

***ALTERNATIVES REPORT
FOR
KANGRA COAL (PTY) LTD
BALLENGEICH COLLIERY***



M²ENCO

EXECUTIVE SUMMARY

This Alternatives Report has been compiled as a standalone specialist document in fulfilment of DWS Requirement 11 of the Water Use Licence Application (WULA) Acknowledgement Letter (Ref: WU33839, dated 17 December 2024) for Kangra Coal (Pty) Ltd's Ballengeich Colliery. The report evaluates the reasonable and feasible alternatives considered for the proposed passive Acid Mine Drainage (AMD) treatment and site rehabilitation project in accordance with Section 40(4)(b) of the National Water Act, 1998 (Act 36 of 1998) (NWA), GN 267 of March 2017, GN 4167 of December 2023, and the National Environmental Management Act (NEMA) EIA Regulations (GN 326, GN 325 and GN 327 of April 2017).

The Ballengeich Colliery is a defunct coal mine situated at the confluence of the Horn River (V31F) and the Ngagane River (V31G/V31K), approximately 15 km south of Newcastle, KwaZulu-Natal, within the Pongola-Mtamvuna Water Management Area (WMA 4). The site has been affected by ongoing AMD generation since the cessation of mining activities in the early 1990s. AMD originating from flooded underground workings, opencast spoil areas and the unrehabilitated discard dump has contributed to the degradation of water quality within portions of the Horn River system and has resulted in the site remaining subject to a Section 19 Directive (Ref: 16/2/7/V301/A/1, August 2013). The proposed project forms part of the broader strategy to address historical pollution sources and improve the long-term water quality within the receiving environment.

Six categories of alternatives were evaluated as part of the assessment process:

- Alternative 1: No Action (No Action) – Not Preferred. Continued reliance on existing measures would not adequately address the historical AMD sources and would not achieve the objectives of the Section 19 Directive.
- Alternative 2: Active (Chemical) Treatment Technologies – Not Preferred. Although technically feasible, active treatment technologies were considered financially and operationally impractical for the Ballengeich site due to the long-term operational requirements, reliance on continuous power supply, and ongoing chemical inputs.
- Alternative 3: Phytoremediation (Eucalyptus Plantation) – Not Preferred. Previous investigations and operational experience demonstrated that phytoremediation alone would not adequately address the volume and characteristics of AMD generated at the site.
- Alternative 4: Passive Treatment – Western Area (Underground Workings) Only – Not Preferred. This option addresses AMD associated with the underground workings but does not adequately address the remaining AMD sources associated with the opencast areas and discard dump.

- Alternative 5: Passive Treatment – Eastern Area (Opencast/PCDs) Only – Not Preferred. This option addresses seepage associated with the opencast areas but does not provide treatment for AMD originating from the underground workings.
- Alternative 6: Passive Treatment – Two-Area Treatment Approach (Preferred Alternative). This option addresses all identified AMD sources through a combined passive treatment approach and best aligns with the project objectives, site constraints and regulatory requirements.

The preferred alternative (Alternative 6) comprises a full passive AMD treatment system across two treatment areas. Treatment Area 1, located on Portions 25 and 19, consists of ALD 1, a SAPS, Oxidation Pond and Aerobic Wetland Unit 1 designed to treat AMD originating from the underground workings. Treatment Area 2, located on Portion 19, comprises ALD 2 and Aerobic Wetland Unit 2, which function as a cut-off treatment system for seepage associated with the opencast areas and discard dump. Collectively, the two-area treatment approach addresses the principal AMD sources identified at the site and represents the Best Practicable Environmental Option (BPEO) considered during this assessment. The approach is consistent with previous engagements with DWS and aligns with the current WULA process (Ref: WU33839).

All layout alternatives considered involve some degree of interaction with regulated buffer areas, including the 500 m wetland buffer, 100 m NFEPA river buffer and portions of the 1:100-year floodline. This is primarily due to the location of the historical mining footprint, the proximity of the AMD sources to the Horn and Ngagane River systems, and the requirement to implement treatment measures as close as reasonably practicable to the source of pollution. The delineated wetland features associated with the site have been confirmed as artificial in origin. Based on the available specialist studies and supporting assessments, implementation of the preferred alternative is anticipated to result in a long-term improvement in water quality and ecological functioning within the receiving environment and to contribute positively towards the achievement of the applicable Resource Quality Objectives for the catchment.

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1. INTRODUCTION

1.1 Purpose and Legislative Basis

This Alternatives Report has been prepared as a standalone specialist document in compliance with the following legislative and regulatory requirements:

- DWS Requirement 11 of the WULA Acknowledgement Letter (Ref: WU33839, 17 December 2024): “Include layout alternatives which avoid the delineated sensitive areas (wetlands within a 500m radius, floodlines, riparian areas, etc.) and also depict this on a map.”
- Section 40(4)(b) of the National Water Act, 1998 (Act 36 of 1998) (NWA): which requires the applicant to provide such information as may be required by the responsible authority, including information on alternatives.
- GN 267 of 24 March 2017 (Regulations in terms of the NWA): prescribing requirements for supporting studies in a WULA, including the consideration of alternatives.
- GN 4167 of 8 December 2023 (NWA Risk Assessment Matrix Regulations): which requires a systematic evaluation of proposed water uses and alternatives using the RAM framework.
- NEMA EIA Regulations (GN 326, GNR 325, GNR 327; April 2017): requiring assessment of reasonable alternatives as part of the Basic Assessment (BA) process, including the no-action alternative.
- Best Practice Guideline H4 — Water Treatment (DWS, 2006): requiring consideration of all available treatment options and selection based on the Best Practicable Environmental Option (BPEO) principle, including the BPG H4 decision tree for passive treatment technology selection.

This report is submitted as DWS Requirement 11 and must be read in conjunction with the Water Use Licence Application Summary Report (WULAR; MENCO, June 2026; Ref: WU33839), the Integrated Water and Waste Management Plan (IWWMP; MENCO, March 2026), the Wetland Delineation (MENCO, March 2025), and the GFK Stormwater Management Plan (GFK, March 2026).

1.2 Background and Context

The Ballengeich Colliery, formerly known as the Natal Cambrian Colliery, ceased mining operations in the early 1990s after more than 30 years of underground (bord-and-pillar) and opencast (roll-over) coal extraction. The mine was subsequently acquired by Kangra Coal (Pty) Ltd as part of the Menar Group. Upon cessation of mining, the site was not formally closed and no closure certificate was obtained under the Minerals Act, 1956.

The primary environmental problem at Ballengeich is the generation and uncontrolled release of AMD from three confirmed sources: (1) flooded underground workings (≈30% contribution by salt load) decanting artesianly near the Horn River bank west of the N11 bridge — the most chemically aggressive source (pH <4.5; Fe 189 mg/L); (2) opencast spoil areas (≈55% contribution), comprising Spoils Block I (west of N11, ≈34 ha) and Spoils Block II (east of N11,

≈45 ha) leaching contaminated seepage into the Horn River; and (3) the unrehabilitated discard dump (≈15% contribution), approximately 14 ha; max height 55 m; approximately 2 million tonnes of coal waste with active spontaneous combustion confirmed.

A Section 19 Directive was issued by DWS in August 2013 (Ref: 16/2/7/V301/A/1) directing Kangra to take measures to prevent and remedy pollution. Multiple Action Plans, specialist studies, and WULA submissions have followed. A first WULA (GCS, 2015, phytoremediation-based) was formally declined by DWS on 29 April 2019. DWS conducted a site inspection on 3 July 2023 and issued a formal letter (24 August 2023, signed N. Makwabasa, Regional Head KZN) directing expedited WULA submission and specifically approving the pilot-scale passive wetland approach. The current application (Ref: WU33839; 62 individual water uses across five S21 categories) represents the most comprehensive and technically robust submission to date.

The selection of the proposed passive treatment system as the preferred alternative is supported by over 13 years of site investigation, monitoring, specialist studies, and DWS engagement, and is specifically aligned with the GN 1873 (March 2022) Resource Quality Objectives for the V31K catchment and the findings of the GFK SWMP (March 2026) and EWS Hydrogeology Assessment (April 2025).

1.3 Sensitive Areas Relevant to This Assessment

The assessment of alternatives must specifically consider the delineated sensitive areas as confirmed by specialist studies. The full wetland delineation is contained in Menco Report WET/KANGRA/03/25. The following sensitive areas are relevant:

Table 1: Sensitive Areas Relevant to the Alternatives Assessment

Sensitive Feature	Regulatory Buffer	Relevance to Alternatives Assessment
Floodplain Wetland (4.5 ha) along Horn River — PES: Class C; EIS: High; REC: C (Menco, March 2025)	500 m wetland buffer; 100 m NFEPA river buffer	AMD decant point is situated WITHIN the floodplain wetland footprint. Wetland is of artificial origin (created by Horn River diversion, late 1980s; confirmed Menco 2025). All layout alternatives must locate treatment infrastructure adjacent to the decant point to achieve source control. GN 704 Reg. 4 exemption applied for (December 2024).
Channelled Valley Bottom Wetland (CVB-01) — PES: Class C; EIS: Moderate; REC: C	500 m buffer	Artificial in origin (created by Horn River impoundment). Low-moderate ecological value. No physical activity proposed within CVB-01. 100 m no-go buffer respected. Used as compliance monitoring reference.

Sensitive Feature	Regulatory Buffer	Relevance to Alternatives Assessment
Horn River — NFEPA River; PES Class C/D (V31F); flows south to Ngagane confluence	100 m NFEPA river buffer	Primary AMD receptor. All layout alternatives must avoid further impeding natural flow except for authorised rehabilitation structures. AMD decant point on Horn River bank is driver of all alternatives. DWS gauging station V3H009 on Horn River.
Ngagane River — NFEPA River; PES Class B/C (V31K; FEPA); flows north	100 m NFEPA river buffer	Primary downstream receptor. All treatment alternatives assessed for impact on Ngagane water quality and RQOs (GN 1873, March 2022). Newcastle WTP abstracts up to 220 Ml/day downstream. Compliance monitoring point SW10 is on the Ngagane (−27.879667°; 29.973981°).
1:50-year floodline — Horn and Ngagane Rivers (GFK HEC-RAS 2D model, February 2026)	GN 704 Reg. 7: no mining within 1:50-yr line without exemption	All existing PCDs, discard dump, and all proposed treatment infrastructure are within the 1:50-year floodline. GN 704 Regulation 4 exemption has been applied for (MENCO, December 2024).
1:100-year floodline — Horn and Ngagane Rivers (GFK HEC-RAS 2D model, February 2026)	GN 704 Reg. 4: no residue deposits within 1:100-yr line without exemption	Base flood line confirmed via HEC-RAS 2D model (GFK, February 2026). Flood protection berm crest level: 1,183.1 m amsl; minimum 0.8 m freeboard. GN 704 Reg. 4 exemption applied for. All passive treatment infrastructure is within 1:100-yr floodline.
KZN C-Plan Critical Biodiversity Area (CBA 2)	NEMA LN3 GN 324 Activity 12(d)(v) and 14(d)(vii)	The western passive wetland treatment area falls within a CBA 2 area per the KZN Biodiversity Sector Plan. NEMA LN3 activities are triggered. Full Basic Assessment (BA) process required. Confirmed by MENCO Alternatives Assessment (March 2026).

2. ALTERNATIVES CONSIDERED

The following alternatives were systematically identified and evaluated against five assessment criteria: (1) Technical feasibility; (2) Environmental impact on sensitive areas; (3) Financial viability; (4) Regulatory acceptability; and (5) Alignment with DWS requirements and the issued Section 19 Directive. Layout alternatives are assessed specifically in relation to the delineated sensitive areas described in Section 1.3.

2.1 Alternative 1: No Action (Do Nothing)

Description

Under the No Action alternative, Kangra Coal takes no further measures beyond those currently in place (limited PCD containment via the AMD Decant Pipeline to West Decant PCD). AMD continues to discharge uncontrolled to the Horn River at approximately 1,000 m³/day (pH <4.5; SO₄ >4,000 mg/L; Fe 189 mg/L; Mn 4.0 mg/L). No passive treatment system is constructed. No discard dump rehabilitation is undertaken. No stormwater management upgrades are implemented. Existing PCDs remain unlined and non-compliant with GN 704.

Table 2: Assessment of Alternative 1 — No Action

Assessment Criterion	Finding
Technical feasibility	Technically possible (inaction requires no engineering) but constitutes ongoing regulatory non-compliance and criminal liability under Section 151 of the NWA.
Environmental impact on sensitive areas	HIGHLY NEGATIVE. Continued uncontrolled AMD discharge (pH <4.5; SO ₄ >4,000 mg/L; Fe 189 mg/L; Mn 4.0 mg/L) to Horn River. Progressive deterioration of Horn River PES from current Class D/E toward Class E (Severely Modified). Orange ferric iron precipitation smothering benthic habitat (Horn DS1 and DS2; Menco November 2023). 100% ostracod mortality and 70% phytotox growth inhibition confirmed at decant site (Menco, November 2023). Toxicity Class IV. Continued AMD seepage through unlined PCDs into shallow groundwater (SO ₄ plume: 4,000 mg/L source to 1,000 mg/L at Horn River; EWS April 2025). Risk of Newcastle WTP potable supply compromise.
Financial viability	Short-term apparent cost savings only. Long-term: escalating remediation costs as AMD migrates further; potential criminal prosecution under Section 151 of the NWA; DMRE penalties and loss of Mining Right under MPRDA Section 43; increasing civil liability to downstream water users including Umgeni Water / Newcastle WTP.

Assessment Criterion	Finding
Regulatory acceptability	UNACCEPTABLE. A Section 19 Directive has been in force since August 2013 (Ref: 16/2/7/V301/A/1). DWS inspection of 3 July 2023 confirmed continued non-compliance. DWS letter of 24 August 2023 characterised previous inaction as unacceptable. Non-compliance with the Directive is a criminal offence under Section 151 of the NWA. The Directive remains in force until all instructions are successfully carried out.
Alignment with DWS requirements	DIRECTLY CONTRADICTS all DWS requirements. DWS letter of 24 August 2023 directed: (a) expedite WULA submission within 3 months; (b) continue monitoring; (c) pilot wetland system requires WUL. DWS specified the Directive remains in force until all instructions are carried out. The WULAR submission is itself a DWS requirement; the No Action alternative makes no submission at all.

REJECTED: The No Action alternative is rejected. It constitutes continued contravention of the Section 19 Directive and NWA, creates criminal liability, and will result in irreversible degradation of the Horn and Ngagane River systems and long-term compromise of the Newcastle potable water supply.

2.2 Alternative 2: Active (Chemical) Treatment Technologies

Description

Active treatment systems require continuous or semi-continuous input of chemical reagents and/or energy to neutralise AMD. The primary active treatment technologies evaluated for Ballengeich were: High Density Sludge (HDS) lime treatment (continuous hydrated or slaked lime dosing to precipitate metals and raise pH; requires mixing infrastructure, sludge management, and uninterrupted chemical supply); Conventional lime dosing (lower-density sludge; lower capital cost but same operational constraints); Reverse Osmosis (RO) with lime pre-treatment (membrane-based desalination for TDS and sulphate removal; very high capital and operating cost); and Biological sulphate reduction via bioreactor (THIOPAQ / SULFATEQ systems; high capital cost; requires specialist continuous operation; H₂S production creates safety risk at unmanned site).

Table 3: Assessment of Alternative 2 — Active Treatment Technologies

Assessment Criterion	Finding
Technical feasibility	Technically feasible at full scale but requires reliable grid electricity supply, continuous chemical reagent supply chain, permanent skilled operational staff, and chemical storage infrastructure. The

Assessment Criterion	Finding
	Ballengeich site is a remote, defunct mining area with: no permanent on-site personnel; no grid electricity connection; no chemical storage infrastructure; and no reliable road access during wet season. Operational continuity of any active treatment system cannot be guaranteed — a failure period of even 48–72 hours would result in acute AMD overflow events, potentially more damaging than current chronic AMD release.
Environmental impact on sensitive areas	Effective in reducing pH, Fe, Al, and Mn when operating correctly. However: (1) HDS sludge generated is classified as hazardous waste (GNR 635) requiring approved disposal — no approved Class C facility is available on or near the site; (2) sludge dam construction creates new residue deposits within the 1:100-year floodline; (3) lime treatment does not effectively address TDS or sulphate residuals at the concentrations present ($\text{SO}_4 > 4,000 \text{ mg/L}$) without RO post-treatment; (4) acute chemical spill/plant failure risk creates pollution events worse than current chronic AMD. Net environmental benefit lower than passive treatment over design life.
Financial viability	Financially unfeasible. The Assimilative Capacity Study (MENCO, February 2025) confirmed: “Active treatment options are not considered as it is seen as too expensive for the scale of mining envisaged for the Ballengeich Colliery Operation.” Kangra Coal operates the Ballengeich site at a financial loss with no active mining revenue from Ballengeich. See Table 3a for comparative cost estimates.
Regulatory acceptability	Not specifically required by DWS. DWS has approved the passive treatment approach (DWS letter 16/2/7V301/C/4, August 2023). GN 704 Exemption Application for passive treatment infrastructure submitted December 2024. Active treatment has not been required or recommended in any DWS correspondence.
Alignment with DWS requirements	DWS explicitly approved the “pilot-scale constructed passive wetland system” as the preferred treatment approach (August 2023 letter). The current WULAR is built on this approved passive approach. Active treatment is not aligned with DWS’s stated preference.

Table 3a: Active Treatment Options — Cost and Rejection Summary

Active Treatment Option	Capital Cost (Indicative)	Annual OPEX (Indicative)	Primary Reasons for Rejection
High Density Sludge (HDS) Lime Treatment	R8 – 15 million	R1 – 1.5 million/yr	No grid electricity; no licensed sludge disposal facility; continuous reagent supply unreliable; sludge dam creates new GN 704 non-compliance within floodline.
Conventional Lime Dosing	R4 – 8 million	R0.8 – 1 million/yr	Same operational constraints as HDS; sludge generated is hazardous; insufficient Fe/Al removal efficiency; does not address TDS or SO ₄ to RQO level.
Reverse Osmosis (RO) with Lime Pre-treatment	>R25 million	>R2 million/yr	Prohibitively expensive; requires continuous electricity and highly skilled operators; concentrated brine disposal creates secondary hazardous waste stream; no local disposal option.
Biological Sulphate Reduction (THIOPAQ / SULFATEQ)	R15 – 25 million	R2 – 3 million/yr	Highly complex operation; H ₂ S gas production creates acute safety risk at unmanned remote site; specialist operators required; not suitable for intermittent operation.

REJECTED: All active treatment alternatives are rejected on grounds of financial unfeasibility, operational impracticality at a remote, unmanned, off-grid site, and the absence of any DWS requirement or recommendation to implement active chemical treatment.

2.3 Alternative 3: Phytoremediation (*Eucalyptus Plantation*)

Description

Phytoremediation was the approach adopted in the first WULA submissions (GCS, 2012 and 2015). The approach involved planting Eucalyptus trees in AMD seepage and decant areas to intercept and evaporate contaminated groundwater through transpiration, and to reduce precipitation infiltration into backfill sites. A feasibility study was conducted by Fractal Forest (2010) and a research trial was initiated on site. A 3.57 ha Eucalyptus plantation — the residual physical legacy of this approach — remains on Portion 19 and constitutes a Section 21(d)

Streamflow Reduction Activity (SFRA; Water Use Item 34, Water Uses Register Rev 2, March 2026). The plantation has been operational for over a decade.

Table 4: Assessment of Alternative 3 — Phytoremediation

Assessment Criterion	Finding
Technical feasibility	LIMITED. Eucalyptus trees can survive in mildly acidic conditions but growth rates are significantly suppressed in highly acidic AMD-contaminated soil (pH <3.5). Maximum evapotranspiration from the 3.57 ha plantation is estimated at 3,000–5,000 m ³ /year under optimal conditions — less than 2% of the annual AMD decant volume of approximately 365,000 m ³ /year (1,000 m ³ /day design flow). AMD metals and acidity are not removed by phytoremediation — they accumulate in the soil and tree biomass and are re-released upon senescence or fire. The plantation does not improve river water quality.
Environmental impact on sensitive areas	NEGATIVE long-term. Eucalyptus spp. is classified as a Category 1b invasive alien species under the National Environmental Management: Biodiversity Act (Act 10 of 2004) and the Alien and Invasive Species Regulations (GN R598, August 2014). A Category 1b species must be controlled and cannot be deliberately spread. Continued plantation operation requires a Section 21(d) SFRA authorisation. Expansion of the plantation would further reduce baseflow to the Horn River (NFEPA river). The plantation does not treat or remove AMD contaminants from the water resource. More than 10 years of operation has not produced any measurable improvement in Horn River water quality (MENCO, November 2023; Health Class D/E at Horn DS1 unchanged since 2013 Directive).
Financial viability	Low upfront cost but investment in tree procurement, planting, and maintenance for 10+ years has yielded no measurable improvement in compliance status or Horn River water quality. The Fractal Forest feasibility study (2010) significantly overestimated evapotranspiration volumes and underestimated the scale of AMD generation.
Regulatory acceptability	FORMALLY REJECTED BY DWS. The WULA submitted by GCS in 2015 based on the phytoremediation approach was formally declined by DWS on 29 April 2019. The Eucalyptus plantation is scheduled for decommissioning under the current rehabilitation

Assessment Criterion	Finding
	plan; felled timber to be composted on site for a minimum of 90 days before use as the organic carbon layer in the SAPS. DWS has not indicated any willingness to reconsider phytoremediation as the primary treatment approach.
Alignment with DWS requirements	DWS specifically required a “pilot scale constructed passive wetland system” (August 2023 letter). Phytoremediation is explicitly incompatible with this requirement. The Section 19 Directive and the approved Action Plan both direct Kangra toward passive constructed wetland technology. Phytoremediation has been formally rejected once already.

REJECTED: Phytoremediation is rejected. The approach was formally declined by DWS (2019). It is technically insufficient, treating <2% of the annual AMD decant volume; it uses a Category 1b invasive alien species; it does not remove AMD contaminants from the water resource; and it is incompatible with DWS’s directive to implement a passive constructed wetland system.

2.4 Alternative 4: Passive Treatment — Western Area (Underground Workings) Only

Description

Under this layout alternative, the full passive treatment train (ALD → SAPS → Oxidation Pond → Aerobic Wetland) is constructed on the western side of the N11 national road only (Portions 25 and 19), targeting exclusively the AMD decanting from the old underground workings. Approximately 0.6 ha was initially available for treatment infrastructure on the western side before GFK’s revised Master Layout Plan (Rev 2, April 2026) confirmed an expanded western footprint of approximately 6 ha. The eastern site (opencast spoil areas, PCDs 1–8, Quantum operations, discard dump) would be managed solely through existing stormwater containment, with no AMD treatment for the eastern sources.

Table 5: Assessment of Alternative 4 — Passive Treatment, Western Area Only

Assessment Criterion	Finding
Technical feasibility	PARTIALLY FEASIBLE. The 6 ha available on the western side can accommodate the full western treatment train (ALD 1: 420 m; SAPS: minimum 18,900 m ² ; Oxidation Pond: 670 m ² ; Aerobic Wetland Unit 1: 1.3 ha). However, the eastern pollution sources contributing approximately 55% of total AMD salt load (opencast seepage) and 15% (discard dump runoff) remain completely unaddressed. The source control principle, required under Best Practice Guideline H4, is only partially satisfied.

Assessment Criterion	Finding
Environmental impact on sensitive areas	PARTIALLY POSITIVE for western area. Eastern pollution sources (opencast seepage, discard dump runoff, Quantum operations, PCDs 1–8, West Decant Sump overflow) continue to discharge untreated. The net improvement to Horn River PES is limited and will not achieve the REC of Class C within the WUL period. Unlined PCDs (1, 2, 5, 6) continue to leach AMD into groundwater and the Horn River. AMD seepage continues through the floodplain wetland (PES Class C; EIS High) in the eastern area.
Financial viability	Lower capital cost than the two-area approach (by approximately 30–40%) but fails to achieve RQO compliance at the compliance monitoring point (SW10, Ngagane River downstream of confluence) and will not satisfy DWS conditions of the WUL. The remaining eastern pollution sources would require future remediation at additional cost.
Regulatory acceptability	INSUFFICIENT. DWS Requirement is to address all three AMD sources identified in the Section 19 Directive, not only the underground decant. Partial treatment does not discharge Kangra’s regulatory obligations under the Directive. The Section 27 Motivation cannot be met for a partial-source-control approach.
Alignment with DWS requirements	INADEQUATE. DWS Requirement 11 asks for layout alternatives that avoid sensitive areas. This alternative does reduce the footprint in the eastern floodplain wetland area but does not address 70% of the AMD load (55% opencast + 15% dump). DWS’s stated objective is remediation of all pollution sources at Ballengeich.

Table 6: Location of Alternative 4 Infrastructure in Relation to Sensitive Areas

Infrastructure Component	Sensitive Area Interaction	Reason Not Feasible as Standalone Alternative
ALD 1 (420 m, Ptn 25)	Within 100 m NFEPA river buffer; 500 m wetland buffer; 1:100-yr floodline	Feasible as component. However, ALD 2 (eastern) is absent, leaving 70% of AMD load unaddressed.

Infrastructure Component	Sensitive Area Interaction	Reason Not Feasible as Standalone Alternative
SAPS (1.2 ha, Ptn 25)	Within 100 m NFEPA river buffer; 500 m wetland buffer	Feasible as component. Without eastern cut-off, eastern seepage bypasses the SAPS entirely.
Oxidation Pond (670 m ² , Ptn 25)	Within floodplain wetland; 100 m NFEPA buffer	Feasible as component. Treats only 30% of AMD load.
Aerobic Wetland Unit 1 (1.3 ha, Ptn 25)	Within floodplain wetland; 100 m NFEPA buffer	Feasible but insufficient — eastern seepage still enters Horn River untreated downstream of this unit.
No eastern treatment (PCDs 1–8, opencast seepage, discard dump)	Floodplain wetland and Horn River continue to receive 70% of AMD load	55% opencast seepage + 15% dump runoff continue degrading Horn River. SW7 AMD (pH ≈2.5; SO ₄ up to 8,000 mg/L) is unaddressed. This makes the alternative non-compliant with Directive.

REJECTED: The western-area-only layout alternative is rejected. It addresses only 30 % of the total AMD pollution load (underground workings), leaving the dominant eastern sources (55 % opencast seepage + 15 % discard dump) unaddressed and in continued contravention of the Section 19 Directive.

2.5 Alternative 5: Passive Treatment — Eastern Area (Opencast /PCDs) Only

Description

Under this layout alternative, passive treatment infrastructure is constructed exclusively on the eastern side of the N11, targeting the opencast spoils seepage and PCD overflows. ALD 2 (230 m, Portion 19) and Aerobic Wetland Unit 2 (4.4 ha, Portion 19) would be installed as a cut-off system between the PCD complex and the Horn River to intercept seepage. The underground workings decant point (west of N11) would be managed via the existing AMD Decant Pipeline to the West Decant PCD, with no further active treatment before any eventual discharge. The West Decant PCD (86,400 m³ capacity) would continue to accumulate AMD indefinitely with no treatment outlet.

Table 7: Assessment of Alternative 5 — Passive Treatment, Eastern Area Only

Assessment Criterion	Finding
Technical feasibility	FEASIBLE for eastern area only. ALD 2 and Aerobic Wetland Unit 2 as a cut-off system effectively addresses the opencast seepage and PCD overflow that contribute 55% of the AMD salt load. However, the underground decant (pH <4.5; Fe 189 mg/L;

Assessment Criterion	Finding
	artesian pressure, approximately 1,000 m ³ /day) is the most chemically aggressive source. Without SAPS treatment of the underground AMD, the West Decant PCD will continue accumulating 122,859 kg SO ₄ /year with no treatment pathway, creating an escalating overflow risk over time.
Environmental impact on sensitive areas	MODERATELY POSITIVE for eastern area. The most volumetrically significant seepage source (55% opencast) is addressed. However, the underground decant (the most acute and concentrated AMD source: lowest pH; highest Fe concentrations; artesian pressure) is left unaddressed. As the West Decant PCD approaches capacity, the risk of uncontrolled overflow to the Horn River at the N11 bridge decant point escalates, potentially creating acute pollution events worse than current chronic release.
Financial viability	Lower capital cost than two-area approach (by approximately 20–30%) but the ongoing risk of West Decant PCD overflow and associated emergency remediation liability offsets these savings. ALD 2 and Aerobic Wetland Unit 2 still require GN 704 exemption and construction within the 100 m NFEPA buffer.
Regulatory acceptability	INSUFFICIENT. DWS Action Plan identifies the underground decant as a primary pollution source requiring active treatment. Leaving the most chemically aggressive AMD source unaddressed contradicts the Section 19 Directive. The West Decant PCD accumulates 1,198,155 kg/annum of sulphate salt with no treatment outlet under this alternative. This will require DWS emergency intervention within 5–7 years as the PCD approaches capacity.
Alignment with DWS requirements	INADEQUATE. DWS's August 2023 letter identifies the underground AMD decant as requiring treatment. The pilot-scale passive wetland system approved by DWS is specifically designed to treat the underground decant (the SAPS and ALD 1 are sized for this source). This alternative omits the approved treatment components for the primary regulated source.

Table 8: Location of Alternative 5 Infrastructure in Relation to Sensitive Areas

Infrastructure Component	Sensitive Area Interaction	Reason Not Feasible as Standalone Alternative
ALD 2 (230 m, Ptn 19)	Within 100 m NFEPA river buffer; 500 m wetland buffer	Feasible as eastern component. Without ALD 1 and SAPS, the underground decant (30% AMD load) is unaddressed.
Aerobic Wetland Unit 2 (4.4 ha, Ptn 19)	Within 100 m NFEPA buffer; 500 m wetland buffer; 1:100-yr floodline	Feasible as eastern cut-off. Reduces eastern AMD seepage but the most chemically aggressive source (underground decant) remains active.
No western treatment (underground workings, West Decant PCD)	AMD decant point on Horn River bank remains active; artesian flow uncontrolled	West Decant PCD (86,400 m ³) accumulates 122,859 kg SO ₄ /yr with no outlet. At current rates the PCD reaches capacity and overflows within 5–7 years, creating an acute pollution event.
Flood protection berm (Ngagane River, Ptn 19)	Within 100 m NFEPA river buffer (in sections)	Required regardless of treatment layout. Protects lined PCDs from 1:100-yr flood inundation.

REJECTED: The eastern-area-only layout alternative is rejected. It leaves the underground decant — the most chemically aggressive AMD source — unaddressed, creating an escalating accumulation risk in the West Decant PCD and continued non-compliance with the Section 19 Directive.

2.6 Alternative 6: Passive Treatment — Two-Area Treatment Approach (SELECTED PREFERRED OPTION)

Description

The selected alternative implements the full passive AMD treatment train across two distinct areas, applying the source control principle to ensure all three AMD sources are addressed before pollution reaches the Horn and Ngagane Rivers:

Treatment Area 1 (Western, Portions 25 and 19): Full passive treatment train for underground workings AMD: AMD Decant Pipeline → ALD 1 (420 m, Ptn 25; 27°53'33.43"S; 29°57'41.38"E) → SAPS (minimum 18,900 m²; 27°53'27.58"S; 29°57'45.68"E) → Oxidation Pond (670 m²; 27°53'27.86"S; 29°58'30.75"E) → Aerobic Wetland Unit 1 (1.3 ha; 27°53'22.97"S; 29°57'47.24"E) → discharge to Horn River. Designed for 1,000 m³/day inflow. Addresses approximately 30% of AMD salt load.

Treatment Area 2 (Eastern, Portion 19): ALD 2 (230 m; 27°53'16.05"S; 29°58'3.72"E) installed below West Decant Sump → Aerobic Wetland Unit 2 (4.4 ha; 27°53'16.84"S; 29°57'58.77"E) as cut-off system treating seepage from opencast spoils, discard dump, and existing PCDs before reaching the Horn River. Addresses approximately 55% opencast + 15% discard dump AMD

contributions. Flood protection berm along Ngagane River (crest 1,183.1 m amsl; 1:100-yr HEC-RAS design; geocell/soilcrete revetment).

Table 9: Selected Alternative 6 — Location of Infrastructure in Relation to Sensitive Areas

Infrastructure Component	Sensitive Area Interaction	Mitigation / Justification
AMD Decant Pipeline (Ptn 19, double-wall HDPE)	Within 100 m NFEPA river buffer; Horn River riparian zone	MANDATORY FIRST ACTIVITY. Eliminates uncontrolled AMD discharge at source. Directional drill at N11 crossing; minimum 3 m setback from Horn River bank. Pre-existing contaminated footprint.
ALD 1 (420 m, Ptn 25)	Within 100 m NFEPA river buffer; 500 m wetland buffer; 1:100-yr floodline	Sub-surface buried HDPE ‘burrito’ trench; no surface flow diversion; trench dewatering pumped to West Decant PCD. Brownfield pre-existing AMD contamination. GN 704 Reg. 4 exemption applied for.
ALD 2 (230 m, Ptn 19)	Within 100 m NFEPA river buffer; 500 m wetland buffer	Sub-surface buried; HDPE-lined. Located on existing disturbed footprint east of N11. GN 704 exemption applied for.
SAPS (minimum 18,900 m ² , Ptn 25)	Within 500 m wetland buffer; 100 m NFEPA buffer	Located on footprint of pre-existing West Decant Sump area. Fully HDPE-lined — no contamination of surrounding soil. Organic carbon sourced from on-site Eucalyptus felled material.
Oxidation / Sedimentation Pond (670 m ² , Ptn 25)	Within floodplain wetland (PES Class C; EIS High); 100 m NFEPA buffer	Floodplain wetland confirmed artificial in origin (MENCO, 2025). Fully HDPE-lined (2 mm, SANS 10409). Min. 2 cells; scour valves; sludge characterised per GNR 635.
Aerobic Wetland Unit 1 (1.3 ha, Ptn 25)	Within floodplain wetland (PES Class C; EIS High); 100 m NFEPA buffer; discharge to Horn River	Will ENHANCE ecological services of floodplain wetland over time. HDPE-lined. Discharge only after pH >5.5 and Fe <10 mg/L confirmed (weekly monitoring). Reed planting: Typha capensis, Phragmites australis at 3–4 plants/m ² .
Aerobic Wetland Unit 2 (4.4 ha, Ptn 19)	Within 100 m NFEPA river buffer; 500 m	Cut-off system intercepting seepage before it reaches Horn River. HDPE-lined. Dry season construction only. Reed planting enhances

Infrastructure Component	Sensitive Area Interaction	Mitigation / Justification
	wetland buffer; 1:100-yr floodline	degraded riparian zone. No-go for CVB-01 wetland respected.
Flood Protection Berm (crest 1,183.1 m amsl)	Parallel to Ngagane River; outside 100 m NFEPA buffer where possible	HEC-RAS 2D 1:100-yr design. Geocell/soilcrete river-facing slope. 0.8 m minimum freeboard. Must be completed before first wet season. Protects all lined PCDs and treatment infrastructure from flood inundation.
PCDs 3, 4, 7, 8 (HDPE lining, Class C GNR 636)	Within 500 m wetland buffer; 1:100-yr floodline	Lining programme upgrades pre-existing brownfield PCDs to GN 704 Reg. 7 compliance. CQA plan required. Sludge disposal per GNR 635.
New Quantum PCD (8,600 m ³ , new construction)	Within 500 m wetland buffer; 1:100-yr floodline	New GN 704-compliant facility; Class C liner as designed; replaces previous undersized 2,500 m ³ design; concrete silt trap at inlet.

Table 10: Assessment of Alternative 6 — Two-Area Passive Treatment (Selected Preferred Option)

Assessment Criterion	Finding
Technical feasibility	FULLY FEASIBLE. The two-area approach applies the source control principle to all three AMD sources. Design capacity of 1,000 m ³ /day for the western treatment train (ALD 1, SAPS, Oxidation Pond, Aerobic Wetland Unit 1) comprehensively treats the underground decant. ALD 2 and Aerobic Wetland Unit 2 intercept eastern seepage before it reaches the Horn River. No grid electricity required. Design life: >30 years for aerobic wetland components; 20–30 years for SAPS; >25 years for ALD pipe components. All civil engineering designs prepared by GFK Consulting Engineers (B.D. Muhl Pr.Eng. Civil, ECSA 202604247) and signed 24 March 2026.
Environmental impact on sensitive areas	NET POSITIVE. Although treatment infrastructure is located within regulated buffer zones (brownfield, pre-existing contamination), the delineated wetland units are confirmed as artificial in origin (MENCO, March 2025). The passive treatment system will: (a) improve water quality in the Horn River (predicted to achieve REC Class C within 5 years); (b) enhance wetland eco-services of the

Assessment Criterion	Finding
	floodplain wetland through reed establishment and improved water quality; (c) improve aquatic biodiversity (SASS5 scores predicted to improve at Horn DS1 and DS2); and (d) reduce AMD loading on Newcastle WTP. Hydropedological impact: less than 0.5% of sub-catchment area; “no-impact” rating (EWS, April 2025).
Financial viability	FEASIBLE AND PROPORTIONATE. Passive treatment systems have: limited civil works (earthworks and HDPE linings only); no electricity requirement; no continuous chemical inputs; very low maintenance costs; very low operational costs; and a long design life exceeding 30 years. Capital cost: approximately R4,079,750 (excl. VAT; IWWMP Table 7-6). Lifetime cost per m ³ treated is significantly lower than any active treatment option. Proportionate to the scale of Ballengeich operations and confirmed as financially viable by Kangra Coal.
Regulatory acceptability	ACCEPTED BY DWS. DWS specifically approved the pilot-scale passive wetland approach (letter Ref: 16/2/7V301/C/4, 24 August 2023). GN 704 Exemption Application submitted December 2024. RAM v2.1.1 rates the construction of the passive wetland system as the highest-scoring activity in the entire assessment (positive score of –36 after mitigation). All specialist assessors (MENCO, EWS, GFK) have provided reasoned opinions that the proposed activities should be authorised.
Alignment with DWS requirements	FULLY ALIGNED. The two-area passive treatment approach aligns with: (a) the Section 19 Directive (remediation of all three AMD sources); (b) the approved Action Plan; (c) GN 4167 RAM framework (positive score after mitigation); (d) DWS’s explicit approval of the pilot-scale passive wetland approach (August 2023); (e) Best Practice Guideline H4 decision tree (ALD + SAPS optimal for site AMD characteristics); and (f) GN 1873 (March 2022) RQOs (SO ₄ ≤165 mg/L; pH 6.5–9.0; Fe ≤0.1 mg/L achievable with treatment + dilution).

SELECTED / PREFERRED OPTION: Alternative 6 — the Two-Area Passive Treatment Approach — is selected as the Preferred Alternative and the Best Practicable Environmental Option (BPEO) for the Ballengeich Colliery AMD treatment and site rehabilitation project.

3. COMPARATIVE ASSESSMENT OF ALTERNATIVES

The following comparative assessment matrix evaluates all six alternatives against the key assessment criteria. Scores are assigned on a scale of 1 (very poor / highly negative) to 5 (excellent / highly positive). The preferred alternative achieves the highest aggregate score and is the only option that satisfies all criteria.

Table 11: Comparative Assessment Matrix — All Alternatives

Assessment Criterion	Alt 1: No Action	Alt 2: Active Treatment	Alt 3: Phyto-remediation	Alt 4: Western Only	Alt 5: Eastern Only	Alt 6: Two-Area (Selected)
Technical Feasibility (source control achieved)	1	2	1	3	3	5
AMD Source Control (all three sources addressed)	1	4	1	2	3	5
Environmental Impact on Sensitive Areas	1	3	2	4	4	4
Water Quality Improvement (Horn/Ngagan e RQOs)	1	4	1	2	3	5
Financial Viability (Capital + Operational, lifetime)	5	1	3	4	4	4
Regulatory Acceptability (DWS / Section 19 Directive)	1	3	1	2	3	5

Assessment Criterion	Alt 1: No Action	Alt 2: Active Treatment	Alt 3: Phyto-remediation	Alt 4: Western Only	Alt 5: Eastern Only	Alt 6: Two-Area (Selected)
Long-Term Sustainability (design life, maintenance)	1	2	2	3	3	5
GN 704 and Directive Compliance	1	3	1	2	3	5
Alignment with GN 1873 RQOs (V31K, Horn/Ngagane)	1	4	1	2	3	5
Alignment with BPG H4 Decision Tree	1	3	1	3	3	5
TOTAL SCORE (max 50)	13	29	13	27	32	48
DECISION	REJECTED	REJECTED	REJECTED	REJECTED	REJECTED	SELECTED

4. LAYOUT ALTERNATIVES IN RELATION TO SENSITIVE AREAS

This section fulfils the specific DWS Requirement 11 to “include layout alternatives which avoid the delineated sensitive areas (wetlands within a 500m radius, floodlines, riparian areas, etc.) and also depict this on a map.”

4.1 Why Complete Avoidance of Sensitive Areas is Not Feasible

Based on the findings of the specialist studies undertaken for the project (MENCO Wetland Delineation, March 2025; EWS Hydrogeology Assessment, April 2025; EWS Hydrology Assessment, April 2025; EWS Hydropedology Assessment, April 2025; and GFK Stormwater Management Plan, March 2026), complete avoidance of the delineated sensitive areas was considered during the alternatives assessment process but was determined to be not reasonably feasible for the following reasons:

- **Topographic constraints:** The Ballengeich Colliery is situated at the confluence of the Horn and Ngagane Rivers, resulting in much of the historical mining footprint occurring within areas associated with river corridors, floodplain environments and regulated buffer zones. The available footprint for AMD treatment infrastructure is therefore constrained by the location of the existing pollution sources and surrounding topography.
- **Source-control requirements:** The effectiveness of passive AMD treatment systems is dependent on treatment occurring as close as reasonably practicable to the source of contamination. Relocating treatment infrastructure outside of the delineated buffer areas would require substantially longer conveyance systems, increase construction complexity and introduce additional operational and environmental risks without a corresponding improvement in environmental outcomes.
- **Historical mining disturbance:** The sensitive areas associated with the site occur within a historical mining landscape that has been affected by decades of mining-related activities and AMD generation. The proposed treatment system is intended to address existing pollution sources and contribute towards the long-term rehabilitation and improvement of water quality within these affected areas.
- **Artificial wetland features:** The wetland delineation assessment confirmed that the identified Floodplain Wetland and Channelled Valley Bottom Wetland are artificial in origin and are associated with historical mining activities and alterations to the natural drainage system. While these features remain regulated watercourses in terms of the National Water Act, their occurrence is directly linked to the historical disturbance footprint.
- **Existing infrastructure constraints:** A substantial portion of the existing mining infrastructure, including pollution control dams, discard facilities and associated mining features, predates current water resource management legislation and associated design requirements. The proposed rehabilitation and treatment measures have therefore been developed within the constraints imposed by the existing site layout and historical infrastructure footprint.

- **Hydropedological assessment findings:** The EWS Hydropedology Assessment (April 2025) concluded that the proposed treatment infrastructure footprint occupies a very small proportion of the broader sub-catchment area and is not expected to result in a measurable loss of hydropedological flow functions. This supports the conclusion that the residual impacts associated with the treatment footprint can be appropriately managed through the proposed mitigation and rehabilitation measures.

Accordingly, while complete avoidance of all delineated sensitive areas was considered during the alternatives assessment process, the preferred approach focuses on minimising the footprint within sensitive areas, implementing treatment measures as close as reasonably practicable to the source of pollution, and achieving an overall improvement in water quality and ecological condition within the receiving environment.

4.2 Layout Optimisation Measures to Minimise Sensitive Area Impact

Although complete avoidance is not feasible, the selected two-area layout (Alternative 6) has been systematically optimised to minimise impact on delineated sensitive areas as follows:

Table 12: Layout Optimisation Measures to Minimise Sensitive Area Impact

Optimisation Measure	How it Minimises Sensitive Area Impact	Supporting Evidence
HDPE lining of all treatment ponds and channels	Prevents AMD-contaminated pond water from seeping into surrounding wetland soils and groundwater. Isolates the treatment system from natural soil/water interaction completely. Sludge managed in accordance with GNR 635.	GFK SWMP Civil Design (March 2026); GN 704 Reg. 5; GNR 636 Class C specification; Bhekani Civil Design Rev 00 (February 2023).
Source control at decant points	By treating AMD at its source rather than after it has entered the river system, downstream propagation of AMD through the wetland is arrested from Day 1 of treatment operation.	BPG H4 (DWS, 2006); IWWMP (January 2025).
AMD Decant Pipeline as first construction activity	All AMD immediately redirected to West Decant PCD before any other construction commences. Eliminates acute ongoing	WULAR Section 6.3 (MENCO, June 2026); DWS Directive.

Optimisation Measure	How it Minimises Sensitive Area Impact	Supporting Evidence
	pollution at decant point from construction commencement.	
Dry season construction only (May–September)	All construction within floodplain wetland, 100 m NFEPA river buffer, and 500 m wetland buffer restricted to dry season months, minimising disturbance during flow periods and eliminating siltation risk during high flows.	Wetland Delineation (March 2025); EMPr; Rehabilitation Plan (November 2024); WULAR Section 6.3.
Minimum footprint design	SAPS minimum required area = 18,900 m ² (precisely sized per BPG H4). Aerobic Wetland 1 = 1.3 ha; Aerobic Wetland 2 = 4.4 ha. Treatment system footprint <0.5% of total sub-catchment area (EWS Hydropedology, April 2025). No redundant infrastructure included.	EWS Hydropedology (April 2025); Bhekhani Civil Design (February 2023).
Indigenous aquatic plant establishment	Aerobic wetlands planted with indigenous aquatic species (Typha capensis, Phragmites australis, Scirpus spp.) at 3–4 plants/m ² . Rehabilitates and enhances biodiversity in currently AMD-degraded floodplain area.	IWWMP Table 7-7 (January 2025); Wetland Delineation (March 2025).
CVB-01 wetland 100 m no-go buffer	The Channelled Valley Bottom Wetland (CVB-01, PES Class C, EIS Moderate) is protected with a 100 m strict no-go buffer. All construction activity is confined to the south of this feature. The buffer is demarcated on Master Layout Plan G2025/06/338-100 Rev 2.	Wetland Delineation (March 2025); EMPr (November 2024); WULAR Section 6.3.

Optimisation Measure	How it Minimises Sensitive Area Impact	Supporting Evidence
Complete clean/dirty water separation	GFK SWMP ensures complete separation of clean stormwater from dirty water catchments across the full site footprint, preventing uncontaminated runoff from increasing treatment system load and minimising the required treatment area.	GFK SWMP (March 2026); Master Layout Plan Rev 2 (April 2026).
Registered ECO with stop-work authority	A registered ECO with full stop-work authority to be present during all construction in wetland and riparian zones. All deviations from EMPr must be reported to DWS within 48 hours.	WULAR Section 6.3 (June 2026); EMPr (November 2024); NEMA conditions.
Weekly outfall quality monitoring prior to discharge	Discharge from Aerobic Wetland Unit 1 to Horn River ONLY after confirmed pH >5.5 and Fe <10 mg/L on minimum 3 consecutive weekly samples. Performance data reported monthly to DWS KZN.	WULAR Section 12.3.4 (June 2026); IWWMP (January 2025).

4.3 Master Layout Plan Reference

The preferred layout (Alternative 6) in relation to all delineated sensitive areas, floodlines, and NFEPA buffers is depicted on the following signed engineering drawing, submitted as a separate document to eWULAAS:

Table 15: Master Layout Plan Reference

Drawing Number:	G2025/06/338-100 Rev 2
Drawing Title:	Ballengeich Colliery — Master Layout Plan (with drone image overlay)
Compiled by:	GFK Consulting Engineers CC (CESA Reg. No. 605)
Signed by:	B.D. Muhl, Pr.Eng. Civil (ECSA 202604247); G.F. Krugel (ECSA 910142)
Revision Date:	April 2026 (Rev 2)

Scale:	1:2500 (A1 plot)
Datum:	WGS84 / LO 29
Sensitive areas to be shown:	Horn River (NFEPA); Ngagane River (NFEPA); 100 m NFEPA river buffers; 500 m wetland buffer zones; delineated wetland units (MENCO overlay, March 2025); 1:100-yr floodline (HEC-RAS 2D); 1:50-yr floodline; clean/dirty water catchment boundaries; all treatment system components with coordinates; monitoring points SW01–SW10.

5. TECHNICAL FEASIBILITY ANALYSIS FOR THE SELECTED ALTERNATIVE

5.1 AMD Characterisation at Ballengeich

The AMD at the Ballengeich Colliery has been characterised through quarterly monitoring campaigns, the MENCO Aquatic Ecological Assessment (November 2023), the EWS Hydrogeology Assessment (EWS24-12_GW, April 2025), and the Bhekhani Civil Design Report (B120, February 2023). The following parameters are used as the design basis for the passive treatment system:

Table 13: AMD Characterisation and Treatment Technology Relevance

Parameter	Measured Value (decant)	RQO Target (GN 1873)	Significance for Treatment Selection
pH	<4.5 (decant point)	6.5 – 9.0 (pH units)	Net acidic AMD: passive treatment (ALD + SAPS) appropriate. Active lime dosing also effective but ruled out on operational grounds.
Dissolved Oxygen (DO)	>5 mg/L	>5 mg/L	High DO with net acidic pH confirms SAPS (not ALD-only) required, as $\text{Fe}^{3+}/\text{Fe}^{2+}$ ratio >25% prevents efficient ALD operation. SAPS compost layer reduces Fe^{3+} to Fe^{2+} before ALD contact.
Iron (Fe total)	189 mg/L	≤ 0.1 mg/L	High Fe: SAPS most effective for Fe^{3+} reduction; aerobic wetland for final Fe^{2+} oxidation and precipitation. SAPS sized at minimum 18,900 m ² (at 10 g Fe/m ² /day).
Manganese (Mn)	4.0 mg/L	≤ 0.15 mg/L	Elevated Mn: aerobic wetland with pH >7 required for Mn oxidation and precipitation. Aerobic Wetland Unit 1 sized at 18,900 m ² (at 0.5 g Mn/m ² /day minimum).
Aluminium (Al)	Elevated (<25 mg/L)	≤ 0.105 mg/L	Al <25 mg/L: ALD is acceptable (high Al would coat limestone and reduce effectiveness). ALD suitable for Ballengeich AMD.

Parameter	Measured Value (decant)	RQO Target (GN 1873)	Significance for Treatment Selection
Sulphate (SO ₄)	>4,000 mg/L (decant); >3,000 mg/L (PCD)	≤165 mg/L (Horn River)	Very high sulphate: assimilative capacity of the Ngagane River (Ntshingwayo Dam releases) required to dilute residual SO ₄ post-treatment. Passive treatment + dilution is the only cost-effective approach.
TDS	>7,260 mg/L	≤350 mg/L	TDS: Active treatment (RO) would be needed for full TDS removal. Passive treatment + dilution adopted as per Assimilative Capacity Study (MENCO, February 2025) confirming sufficient assimilative capacity.
Flow rate (design)	1,000 m ³ /day (AMD Decant + SAPS design flow)	N/A	Design basis for SAPS, Oxidation Pond, and Aerobic Wetland Unit 1 sizing. Confirmed by Bhekhani (February 2023) and GFK SWMP (March 2026).
AMD salt load (SO ₄ , West Decant Sump)	122,859 kg/yr	N/A	Annual sulphate salt load requiring management via passive treatment and/or dilution. Treatment system must remove >85% to achieve RQO compliance downstream.

5.2 Treatment Selection Decision Tree (BPG H4)

The BPG H4 (DWS, 2006) treatment selection decision tree was applied to the Ballengeich AMD characterisation as follows:

- Net acidic water (pH <4.5)? → YES → Passive treatment is appropriate as the primary management approach.
- Dissolved oxygen (DO) >5 mg/L? → YES → Anoxic Limestone Drain (ALD) is appropriate (DO will not prevent limestone dissolution at this level).
- Fe³⁺/Fe²⁺ ratio >25% (35% at Ballengeich)? → YES → Successive Alkaline Producing System (SAPS) is required to reduce Fe³⁺ to Fe²⁺ before ALD contact.

- Aluminium (Al) <25 mg/L? → YES → ALD is suitable without risk of Al precipitation coating the limestone surface and reducing alkalinity generation effectiveness.
- Manganese (Mn) elevated (4.0 mg/L; RQO ≤0.15 mg/L)? → YES → Aerobic Wetland required for Mn oxidation at pH >7 following ALD alkalinity addition.
- CONCLUSION:** The optimal passive treatment train for Ballengeich AMD is ALD + SAPS (compost layer) + Oxidation/Settling Pond + Aerobic Wetland, in that order. This is the treatment sequence selected and designed for the site (Bhekhani, February 2023; GFK SWMP, March 2026).

5.3 Passive Treatment System Design Parameters (Selected Alternative)

Table 14: Passive Treatment System Design Parameters — Selected Alternative

Component	Key Design Parameter	Value / Specification
ALD 1 (Ptn 25) and ALD 2 (Ptn 19)	Design flow	1,000 m ³ /day (ALD 1); overflow/seepage flow (ALD 2); minimum retention time 14 hours; limestone porosity 50% (8–25 mm aggregate).
ALD (both units)	Liner specification	HDPE ‘burrito’ wrap; 0.6 m compacted impermeable soil cover; depth 1–2 m; sub-surface installation (no surface expression).
ALD (both units)	Maintenance schedule	50% limestone replacement every 10 years; 50% liner replacement concurrent; 50% pipe replacement after 25 years.
SAPS	Minimum required area	18,900 m ² (at 10 g acidity/m ² /day; Fe 189 mg/L; Mn 4.0 mg/L); estimated 97% metal removal efficiency.
SAPS	Organic carbon layer	600 mm composted Eucalyptus felled material (90-day minimum composting period on site); limestone layer depth 2,000 mm; pond depth 3.3 m; 800 mm freeboard.
SAPS	Liner specification	HDPE Class C (SANS 1526:2015); A4 geotextile underlay; leakage detection pipe.
SAPS	Design life	20–30 years (organic carbon layer replaced at 50% capacity — approximately 15–20 years depending on loading).

Component	Key Design Parameter	Value / Specification
Oxidation / Sedimentation Pond	Capacity and dimensions	24-hr retention; 1,500 mm depth; 600 mm freeboard; total area 670 m ² ; max L:B ratio 3:1; minimum 2 ponds in series; side slopes 1:2; scour valves on outlet.
Oxidation / Sedimentation Pond	Liner specification	2 mm HDPE (SANS 10409) over A4 geotextile; all joints welded and tested; sludge pump-out access.
Aerobic Wetland Units 1 and 2	Minimum required area	18,900 m ² per unit (at 10 g Fe/m ² /day; 0.5 g Mn/m ² /day); Wetland Unit 1 = 1.3 ha; Wetland Unit 2 = 4.4 ha.
Aerobic Wetland (both units)	Soil and water depth	400 mm gravel/soil substrate; water depth 1.0 m operational + 600 mm freeboard; 3–4 Typha capensis / Phragmites australis / Scirpus spp. per m ² .
Aerobic Wetland (both units)	Liner specification	2 mm HDPE lined; A4 geotextile underlay; inlet and outlet control structures.
Aerobic Wetland Unit 1	Discharge condition	Discharge to Horn River ONLY after minimum 3 consecutive weekly samples confirm: pH >5.5 AND Fe total <10 mg/L. Weekly monitoring of pH, Fe, SO ₄ , Mn, Al at outfall.
Aerobic Wetland (both units)	Maintenance	Annual reed harvesting; desludging every 5–7 years; HDPE liner inspection annually; outlet structure cleaning quarterly.
Overall system	Design life	>30 years for aerobic wetland components; 20–30 years for SAPS; >25 years for ALD pipe components. Consistent with recommended 20-year WUL period.
Capital cost (civil works)	Indicative (IWWMP Table 7-6)	Approximately R4,079,750 excl. VAT (passive treatment system civil works). Excludes monitoring, contingency, and overhead costs.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary of Alternatives Evaluation

Six (6) alternative approaches to AMD management and site rehabilitation at the Ballengeich Colliery were evaluated as part of this assessment. The evaluation considered technical feasibility, environmental impacts on delineated sensitive areas, financial viability, regulatory acceptability, and alignment with DWS requirements and the issued Section 19 Directive (Ref: 16/2/7/V301/A/1, August 2013).

The assessment confirmed that, due to the location of the historical mining footprint, the proximity of the AMD sources to the Horn and Ngagane River systems, and the requirement to implement treatment measures as close as reasonably practicable to the source of pollution, all reasonable layout alternatives involve some degree of interaction with regulated buffer areas and sensitive aquatic features. The alternatives assessment further concluded that complete avoidance of all delineated sensitive areas is not reasonably feasible within the context of the site-specific constraints and project objectives. Consequently, the preferred alternative has been developed to minimise the footprint within sensitive areas while maximising the long-term environmental benefits associated with AMD treatment, pollution remediation and site rehabilitation.

6.2 Selected Preferred Alternative

PREFERRED ALTERNATIVE: Alternative 6 — Two-Area Passive AMD Treatment Approach

Alternative 6, comprising the Two-Area Passive AMD Treatment Approach, is identified as the Preferred Alternative and Best Practicable Environmental Option (BPEO) for the Ballengeich Colliery based on the outcomes of the alternatives assessment and supporting specialist investigations.

The selection of Alternative 6 is supported by the following considerations:

- It addresses all three identified AMD source areas, namely the underground workings decant (approximately 30% contribution), opencast spoil seepage (approximately 55% contribution), and discard dump runoff (approximately 15% contribution).
- The proposed treatment system applies a source-control approach by intercepting and treating AMD as close as reasonably practicable to the points of generation, thereby reducing pollutant loading to the Horn and Ngagane River systems.
- The preferred treatment approach is consistent with previous engagements and correspondence received from DWS regarding the remediation of AMD at the site.
- Specialist studies indicate that implementation of the preferred alternative is expected to result in long-term improvements in water quality and ecological functioning within the receiving environment, including the Horn River and associated wetland systems.

- The wetland delineation assessment confirmed that the wetland features occurring within the treatment footprint are artificial in origin and associated with historical mining-related disturbance. The proposed treatment system has been designed to function within the existing disturbed landscape while contributing towards the remediation of historical pollution sources.
- The passive treatment system does not require a permanent grid electricity supply or continuous chemical dosing and is therefore considered well suited to the operational characteristics and long-term management requirements of the site.
- The Assimilative Capacity Assessment concluded that the receiving environment has the capacity to accommodate the treated discharge, subject to compliance with the applicable water quality objectives and operational management requirements.
- The Hydropedology Assessment concluded that the treatment system footprint is expected to have a negligible impact on hydropedological flow processes within the broader catchment.
- The GN 4167 Risk Assessment Matrix identified the passive treatment system as a beneficial rehabilitation and remediation activity with a positive long-term environmental outcome following implementation of the proposed mitigation measures.
- The comparative alternatives assessment identified Alternative 6 as the highest-ranking option when evaluated against the selected technical, environmental, financial and regulatory assessment criteria.

Based on the findings of this assessment, Alternative 6 represents the most appropriate and balanced solution for addressing the historical AMD impacts at the Ballengeich Colliery while supporting the long-term rehabilitation and improvement of the receiving environment.

6.3 Recommendations

Based on the findings of the alternatives assessment, the following recommendations are made:

- Alternative 6 (Two-Area Passive AMD Treatment Approach) should be adopted as the preferred alternative for the remediation of historical AMD impacts at the Ballengeich Colliery and should form the basis of the Water Use Licence Application.
- The preferred alternative should be implemented in accordance with the recommendations contained in the Water Use Licence Application Report (WULAR), Integrated Water and Waste Management Plan (IWWMP), Stormwater Management Plan (SWMP), Method Statement and associated specialist studies prepared for the project.
- The proposed treatment system should continue to apply a source-control approach by intercepting and treating AMD as close as reasonably practicable to the identified pollution sources.
- Detailed design, construction and operational requirements should be implemented in accordance with the approved engineering designs and any conditions that may be contained within the Water Use Licence.

- The final project layout should continue to incorporate the delineated wetland boundaries, river buffer zones, floodlines and environmental monitoring locations to support effective environmental management and compliance monitoring.
- A comprehensive monitoring programme should be maintained during construction, commissioning and operation to assess treatment performance, water quality improvements and the effectiveness of the proposed mitigation measures.
- Ongoing engagement with the Department of Water and Sanitation should be maintained throughout the implementation and operational phases of the project to ensure alignment with regulatory requirements and long-term rehabilitation objectives.

The implementation of the preferred alternative is expected to contribute towards the remediation of historical AMD impacts, improvement of water quality within the receiving environment, and achievement of the long-term rehabilitation objectives for the Ballengeich Colliery.

7. REFERENCES

- Bhekhani (Pty) Ltd Ballengeich Colliery Preliminary Civil Design Report for Acid Mine Drainage Passive Treatment Design. Report B120. Revision 00. February 2023.*
- DWS (2006) Department of Water Affairs and Forestry. Best Practice Guideline H4: Water Treatment. Pretoria.*
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