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The Mt Bischoff mine: designing a robust closure landform

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Abstract

Waste rock dumps containing high proportions of potentially acid forming (PAF) material present a significant long-term closure challenge, often resulting in ongoing acid and metalliferous drainage (AMD) and perpetual water treatment requirements. Conventional surface-based controls are frequently insufficient to manage oxygen ingress and water-rock interaction in these systems.

The Mt Bischoff mine is a historic tin mining operation located in northwestern Tasmania, with a complex legacy of underground and open pit mining spanning more than a century. Recent open pit operations (2008–2010) resulted in the construction of several surface waste rock landforms, most notably the Happy Valley waste rock dump (HVWRD). The HVWRD presents an ongoing risk to the receiving environment, as acid neutralising capacity within the landform is predicted to deplete in the short term.

To address long-term closure and water quality objectives, a revised closure strategy was developed that represents a fundamental shift from surface-based AMD controls to construction of an integrated closure landform. Central to this strategy is the progressive deconstruction of the HVWRD and relocation of waste rock into the Main Pit, transforming the pit from a hydraulic control and water quality risk into a stable, backfilled landform. This approach prioritises the management of water movement during and after construction, with the objective of maximising non-contact water and minimising contact water generation.

The closure strategy is to be implemented through sequenced construction phases, including (1) dewatering of the Main Pit to enable construction activities, (2) blasting of the upper North Wall, (3) deconstruction of the HVWRD, (4) progressive backfilling and active water management, (5) North Wall backfilling and cover system construction, (6) installation of a 'hidden' berm and monitoring infrastructure, and (7) repurposing of the Happy Valley settling pond footprint. Sequencing of these activities is critical to controlling contact water generation, maintaining constructability and progressively reducing AMD risk throughout the works.

This paper presents the closure design and construction staging for the Mt Bischoff mine. It outlines how staged earthworks, controlled material placement and integrated water management are combined to deliver a geotechnically stable, geomorphically resilient and environmentally robust landform capable of meeting long-term closure objectives. The Mt Bischoff mine is Tasmania's first non-abandoned mine to reach the engineered closure phase, setting a benchmark for community expectations and the state's regulatory framework around relinquishment of the mining leases.

Keywords: *mine closure, construction sequencing, waste rock relocation, pit backfilling, acid and metalliferous drainage, closure landform design*

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1 Introduction

The Mt Bischoff mine (Mt Bischoff), located approximately 1.5 km north of the town of Waratah in northwestern Tasmania, has a long history of tin mining. The tin deposits at Mt Bischoff were first discovered at Tinstone Creek in 1871 and marked the first significant mineral discovery on the west coast of Tasmania (John Miedecke & Partners 2006). Mining has occurred in various forms (alluvial, underground, quarrying) at Mt Bischoff since the 1880s. In 2006 the Bluestone Mines Tasmania Joint Venture (BMTJV) received approval to mine certain areas of the site.

The BMTJV actively mined at Mt Bischoff between 2008 and 2010. The main areas disturbed and influenced by the BMTJV's activities included the Main Pit, Browns Face waste rock dump (BFWRD) and the Happy Valley waste rock dump (HVWRD) as shown in Figure 1. Mining of the Main Pit ceased in July 2010. The site was placed in 'care and maintenance' in 2010 and the Main Pit was allowed to flood.

Figure 1 Layout of Mt Bischoff (looking north) (Bluestone Mines Tasmania Joint Venture photo taken in 2016)

Waste rock at Mt Bischoff is known to generate acid and metalliferous drainage (AMD) from both legacy operations and areas disturbed during the BMTJV operational period. The Main Pit collects contact water (AMD-impacted; Figure 2a) from the surrounding catchments and requires lime dosing for pH adjustment to enable discharge criteria to be met for release to the receiving environment (Waratah River). Approximately 73,000 m^3 of sediment and sludge, resulting from pit wall erosion, catchment-derived inputs and lime treatment of the pit lake has accumulated on the pit floor. The HVWRD, a key source of AMD risk, was constructed within a steep-sided valley and comprises a layered waste rock configuration, including a basal non-acid forming (NAF) zone, overlain by clay-separated potentially acid forming (PAF) and high-capacity PAF (HC-PAF) materials (Figure 2b).

Acknowledging the AMD risk, the BMTJV completed rehabilitation works at the BFWRD, Slaughter Yard, and HVWRD both during, and shortly after, the operational phase. In 2010 the BFWRD was capped with a weathered and compacted argillite layer to shed surface water and limit oxygen ingress into the underlying PAF material. Slaughter Yard, known for generating AMD, was filled with NAF material and recontoured to direct water flow towards the rehabilitated BFWRD. Additionally, a cover system was applied to the HVWRD, though it has since proven ineffective at managing AMD over the long term (discussed further below).

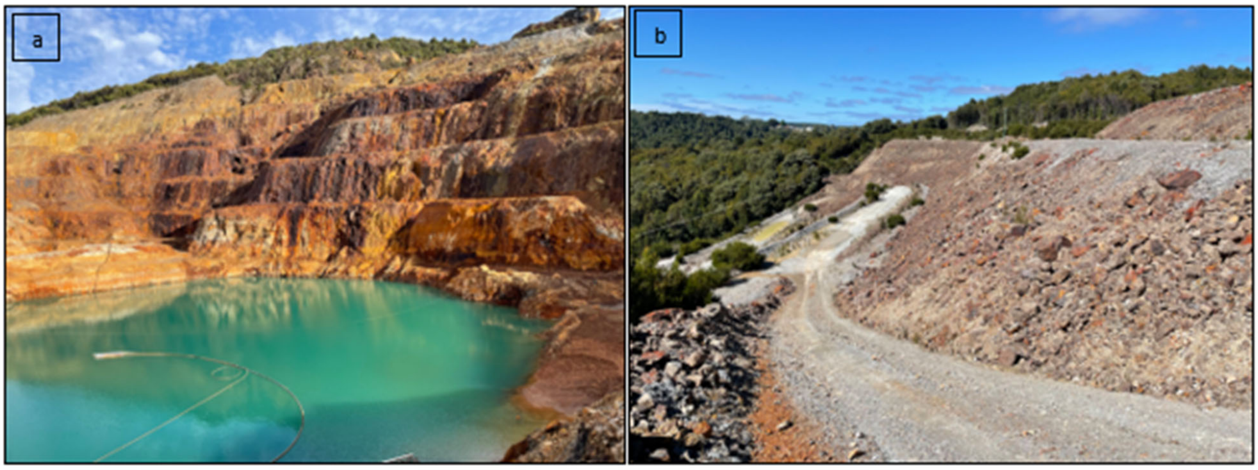

Figure 2 (a) Main Pit North Wall and lime-dosed pit lake, (b) Upper Happy Valley waste rock dump lifts (Photo taken in 2026 by Okane personnel)

In 2016 the BMTJV expressed intention to decommission the site and relinquish the mining leases (BMTJV 2017; Okane Consultants 2026). To reduce long-term AMD risks to the downgradient Waratah River, a conceptual closure strategy was initiated in 2018 and subsequently developed into a detailed closure plan that focuses on the progressive relocation of HVWRD material into the Main Pit (Okane Consultants 2026). This strategy represents a fundamental shift in closure philosophy, moving from surface-based AMD controls to an integrated closure landform that aims to maximise the release of non-contact water to the receiving environment. Non-contact water refers to water that does not come into direct contact with potentially contaminated materials or disturbed land.

The Okane Consultants (2026) report reference is not publicly available and remains under review by the BMTJV. A project summary is provided on the BMTJV webpage (http://bluestonetin.com.au/project/mount-bischoff-closure-plan/).

The focus of this paper is the staged engineering strategy for relocation of the HVWRD into the Main Pit, followed by covering of the Main Pit. The main objective is to achieve a net improvement in the water quality to the receiving environment as compared to a 'do nothing' base case which would result in the long-term generation of AMD from the HVWRD, in-perpetuity water treatment and the inability to relinquish the mining leases.

2 Environmental setting

The challenging landscape of Mt Bischoff has shaped all aspects of the detailed closure plan. Mt Bischoff has an elevation of approximately 785 m above sea level. The terrain is steep with many areas not easily accessible. The change in elevation from the Slaughter Yard closure domain to the Happy Valley Settling Pond (HVSP) at the toe of the HVWRD is 200 vertical metres over a lateral distance of 750 m.

Mt Bischoff is located within the headwaters of the Arthur River. The Arthur River Valley lies to the west, the Waratah River to the east and the Waratah River Valley to the north, where the Waratah and Arthur Rivers converge (John Miedecke & Partners 2006; Okane Consultants 2026). The average annual rainfall for Mt Bischoff is 2,180 mm (http://www.bom.gov.au), resulting in high run-off generation and rapid hydrological response across disturbed landforms.

The Mt Bischoff area consists of Late Proterozoic to Cambrian relatively unmetamorphosed siltstone, sandstone, shale and dolomite intruded by granitic (porphyry) dykes and sills, and is partially capped by Tertiary basalts. One of the key mineralisation styles is the stratiform replacement of dolomite (skarn alteration) by massive sulphide minerals containing cassiterite. The stratiform replacement style comprises the majority of the ore and is the major source of AMD.

No topsoil stockpiles are available for rehabilitation works at Mt Bischoff.

Groundwater conditions at Mt Bischoff have been substantially altered by historic underground mining. The connection between groundwater and the underground workings is outside the scope of this paper.

3 The decision to relocate the Happy Valley waste rock dump

Pyrite and pyrrhotite are the dominant sulphide minerals within the waste rock, with total sulphur contents commonly exceeding 10%. Approximately 70% of the HVWRD comprises HC-PAF material, resulting in a substantial long-term acid generation liability (Okane Consultants 2026).

The HVWRD was constructed as a valley-fill landform, forming a large, elevated waste rock mass with significant internal void space and high permeability. This configuration promotes efficient oxygen ingress via both advective and diffusive processes, sustaining sulphide oxidation throughout the dump. Internal drainage pathways allow infiltrating rainfall to interact extensively with reactive waste rock, generating sulphate and metal(loid) rich seepage that is collected in the HVSP. Drainage captured in the HVSP is then pumped back upslope for lime treatment in the Main Pit.

Although some neutralisation capacity is provided by carbonate-bearing (dolomite) lithologies within the waste rock, this buffering is predicted to exhaust in the coming decades. Importantly, the valley-fill geometry and depth of reactive material mean that surface-based controls alone (e.g. covers and run-off diversion) cannot adequately limit oxygen and water ingress to the reactive core over the long term. As oxidation progresses, the HVWRD continues to accumulate stored acidity, increasing long-term water quality risk and dependency on perpetual water management. The combination of waste rock geometry, high sulphide content and strong hydrological connectivity to the receiving environment means that closure strategies relying solely on in situ encapsulation or surface water controls are unlikely to achieve sustainable closure outcomes. These constraints directly informed the decision to relocate HVWRD material into the Main Pit, where both oxygen ingress and water-rock interaction can be fundamentally altered.

4 The Mt Bischoff closure strategy

The Mt Bischoff closure strategy has been developed through a series of clearly defined and staged activities, including:

- Stage 1: dewatering of the Main Pit to enable construction activities
- Stage 2: blasting of the upper North Wall
- Stage 3: deconstruction of the HVWRD
- Stage 4: progressive backfilling and active water management
- Stage 5: North Wall backfilling and cover system construction
- Stage 6: installation of a ‘hidden’ berm and monitoring infrastructure
- Stage 7: repurposing of the HVSP footprint.

These stages have been deliberately sequenced to control contact water generation and progressively reduce AMD risk during construction of the closure landform.

Site-wide closure objectives at Mt Bischoff include creating geotechnically and geomorphically safe and stable landforms, achieving agreed post-mining land use outcomes, maximising non-contact water and minimising contact water discharge to the receiving environment. Each closure domain has its own objectives, design criteria and completion criteria aligned with these overarching goals.

4.1 Stage 1: dewatering of the Main Pit

Waste rock backfill will be executed by truck and shovel material movement, with a starting tip head at the existing in-pit ramp (yellow arrow in Figure 3). The water level in the Main Pit will need to be reduced to expose the in-pit ramp prior to the start of backfilling activities. The existing in-pit ramp will be assessed for stability and the sludge/sediment cleared to establish a safe working platform. A trigger action response plan (TARP) has been developed to guide adaptive management and ensure that dewatering activities can be modified or halted should unacceptable risks arise. The extent of this dewatering is shown in Figure 3.

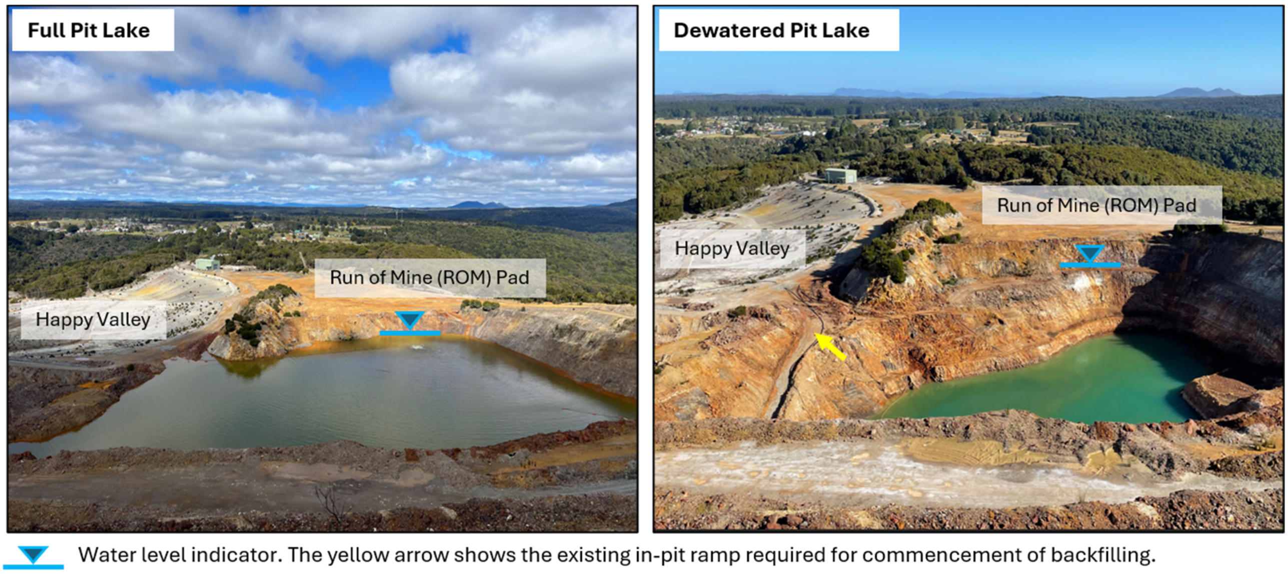

Figure 3 Stage 1: dewatering of the Main Pit (Okane Consultants 2026)

Risk management during active dewatering and early backfilling considered water quality deterioration due to sludge disturbance, seasonal rainfall and run-off contributions, and pit wall stability. While pit water provides a stabilising influence on pit walls, drawdown was assessed and the dewatering designed to present minimal geotechnical risk. This included an observational approach supported by the TARP and allowance for monitoring of pit wall and ramp stability during drawdown. Construction scheduling was therefore informed by climate and seasonality to minimise recharge during the critical early stages of backfilling and to maintain control over the water balance and discharge water quality.

4.2 Stage 2: blasting of the upper North Wall

Following dewatering of the Main Pit, the steep, upper benches along the northern portion of the pit wall will be reshaped using drilling and blasting methods (Figure 4). Due to the limited amount of material available within the HVWRD for backfilling and covering of the Main Pit, combined with the steepness of the existing pit walls, it is not deemed possible to construct a backfill slope at a 2H:1V (horizontal to vertical ratio) gradient over the Main Pit without undertaking blasting of a section of the northern pit wall. The insufficient volume of HVWRD material to backfill the Main Pit is due to the early open pit mine rock being utilised to fill in Browns Face, forming the rehabilitated BFWRD upgradient of the Main Pit (Figures 1 and 4). This blast will provide additional material volume for pit wall coverage and create an in situ surface with a shallower angle to backfill upon, ensuring the landform can be constructed to achieve a global Factor of Safety (FoS) of 1.3 and a veneer stability FoS of 1.1. The vertical extent ranges from the upper pit crest area (685 RL) down to 655 RL. Approximately 87,400 bank cubic metres (BCM) of material is proposed to be removed from the upper North Wall.

Figure 4 Stage 2: blasting section along the upper North Wall (Okane Consultants 2026)

4.3 Stage 3: deconstruction of the Happy Valley waste rock dump

All waste rock (1.1 million BCM) from Happy Valley will be removed to the Main Pit (including NAF material; Figure 5) via haul roads progressed into the valley from the southern hillslopes. Removal of the upper PAF material benches to RL578 (red arrow in Figure 5a), comprising approximately 70% of the total PAF material volume, will occur as early as possible. Removal of the upper PAF benches will occur at the beginning of the spring season to capitalise on the drier months to mitigate rainfall disruption and catchment run-off onto exposed PAF rock during deconstruction.

As waste rock is being relocated to the Main Pit, erosion and scour will be a key consideration for short-term valley stability. Measures to ensure sediment retention may include check dams, light cross-ripping and use of available coarse woody debris, which will also encourage microhabitat development and enhance revegetation. The desired vegetation and ecological communities will then successfully establish themselves on the remaining landform in the valley.

Relocation of the waste rock is not merely a preferred option but is considered necessary to materially reduce long-term AMD risk and associated closure liability at Mt Bischoff compared to leaving the material in situ.

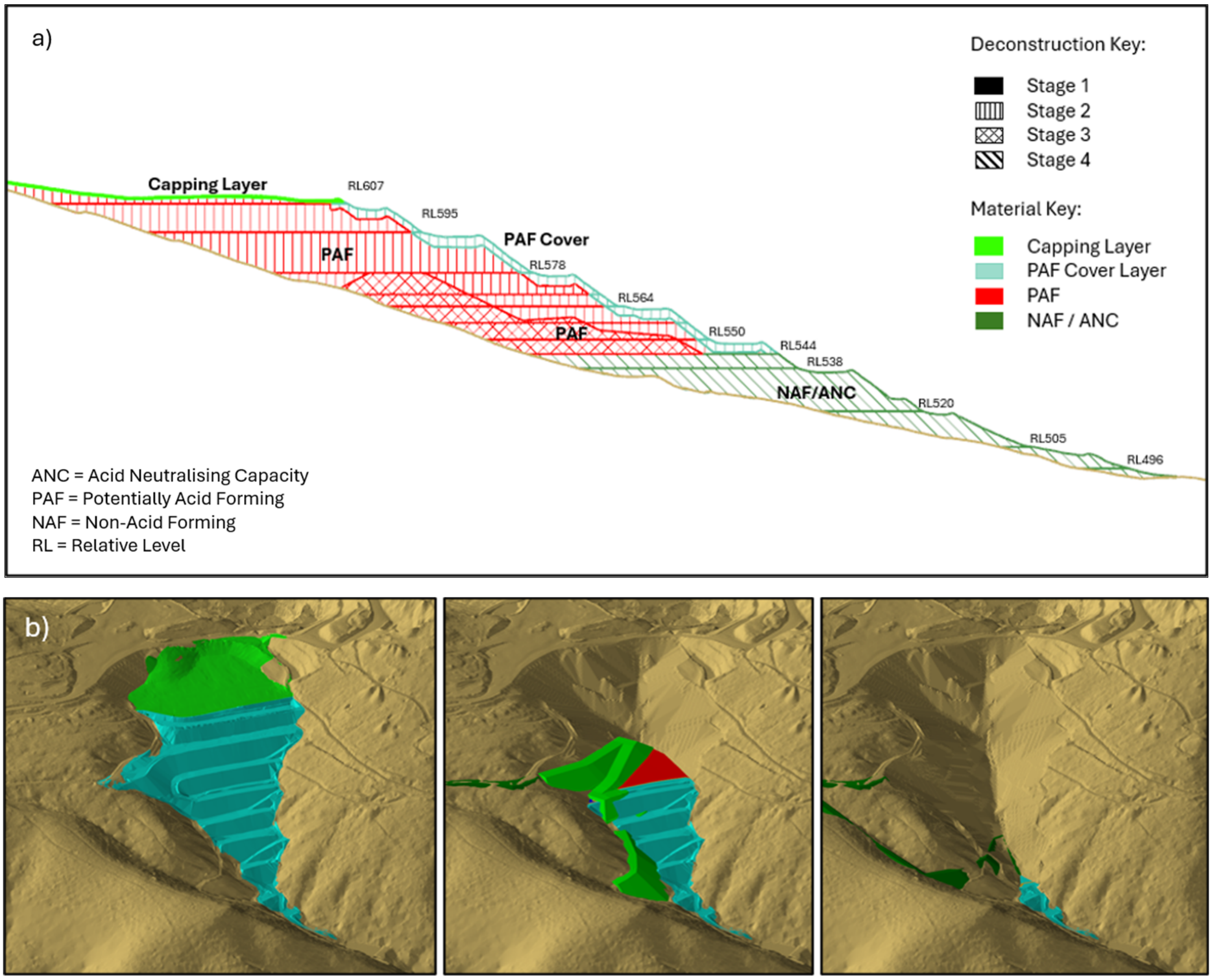

Figure 5 **(a) Cross-sectional view of the Happy Valley waste rock dump (HVWRD); (b) Stage 3: top-down deconstruction (left to right) of the HVWRD (Okane Consultants 2026)**

4.4 Stage 4: progressive backfilling and active water management

The PAF waste rock from the upper benches of the HVWRD will be placed directly into the remaining water and sludge in the base of the Main Pit. This will prevent further oxidation in the subaqueous environment. The sludge material is expected to have a high water content and to migrate into pore spaces within the waste rock during backfilling (recognising that a period of settlement will be required).

Backfilling will proceed from 2 tip heads to ensure in-pit batter stability, resulting in contact water rising and accumulating in a single void (Figure 6). To manage the uncertainties associated with sludge settlement and water quality implications upon disturbance, lime dosing will continue throughout the backfilling process so as to enable dewatering via pumping at the southern pit crest. Consistent with the operational phase, pumped water from the in-pit sump void will be released to Happy Valley Spur Creek (HVSC).

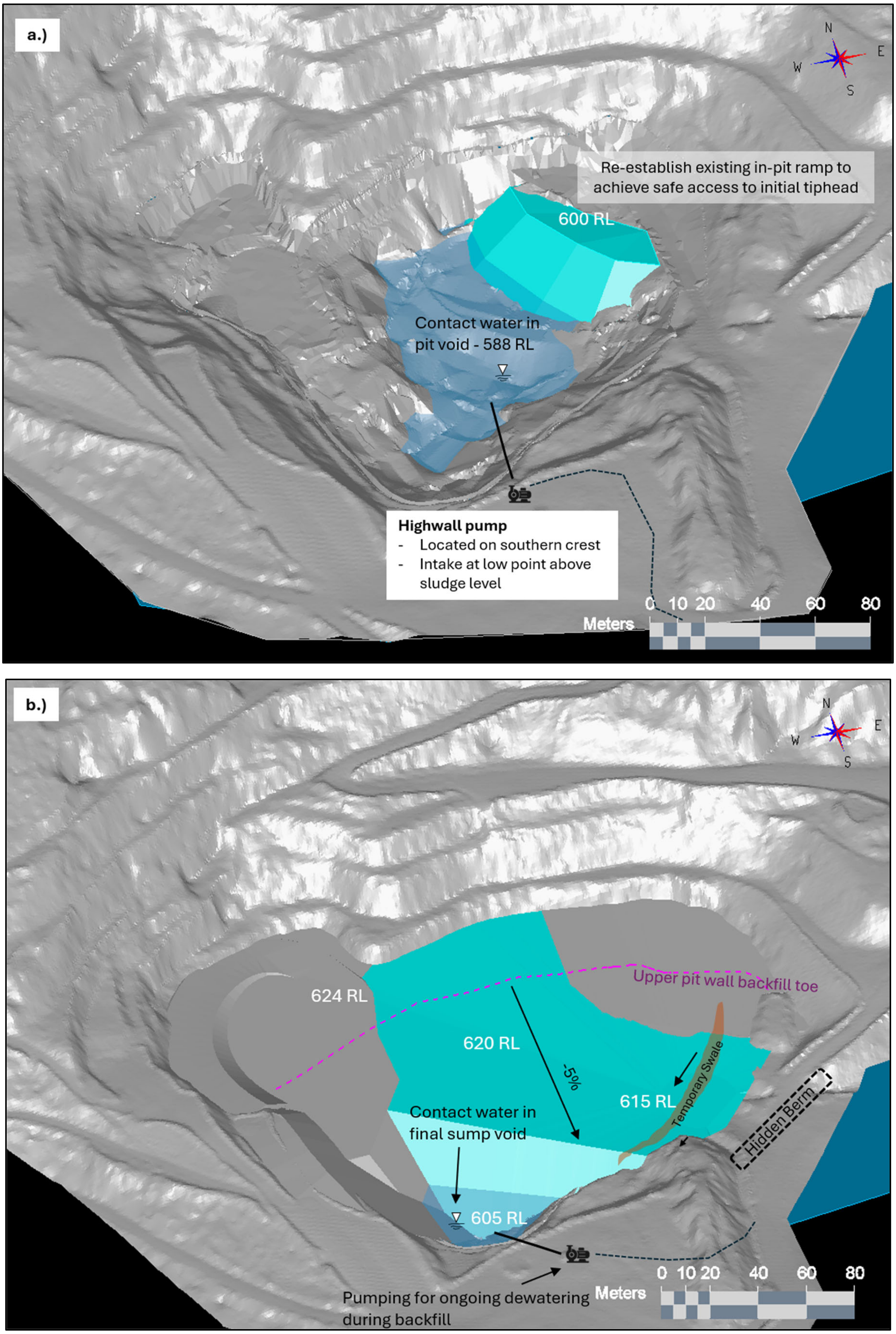

Figure 6 (a) Stage 4 initial backfilling from the existing in-pit ramp; (b) Nearing final surface backfill grade (Okane Consultants 2026)

4.5 Stage 5: North Wall backfilling and cover system construction

Following backfilling up to the Main Pit crest, HVWRD material placement up the North Wall will begin, ultimately achieving a maximum 2H:1V slope across the Main Pit landform (Figure 7). As each lift is placed, the cover system will be laid down and anchored (Figure 7). The cover system will comprise a high-friction bituminous geomembrane (BGM) liner overlain by 1.0 m of competent NAF material. A bedding layer of fine material will be installed beneath the BGM to prevent punctures during construction. The cover system is designed to minimise water infiltration into the underlying waste rock, targeting 'very low' percolation rates in line with International Network for Acid Prevention guidelines (INAP 2017).

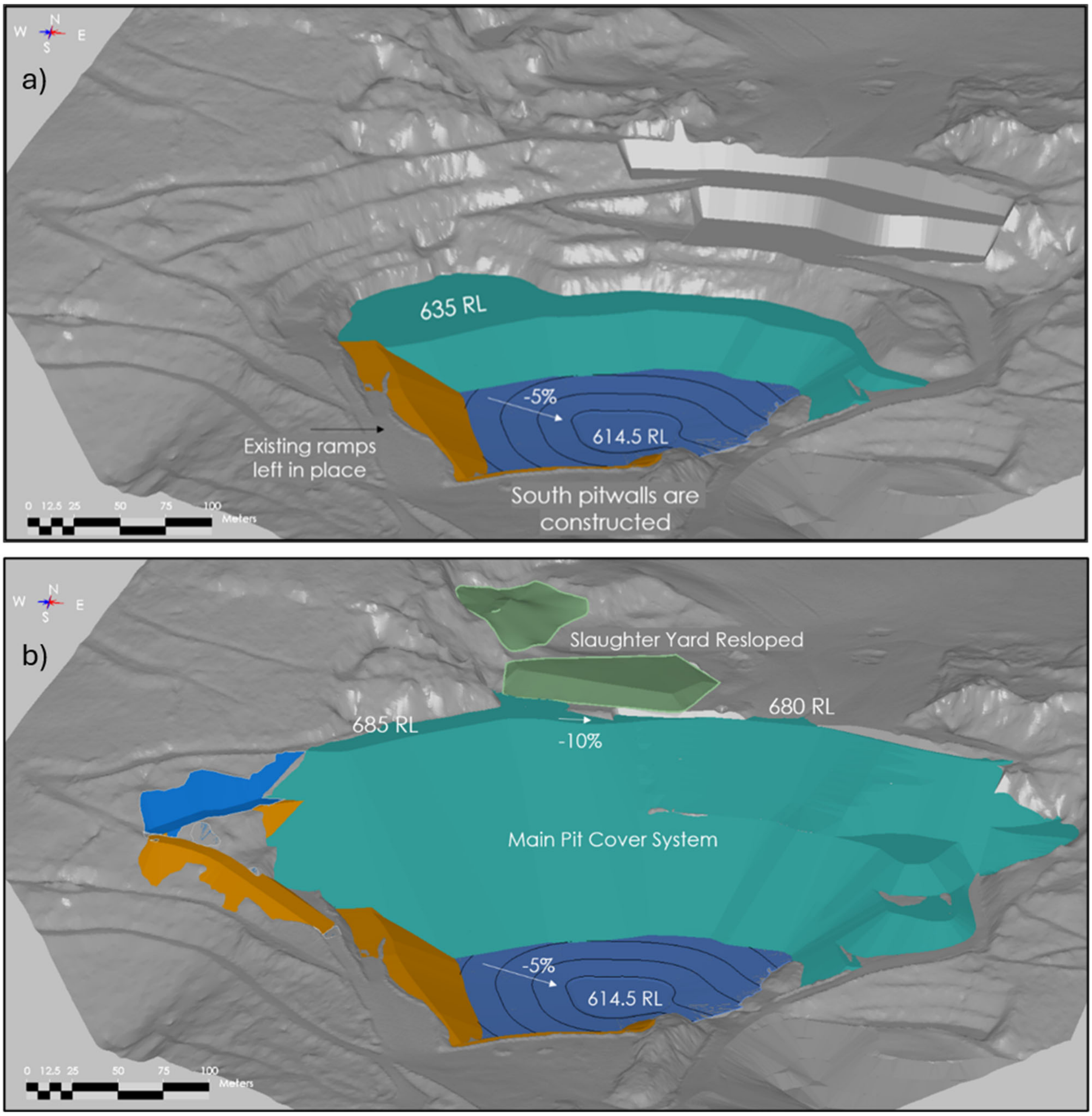

Figure 7 (a) Stage 5 North Wall backfilling and resloping; (b) Completion of the Main Pit cover system (Okane Consultants 2026)

The BGM liner will be anchored at the top of each lift and overlapped for welding (similar to a roof tile design), and the rock material pushed down the slope to achieve the required thickness before any traffic.

Importantly, this design ensures that any localised BGM instability in the post-closure phase does not compromise the integrity and stability of the entire BGM liner extent.

Due to the relatively steep slope of 2H:1V, erosion and veneer stability are key considerations in the cover design. Hydraulic and stability analyses have been conducted to ensure the cover system can manage interflow and withstand a 1:100-year rainfall event without failure. Using coarser rock with minimal sand, silt and clay will enhance erosion resistance, while the geosynthetic layers improve drainage capacity and puncture resistance. A diversion drain will also be constructed above the Main Pit North Wall to minimise run-off interacting with the cover system and increasing erosion rates.

Where rainfall and run-off cannot be diverted and do interact with the Main Pit cover system, surface flows, interflows and the entrained sediment will be captured in a broad, shallow central sediment basin on the pit floor (Figure 8). The sediment basin will occupy ~0.23 ha and is 0.3 m deep, providing ~700 m^3 of storage capacity. Water from the basin will then pass to the rehabilitated Happy Valley through a controlled, riprap armoured outlet located at the southeastern pit perimeter (Figure 8).

The BGM liner will be extended across a large portion of Slaughter Yard above the Main Pit North Wall, with 1.0 m of competent NAF material then placed over the BGM. The purpose of this cover will be to reduce seepage and infiltration to the Main Pit backfill.

It is not currently proposed to extend the BGM liner across the run of mine (ROM) pad to the south of the Main Pit, consistent with the relatively lower AMD risk profile of this area (Figure 1). The ROM pad will be covered with low permeability NAF argillite/bentonite sourced from the HVWRD capping material. The area will then be recontoured to direct surface run-off down the rehabilitated Happy Valley.

4.6 Stage 6: hidden berm construction and Main Pit monitoring

The hidden berm, which includes a subsurface pipe network in the upper portion of the backfill, will provide hydraulic relief from the Main Pit backfill to the retention pond (Figures 6 and 8). The primary function of the hidden berm is to regulate the water level within the backfill to ensure the rising phreatic surface does not interact with the cover system. The piped system activates when the phreatic surface rises to approximately 614 m RL. Water from the hidden berm then flows into the retention pond and, under equilibrium conditions, a passive flow-through system is established.

The retention pond will remain in its current configuration, serving as a key location for collecting and monitoring recharge from the backfill that may emerge at surface via the hidden berm. The pond also provides attenuation capacity, enabling the settlement of sediments and precipitates that may be present in the discharge.

As shown in Figure 8, a range of geotechnical, geomorphic and geochemical aspects will be monitored to confirm the long-term integrity of the Main Pit final landform.

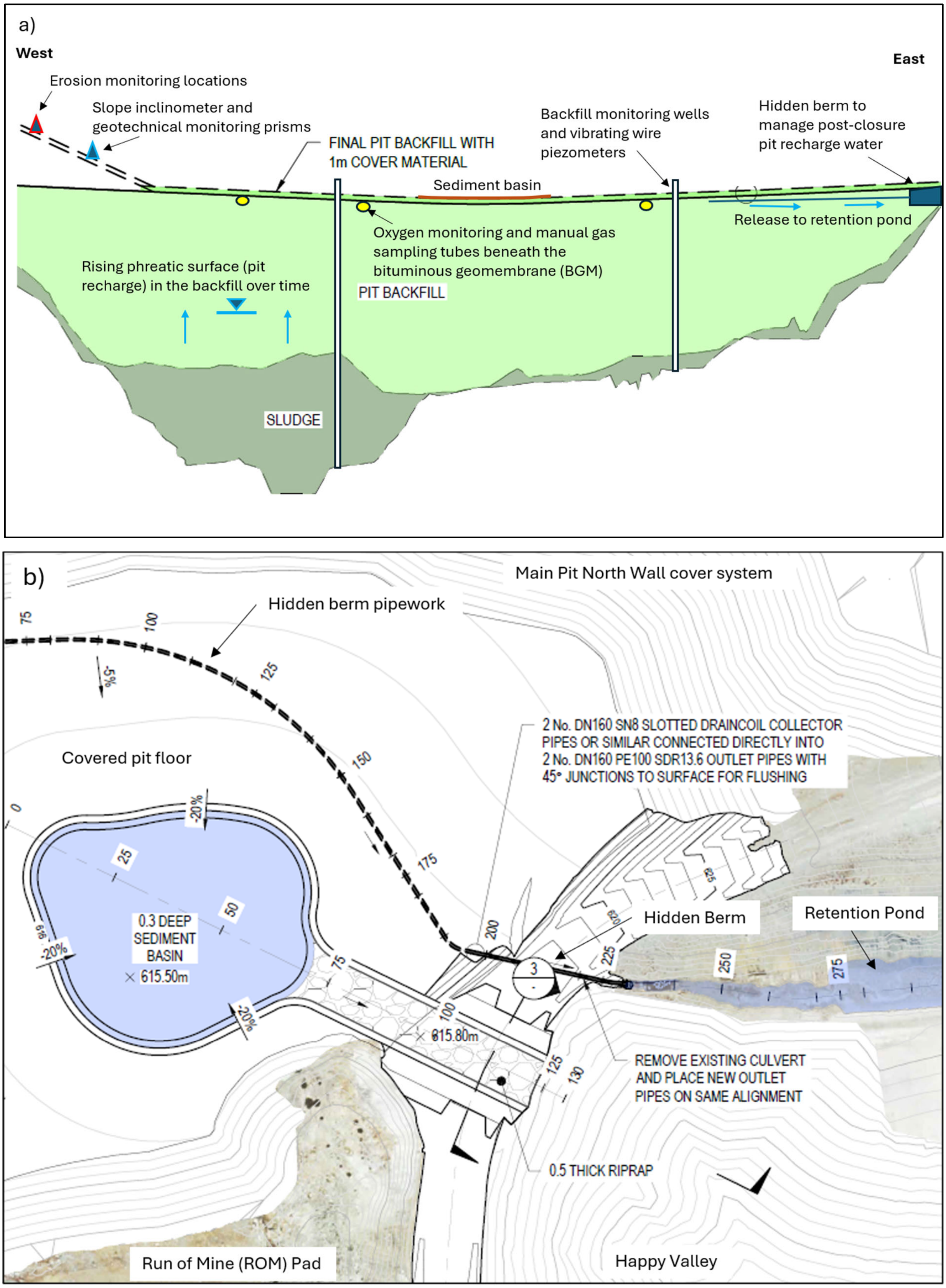

Figure 8 **(a) Stage 6 cross-section of the Main Pit backfill and monitoring equipment; (b) The hidden berm pipe network and retention pond (Okane Consultants 2026)**

4.7 Stage 7: repurposing of the Happy Valley Settling Pond footprint

The HVSP is a 4,500 m³ sedimentation pond at the base of the HVWRD, with a clay-core embankment approximately 10-15 m in height (Figure 9a). The HVSP is currently operated as an active water management structure for the HVWRD, with water levels controlled by a fixed dewatering pump that transfers captured water back up to the Main Pit for treatment prior to discharge via HVSC in accordance with regulatory requirements. The HVSP (including contaminated sediment and sludge) will be decommissioned at closure, with material removed to the Main Pit sump void prior to the cover system being installed. The main driver for decommissioning is to prevent the need for ongoing dam safety inspections over the long term.

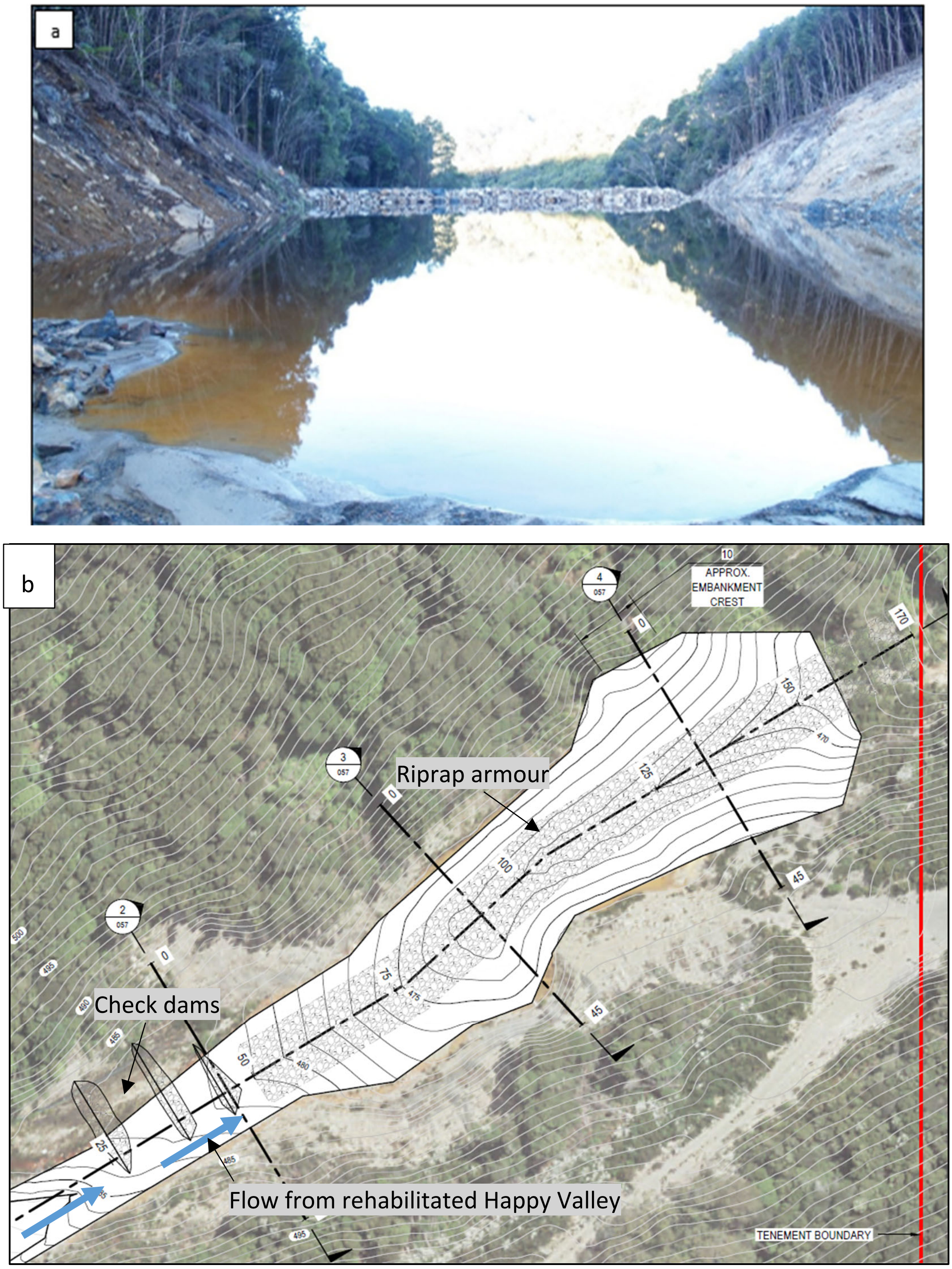

Figure 9 (a) Stage 7: Installation of the Happy Valley Settling Pond (HVSP) (BMTJV 2008); (b) The design of the reshaped and repurposed HVSP footprint at closure (Okane Consultants 2026)

The HVSP footprint will be excavated and reshaped to a similar profile to the pre-mining topography, with check dams, riprap armour and coarse woody debris installed (extending to the tenement boundary) to reduce stream power and erosion risk, and promote sediment retention (Figure 9b). Retention of sediment will promote the return of vegetation and microhabitat, that will in turn ensure gradual improvements to water quality being released to the Waratah River.

5 A rehabilitated landscape

The post-mining land use for the Main Pit landform is natural vegetation (Western Regrowth Complex) resembling that of pre-mining (late 1800s) conditions. Relocation of the waste rock is not merely a preferred option but is considered necessary to materially reduce long-term AMD risk and associated closure liability at Mt Bischoff, compared to leaving the material in situ. Specific to the Main Pit, the cover system will reduce water ingress, limit oxygen exposure and minimise contaminant loads. The execution of the 7 construction stages is expected to support development of an integrated closure landform and achievement of the site-wide closure objectives of a safe, stable, and non-polluting landform that permits the BMTJV to relinquish the mining leases (Figure 10). The BMTJV considers the development of a relinquishment pathway a highly collaborative exercise and has (and will continue to) actively engage with the relevant authorities, landowners and community stakeholders as the closure strategy is implemented.

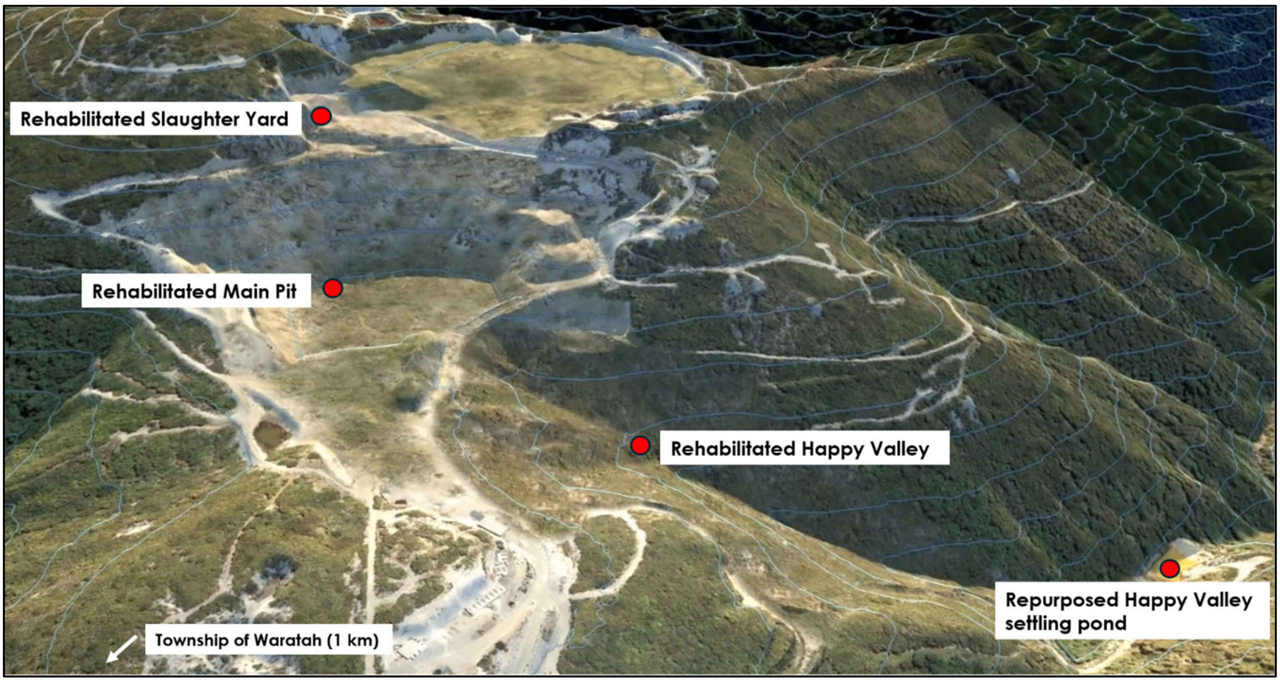

Figure 10 (a) A digital model of the Mt Bischoff mine rehabilitated landform looking north from Waratah

6 Conclusion

Implementing the Stage 1-7 closure strategy presented in this paper will reduce the impact the Mt Bischoff mine has on the receiving environment and result in substantial net improvement to the overall environmental condition when compared to the legacy acid and metalliferous drainage impacts that existed prior to the Bluestone Mines Tasmania Joint Venture (BMTJV) operations. Importantly, the outcome will reduce the future risk associated with the Happy Valley waste rock dump and the need for ongoing (costly) treatment of the Main Pit water. The closure strategies and methodologies were selected with a view to also providing the greatest possible benefit to other areas of Mt Bischoff that were not disturbed by the BMTJV. The Mt Bischoff mine is Tasmania's first non-abandoned mine to reach the engineered closure phase, setting a benchmark for community expectations and the state's regulatory framework around relinquishment of the mining leases.

6.1 Limitations and assumptions

This paper has been written while engineering designs for the rehabilitation of Mt Bischoff mine remain ongoing. While the overarching closure strategy has been committed to by the Bluestone Mine Tasmania Joint Venture, the methodology presented is based on current design assumptions and is subject to refinement through detailed design, construction planning, regulatory review and field verification. Minor design updates may occur as part of regulatory review, and adaptive onsite management will be required during construction. It is outside the scope of this paper to comment on the timeframe to relinquishment of the mining leases.

At the time of writing this paper, community consultation in the township of Waratah remains ongoing. Community engagement sessions are focused on communicating the closure strategy outlined in this paper and aligning this with feedback on heritage preservation and appropriate post-mining land uses.

Acknowledgement

The authors acknowledge the contributions of the Bluestone Mines Tasmania Joint Venture for providing access to site data, field investigations and historical records essential to the development of this assessment.

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