CLOSURE COST ESTIMATING METHODOLOGIES: A REVIEW OF MINE CLOSURE COST ESTIMATING METHODOLOGIESAND FOR DIFFERENT REPORTING PURPOSES

R. Haymont, Director. Trajectory

ABSTRACT

Mine closure liability cost estimation methodology is not always supported by clearly defined or mandated guidance tools. There are a range of different liability estimation requirements and approaches depending on the reporting objective or purpose of the liability assessment. These often include bankable feasibility studies, due diligence assessments, fulfilment of international, national or internal accounting standards or estimates for the calculation or performance bonds or assurances which vary for the different regulatory jurisdictions in Australia. The Western Australian government recently finalised a "Guideline for the Preparation of Mine Closure Plans" which includes a requirement for the preparation estimates of mine closure liabilities. Although these estimates are reportable only upon request by the Department of Minerals and Petroleum, the methodologies through which they are derived must be provided within Mine Closure Plans. This paper discusses the various applications of mine closure liability estimation and expands upon several of the standard methodologies applied to derive such estimates and the sensitivity which exists with respect to various methodology options.

1. Introduction

There is no right answer and there is no correct number with respect to mine closure liability estimating to the extent that different methodologies may be applied for different reporting purposes. This is entirely appropriate as a closure liability estimate should be conducted within a specified context such that it meets the needs of the target user or audience. Within different methodological settings however, liability estimates can be reasonably accurate if appropriately resourced and conducted. Liability estimates are models, and as with all models they are sensitive to the assumptions used to construct the model and the input data provided. Determination of the scope, limitations, inclusion, exclusions, physical measurements, accounting treatments and degree to which probability, uncertainty and contingency are applied to estimates are all an essential part of the development of estimating processes. Ultimately however the factor which can have most influence on an estimate is the "sentiment" of the entity controlling or requiring the estimate. All of this suggests that a very clear determination of the intended methodologies, inputs, exclusions and contingencies is essential to getting a result which corresponds to the reporting purpose

2. Why Estimate Mine Closure

The most recent development in mine closure estimating is the finalisation of the WA guidelines for the preparation of Closure Plans which requires that a methodology through which closure provisions are calculated is provided.

"The process and methodology for calculating the cost estimates must be transparent and verifiable. Refining closure cost estimates will be a key component of the review of the Mine Closure Plan required under the Mining Act 1978 or as defined by the EPA.

Estimated costs must take into account all aspects of closure costs. The estimate should include:

- *Earthmoving and land forming*
- *Management of problematic materials where relevant*
- *Research and trials*
- *Decommissioning and removal of infrastructure*
- *Remediation of contamination*
- *Survey program*
- *Remediation program*
- *Maintenance and monitoring*
- *Progressive and final rehabilitation*
- *Maintenance and monitoring programs (including post closure phase)*
- *Ongoing stakeholder consultation process*
- *Closure project management costs*
- *Administration*
- *Specialist Consulting Fees*
- *Legal requirements*
- *Provision for unplanned closure / care and maintenance*
- *Need to allow for earthmoving machinery to be available on site after*

Closure for remedial earthworks (or else provide funding for remobilisation of equipment if required)

The Mine Closure Plan is required to contain a summary of mine closure costing methodology, assumptions and financial processes to demonstrate to DMP and/or the EPA that The corporate entity has properly considered and fully understood the costs of meeting closure outcomes identified in the plan, and made adequate provisions in corporate accounts for these costs.

Reference to the detailed closure costing report is to be provided in the Closure Plan. DMP and/or the EPA may require a full/detailed closure costing report to be submitted for review, and/or an independent audit to be conducted on the report to certify that the company has adequate provision to finance closure"

This follows the development of estimating tools for bond calculations from the NSW and NT mine regulators and a guidance document from the Qld mine regulator for the calculation of Financial Assurances. Importantly there are a number of other circumstances when an understanding of liability is required for internal or external reporting purposes. Set forth below are five different occasions for which liability estimates might be generated. What's worth noting is that for each of these types of estimates there may be a number of different assumptions, criteria or methodologies which can be applied.

2.1 Due Diligence

This activity should be one of the most important, rigorous and carefully scrutinised kinds of estimates. It is the estimate which is undertaken when an entity is considering taking over accountability, usually via asset purchase, of a mining liability. It should involve careful scrutiny of existing estimates or reproduction of new estimates if existing estimates are not sufficiently robust. Frequently there is insufficient time or resources allocated to realise a true picture or extent of the liabilities involved.

2.2 Bankable Feasibility

During feasibility or Bankable Feasibility studies where external investment entities are involved, estimates of residual liability after mine operation are often calculated. These estimates are generally intended to be prepared to the same level of accuracy, + or – 10% for example, as the construction, commissioning and operational phase estimates. This is often a challenge as closure designs are sometimes only conceptual in nature whereas the level of estimating detail is expected to reflect more robustly designed operational phases. There are Australian Accounting Standards Board 137 guidelines, *Provisions, Contingent Liabilities and Contingent Assets,* which can be referred to for this purpose or other estimating purposes within Australia

2.3 Reporting for foreign Stock Exchanges

North American companies listed on the US or Canadian Stock exchange must report in compliance with the *Financial Accounting Standards Board* Standard (FAS 5 and FAS 143) for the US and for Canada the Canadian Institute of Chartered Accountants *Asset Retirement Obligation* Standards. The international Financial Reporting Standards, IAS 37, *Measurement of Liabilities*, is broadly similar to this. All of these standards have the same general principles which are:

- Reports estimate the amount of liability actually incurred up to a specific reporting date
- Off sets for sale of assets cannot be included
- Obligations can include legally binding obligations or public commitments
- Estimates need to be completed assuming "fair value" which is what an informed entity would charge to take accountability for and mitigate the liability. This is usually interpreted as "third party costs" i.e. what a third party would charge to retire the liability.

2.4 Government Bonds, Sureties, Assurances

As mentioned above there are a number of methodologies and models to calculate government bonds, sureties or assurances. The WA government is still in the process of determining a revised approach in WA. Some models which have been considered include the NT and NSW model each which use a calculation tool, the Qld Model which provides textual guidance and the Nevada model, the RCE, Reclamation Cost Estimator, which has been further developed by Barrick into BRCE.

2.5 LOM Operational and Rehabilitation Budget

An important internal requirement of estimating is the whole of life cycle or LOM cost estimate. This estimate may or may not be reportable externally, but it is an important process of development of budgets such that costs for progressive rehabilitation and closure phases are estimated and scheduled such that appropriate budgetary provisions can be made.

3. Methodologies

The various inputs, once established need to be combined through prescribed methodologies. These are set out below in the following broad areas:

- Assumptions, Criteria and Limitations
- Cost Structure and Model
- Physicals
- Direct Cost Estimates - Equipment, Unit and Activity Costs
- Indirect Cost Estimates – Owners Costs, Post Closure Costs and Mob and De Mob
- Contingency

3.1 Assumptions

The following general assumptions from the closure plan and regulatory conditions and commitments are often applied and used to calculate the rehabilitation and closure costs where no specific guidance is provided in via specific assumptions or criteria.

- Demolition – demolition and/or removal of infrastructure and services no longer needed during, and at the end of mine life.
- Cleanup and Remediation – clean-up of contaminated areas of soil and water during, and at the end of mine life.

- Rehabilitation and Revegetation – development of a stable non-polluting and self-sustaining landform that has been disturbed by mining operations. Rehabilitation and revegetation is conducted progressively during operations and at the end of mine life.

The mine site closure cost estimate are usually based on the scope of closure works that the corporate entity has committed to in various approvals and project documents, and can rely on the internal unit and activity cost estimates. There are opportunities to refine the scope of closure works for each domain, based on the outcomes of closure planning tasks undertaken prior to cessation of operations.

The following parameters are frequently applied to the cost estimate:

- The closure cost estimate includes costs for all physical works that the corporate entity will be responsible for undertaking in implementing the mine site Closure Plan.
- It is assumed that all required closure works will be undertaken after cessation of operations including landform profiling, construction of abandonment bunds etc. The corporate entity may however schedule for closure works to be undertaken during operations.
- Owner's management costs or those costs that will be incurred by the corporate entity in supporting the closure program (accommodation, messing, management etc) have been estimated.
- The closure cost estimate has been delivered in current AUD figures.
- A contingency allowance nominated by the corporate entity has been applied to the closure cost estimate. This was applied at different rates to different aspects according to confidence levels.
- It is sometimes assumed that the mining and earthworks contractors will be available to undertake all closure earthworks as required by the mine site mine closure plan. As such specialist earthworks contractors may or may not be mobilised to site.
- Post closure costs (including environmental monitoring and reporting, rehabilitation maintenance and lease payment costs) are often estimated to continue for 10 years beyond the cessation commercial production. Costs can be scaled down appropriately during over this period. It is often assumed that lease relinquishment will be achievable after 10 years but this may not be the case.
- Costs may be estimated for both the current footprint liability as of a specific date and for the full footprint of the project as indicated in approvals documentation using the full life of mine costs and then estimating the percentage of footprint disturbed as a surrogate of liability incurred. Costs can be included / excluded from the full footprint closure cost estimate progressively as the project expands or as otherwise required.

The following limitations in relation to the cost estimates are sometimes applied:

- The estimate excludes all costs associated with redundancies, repatriation, retraining and outplacement of the corporate entity workforce and of any contractors' workforce.
- The estimate excludes all costs associated with sudden or unplanned closure

- The estimate excludes all costs associated with care and maintenance or preservation activities
- The estimate excludes all costs associated with disposal of stores inventory.
- The estimate excludes all costs associated with removal of the corporate entities non-fixed assets (as described in), redundant equipment and scrap; it is assumed that this will be removed prior to closure.
- No cost offset has been assumed for the resale of any assets or scrap.
- The estimate excludes all costs associated with closure planning, design, reporting and related professional costs prior to cessation of operations.
- The estimate excludes all costs associated with any change in closure obligations which may arise during the life of the operation or after closure.
- The estimate makes no allowance for inflation to closure, calculation of net present value, or amortising etc. Such mechanisms may be applied according to the accounting standards used but are not usually built into the basic estimate

3.2 Cost Structure and Model

The cost model is best developed to align with the closure plan whereby the project is divided into the domains which deal with the various spatial and post closure aspects of the project.

Each Domain is further divided into Areas or Features, which are generally defined by spatial or specific management area boundaries.

Each Area is divided into Activities which are the specific actions for which units of measure and costs can be combined to form an estimate.

From an accounting and cashflow perspective the mine site closure cost estimate has been assembled into a series of worksheets which separate costs into various tiers of detail:

1. Summary
2. Cashflow
3. Details per domain
4. Unit and activity cost register

The summary table represents high level summary costs for each domain. The cashflow table provides scheduled expenditures for closure costs incurred through time, both before and after cessation of operations, until obligations associated with the mine site tenements cease.

The detailed domains worksheets are often divide each domain into relevant disturbed sites. Details of the closure tasks associated with each disturbed site are outlined, the cost assumptions and calculation inputs are detailed, and the closure cost is itemised for each closure task.

3.3 Physicals

Getting the right physical measurements in crucial to estimating and a failure to do so is often a source of poor estimating outcomes .It is essential that the physical measures derived correspond with the conditions and commitments so that they are an accurate reflection of legal obligations. Such measures can include:

- Depths of cover to be placed (sometimes multiple covers at different depths or different coverers over different spatial locations
- Spatial area of disturbance
- Length of corridors, roads, pipelines, powerlines, bunds etc
- Footprint area of different types of infrastructure
- Specific Gravity of various materials to be moved
- Angles of slopes and batters
- Widths of berms and bunds
- Depths of ponds and dams

These measures should be captures within the estimates spreadsheet and ideally reference the source/activity through which they were derived

3.4 Equipment, Unit and Activity Costs

The methodologies adopted to estimate closure costs for each category of closure tasks, follow customary mining and demolition industry standard practices. Estimates have been derived from a number of cost areas including:
Equipment costs;
Unit costs; and
Activity costs.

These costs may be applied to:
Earthworks Costs;
Revegetation Costs;
Demolition Costs; and
Indirect Costs.

Equipment Costs

Equipment costs form the basis of many unit and activity costs. Equipment costs can be derived via a number of methodologies or combinations of methodologies. In the case that there is only limited equipment costs available from existing contracts for equipment, which is intended to be used for both operational and closure activities.

Consequently most unit and activity costs associated with equipment have been derived from 'hourly hire costs' or 'price per volume managed' costs already derived and aligned within the cost estimates. Where these are not available costs are derived through the utilisation of relevant benchmark or analogue third party costs derived from recent earthworks activities in the region. These are generally a reliable guide to cost estimating. Hence, where planned closure activities have no contractual precedents on site, costs have been derived from one of the following sources:

Costs derived from similar projects in Western Australia or the Northern Territory where contract or actual costs are available and services are delivered by a third party.

Costs from published estimating tools such as those produced by the NSW Department of Primary Industries and Northern Territory Department of Resources which have been benchmarked and researched extensively.

Costs derived from first principles using standard cost development methodologies (rental, labour, fuel, wear, preventative maintenance, tyres, supervision, overheads and profit).

Equipment costs generally need to be calibrated based on productivity and correction factors which consider haul distance, elevation, material nature, competency of operator, slope and visibility. The impact of push length on dozer productivity is demonstrated in the figures below. The level of this specification is general as design parameters which would dictate several of these inputs are still not specified to a high level of accuracy in some cases.

Unit Costs

Unit costs are the basic units of the cost estimating process including:

- Hour of machine time;
- Cubic meters moved;
- Kilogram of seed;
- Hour of labour;
- Suite of water analysis; and
- Plugging of a drill hole.

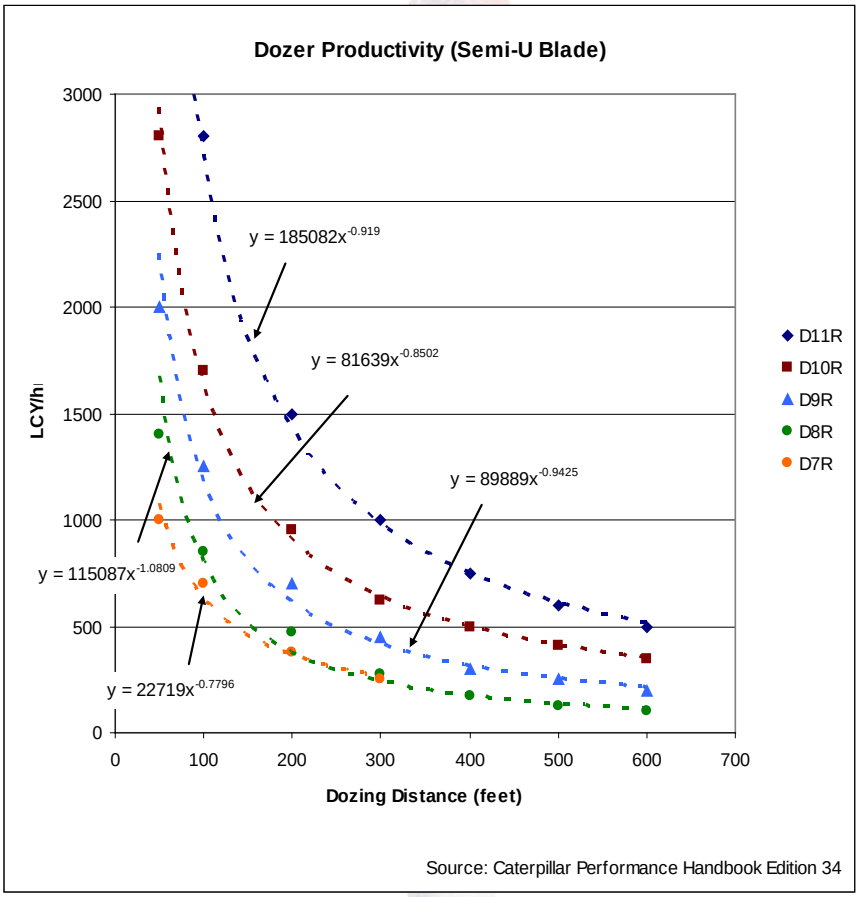
Unit costs for a mine site are often derived by site contract rates or relevant cost experience in the region. The following is a list of some typical unit costs:

- Dozer push to reprofile slopes ($/m3);
- Load, haul and spread over various distance increments ($m3/km);

- Demolition Labour ($/hr);
- Seed Mix ($/kg); and
- Accommodation costs ($/night).

Figure 1 and 2 provides examples of how some unit costs can be calibrated using dozer efficiency tables.

Figure 1: Dozer Productivity versus Push Length



Source: Caterpillar Performance Handbook Edition 34

Table 2: Dozer Productivity versus Push Length

Dozer Productivity vs. Grading Distance					
Average Dozing Distance (feet)	Production (LCY/hr)				
	D11R	D10R	D9R	D8R	D7R
50	4800	2800	2000	1400	1000
100	2800	1700	1250	850	700
200	1500	950	700	475	375
300	1000	625	450	275	250
400	750	500	300	175	
500	600	410	250	125	
600	500	350	200	100	

Source: Caterpillar Performance Handbook Edition 34

Activity Rates

Activity Rates are usually a combination of units of cost and are measured in lengths and areas or unit of service:

- Hectares of topsoiling;
- Hectares seeding;
- Kilometres of road rehabilitation;
- Area of drain lining (m2);
- Volume of contaminated material managed (m3)and
- Report preparation.

Activity rates have been developed for the mine sites using local or relevant analogue costs.

Deconstruction

Deconstruction includes all activities associated with dismantling aboveground fixed assets and infrastructure to concrete level or ground level, removing saleable items, and disposing of other items as required. Deconstruction includes removal or burial of concrete, removal of potentially contaminated soils and reprofiling ground levels. Deconstruction activities are estimated primarily through a combination of the following:

- Unit rates per m2 of different infrastructure categories derived through benchmarks or from various government bodies.
- Specialised equipment hourly hire rates (cranes, forklifts and excavators with shears or rock breakers as required).
- Skilled labour (supervision, oxy cutting, dogman and machine operators).
- Overheads (project management, mobilisation and demobilisation, consumable and profit).

Generally an assessment is made of the volume of material involved, its footprint or the number of similar units and, based on experience and industry guidelines, an estimate of the number of hours a skilled demolition team would take to complete the task.

Revegetation

The revegetation program for mine sites are frequently developed through the following processes:

- The site flora species list was reviewed and placed within a spreadsheet.
- Seed purchase costs were identified from three suppliers where the species specified were identified on seed supply lists (Nindethana Seeds, Kimseeds and Mulka Seeds as an example).
- Where no costs were available some indicative costs were used for similar species.

- Average costs per kilogram were established through the averaging of the entire available price per kilogram data.
- Rates of seeding per hectare were roughly assigned for each species.
- A rate of seed to be provided per hectare was determined based on average regional seeding rates.
- Rates for fertilizer, mechanical or hand seed spreading, contour ripping and supervision were each established.

Through this total rates per hectare established.

Indirect Costs

Technical Studies and Investigations

Financial provisioning estimates need to include include for the following studies and investigations which should be undertaken throughout operations:

- closure related technical studies;
- social studies; and
- rehabilitation trials.

The closure related which may be undertaken and require estimates to be provided include:

- hydrogeological/ ground water modelling;
- pit-lake recharge/water quality studies;
- landform erosion modelling;
- final landform design;
- development of landform decommissioning plans;
- tailings geochemistry studies;
- waste characterisation and rehabilitation material balance studies; and
- surface water drainage assessment studies.

Social and stakeholder studies to be undertaken for estimating may include:

- social impact assessments; and
- post closure land management plan.

Owner's management

Owner's management costs include the following cost items:

- Project management
- Engineering and technical support
- Supervision and professional
- Operators, deconstruction, trades and general labour
- Flights, travel, messing and accommodation

All of the above costs have can generally be from actual owner's costs, contractor rates or relevant regional analogues from recent projects. Duration estimates can be derived from the volumetric estimates and machine productivity rates, or from the work rates of demolition, earthworks and/or technical teams as required.

Post operations management and maintenance

Post operations management, in addition to owner's management costs, include:

- Reporting costs which are derived from current actual report preparation costs based on third party consultants providing this service.
- Specialist consultant reports with respect to groundwater, engineering design, designs of surface water control measures, contaminated sites assessments or liability estimating. These are also derived from recent industry experience using third party consultants.
- Lease holding costs were derived using the current mining lease rental costs.
- Vehicle, utility and incidentals were derived using operational costs as a benchmark.

Post operations monitoring

The mine site should have a limited and well defined post closure monitoring strategy. Post closure monitoring is primarily focussed on rehabilitation and revegetation performance will include routine assessments of land stability, floristic diversity and abundance, and ecosystem sustainability. Water, sediment and in some circumstances dust monitoring may also be important features of the monitoring estimate. Estimates for post closure monitoring have been derived from experience within the Western Australian mining industry.

Contingency

Contingency settings are made in response to uncertainty in estimating, where the level of accuracy or the probability of liability adjustments which cannot be currently forecast, requires recognition. In many of the mine site contingency settings have been determined based on generally accepted standards in the mining industry; the contingency setting for each area of the liability has been calibrated based on confidence levels. As a general

rule contingency can be set at 10 to 15% which is consistent with the upper bound of what some of regulatory authorities nominate within Australia.

Contractor demobilisation

Demobilisation costs for contractor plant and equipment should be included in the mine site estimate. Costs for mob and demob are sometimes derived by calculating 1% of the total project costs

Conclusions

Mine Closure and Rehabilitation Liability Assessments are essential to understanding the complete picture of the business in the long term and fulfilling a number of reporting requirements. Accurate estimates can ensure that mine closure and rehabilitation is given adequate management focus and can influence decision making appropriately and avoid unforeseen costs and impediments to the business as the project matures. There are many influences on mine closure estimating processes. It is sometimes a challenge to secure enough resources and expertise to conduct rigorous estimates, particularly when the results of such activities generally lead to increases is business liabilities, many of which must be reported externally. This can lead to subtle (and sometimes not so subtle) pressures to either avoid too much rigour or to continually delay the acknowledgement of liabilities through a continual resort to “further studies”. Although this may fulfill the short term interests of some within the business leadership, it damages the long term interest of the business through a lack of understanding and preparedness for liabilities and a lack of focus on what optimisation, mitigation and operational phase opportunities exist to reduce these liabilities in the near term.