriate technical experts.
- The presence of hazardous materials.
- Decommissioning and decontamination requirements.
- The specific equipment requirements and associated mobilisation/demobilisation.
- The height and/or elevation of the structures.
- The geographical location of the mine site.
- The true costs associated with demolition activities.

The rudimentary method of calculating the demolition component of a closure cost estimate outlined above generally fails to account for any of these factors, and in turn results in a significant under estimation of the true cost to fully decommission a site. In effect, these cost estimates are precisely that, an estimate without any validation of the required expenditure to remove what is typically a sizable infrastructure footprint.

This is further accentuated by the fact that the size of mining infrastructure is at proportions previously unseen, and will in turn require greater levels of planning and engineering to ensure they are demolished safely and cost effectively. In addition, misguided assumptions are often applied to the infrastructure component of the cost estimate including:

- Onsite voids will be used for depositing demolition materials – mine planners haven't allowed for this in their calculations.
- The return on scrap steel will cover the cost of decommissioning and demolition and therefore no provision is required for the demolition and removal of infrastructure.
- An alternate user for some/all of the infrastructure will be identified at the cessation of operations.
- Mining related machinery can be used for decommissioning and demolition.

While the use of voids for the disposal of demolition materials can be resolved by better planning, other assumptions made in closure cost estimations such as the perceived returns from scrap steel, and opportunities for reuse and on-sale of equipment must be robustly assessed and validated.

Figures 2 and 3 show some of specialist techniques and equipment required to safely execute a decommissioning and demolition strategy.

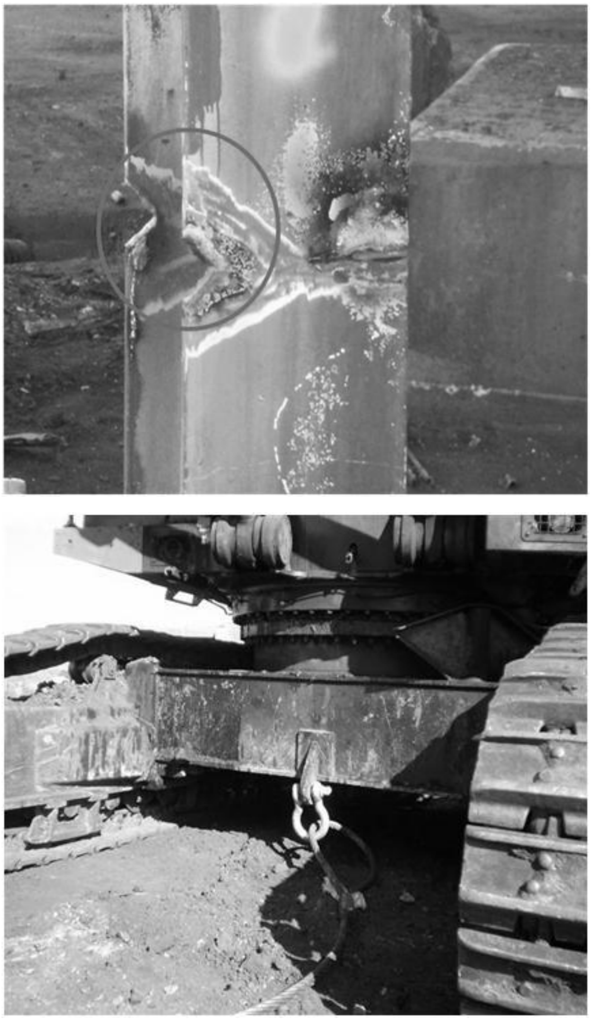

Figure 2 Structure weakening and attachment to machinery in preparation for pulling it over

Figure 3 A 47 tonne excavator with grab attachment

3 Predicted returns from ferrous scrap

Annualised returns from scrap steel were less than US$ 50 per tonne up until the mid 1970s. In 1974 it broke the US$ 100 per tonne mark. From the 1970s until approximately 2000 returns were anywhere between US$ 70 and US$ 140 per tonne. Figure 4 shows the annualised average scrap steel price from 1907 until 2009.

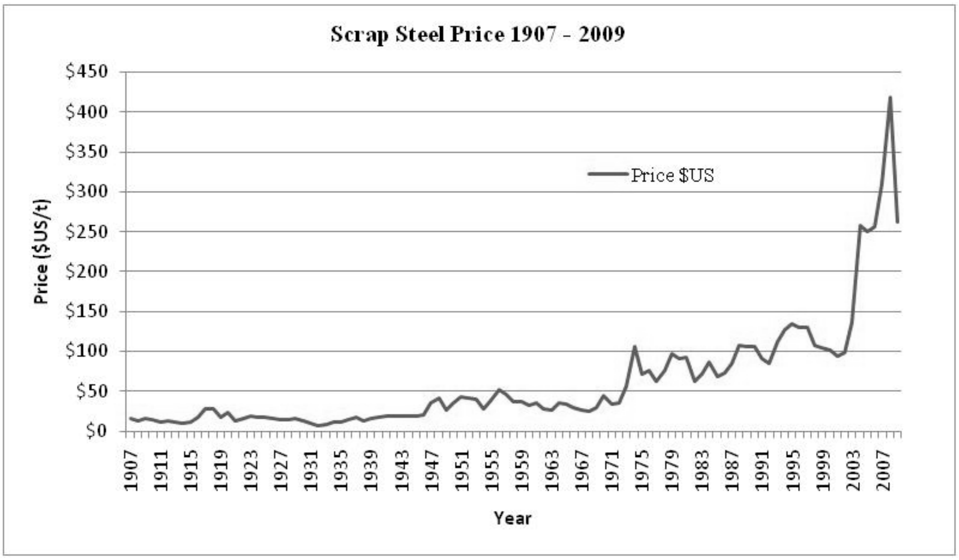

Figure 4 Annualised scrap steel prices 1907–2009 (data taken from Fenton, 1999)

Since 2000 the price of scrap steel has steadily increased reaching over US$ 400 per tonne in 2008. This dramatic increase may well have provided the impetus for the assumption that decommissioning and demolition costs will be covered by the returns from scrap steel. Figure 5 shows the significant increase in scrap steel prices since 2000.

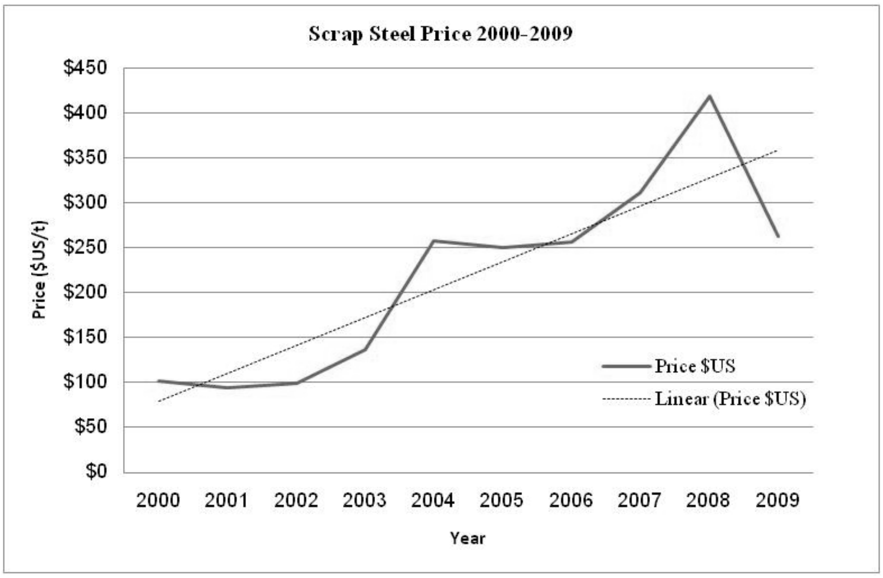

Figure 5 Annualised scrap steel prices 2000–2009

An evaluation of data collected from recent demolition projects allowed us to test the assumption that the returns on scrap steel will cover the cost of decommissioning and demolition, and therefore no additional provision is required at closure.

Table 2 provides an estimate of the available tonnages of recoverable scrap steel as assessed by demolition experts and civil engineers from a range of projects undertaken in Australia.

Table 2 Estimated scrap steel tonnages from a range of mine closure projects in Australia

Site Number	Type of Operation	Amount (tonnes)
1	Small underground coal mine	3,932
2	Large open cut coal mine	14,656
3	Iron ore beneficiation plant	8,785
4	Large open cut coal mine	11,409
5	Small diamond mine	5,515

Site 1 from Table 2 is a small underground coal mine in New South Wales, Australia. A specialist demolition company conducted a detailed assessment of the site and estimated the cost to decommission and demolish the infrastructure and dispose of demolition waste on-site to be US$ 4,327,000.

The scope of works covered by this cost estimate includes the following activities:

- Disconnect and terminate services.
- Demolish and remove the entire CHPP.
- Demolish and remove all other buildings.
- Demolish and remove on ground and overhead conveyors.
- De-construct and dispose of thickener tanks.
- Removal of all concrete pads and footings.
- General removal of carbonaceous material from stockpile areas.
- Sealing all portals and mine entries.
- General civil and earthworks for infrastructure areas.

If we compare the detailed cost estimate against the expected return from the scrap steel using the estimated tonnage, we can quantify any discrepancy between the values. Figure 6 shows the short fall from scrap steel returns from the estimated tonnage for Site 1 in Figure 5, against the detailed decommissioning and demolition cost estimate.

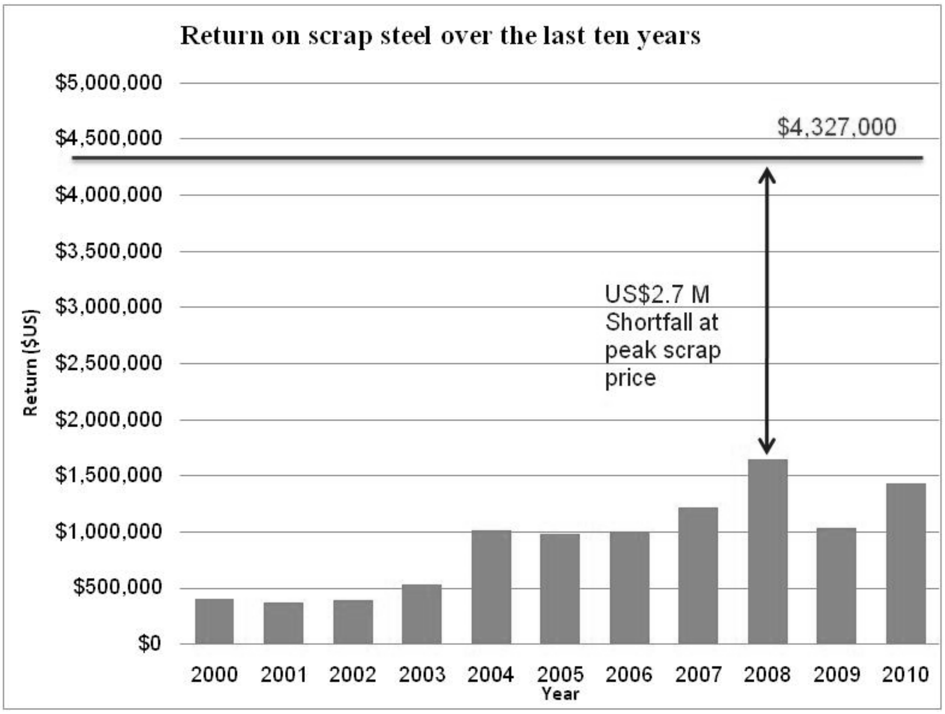

Figure 6 The difference between the actual cost of demolition and the expected return from scrap steel for a small underground coal mine in Australia

Using the peak annualised scrap price from 2008 of around US$ 420/t, the returns from scrap steel cover less than 40% of the total decommissioning and demolition costs.

Site 2 from Table 2 is a large open cut coal mine in New South Wales, Australia. Using the same methodology Figure 7 shows that with a detailed decommissioning and closure cost estimate of US$ 7,860,000, we again fall short of covering costs albeit not quite as significant.

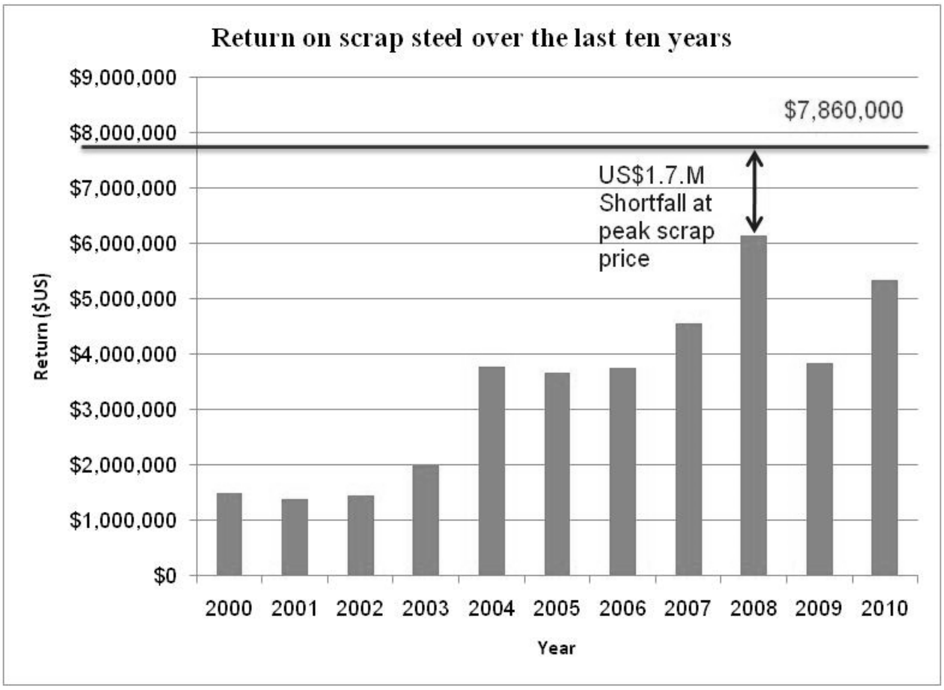

Figure 7 The difference between the actual cost of demolition and the expected return from scrap steel for a large open cut coal mine in Australia

Again using the annualised peak scrap price from 2008 of around US$ 420/t the returns from scrap steel cover less than 80% of the total decommissioning and demolition costs.

4 Dismantling and reuse of mine plant and equipment

While opportunities may exist to reuse mobile mine plant, often within the wider company or organisation and sometimes by third parties willing to purchase the equipment, the assumption that fixed plant has an on-sale value at the end of mine life is artificial. Plant that is 10, 20 or even 30 years old may seem like an asset during conceptual closure planning, however unless the plant has a specific value due to proprietary technology (or similar), history tells us this is not the case. There are a number of reasons for this including:

- There is no guarantee that a suitable buyer will be identified for the on-sale of the plant or equipment.
- The cost to dismantle fixed plant suitable for reassembly can be two and a half times the cost of demolition (this does not include transport costs associated with relocation).
- The transportation of the plant to the desired location and the reassembly costs are often prohibitive; particularly if it’s a long haul relocation.
- While the specific processing methodology may not have advanced significantly, on closer evaluation the reuse of 20+ year old plant will most likely be uneconomical due to engineering improvements such as automation, and processing efficiencies that will be available in new plant bought fit for purpose.
- Other factors such as costs associated with plant modifications to ensure the orientation is suitable at the new location.

In some cases mining companies assume that there will be opportunities for a post mining landholder to make use of the mining related infrastructure. While this again seems like a reasonable assumption during conceptual closure planning, without adequate consultation this will most likely result in a detrimental outcome to the mining company, the environment and/or the local community. The reasons for this include:

- The remote location of many mining operations may restrict the number of opportunities for post mining utilisation of the infrastructure.
- Unless the post mining landholder is another mining company, the scale of the infrastructure will often exceed the operational requirements of other potential landholders.
- The maintenance requirements on infrastructure that is 20+ years old and of the scale of equipment used for mining may significantly limit the cost effectiveness for many non-mining related industries.

While the previous owners may have exited with the best intentions, unused dilapidated infrastructure is a legacy item on disused or derelict mines, and the responsibility for the long term management is often left to the government and/or local communities. This can come at substantial cost, as implementing and maintaining safety standards, and prevention or management of environmental pollution comes at considerable expense. All of which often has to be funded by the local, regional or state governments and possibly the local community. In addition the visual amenity of an abandoned structure in a state of disrepair is lamentable. All these factors will undoubtedly impact the reputation of the original owner (the mining company) to some extent.

5 Conclusions

Like many other facets of a project in the early lifecycle phases, conceptual closure planning and costing is based heavily on assumptions. While technical detail and engineering is refined as the project moves through design, into construction and operation, many companies/operations place little value on developing a relative measure of detail for closure planning and costing. Any refinements made to the closure cost estimate are usually concentrated on the core business activities such as bulk earthworks and rehabilitation.

Assumptions relating to infrastructure made during the initial closure costing are often carried through the project and are never validated.

The reliance on costing assumptions relating to infrastructure decommissioning and demolition is a result of the mining industries limited experience and a genuine lack of understanding of the specific requirements regarding personnel, planning, technique, equipment, site access requirements, decontamination, safety, and general management of demolition activities. Therefore, the provision set aside for the infrastructure demolition component of a mine closure plan can fall well short, and in some cases may only cover as little as 40% of the actual cost. And with decommissioning and demolition accounting for approximately 25% of the total costs at closure, it is one of the 3 high risk areas to the successful execution of a closure strategy and requires an appropriate level of consideration.

In addition, opportunities for transferring mine plant to an alternate user at the end of a facility life, whether it be for related or unrelated use, are the exception not the rule and such assumptions should be rigorously challenged.

Opportunities to mitigate the potential for a closure cost over-run and/or avoid the uncertainty surrounding post mining options for infrastructure include:

- Consider decommissioning and demolition requirements during project design – significant savings in demolition may be available.
- Include a robust closure cost estimate in the project feasibility assessment.
- Engage a demolition specialist to validate any relevant assumptions made for closure cost estimates.
- Develop a strategy to investigate equipment reuse and on-sale opportunities well before closure.
- Include decommissioning and closure in the stakeholder and community engagement strategy.
- Develop a detailed closure planning strategy 5–10 years prior to the end of facility life.
- Conduct a detailed decommissioning and demolition estimate as part of the detailed closure planning strategy to ensure closure costs will be adequately provisioned for.

In summary, the financial benefits identified during conceptual closure planning such as returns from scrap steel, opportunities to on-sell or alternate post mining uses for infrastructure are rarely realised. This will result in a considerable shortfall in the provision available for activities associated with mine closure, and the potential for damage to the reputation of the mining company. In most cases this scenario can be avoided if appropriate attention is given to closure planning and costing during the relevant phases stages of the project lifecycle. And of course, this situation is not unique to the mining industry.

References

Fenton, M. (1999) Metals Prices in the United States through 1998, U.S. Geological Survey, pp. 65–67.