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Optimising mine closure strategies: a sprint-based framework for value-driven decision-making

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Abstract

Choosing an ethical, community-accepted and cost-effective closure strategy is challenging for asset owners. As mineral resources are declining and closures are planned, deciding an asset's future becomes crucial for managing liability. This paper outlines the methodology, key insights and benefits of applying a value optimisation (VO) sprint, demonstrating how targeted analysis of key decisions can improve closure outcomes.

Once closure cost is estimated, many organisations assume the strategy is fixed. This is instead when the greatest opportunity for optimising value emerges because the basis is now understood. A structured VO sprint at this point enables owners to interrogate the basis and assumptions (levers) underpinning their closure strategy. There is also opportunity to identify innovative options to reduce cost, accelerate relinquishment, or enhance end-use outcomes.

The VO sprint approach delivers a framework for comparing closure scenarios whereby cross-functional teams evaluate the key cost levers: execution models, project scope and rehabilitation strategies. Execution models – from integrated contractor to owner-led delivery – can materially shift cost profiles, risk allocation and schedule certainty. Similarly, adjusting the duration of closure works can unlock efficiencies, reduce overheads or build the capacity of local businesses. Options can be challenged to explore alternative landform designs, material movement philosophies, or end-use objectives that meet regulatory and community requirements and achieve relinquishment objectives, but prioritise and balance resources. This enables asset owners to select the most suitable strategy for the site's physical, regulatory and social context. Focus is not solely on a lower-cost plan. Rather, aspects of multicriteria analysis (MCA) together with a VO sprint are adopted so the closure strategy balances the full spectrum of value, encompassing financial considerations alongside environmental and community-driven outcomes.

Keywords: *mine closure liability, value optimisation, cost estimation*

1 Introduction

Mine closure represents one of the most complex challenges facing the global mining industry, with historical mining practices resulting in environmental degradation, social disruption and significant financial liabilities. Poorly planned closure continues to result in persistent residual liabilities, delayed relinquishment and abandoned sites, undermining regulatory confidence, community trust and balance sheet outcomes (Parshley et al. 2009; Wilson et al. 2022; Gregory et al. 2023). Closure is therefore no longer a purely technical end of life activity, but rather a complex socio-environmental transition that carries long-term financial, regulatory and reputational liabilities if poorly planned. This requires strategies that are defensible, achievable and accepted by communities and governing bodies (Gregory et al. 2023; Selame & Simpson 2025). Across jurisdictions, inadequate closure planning has contributed to persistent residual liabilities,

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delayed relinquishment and abandoned sites, reinforcing the need for closure strategies that are defensible and value-driven (Parshley et al. 2009; Selame & Simpson 2025).

Despite this complexity, closure costs are frequently treated as fixed once an initial estimate is prepared. The literature consistently demonstrates that closure outcomes are largely determined by early strategic assumptions rather than execution detail. Decisions relating to execution models, sequencing, rehabilitation strategies, infrastructure retention or demolition, and post-mining land use (PMLU) fundamentally shape closure cost profiles and long-term risk exposure (Fletcher et al. 2011; Eshun et al. 2018). Closure cost estimates are inherently assumption-laden and particularly sensitive to non-core activities such as demolition, water management and post-closure monitoring, where uncertainty is high and systematic underestimation is common (Espezúa & Vasquez 2023; Sanders et al. 2024). When embedded early into corporate provisions and governance processes, these assumptions become difficult to revisit, constraining strategic choice and reinforcing conservative, least-regret closure pathways (Gregory et al. 2023).

Project management frameworks such as the Project Management Body of Knowledge emphasise aligning cost estimates with scope maturity and risk, supporting progressive refinement as knowledge improves (Project Management Institute 2021). Agile project management is a flexible and iterative approach that emphasises early value delivery, continuous stakeholder feedback and adaptive planning in response to changing project conditions. Scrum is a specific agile project management framework used to manage and deliver projects through short, iterative cycles, enabling teams to collaborate and adapt as they go. A sprint is the core working cycle in Scrum. It is a fixed, time-bound period during which a team works to complete a defined set of tasks and deliver a usable outcome (Schwaber & Sutherland 2020).

Applied to closure planning, these principles reinforce that early estimates should inform decision-making rather than constrain it, but provide limited guidance on how to practically interrogate and optimise closure strategies once costs are first defined. Bespoke approaches using elements of agile project management have emerged as a robust paradigm for navigating complexity and uncertainty in decision-making environments where outcomes cannot be fully specified in advance. Moreover, the Scrum framework, as articulated in contemporary agile project management literature, formalises this approach through the pillars of transparency, inspection and adaptation, enabling teams to iteratively test assumptions and respond to emerging insights (Dingsøyr et al. 2012).

Although mine closure planning and cost estimation guidance is well established, a critical gap persists between developing the closure cost estimates and actively optimising the underlying closure strategy. Existing frameworks focus on producing mine closure plans and defensible estimates that satisfy regulatory and financial assurance requirements but provide limited direction regarding how to systematically interrogate key assumptions, explore alternative execution pathways and evaluate trade-offs once a cost basis has been defined (ICMM 2019; Lourel et al. 2022). This creates a structural disconnect, whereby closure strategies are often progressed into corporate reporting cycles – such as annual closure liability or provision updates – without a formalised step to challenge or refine the basis of estimate before cost recognition.

A growing body of literature identifies this post-estimate stage as the point where the greatest opportunity exists to reshape scope, execution pathways and PMLU objectives to reduce liability and improve environmental and social outcomes (Eshun et al. 2018; Clark et al. 2025). However, repeatable and defensible methodologies for doing so remain limited. This paper presents a structured, governance-led value optimisation (VO) sprint applied once the cost basis is understood and before execution costs are endorsed, to systematically challenge assumptions and compare closure strategies before liabilities are locked in.

2 Value optimisation and sprint process

The VO sprint methodology provides a structured, time-bound approach to evaluating closure decisions and optimising outcomes across environmental, social and economic dimensions. Applied at the point where closure costs and strategies are sufficiently defined, the approach reframes closure from a static compliance exercise into a strategic opportunity to interrogate execution models, scope definition, rehabilitation strategies and PMLU objectives. By convening environmental, social, operational, commercial and estimating expertise around specific closure opportunities, the VO sprint enables informed comparison of alternative closure scenarios and identification of options to reduce long-term liability, improve delivery feasibility and enhance stakeholder outcomes. Optimising closure value depends on engaging subject matter experts and decision-makers who own closure risks and have authority to endorse changes to strategy, scope and cost.

Governance during the VO sprint phase provides structure for setting priorities, reviewing assumptions, monitoring progress and formally endorsing value opportunities so outcomes translate into implementable closure strategies rather than remaining theoretical exercises (Lourel et al. 2022). Adapted from agile project management methodologies, the VO sprint approach compresses intensive analysis and decision-making into a series of structured workshops spanning a designated timeframe, as illustrated in Figure 1 and described in detail as a series of process steps in sections 2.0 to 2.8.

The sprint is a collaborative process that brings together key stakeholders to systematically analyse critical decisions, identify opportunities for creating value, and develop consensus-driven solutions. Lourel et al. (2022) also emphasise that effectively optimising closure value depends on actively engaging a broad set of stakeholders to align closure design maturity with cost estimate confidence, rather than treating optimisation as a purely technical or estimating exercise. Their core finding is that mismatch between who makes closure decisions and who owns or understands the resulting risks is a primary driver of cost escalation and loss of value. Considering this, it is important the governance applied to the VO sprint considers engaging and gaining endorsement of VO across the appropriate levels of business.

Figure 1 Scrum model repurposed to structure a mine closure VO sprint

2.1 Process steps for a VO sprint

The VO sprint process steps outlined in the next sections of this paper are summarised in Figure 2. These steps underpin the VO sprint framework presented conceptually in Figure 1. A VO sprint is a defined, iterative optimisation cycle in which cross-disciplinary teams evaluate and refine closure strategies, translating value opportunities into decision-ready outcomes and updated cost estimates before formally consolidating costs (Schwaber & Sutherland 2020). The process comprises 9 sequential and iterative steps, beginning with establishing governance and aligning stakeholders, and progressing through identifying, shaping, assessing and integrating VO opportunities into closure cost estimates.

The sprint is initiated by reviewing the cost estimate basis to identify potential VO opportunities, which are then progressed through a defined cycle of planning, implementation, review and refinement over a period of 4–6 weeks. Outputs from the sprint workshops are then transferred to the estimating and scheduling teams to revise or update closure cost estimates and complete estimate trending. These trends are subsequently presented to key internal and external stakeholders to confirm alignment with closure objectives and to seek endorsement of recommended opportunities. Once endorsed, VO outcomes are formally incorporated into the closure cost estimate and, where applicable, corporate closure provisions, ensuring reported liabilities reflect tested, governance-approved strategies.

2.2 Step 0: Establish the governance framework and identify key stakeholders

Governance applied during the closure VO sprint described in Step 5 (Section 2.7) includes:

- The VO project team holds a stand-up meeting 3 days per week on alternate days to determine key priorities and track the actions and tasks related to refining each opportunity. The Scrum Lead leads the meeting and the project team members are responsible for reporting on the status of the opportunities.
- Managers (Closure Studies Sponsor/Study Lead, Project Manager) check in once a week to report on the progress of the week's VO opportunities to maintain business alignment with key objectives. The Project Manager, Closure Study Lead and Scrum Lead are responsible for reporting to the Closure Studies Sponsor.
- Company Directors and the General Manager check in fortnightly with the Closure Studies Sponsor and Scrum Lead to formally approve assumptions, gain approval (staged) for banked value opportunities, and provide strategic business support for decision-making.

Typical stakeholders for a mine closure VO sprint are outlined in Table 1

Table 1 Typical stakeholders for value optimisation sprint

Generic title/role	Primary role in closure and value optimisation
General Manager/Closure Manager – Sponsor	Endorses key assumptions and decisions, approves investment requests and approves final cost estimates for shareholder release.
Closure Study Technical Lead (also performs the role of the Scrum Lead)	Accountable for delivering closure and VO studies; integrates technical, commercial and social inputs.
Senior Advisor – Social & Community Performance	Embeds Indigenous peoples and local community considerations in closure options.
Senior Advisor – Business Analysis & Strategy	Assesses financial, commercial and strategic implications of closure options.
Closure Project Manager	Manages the transition from study outcomes to execution planning and delivery integration.
Project Estimator	Develops and reviews closure cost estimates and tests assumptions.
Specialist – Rehabilitation Planning	Responsible for rehabilitation performance, governance and regulatory alignment. Develops landform and rehabilitation strategies aligned with PMLU.
Environmental/Hydrology Specialist	Assesses long-term water risks and closure performance implications.
Geotechnical/Landform Specialist	Provides landform stability and earthworks advice, influencing scope and cost.
Legal/Regulatory Advisor	Advises on approvals, liability transfer and relinquishment risks.

0 Establish the governance framework and identify key stakeholders

Progress updates and dashboards track progress and highlight value achieved and any emerging risks or opportunities.

Scrum Element: Review and control

Inputs:
- Approved Mine Closure Plan (current)
- Preliminary closure cost estimate (baseline)
- Corporate governance requirements
- Closure objectives and business strategy
- Key stakeholder register

Activities:
- Define VO governance structure and decision authority
- Confirm Scrum Lead, Study Lead and Sponsor roles
- Establish reporting cadence (daily scrums, weekly reviews, fortnightly endorsements)
- Identify and confirm stakeholder participation across technical, social, regulatory and commercial domains

Outputs:
- VO governance framework
- Agreed stakeholder map and RACI
- Reporting and decision escalation structure
- Endorsed VO process and timing

1 Review the cost estimate and establish a baseline

Third Party Review of current closure cost estimate and identification of site-specific cost levers. The process checks alignment with planning documents, validates scope and assumptions, and compares against similar projects.

Scrum Element: Backlog and baseline

Inputs:
- Closure cost estimate
- Basis of Estimate
- Mine Closure Plan
- Supporting studies (rehabilitation, landform, water, demolition, social)
- Risk and opportunity registers
- Benchmarking data

Activities:
- Independent or facilitated cost estimate review
- Validate scope–cost–confidence alignment
- Identify immature assumptions and latent liabilities
- Identify strategic cost levers and value drivers

Outputs:
- Reviewed and validated baseline cost estimate
- Clear articulation of cost drivers and assumptions
- Defined VO opportunity space
- Agreed baseline for trending and comparison

2 Hold a value optimisation kick-off to agree scope and key drivers

A cross-functional meeting sets the focus for value optimisation, identifies main cost drivers and risks, and aligns with strategy and approvals. Key levers are nominated for further assessment.

Scrum Element: Sprint planning

Inputs:
- Cost estimate review findings
- Identified cost levers and risks
- Closure objectives (financial, environmental, social)
- Regulatory and stakeholder commitments

Activities:
- Cross-functional workshop to confirm VO scope
- Prioritise material cost and risk drivers
- Confirm alignment with closure strategy and approvals
- Nominate VO opportunities for assessment

Outputs:
- Agreed VO opportunity list
- Defined scope and objectives for the sprint
- Alignment across disciplines and decision-makers

3 Hold value optimisation shaping workshops

This workshop prioritises key initiatives, assigns roles, and sets timelines to address identified risks and cost drivers.

Scrum Element: Sprint planning

Inputs:
- Agreed VO opportunity list
- Closure technical constraints and performance criteria
- Available specialist knowledge and datasets

Activities:
- Prioritised VO opportunities
- Shape each VO opportunity (intent, boundaries, constraints)
- Define success criteria and assumptions
- Assign roles, accountabilities and timelines
- Prioritise opportunities for sprint execution

Outputs:
- Structured VO opportunities
- RACI matrix for VO assessments
- VO schedule and dashboard
- Clear assessment pathway for each opportunity

4 Prepare value optimisation sprint packs

VO sprint pack documents the baseline, alternative options and indicative OoM cost impacts, with MCA used where appropriate.

Scrum Element: Sprint planning

Inputs:
- Shaped VO opportunities
- Baseline closure cost and schedule
- MCA criteria (technical, environmental, social, regulatory, commercial)

Activities:
- Develop standardised VO sprint packs
- Document baseline vs alternative options
- Prepare order-of-magnitude cost impacts
- Undertake MCA where required
- Document risks, enablers and assumptions

Outputs:
- VO sprint packs (one per opportunity)
- MCA results (where applicable)
- Pre-read materials for sprint workshops

5 Hold value optimisation sprint workshops

Series of targeted workshops with subject matter experts unpack and progress each initiative, produce estimating inputs, and validate assumptions.

Scrum Element: Sprint execution

Inputs:
- VO sprint packs
- Specialist technical inputs
- Operational, regulatory and social insights

Activities:
- Run focused sprint workshops (typically 4–6 weeks total)
- Test assumptions and feasibility
- Resolve data gaps
- Mature preferred options and alternatives
- Validate execution logic and sensitivities

Outputs:
- Refined VO options
- Agreed technical and execution assumptions
- Estimating and scheduling inputs
- Updated VO dashboard (banked, conditional, sensitivity)

6 Refine estimating inputs, evaluate options and establish trends

Outputs from the sprint workshops are transferred to the estimating and scheduling teams to trend or accurately compare VO and baseline savings

Scrum Element: Sprint close out

Inputs:
- Outputs from sprint workshops
- Baseline cost estimate and schedule
- Refined MCA outcomes

Activities:
- Update quantities, rates, sequencing and durations
- Attribute direct and indirect cost impacts
- Classify value as banked, conditional or sensitivity
- Establish transparent estimate trending

Outputs:
- Updated closure cost estimate (working version)
- Cost trend register with audit trail
- Clear linkage between decisions and cost movements

7 Perform final review and gain endorsement

*A final workshop **presents and** approves recommendations, assumptions, and new inputs through a formal process, ensuring clarity and alignment.*

Scrum Element: Review and control

Inputs:
- Updated cost trends and VO outcomes
- Supporting technical, social and regulatory justifications

Activities:
- Final VO review workshop
- Confirm alignment with closure objectives
- Approve assumptions and banked value
- Explicitly accept trade-offs between cost, risk and outcomes

Outputs:
- Endorsed VO opportunities
- Governance sign-off on preferred closure strategy
- Approved basis for estimate update

8 Update the closure cost estimate

Endorsed value optimisation initiatives are formally incorporated into the closure cost estimate

Scrum Element: Sprint close out

Inputs:
- Endorsed VO opportunities
- Approved assumptions and strategy changes

Activities:
- Formally integrate banked VO outcomes into the cost model
- Update Mine Closure Plan and Basis of Estimate
- Reset baseline for reporting and assurance

Outputs:
- Updated, defensible closure cost estimate
- Updated Mine Closure Plan
- Audit-ready closure liability position

Figure 2 Value optimisation process map

2.3 Step 1: Review the cost estimate and establish a baseline

Reviewing the closure cost estimate provides an opportunity to identify immature assumptions, misaligned confidence and latent liabilities before closure pathways and financial commitments become irreversible (Sanders et al. 2024). Estimates may be reviewed as part of a stage-gate process immediately after they are prepared, periodically throughout the mine life, or during due diligence before asset transfer, to ensure closure liability maturity is well understood. Independent review is recommended to reduce optimism bias, strategic misrepresentation and organisational influences that can distort internally prepared estimates, and to strengthen credibility for decision-makers and external stakeholders. Evidence from large infrastructure projects demonstrates that applying an independent 'outside view', grounded in comparable outcomes, materially improves estimate realism and defensibility (Flyvbjerg 2008, 2014).

A robust review assesses whether the estimate is suitable for its intended purpose and appropriately aligned with the maturity of the underlying closure scope. Good practice extends beyond cost arithmetic to testing scope definition, assumptions, methodology, treatment of uncertainty and estimate classification (Association for the Advancement of Cost Engineering Recommended Practices 31R-03; 34R-05 [AACE International 2009]). In a mine closure context, this review also assesses alignment between the mine closure plan, the cost estimate and broader business objectives, recognising that closure planning evolves as knowledge improves (Demers 2024; ICMM 2025).

The mine closure plan and the basis of estimate are the primary documents underpinning this review because, together, they define closure objectives, scope, assumptions and execution strategy. The mine closure plan establishes PMLU objectives, performance criteria and regulatory commitments, while the basis of estimate documents how these requirements are translated into quantities, unit rates, contingencies and risk allowances (ICMM 2019). Empirical analyses show that misalignment between these documents – such as conceptual designs costed with inappropriate confidence or poorly articulated assumptions – is a major contributor to escalating costs as closure approaches (Fletcher et al. 2011; Sanders et al. 2024). Concurrent and integrated review of both documents is therefore essential to confirm suitability-for-purpose and consistency between scope maturity and the estimate's suitability for purpose and alignment of confidence (Lourel et al. 2022).

Review outcomes are strengthened by supplementing core documentation with supporting evidence, including closure design and constructability studies, risk and opportunity registers, execution schedules, and benchmarking against comparable closures. Case studies demonstrate that triangulating estimates with empirical datasets – such as spatial data, infrastructure registers, field trial results and landform or water management designs – enables companies to validate critical inputs and identify latent liabilities, particularly relating to water management, infrastructure decommissioning and long-term monitoring (Fletcher et al. 2011; Lourel et al. 2022; Sanders et al. 2024).

Ultimately, Step 1 establishes a defensible baseline by clarifying what is genuinely known, assumed and uncertain within the closure cost estimate. This clarity enables later VO steps to focus on material levers – such as scope definition, execution strategy, sequencing and post-closure obligations – before closure commitments are locked in (Fletcher et al. 2011; Sanders et al. 2024; Lourel et al. 2022).

2.4 Step 2: Hold a value optimisation kick-off to agree scope and key drivers

The purpose of an initial cross-functional meeting or workshop is to define the scope of VO work, drawing directly from findings from the cost estimate review. International Council on Mining and Metals (ICMM 2019), Lourel et al. (2022), Fletcher et al. (2011) and Sanders et al. (2024) advise convening an integrated, cross-functional workshop immediately after the cost estimate review to agree divergent options, prioritise investigations, and structure the subsequent VO process in a transparent, evidence-based and defensible manner. Guided by the mine closure plan and relevant international standards, industry guidance and regulatory frameworks, the session focuses on identifying site-specific cost levers that exert the greatest influence on long-term closure liability, and therefore warrant targeted assessment before finalising the closure strategy (ICMM 2019; International Organization for Standardization 2015, 2018). Applying the lessons from ICMM and other industry bodies, the outputs of the cross-functional meeting should confirm the dominant cost drivers, closure risks and enablers relevant to the mining operation, to align the effort with the agreed closure strategy and maintain consistency with regulatory approvals and social commitments.

Based on the reviewed estimate, the meeting confirms the dominant cost drivers, key risks and enabling conditions relevant to the operation, and establishes a clear scope for progressing VO activities during Step 5 – the sprint phase. The primary outcome is an agreed set of VO opportunities, anchored to material cost levers such as those summarised in Table 2, with provision for follow-up sessions where extra definition is needed. This approach is consistent with guidance that recommends early, facilitated agreement on closure options once the cost basis is understood, to ensure subsequent optimisation efforts are focused, evidence-based and defensible (ICMM 2019; Lourel et al. 2022; Fletcher et al. 2011; Sanders et al. 2024).

Table 2 Key value optimisation opportunities, including key risks and enablers as supported by the literature

VO opportunity (Cost lever)	Outcome	Indicative value mechanism	Key risks	Key enablers	Key supporting literature
Execution model: progressive operational delivery	Closure of earthworks executed progressively using operational fleets and workforce	Lower unit rates; avoided mobilisation and contractor overheads; reduced contingency	Competing production priorities; value not credited in cost model	Integrated life of mine planning; verification and crediting of delivered scope	Parshley 2009; Espezúa & Vasquez 2023; Clark et al. 2025; ICMM 2019
Progressive bulk material rehandling during operations	Bulk reclaim or load and haul are completed during operations, before closure	Removal of earthworks from closure scope; reduced volumes	Incomplete execution; poor documentation of completion	Long-term mine planning; spatial tracking and performance records	Gregory et al. 2023; ICMM 2019
Fleet strategy and productivity uplift	Large, high-productivity fleets are used, aligned to critical path activities	Lower unit rates; shorter duration; reduced indirect costs	Fleet access constraints; unrealised productivity assumptions	Landform access and sequencing design; continuity of work	Parshley et al. 2009; Espezúa & Vasquez 2023; Clark et al. 2025
Minimum viable closure landform design	Landforms are designed to site-specific performance requirements for refined PMLUs	Reduced earthworks volumes; simplified construction	Stability risk; regulatory or stakeholder challenge	Hydro-geotechnical characterisation; performance-based criteria	Harvey et al. 2020; Mackenzie & Smedley 2024; ICMM 2019
Post-mining land use optionality	Selection of PMLUs that reduce long-term liability and maintenance	Avoidance of complex, high-maintenance outcomes; asset retention	Regulatory uncertainty; misalignment with stakeholder expectations	Early engagement; multicriteria analysis (MCA)	Eshun et al. 2018; Selame & Simpson 2025

VO opportunity (Cost lever)	Outcome	Indicative value mechanism	Key risks	Key enablers	Key supporting literature
Timing and duration of closure works	Closure schedules optimised against cost, risk and acceptance	Reduced indirects; avoided escalation; improved bankability	Extended durations increase overheads; rushed relinquishment	Transparent schedule–cost trade-off analysis	Gregory et al. 2023; Lourel et al. 2022
Optimised execution sequencing	Shortened critical path for closure delivery	Reduced the owner's team, preliminaries and supervision costs	Resource constraints; sequencing conflicts	Integrated, resource-loaded schedules	Sanders et al. 2024
Re-use of existing infrastructure and services	Retention of camps, roads and services when delivering closure	Capital avoidance; reduced temporary facilities	Asset degradation; safety constraints	Facilities forecasting; staged demolition planning	Parshley et al. 2009; ICMM 2025
Rehabilitation design efficiency	Optimised growth media, covers and rework allowances	Reduced rehabilitation scope and rework costs	Failure to meet completion criteria	Monitoring feedback; adaptive specifications	Aguirre & Parshley 2025
Demolition staging and asset retention	Demolition deferred or staged to support closure execution	Deferred spend; reduced duplication and rework	Escalation; constructability impacts	Early specialist input; sequencing trade-offs	Fletcher et al. 2011; Sanders et al. 2024
Monitoring and maintenance duration	Monitoring and maintenance period reduced through improved design confidence	Lower long-term operating and holding costs	Incomplete or poorly defined closure criteria	Performance-based closure standards	Gregory et al. 2023; ICMM 2019
Social transition and stakeholder timing	Closure pathways aligned with social acceptance and governance readiness	Reduced delay risk; improved likelihood of relinquishment	Late engagement; loss of social licence	Early engagement; closure-specific social impact assessment	Wilson et al. 2022; Gregory et al. 2023

2.5 Step 3: Hold value optimisation shaping workshops

Targeted VO shaping workshops are conducted to define and refine the opportunities identified in Step 2 before detailed assessment. These workshops are to confirm the intent, boundaries, assumptions and success criteria for each opportunity, directing subsequent analysis toward options with the greatest potential influence on closure outcomes. As part of this process, the roles, responsibilities and indicative timelines are agreed to support disciplined progression through the sprint phase. The responsible, accountable, consulted and informed (RACI) matrix clarifies roles for each task or decision within a project, as presented in Table 3. This illustrates typical roles allocated for assessing mine closure VO opportunities, while the outputs of this step comprise an agreed responsibility framework, a prioritised assessment schedule (Figure 3) and a consolidated VO dashboard to track opportunity status and indicative value (Table 4). Consistent with closure optimisation literature, this shaping phase establishes a clear and defensible basis for progressing opportunities into estimating costs and evaluating options via multicriteria analysis. MCA is a systematic approach used to assess and rank alternatives against a set of weighted criteria, enabling decision-makers to evaluate trade-offs and select the most suitable option (Lourel et al. 2022; Byrne 2024; Pan et al. 2024).

Table 3 Typical value optimisation role as applied to mine closure

Stakeholder/role	RACI role in VO assessment
General Manager/Closure Manager - Sponsor	A – Accountable for endorsement and strategic alignment
Closure Study Lead (Scrum Lead)	A/R – Lead and integrate the assessment process
Senior Advisor – Mine Closure Studies	R – Technical assessment and assumption challenge
Senior Advisor – Social & Community Performance	R – Social licence and Indigenous/community assessment
Senior Advisor – Business Analysis & Strategy	R – Financial, commercial and strategic assessment
Closure Project Manager	C – Advice about delivery and transition implications
Project Estimator	R – Develop and test order-of-magnitude cost estimates
Specialist – Rehabilitation Planning	R – Landform design and PMLU alignment
Environmental/Hydrology Specialist	R – Long-term water and environmental risk assessment
Geotechnical/Landform Specialist	R – Stability, earthworks scope and landform risk
Legal/Regulatory Advisor	C – Regulatory, approvals and relinquishment advice

R= Responsible, A = Accountable, C= Consulted, I = Informed

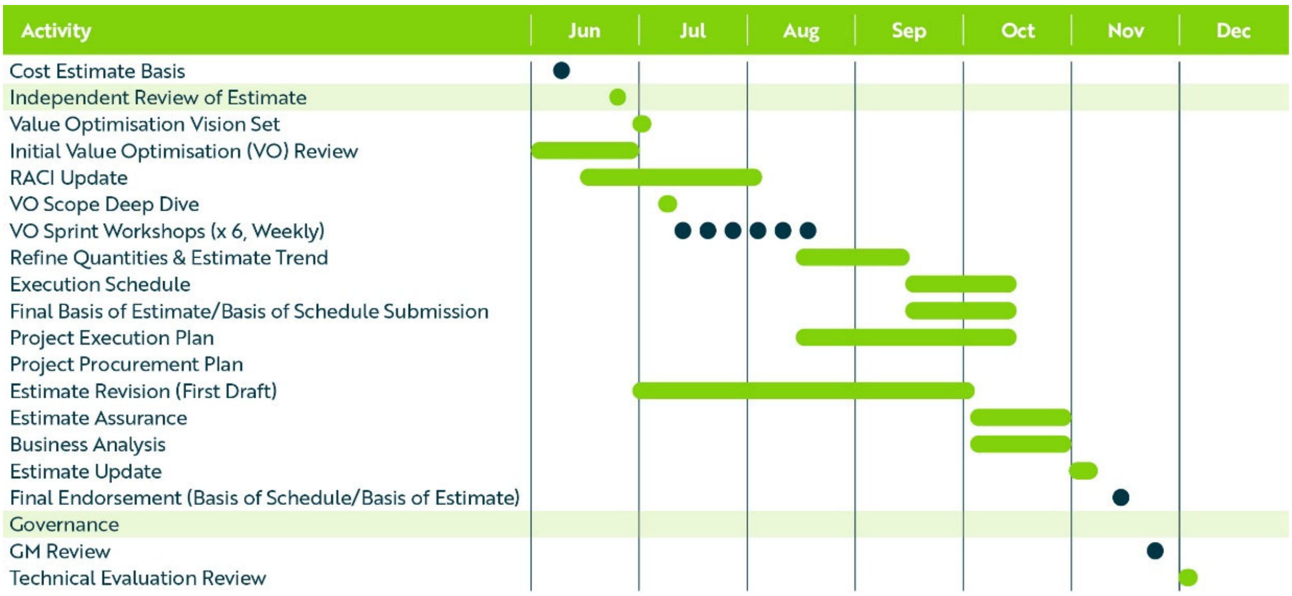

Figure 3 Example of value optimisation schedule for refining closure costs

Table 4 Typical value optimisation dashboard

Value opportunity	Value opportunity outcome	Value (A$M)	Status
Progressive bulk reclaim	Bulk material rehandled during operations, before closure	−30	In progress
Fleet strategy and productivity uplift	Large, high-productivity fleet aligned to critical-path activities	−100	Banked
Minimum viable landform design	Landforms designed to meet site-specific performance requirements for refined PMLUs	−74	Not started
Post-mining land use optionality	Alternative PMLUs selected beyond the default rehabilitation	−24	In progress
Timing and duration optimisation	Closure schedules optimised against cost, risk and acceptance	−70	Not started
Execution sequencing optimisation	Critical path shortened through resequencing of works	−55	Not started
Rehabilitation design efficiency	Growth media, covers and rework allowances optimised	−16	Banked
Demolition staging and asset retention	Demolition deferred or staged to support closure execution	−23	Banked
Social transition timing	Closure pathway aligned with social acceptance and governance readiness	+65	In progress
Total potential/banked saving		**327**	

Note: values are based on expert judgement only and are not verified costs, for example.

2.6 Step 4: Prepare value optimisation sprint packs

For each priority opportunity, a standardised VO sprint pack is prepared. These packs document the baseline condition, alternative concepts or execution options, and indicative order-of-magnitude cost impacts relative to the baseline cost estimate. Where appropriate, separate MCA workshops are held to assess options against agreed technical, environmental, social, regulatory and commercial criteria, outlined in Table 5. These design principles and success measures are provided as an example, but should be carefully considered and developed unique to the core values of each organisation. The outcomes of these workshops are presented in the sprint packs to provide a balanced view of costs savings and document trade-offs between cost, risk, schedule and non-financial outcomes, supporting transparent and repeatable decision-making.

Key stakeholders should agree the template for these sprint packs. They should be presented in a consistent format at each VO sprint workshop. Details of the key risks, enablers and assumptions relevant to each VO opportunity should also be documented within the sprint packs. It is advisable to send out the sprint packs before the workshops so stakeholders can review the VO content and come to the workshop with any queries to resolve or actions to close out. This focuses the workshops and prevents wasting time in familiarising people with the background and content.

Table 5 Mine closure value optimisation – design principles and measures of success

Design principle	Measures of success
Focus on core business to drive closure performance	Closure objectives are achieved while minimising the total life of asset closure cost. Closure execution delivers endorsed outcomes: safety, budget and time. Closure obligations are met without compromising operational performance or business continuity. Organisational capabilities are leveraged to eliminate duplication and inefficiency.
Maximise benefits for stakeholders and the environment (environment, social, governance)	Regulators, Indigenous peoples and local communities have an informed understanding of closure outcomes and provide timely agreement. Meaningful opportunities exist for co-design, co-management or participation. Long-term environmental performance, land capability and social outcomes are demonstrably improved. Lessons learned from previous closures are embedded into closure planning. Closure is embedded in operational decision-making.
Integrate closure into operational decision-making	Operational key performance indicators actively support closure objectives. Closure requirements are integrated into operational planning, scheduling and management-of-change processes. Progressive rehabilitation and operational reclaim are formally recognised and credited in cost estimates.
Deliver with a unified team, supported by transparent governance and defined accountabilities	Operational key performance indicators and leadership behaviours actively support closure objectives and long-term land transition goals. Closure requirements are integrated into operational planning and scheduling. Shared assets, services and operational synergies are used to deliver closure works efficiently. Progressive rehabilitation and operational reclaim are formally recognised and credited in cost estimates.
Prioritise people during the closure transition	Retention of critical skills and institutional knowledge supports continuity in closure planning and stakeholder engagement. Redeployment and transition opportunities for the workforce are maximised where practicable. Health, safety and working conditions during closure execution are maintained at standards comparable to those in operational phases. Workforce transition planning supports community stability and long-term social outcomes.

2.7 Step 5: Hold value optimisation sprint workshops

VO sprint workshops are undertaken over a defined period to progress priority opportunities from conceptual definition to estimating-ready inputs. The focus of this step is on testing assumptions, resolving data gaps and refining execution logic for individual opportunities, with sequencing guided by materiality and interaction between levers. Outputs are progressively matured to integrate them into cost estimation and scheduling.

The sprint particularly emphasises landform design and demolition sequencing, as these levers consistently exert a dominant influence on closure cost, execution efficiency and residual obligations. For landform design, the sprint evaluates performance-based alternatives to default configurations, including adjustments to geometry, material placement and cover systems, informed by available hydro-geotechnical evidence and PMLU objectives. The literature demonstrates that site-specific, performance-based landform solutions can materially reduce earthworks volumes and long-term liabilities while remaining compliant with regulatory performance criteria (ICMM 2019; Harvey et al. 2020; Mackenzie & Smedley 2024).

Demolition and decommissioning are examined concurrently, with the sprint assessing alternative sequencing and timing strategies, including staged or deferred demolition, to identify interactions with earthworks productivity, landform access and temporary infrastructure requirements. Empirical studies consistently identify poor demolition sequencing as a major contributor to closure cost escalation and rework, highlighting the importance of resolving these interactions early (Fletcher et al. 2011; Sanders et al. 2024).

Other closure levers are assessed more selectively where they materially influence these primary decisions. Timing and duration of closure works are considered to test indirect cost exposure and constructability constraints associated with different execution sequences (Parshley et al. 2009; Espezúa & Vasquez 2023). Fleet selection and productivity assumptions are reviewed where bulk earthworks sit on the critical path, as mismatches between fleet capability and work sequencing can significantly affect unit rates and schedule efficiency (Parshley et al. 2009; Espezúa & Vasquez 2023). Progressive rehabilitation completed during operations is also examined to confirm what scope can be verified, credited and removed from the closure estimate, avoiding re-costing of work already delivered (ICMM 2019; Gregory et al. 2023). These levers are not treated in isolation, but tested for their influence on landform execution, demolition sequencing and overall closure delivery logic.

Where opportunities interact, the sprint explicitly tests dependencies and trade-offs rather than assessing options independently. Lower-impact opportunities may be progressed outside core workshops where appropriate, provided outcomes are integrated back into the VO process. At the conclusion of this step, each opportunity is defined with sufficient clarity to enable classification and integration through Step 6 (Lourel et al. 2022).

2.8 Step 6: Refine estimating inputs, evaluate options and establish trends

Outputs from the VO sprint workshops are transferred to the mine closure planning, estimating and scheduling teams, to prepare the updates to the closure cost estimate and mine closure plan using revised technical inputs and endorsed assumptions. Opportunities are classified according to maturity as banked, conditional or sensitivity, with only banked opportunities incorporated into the base case estimate. Conditional and sensitivity-based items are retained for testing the scenarios and disclosing uncertainty, reflecting implementable strategies in reported closure liabilities rather than aspirational outcomes.

Banked opportunities are integrated by modifying underlying estimating inputs rather than applying standalone adjustments, to clearly attribute cost movements to specific closure decisions. Direct impacts – such as changes to landform design parameters, earthworks quantities, demolition scope or execution sequencing – are captured at work package level and linked to individual VOs opportunities. Particular attention is given to landform design and demolition sequencing, as these decisions commonly drive secondary effects on earthworks productivity, schedule logic, indirect costs and post-closure obligations.

Flow-on effects arising from revised closure approaches are explicitly identified and consolidated within a cost trend register and mine closure plan change register. These include impacts associated with altered sequencing, changes to demolition timing, adjustments to monitoring and maintenance requirements, and schedule-related effects on preliminaries and escalation. The cost trend register and mine closure plan change register record key technical changes, baseline cost, incremental changes attributable to each VO opportunity, confidence classification and net cost movement, preserving a transparent audit trail of how closure costs and technical decisions evolve as optimisation outcomes are implemented. The final reported values are transferred to the VO dashboard for reporting.

2.9 Step 7: Perform final review and gain endorsement

A final VO workshop is convened with key internal and external stakeholders to review outcomes, confirm alignment with closure objectives, and seek endorsement of recommended opportunities. A list of actions required to ensure banked changes are incorporated into cost estimates and mine closure plans is agreed and endorsed as part of the forward work plan for VO. This step ensures selected options are technically sound, evidence-based and defensible against regulatory, environmental and social expectations. Formal endorsement reduces optimism bias, prevents double-counting or speculative savings, and provides a clear governance point at which decision-makers explicitly accept trade-offs between cost, risk, schedule, environmental, social and long-term performance (Lourel et al. 2022; Sanders et al. 2024).

2.10 Step 8: Update the closure cost estimate

Endorsed VO opportunities must be formally incorporated into the closure cost estimate and mine closure plan so reported liabilities reflect implementable, governance-approved decisions rather than speculative cost reductions. The literature shows that embedding endorsed opportunities within controlled estimating and closure planning processes improves transparency, auditability and estimate credibility, while reducing optimism bias and late-stage liability escalation (Lourel et al. 2022; Sanders et al. 2024; ICMM 2019). The methodology embeds VO outcomes into the mine closure plan in a transparent and auditable manner, rather than cost reduction exercises.

3 Conclusion

This paper presents a structured VO sprint approach applied once closure liability basis is understood, addressing a gap between established closure planning guidance and practical decision-making. What is new is the provision of a repeatable and defensible method for interrogating the assumptions, scope decisions and execution pathways embedded within early closure strategies, with particular focus on material levers such as PMLU planning, social impact, landform design, execution sequencing and demolition strategy.

The methodology is intended to be applied at a specific point in the closure life cycle, aligned with annual provision updates, when costs and strategies are sufficiently defined to allow informed challenge, but before closure pathways are embedded in corporate provisions ahead of procuring execution services and committing to site implementation. In practice, this typically occurs after preparing a mine closure plan and preliminary cost estimate, when assumptions are explicit yet remain adaptable.

By shifting closure cost estimation from a static provision-setting exercise to an active decision-support process, the VO approach changes organisational behaviour. It creates structured space to test alternatives, explicitly attribute value to specific closure decisions, and apply governance-led endorsement before outcomes are embedded into reported liabilities. This enables organisations to move beyond least-regret or default closure pathways and instead select strategies that balance cost, risk, delivery feasibility and environmental and stakeholder outcomes. In doing so, the approach supports closure strategies that are balanced, feasible to deliver, defensible to regulators and communities, and aligned with long-term environmental and social objectives.

Use of artificial intelligence disclosure statement

In preparing this paper, the author used Microsoft 365 Copilot GPT-5 chat model to help draft, structure and refine text. The author has reviewed the content and edited it where required and takes full responsibility for said content.

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