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Closure Planning and Estimating Within the Southern Africa Division of a Global Gold Miner

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Abstract

South Africa's principal minerals legislation, the Mineral and Petroleum Resources Development Act (No. 28 of 2002) and Regulations (R527 of GG26275 23 April 2004) require, inter alia, that environmental management programmes include a description of the environmental objectives and specific goals for mine closure and that mining land "is rehabilitated, as far as practicable, to its natural state, or to a predetermined and agreed standard or land use, which conforms to the concept of sustainable development". Furthermore, these regulations stipulate that the quantum of financial provision required to achieve this is estimated and provided in a prescribed manner, not only for planned closure but also for premature closure, and for post-closure management of residual and latent environmental impacts.

The authors describe how the closure estimate for AngloGold Ashanti's South Africa mines was improved in 2007 through a review, the setting of appropriate objectives and a market-related reassessment of costs. The main findings of the review were that there existed a comprehensive database of quantities and demolition costs for buildings and infrastructure. However, there was an inadequacy in the objectives and specific goals for mine closure and future land use, a lack of provision for premature closure as well as methods and estimates for tailings storage facility (TSF) and waste rock dump rehabilitation which were out-of-date and did not address the prevention of seepage and groundwater pollution. To update the estimates for TSF and waste rock dump rehabilitation, comparisons were made between the Department of Minerals and Energy (DME) Master Rates and estimates from independent contractors of the costs of implementing ecological engineering approaches recommended by the University of the Witwatersrand, Johannesburg. There was an increase in the quantum (R 644 million; US$1 = R 7.50) to provide for the unlikely event of premature closure. Conversely, the amounts that needed to be accounted for in the company's balance sheet and income statement were reduced (R 137 million) because of a greatly-extended life-of-mine (LOM) and favorable discount and inflation rates. Further research is required into future decanting of mine water, treating groundwater, identifying off-site impacts and offsetting costs through the conversion of mine waste to carbon sinks or other resources.

1 Introduction

Together with several other progressive mining- and resource-based companies, AngloGold Ashanti Limited (AGA) is a corporate member of the International Council on Mining and Metals (ICMM), membership of which includes a commitment to measure corporate performance against the ICMM principles on sustainable development. These principles have in common widely-recognized means of preventing serious impacts associated with historically-abandoned mines including, inter alia, requirements for designing and planning for closure, assessing and consulting on social, health, safety, environmental and economic impacts at all stages of the lifecycle, rehabilitation of disturbed land for future use, contributing to community development, and providing adequate resources for closure. These principles are also included in South African legislation. Towards fulfillment of these principles and legal requirements, AGA has compiled conceptual closure plans for its Vaal River and West Wits mining areas, which identify environmental risks, attempt to set scientifically-sound and technically-achievable closure objectives and recognize potential residual risks. These objectives seek to maximize the use of existing mining structures and infrastructure, especially those that are ancillary to the main mining processes, for the betterment of the communities post-closure but without compromising on future safe land use.

2 Legal requirements for mine-closure planning and financial provisioning

South Africa's principal minerals legislation, the Mineral and Petroleum Resources Development Act (No. 28 of 2002) (MPRDA) and Regulations (R527 of GG26275 23 April 2004), prescribe the requirements for mine closure, the principles of which are covered in Regulation 56 (reviewed in Sutton and Weiersbye, 2007). These stipulate that: the closure of a mining operation shall incorporate a process, which starts at the commencement of the operation and continues throughout the life of the operation; risks pertaining to environmental impacts shall be quantified and managed proactively; residual and possible latent environmental impacts shall be identified and quantified; the safety and health requirements in terms of the Mine Health and Safety Act, 1996 (No. 29 of 1996) shall be complied with; and the land shall be rehabilitated, as far as practicable, to its natural state or to a predetermined and agreed standard which conforms with the concept of sustainable development. Towards these aims, Regulation 61 requires closure objectives to be established at the outset of the project in order to guide project design, development and management of environmental impacts, to provide broad future land use objectives and to enable closure costs to be estimated.

In terms of Section 41(1) of the MPRDA, an applicant for a prospecting right, mining right or mining permit (hereafter, referred to collectively as a mining authorization) must, before the Minister of the DME approves the environmental management plan or programme in terms of Section 39(4), make the prescribed financial provision for the rehabilitation or management of negative environmental impacts. According to Regulation 54(1), the quantum of financial provision must include a detailed itemization of costs for: premature closure; decommissioning and final closure of the operation; and post-closure management of residual and latent environmental impacts. Regulation 53 requires that the total quantum of financial provision is provided by one or more of: (a) a contribution to a trust fund, (b) a financial guarantee, (c) a cash deposit, or (d) any other method the Director-General may determine. Thereafter, in terms of Section 41(3), the holder of a mining authorization must annually reassess his or her environmental liability, and increase the financial provision to the satisfaction of the DME, thereby providing not only for cost escalation but also for new developments and findings to be included. Regulation 54(2) requires that a competent person be consulted during this annual review and update of the quantum of financial provision; where such a person is defined as meaning one who is qualified by virtue of knowledge, expertise, qualifications, skills and experience; is familiar with the provisions of the MPRDA and other related legislation; and has been trained to recognize any potential or actual problem in the performance of the work.

The DME has also published a guideline document to assist its staff in evaluating the quantum of closure-related financial provision provided by a mine based on Master Rates (DME, 2005). Subsection 41(4) provides for the possibility that the minister may not be satisfied with the assessment and financial provision submitted. In such an event, the minister is mandated to appoint an independent assessor to conduct the assessment and to determine the financial provision. According to Subsection 41(5), the requirement to maintain and retain the financial provision remains in force until the minister issues a certificate in terms of Section 43 to such holder. Nevertheless, the minister may still retain such portion of the financial provision as may be required to rehabilitate the closed mining or prospecting operation in respect of latent or residual environmental impacts.

Even though the former holder of a mining authorization is no longer liable for environmental damage in terms of the MPRDA, once a closure certificate has been issued in terms of Section 43(1), the provisions of other legislation, such as the National Environmental Management Act (No. 107 of 1998) and the National Water Act (No. 36 of 1998), would still prevail in the event of undisclosed or future environmental damage. Most importantly, if funds are insufficient, the mining company and its directors remain liable. Hence, mining companies and directors should keep abreast of international trends in mine closure in order to proactively minimize their exposure (Sutton and Weiersbye, 2007).

3 Accounting requirements for liability estimates

Accounting requirements for liability estimates are governed by the International Accounting Standards Board (IASB) and are specified in International Financial Reporting Standards (IFRSs) and International Accounting Standards (IASs). IAS 37 provides the basis for accounting and disclosure requirements (IASB, 2007). For companies listed on the New York Stock Exchange, the impact of US Generally Accepted Accounting Practices (GAAP) also needs to be considered; however, it is not the intention to debate the differences between IFRS and US GAAP in this paper, and only the requirements of IFRS will be discussed.

3.1 Liabilities and provisions

A liability is a "present obligation of the entity arising from past events, the settlement of which is expected to result in an outflow from the entity of resources embodying economic benefits" (IASB, 2007), which means that all damage incurred to date must be provided for, as the entity will have to use funds in the future to repair the damage caused by its operations.

As discussed in Section 2, in South Africa the regulator provides for the rehabilitation obligation in legislation. As a result, an entity in South Africa has to comply with both IFRS and legislator requirements. The IFRS acknowledges this situation by referring to a legal obligation, which is an obligation that derives from: (a) a contract; (b) legislation; or (c) other operation of law.

3.2 Decommissioning and restoration

For accounting purposes, the environmental liability of an entity consists of two components (IASB, 2007). In broad terms, these are: decommissioning, which mainly addresses the cost of demolishing or removing infrastructure that did not exist prior to mining activities; and restoration, which addresses the cost of restoring or rehabilitating land, e.g. stabilizing, landscaping and vegetating TSFs. The provisioning is determined by how much rehabilitation work is required to change the land back to a state approaching, or analogous to, the original state or an alternate, predetermined state as agreed to by the regulator.

The reason for splitting the estimate is because the estimate for decommissioning and any later changes go to the balance sheet where decommissioning assets are created; whereas, restoration estimates and future changes go through the income statement.

3.3 Considerations when determining the liability

3.3.1 Best estimate

"*The amount recognized as a provision shall be the best estimate of the expenditure required to settle the present obligation at the balance sheet date*" (IASB, 2007). This requires that reasonable rates and quantities are determined. Thus the rates from rehabilitation and demolition contractors are important, as well as the use of quantity surveyors in measuring structures and infrastructure.

3.3.2 Future events

"*Future events that may affect the amount required to settle an obligation shall be reflected in the amount of a provision where there is sufficient objective evidence that they will occur*" (IASB, 2007). This can best be explained by means of an example. If the formally-approved business plan of an entity reflects operating cost cash outflows and revenue stream inflows for the reprocessing of a TSF, and the business plan reflects a profit, these future events may be used to reduce the calculated liability.

3.3.3 Expected disposal of assets

"*Gains from the expected disposal of assets shall not be taken into account in measuring a provision*" (IASB, 2007). Thus, even if it is a known that, for example, the steel in a defined unit of infrastructure has a scrap value, this possible sale of scrap may not be used to reduce the liability.

3.3.4 Present value

"*Where the effect of the time value of money is material, the amount of a provision shall be the present value of the expenditures expected to be required to settle the obligation*" (IASB, 2007). In practice, the expected life of operations or life of mine (LOM) should be obtained from the business plan and budget. Where these cover a period of years, the cash flows for rehabilitation work should be escalated with appropriate rates and discounted to a net present value (NPV). It is important to note that the charge to unwind the discounted present value from year to year must be shown separately.

3.4 Contingent liabilities

There are circumstances where an entity acknowledges an obligation to remediate, rehabilitate or restore, but it is not possible to attach a financial value to this future work. This may be as a result of research into solutions still being incomplete, or an inability to calculate the true quantum of work to be done with reasonable accuracy. For example, ecological rehabilitation involves long-term biological processes and is not a once-off activity such as a construction project, thus it requires a degree of adaptive management.

A contingent liability is: (a) a possible obligation that arises from past events and whose existence will be confirmed only by the occurrence or non-occurrence of one or more uncertain future events not wholly within the control of the entity or (b) a present obligation that arises from past events but is not recognized because: (i) it is not probable that an outflow of resources embodying economic benefits will be required to settle the obligation or (ii) the amount of the obligation cannot be measured with sufficient reliability (IASB, 2007). Under these circumstances, entities need to disclose: (a) a brief description of the nature of the contingent liability, (b) an estimate of its financial effect, and (c) an indication of the uncertainties relating to the amount or timing of any outflow (IASB, 2007). Thereafter, the users of financial statements can monitor the progress made by the entity to address the outstanding issues and track the movement to actual provisions.

4 Review of previous closure liability estimate

As a basis for updating the closure liability estimate, the closure plan and guideline document are reviewed to determine whether they are still in accordance with legal and other requirements with regard to environmental risks, and to capture any updates or changes in closure objectives, future land use, rehabilitation methodologies and assumptions (Figure 1).

4.1 Closure objectives and future land use

The authors found that the objectives and specific goals for mine closure and for future land use at AGA in South Africa were no longer adequate due to the continuously-improving state of scientific knowledge and more stringent regulatory requirements. For example, the earlier objectives were based on the assumption that contaminated land, such as metallurgical plant footprints and other areas affected by overflows and spillages of tailings and process water, would be returned to grazing land after cleaning. However, cleaning of soil and groundwater may not always be technically achievable within the assumed time frames. The uptake of some metals and naturally-occurring radioactive materials (NORMs) in pasture grasses (Weiersbye et al., 1999) and fodder trees (Weiersbye and Witkowski, 2003) could result in livestock farming being an unsuitable land use. In addition, grazing as an end land use may be sub-economic on highly-disturbed grasslands or rehabilitated mine pastures in the Highveld (O'Connor and Kuyler, 2006). Grazing on disturbed and fragile, rehabilitated or contaminated land also poses a risk to the rehabilitation process itself, and can therefore impair the recovery of ecosystem services (D.J. Tongway, pers. comm.).

4.2 Demolition of buildings and infrastructure

There existed a comprehensive database of quantities and demolition costs for buildings and infrastructure, which includes roads, houses, offices, schools, hospitals, electricity and water supply, water care works, warehouses and offices, all in addition to the mine shafts and metallurgical plants. Infrastructure had been measured by quantity surveyors and demolition rates initially obtained from demolition contractors and subsequently escalated according to rates published by Statistics South Africa (Table 1). However, it was intended that certain land and infrastructure would be incorporated into the community; therefore, the demolition costs had been excluded from the estimate. Although the process of proclamation was underway, it had not been concluded; thus, the liability could remain in the event of premature closure. This finding substantially increased the premature closure liability estimate; but as it remained an assumption that proclamation would occur, it did not affect the final closure estimate. However, this may change because it is considered that residential land uses, within the aqueous and aerial zone of influence from gold and uranium TSFs on the Witwatersrand basin, are at higher risk than other land uses, such as industrial or commercial (Sutton et al., 2006; Sutton and Weiersbye, 2008) and a fully quantitative assessment of risk to human health has not yet been conducted.

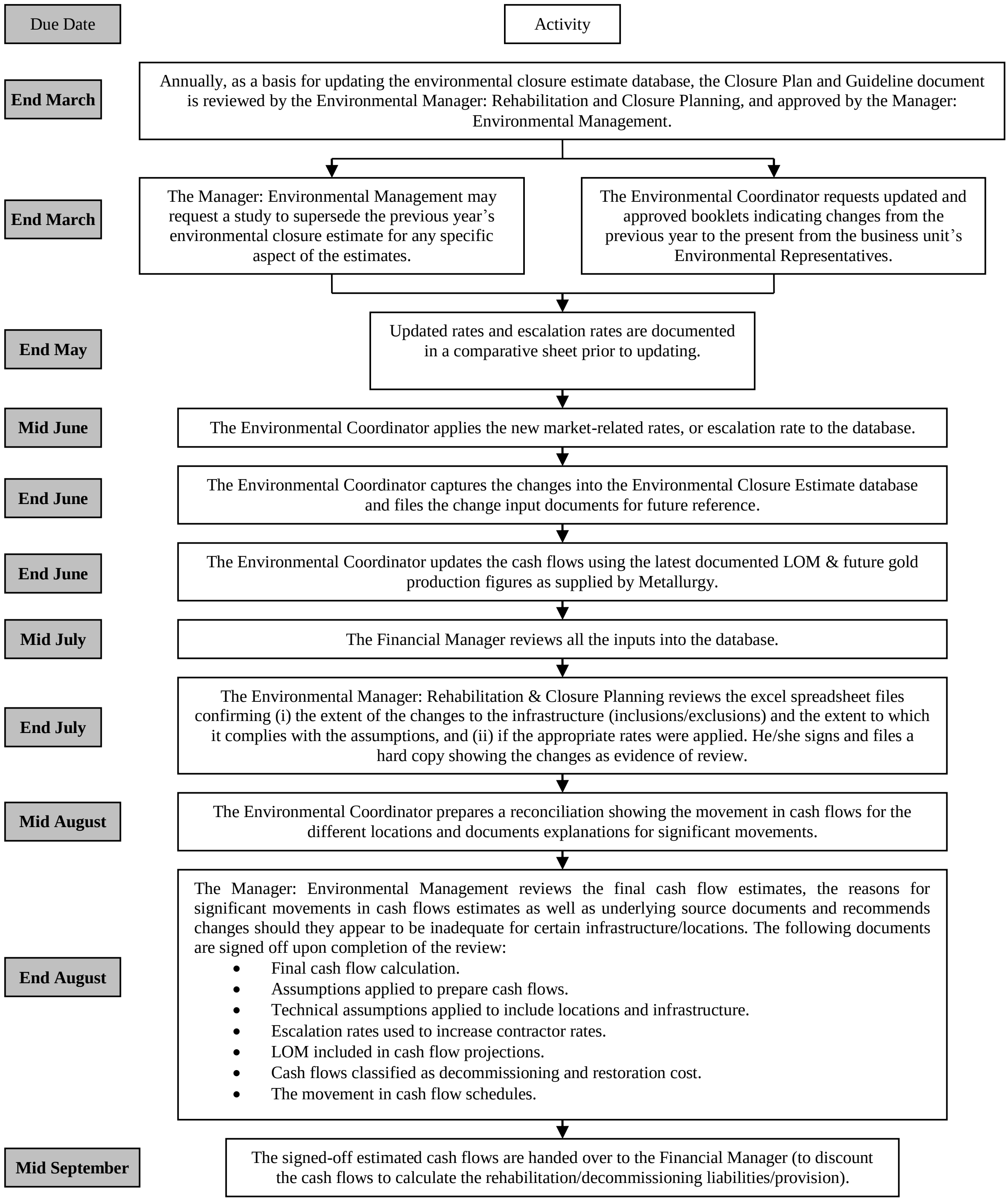

Figure 1 Annual environmental closure estimate updating process to quantify decommissioning and rehabilitation cash flows for discounting purposes

Table 1 Example of quantities and rates used for a demolition estimate (AngloGold Ashanti Limited, 2007a), Great Noligwa Shaft

GIS No.	Description	Unit	Qty	Rate (R/unit)	Amount (R)	Total (R)
1	**Timber yard**			-		1,350,457
	Overall size approximately 36,371 m^2			-		
	Track work, sleepers, steel work, etc. in concrete	t	70.17	3210.65	225,291	
	Track work in earth, including sleepers	t	5.85	1616.10	9454	
	Aprons, slabs, bases, etc.	m^3	5	345.85	1729	
	Reinforced concrete slabs, strip footings, surface beds	m^3	3221	345.85	1,113,983	
49	**Oil store**			-		1697
	Overall size approximately 2.9 m long x 2.7 m wide			-		
	Structural steel, etc.	t	1.27	444.97	565	
	Roof sheeting	m^2	10	19.39	194	
	Reinforced concrete slabs, strip footings, surface beds	m^3	2	345.85	692	
	One brick wall	m^2	6	40.94	246	

4.3 Rehabilitation of tailings dams and waste rock dumps

The previous rehabilitation methodologies for tailings dams and waste rock dumps were designed to control dust, and not to provide for seepage control or long-term ecological rehabilitation; hence they only temporarily addressed aesthetic and stability aspects. The marginally-acid-to-neutral pH of groundwater samples in the vicinity of TSFs on dolomite substrata had been interpreted as meaning there was not significant acid rock drainage (ARD). This view is reinforced by the DME guideline (DME, 2005), which Sutton and Weiersbye (2007) consider erroneously defines gold- and uranium-processing waste as basic and salt producing. However, the generation of ARD and mobilization of metal ions from gold and uranium tailings on the Witwatersrand basin is well established (Rösner et al, 2001; Winde et al., 2004a, b, c; Naiker et al., 2003; Tutu et al., 2003; Mphephu et al., 2004; Sutton, 2008). Some groundwater samples do have a more neutral pH when dolomites or limestones directly underlie the tailings dams, and the magnesium- or calcium-carbonate component is acid-soluble. While this has some advantages in terms of buffering capacity, the salt load remains high and some elements remain in solution across a wide pH range (Tutu et al., 2008). It has been suggested that ARD could result in greater transmissivity and storage volumes within dolomitic substrata, although the impact of this on karstification is unclear (Hodgson et al., 2001).

The rehabilitation methodology described in the 2006 estimate was based on sloping the sides of the TSFs to a lower angle (< 18 degrees) and grassing the sloped-out sides and top surface. It had been assumed that the side slopes were being rehabilitated during operations (except for last lift, i.e. from top bench); therefore the slope quantities in the estimate were for re-sloping and grassing the last lift only. However, in practice the side slopes were being constructed at 27-34 degrees and therefore the estimate was inadequate. In addition, the pasture grassing of slimes dams for dust prevention is not considered a long-term rehabilitation measure (Weiersbye et al., 2006) and due to the winter dormancy and relatively low water-use of grassland (Dye et al., 2008) may also not be adequate for an evapotranspiration cover. Significant financial provision for long-term maintenance would be necessary if pasture grassing of steep side-slopes and slimes dam tops remained the selected method (Weiersbye and Witkowski, 1998), and there is the added risk of creating an “attractive nuisance” for grazing livestock (Weiersbye and Cukrowska, 2008).

It had also been assumed that most of the waste rock dumps would be removed for reprocessing, which was in accordance with the LOM plan, and that the footprints would be rehabilitated from working costs.

4.4 Rehabilitation of polluted soils, sediments and groundwater

Whereas a number of redundant, contaminated sites had been identified and included in a pre-closure programme for concurrent rehabilitation (Figure 2), and this liability had been raised through the company's income statement, it was not included in a premature closure liability estimate. Nevertheless, through the process of concurrent rehabilitation, valuable experience had been gained in planning and estimating for rehabilitation. There was no estimate for groundwater remediation; however, this is declared by the company as a contingent liability in the annual financial statement (AngloGold Ashanti Limited, 2008).

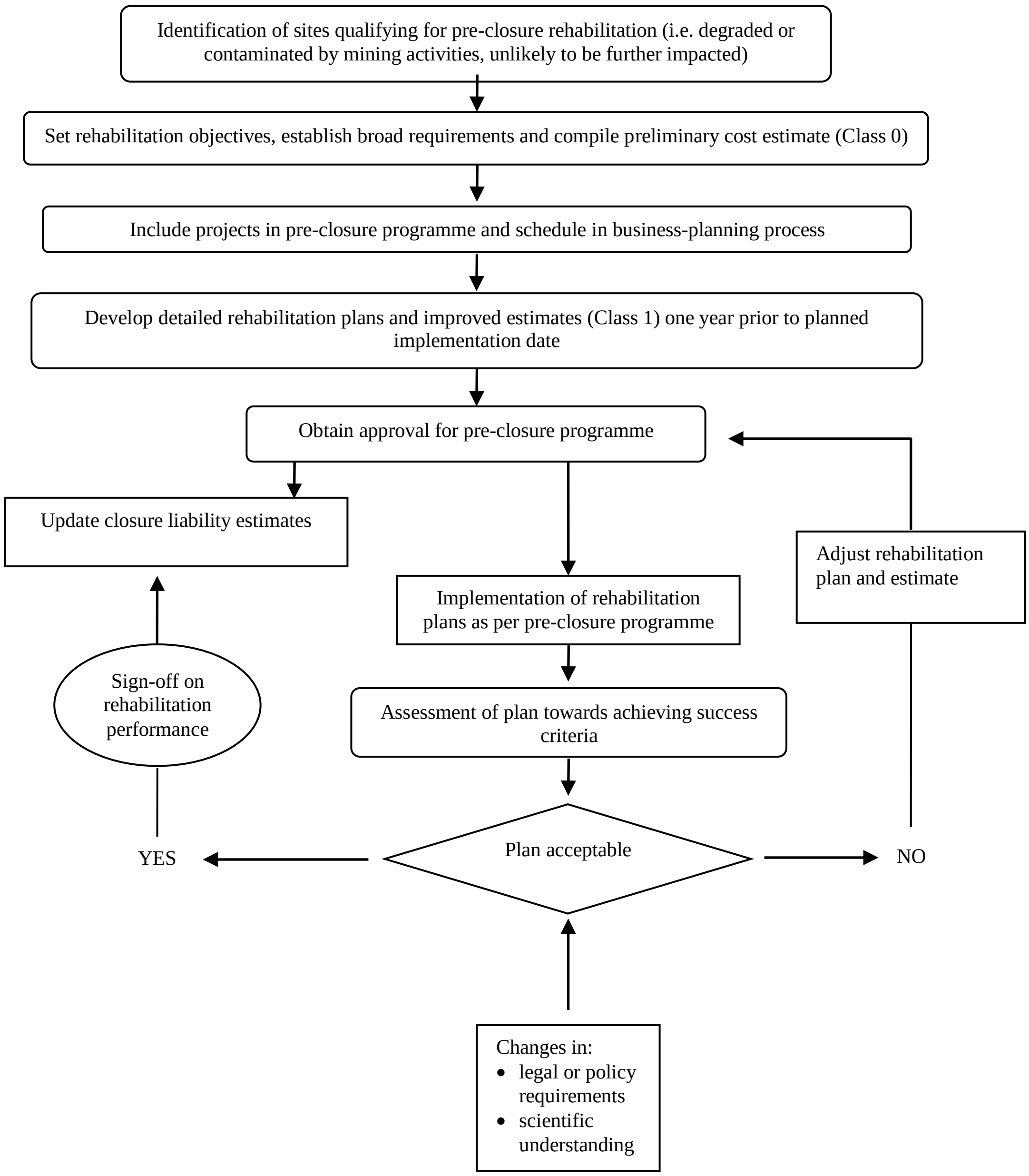

Figure 2 Pre-closure planning process for reducing closure liabilities

4.5 Residual and latent impacts

In the Vaal River mining area (North West Province), a water company has been established between the adjoining mines to pump the underground water from a defunct shaft, thereby preventing flooding of ‘downstream’ mines while they are still operating. The continuation of the pumping to prevent future decanting of this water and possible treatment for supply to third parties post-closure, still has to be investigated; therefore no reliable estimate could be made at this time. A similar scenario is envisaged for the West Wits area (Gauteng Province). Neither legislation nor guidelines provide any practical means for dealing with other residual and latent impacts; therefore, no quantum had been determined or provision made.

5 Updating of the closure liability estimate

5.1 Closure objectives and future land use

Appropriate end land uses and closure objectives are important for minimizing liabilities related to residual and latent risks. Restoration of ‘transformed’ grassland on gold mine properties on the Witwatersrand to their original, biodiverse status is not considered achievable (O’Connor and Kuyler, 2006). Land degradation can compromise the economic viability of future uses that rely on the provision of ecosystem services such as biodiversity, fertile soil and clean water, and therefore safe land uses that would contribute to rehabilitation had to be identified. These included the use of native trees for carbon sequestration, soil rehabilitation and seepage control purposes (Weiersbye, 2007; Dye et al., 2008). However, these findings did not substantially alter the declared cost because residual and latent risks were not included in the 2006 estimate.

5.2 Rehabilitation of tailings storage facilities and waste rock dumps

To address the estimates for TSF and waste rock dump rehabilitation, comparisons were made between the DME Master Rates and estimates from independent contractors of the costs of implementing traditional pasture grassing or ecological engineering approaches recommended by the University of the Witwatersrand, Johannesburg. All these approaches required the reduction of slope angle and a degree of soil cover. The DME Master Rate for basic, salt-producing waste was not considered (R 82,700) because even though the guideline erroneously classifies gold and uranium residue from sulphidic ores as such, this does not obviate the mining company’s legal requirement to carry out the necessary studies to determine the quantum (DME, 2005) and IAS 37 requirements to use the best estimate.

The DME Master Rate for acidic, metal-rich waste (R 240,200 per footprint ha – January 2005) is based on reducing slopes from 35 to 18 degrees, a 750 mm thick cover of sandy/loam material, plus 300 mm thick outer cover of rock armoring or topsoil on slopes, grassing, together with engineered water chutes, a lined pollution control dam and a cut-off drain. However, on examining the detail in the DME guidelines, several calculation errors were identified. In many instances the quantity multiplied by the rate did not equal the amount given, and the cover quantities (armoring and soil) were only half the volumes stated in the text (Table 2). Based on applying the cover volumes from the text which appear correct, and multiplying the quantities by the rates, the Master Rate for acidic, metal rich waste should be R 283,678 per footprint ha.

Table 2 Detail for rehabilitation estimate for process waste (acidic, metal-rich waste) (high sensitivity area and high risk mineral mined) from which the DME Master Rate was calculated showing corrections (Modified after DME, 2005)

Item	Unit	Qty	Rate (R/unit)	Amount (DME calc) (R)	Amount (Qty x Rate) (R)	Qty (cover from text)	Amount (corrected) (R)
Slope modification	m^3	307,801	8	2,308,506	2,462,408	307,801	2,462,408
Shaping	m^3	307,801	2	461,701	615,602	307,801	615,602
Cover: armoring	m^3	26,955	14	226,800	377,370	55,500	777,000
Cover: evaporative	m^3	67,457	14	565,600	944,412	135,000	1,890,000
Grassing/vegetation	Ha	50	5000	250,000	250,000	50	250,000
Pollution dam: liner	m^2	4167	40	166,667	166,680	4167	166,680
Pollution dam: bed	m^3	10,439	25	260,972	260,975	10,439	260,975
Water chutes	no	33	25,000	833,333	825,000	33	825,000
Cut-off trench				6,179,168	6,179,168		6,179,168
Additional items				757,082	757,082		757,082
Total				12,009,829	12,838,697		14,183,915
Cost per ha				240,197	256,774		283,678

The University of the Witwatersrand, Johannesburg's approaches, which were eventually selected by the company (example shown in Table 3 – December 2007) have been developed over a decade specifically for AGA's TSFs, footprints and contaminated soils, with the objectives of minimizing soil and groundwater pollution. Current research objectives include determining to what extent it will be possible to minimize soil excavation and cladding, and offset some of the rehabilitation costs through long-term cost savings or income associated with conversion of mine waste to carbon sinks and further resources.

Table 3 Example of a rehabilitation estimate for a tailings storage facility

No.	Item	Function	Rate (R)	Unit	Qty	Cost (R)
A	**Civils**					**24,641,341**
1	Construct new paddocks	Replace those covered by lowered side slopes	30	m	5302	160,902
2	Excavate new toe trench		49	m	5302	257,444
3	Extend filter drain outlets		43	m	530	22,614
4	Construct new access road		61	m	6802	412,847
5	Erect perimeter fence	Security and access control	73	m	5302	386,166
6	Lower side slopes to 1 in 4 (14-15 degrees) and shape	Minimize erosion and allow use of mechanized equipment for substrate amelioration	12	m^3	1,430,000	17,358,770
7	Construct and clad top ring road	Stabilize	166	m	4139	688,846
8	Farm borrow pits, truck and spread (excavate in layers with inoculation in-between)	100 mm "live" topsoil on 10% equivalent of top area	17	m^3	7260	123,381
		300 mm "live" subsoil (all particle sizes – clay to stone) on slope	17	m^3	283,200	4,812,871
9	Rip to 600 mm and shallow ridge on contours	Knit in soil, construct run-on and run-off zones	2500	ha	167	417,500
B	**Vegetation (native)**					**8,850,846**
1	Brush pack	Capture and retain resources, dust suppression, protection of seedlings and soil invertebrates	3000	ha	72	217,800
2	Banded vegetation on slope inoculated with micro-organisms	Protect surface, dust control, aggregate formation	44,250	ha	94	4,177,200
		Evapotranspiration cover				
		Limit oxygen ingress and leaching through evapotranspiration gradient				
		Mediate organic – chemical transformations to immobilize oxidation products and metal ions				
		Nutrient-cycling and promote soil formation				
3	Vegetation mosaic on tops inoculated with micro-organisms	Evapotranspiration cover as above; various chemical processes dependent on mosaic zone	37,400	ha	72	2,715,240

No.	Item	Function	Rate (R)	Unit	Qty	Cost (R)
4	Woodland on drainage lines entering and exiting TSF on seepage-polluted soils where suitable	- Evapotranspiration, hydraulic control and groundwater protection - Extraction of sulphates and some metals - In situ immobilization of some metals	23,664	ha	73	1,740,606
C	**Maintenance**					**2,748,441**
1	Maintenance to tops at three time periods	Slow release nutrient inputs	3600	ha/yr	21	78,408
2	Maintenance to sides at three time periods	Slow release nutrient inputs	3600	ha/yr	283	1,019,520
3	Maintenance of native woodlands, weeding, fire-protection for five years	Until canopy closure	22	m/yr	26,510	590,113
4	Clean solution trench for five yrs during and five years post rehabilitation	Prevent overtopping, run-off and seepage	20	m/yr	53,020	1,060,400
Works Total			**246,351**	**ha**		**36,240,627**

5.3 Rehabilitation of soils, sediments and groundwater

Environmental contamination as a result of spillages and seepage from gold mines has been the focus of numerous local studies (Cogho et al., 1992; Coetzee, 1995; 2008; Pulles et al., 1996; Rösner and Van Schalkwyk, 2000; Naiker et al., 2003; Tutu et al., 2003; 2008; Cukrowska and Tutu, 2004; Mphefu et al., 2004; Winde et al., 2004a, b, c; Coetzee et al., 2006). Research with the University of the Witwatersrand, Johannesburg has focused on the development of bio- or phyto-technologies for addressing some of these impacts and the costs of implementing them has been included in AGA's updated estimate. Further cost estimates will be developed or revised as each phase of research is completed and peer-reviewed.

5.4 Residual and latent impacts

By definition, latent impacts are unknown or at best merely suspected, and few can be `proven' in a literal sense, which makes financial provision difficult (Sutton and Weiersbye, 2007). However, literature describes environmental impacts from activities associated with gold mining, or analogous scenarios, and a precautionary approach must therefore be applied in accordance with South African law. The following residual and latent risks, identified as being of potential local concern, are being considered and plans made to confirm, quantify and, if necessary, address them; therefore, it is too soon to provide a cost estimate:

- Contaminated water decanting from closed underground mines (Pilson et al., 2000; Hodgson et al., 2001; Coetzee et al., 2003).
- Contamination of soils overlying shallow seepage through capillary rise, or irrigation of crops with mine water (Naiker et al., 2003; Sutton et al., 2006; Joubert, 2007; Sutton, 2008).
- The potential for remobilization of sulphur, metals and NORMs from wetland sink areas due to seasonal influences and wetland degradation (Winde et al., 2004a, b, c; Naiker et al., 2003; Tutu et al., 2003; Coetzee et al., 2006; McCarthy and Venter, 2006; McCarthy et al., 2007).

- Loss of biodiversity or ecosystem services as a result of disturbance or contamination (Angus, 2005; Weiersbye et al., 2006; O'Connor and Kuyler, 2006; Weiersbye and Witkowski, 2007).
- Accumulation of some metals and NORMs by fauna and flora (Weiersbye et al., 1999; Steenkamp et al., 2005a; McIntyre et al., 2008a; Weiersbye and Cukrowska, 2008).
- Impacts of land disturbance, ARD and metals on fauna and flora (Haywood et al., 2004; Steenkamp et al., 2005b; Joubert, 2007; McIntyre et al., 2008b; Weiersbye and Witkowski, 2003; 2007).
- Impacts of land disturbance on ecosystem services and the viability of some land-uses (O'Connor and Kuyler, 2006; D.J. Tongway, pers. comm.).
- Remobilization of metal-bound cyanides through reprocessing of old TSFs (Bakatula et al., 2008).
- Structural damage to structures, and human injury, by mining-exacerbated instabilities, including seismicity and sinkhole formation (Funke, 1990; Buttrick et al., 2001; Le Roux, 2005).

5.5 Quantum of provision

5.5.1 Premature closure

To cater for the highly unlikely event of premature closure the total costs for demolition of all structures and infrastructure within the mining right area are included in the premature closure estimates (Table 4). This includes amounts for redevelopment and pre-closure projects, which are excluded from the final closure estimates because they will be completed earlier. Apart from escalation, the other movements in the estimate between 2006 and 2007 were because of an updated approach to TSF and waste rock dump rehabilitation, and improved measurements by quantity surveyors of some of the buildings.

5.5.2 Accounting provision

The accounting provision is declared as decommissioning and restoration liabilities based on the going concern principle, whereby the formally-approved business plans of the company incorporate operating costs to deal with reprocessing/converting of current closure obligations to a better position (Table 4). To this end, the LOM is considered and the numbers are discounted to NPV. For 2007, the accounting provision decreased by R 137 million because of a greatly-extended LOM and favorable discount and inflation rates (i.e. the predicted discount rates were greater than the inflation rates).

Table 4 Summary of premature closure costs and accounting provision for Vaal River and West Wits mines (AngloGold Ashanti Limited, 2007a; 2007b; 2008)

	R million				
Vaal River and West Wits mines	**2007**			**2006**	**Movement**
	Restoration	**Decommissioning**	**Total**	**Total**	**Total**
Premature closure costs*	-	-	1721	1077	644
Accounting provision	211	492	703	840	(137)

* Combined totals from documents submitted to the DME Regional Offices for Vaal River and West Wits mines

6 Conclusion

There was a substantial increase in the quantum (R 644 million) to provide for the very unlikely event of premature closure mainly as a result of the inclusion of the cost of demolishing all buildings and infrastructure, and updated (market-related) estimates for rehabilitation of TSFs and waste rock dumps. Conversely, the amount that needed to be accounted for was reduced (R 137 million) because of an extended LOM and favorable inflation and discount rates. Further research is required into addressing future decanting of mine water, treating polluted groundwater and for quantifying off-site impacts. It is anticipated that the timely identification of risks and the informed conversion of mine properties to safe land uses will contribute to reducing AGA's future liabilities. It may be possible to offset some of these costs through redeployment of mine infrastructure, and the conversion of mine tailings and polluted soils to carbon sink land uses or other resources.

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