TO: Matakanui Gold Limited
COPY TO: [redacted]
FROM: [redacted]

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Job No: 69137

BENDIGO-OPHIR FRESHWATER STREAM ECOLOGICAL VALUATION

1. Introduction

Matakanui Gold Limited (MGL) has applied for consent under the Fast Track Approvals Act 2024 to develop and operate a new gold mine within the Bendigo area within the Upper Clutha Valley. Proposed mining operations include the construction of an open cut pit, an underground mining complex, associated tailings dams and processing plant. These activities will require land disturbance through earthworks/ground stripping, vegetation removal and will result in direct impacts on streams.

Impacts to streams are proposed to be remediated through permanent stream diversions that will result in a greater overall stream length than that being lost/reclaimed, along with the rehabilitation of stream length following mine closure (Figure 1). Additional enhancement is proposed through the management of crack willow along two watercourses to restore aquatic habitats to a more natural state[1]. The assessment of the effects of mining operations on these watercourses, as well as the proposed remediation measures (including stream diversion) is detailed within the Assessment of Freshwater Ecological Effects, prepared by Boffa Miskell[2].

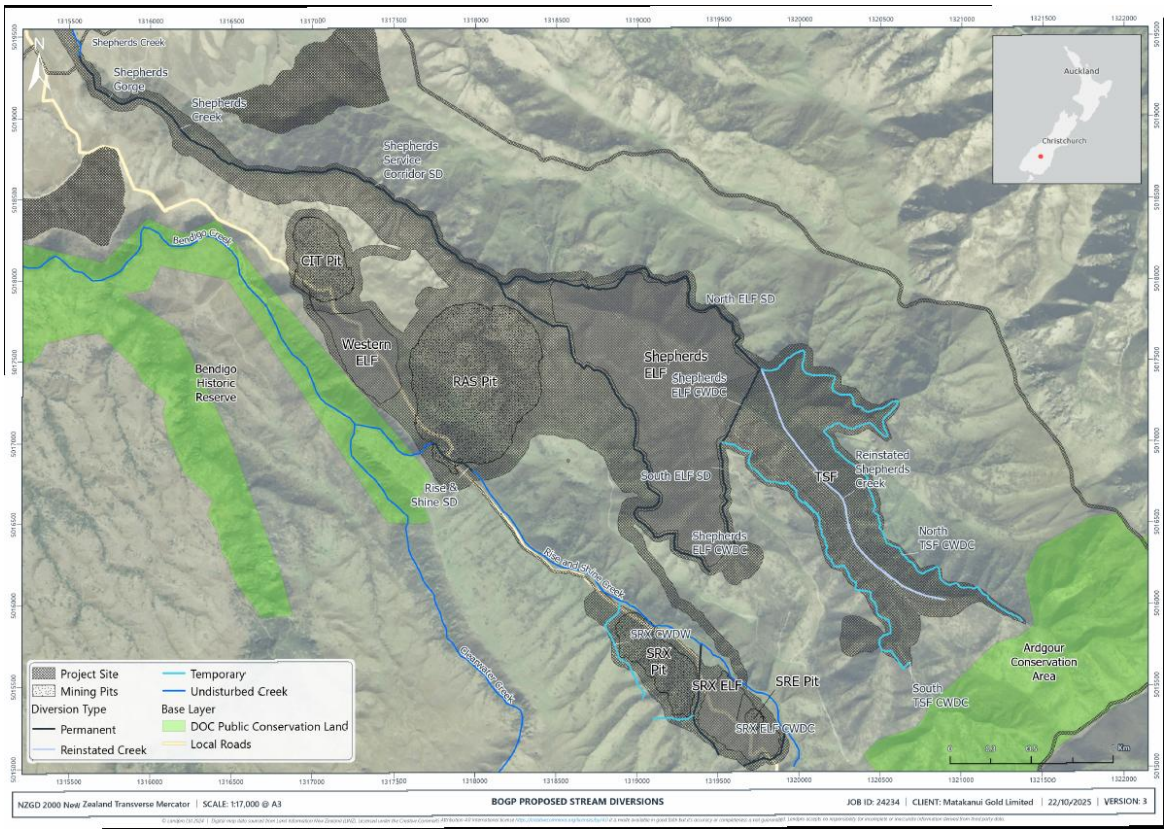

Figure 1. Proposed Stream Diversion Plan. Provided by MGL.

[1] Boffa Miskell (2025). Bendigo Ophir Gold Project. Assessment of Freshwater Ecological Effects.

[2] For the purpose of this assessment, naturalness is considered to be the stream character, morphology, and biodiversity with minimal anthropogenic influences.

Bioresearches
128 Montreal Street, Sydenham, Christchurch
PO Box 2027, Shortland Street,
Auckland 1140, New Zealand
T 03 379 2734 **E** admin@babbage.co.nz
www.bioresearches.co.nz

Bioresearches was engaged by MGL to undertake a Stream Ecological Valuation (SEV) of three streams where impacts are proposed to be remedied through permanent diversion around mine operational areas.

The purpose of this assessment is to describe the current ecological values of the streams within the context of the SEV methodology and to determine the feasibility of achieving equivalent or greater ecological values through stream remediation actions.

This memorandum does not include a review on the impact assessment, remediation and compensation packages, or the diversion stream design of the project as prepared by Boffa Miskell (2025). The assessment focuses on the permanent diversions of Shepherd's Creek, Rise and Shine Creek and Bendigo Creek. The rehabilitated sections of Shepherd's Creek following mine closure, as well as any temporary diversions, are not included within the scope of this assessment.

2. Methodology

Representative reaches along Shepherd's Creek, Rise and Shine Creek and Bendigo Creek were identified via desktop review and validated using a "drive by" method to ensure the appropriate stream lengths were being assessed. Once the representative reaches had been identified, detailed assessments of four reaches of the streams were undertaken using the Stream Ecological Valuation (SEV) methodology (Auckland Council Technical Report 2011/009[3]) on the 30th and 31st of March, 2026.

SEV assessments were conducted across representative reaches of each selected stream using ten cross sections per reach. At each cross section, the relative cross-sectional measurements were recorded, bankfull width of the stream was measured, and reference photographs taken. The upstream and downstream boundaries of each SEV reach were recorded using a handheld GPS.

The SEV methodology enables the overall ecological function of a stream to be assessed and compared with other streams in the Auckland Region. In regions where the SEV methodology has not been locally adapted, such as Otago, reference stream data can be incorporated to ensure appropriate geographic comparisons, particularly for macroinvertebrate and fish communities[3].

The SEV procedure involves the collection of habitat data (e.g. stream depth, substrate type, and riparian cover), along with sampling of fish and macroinvertebrate communities (e.g. insect larvae and snails), which are recognised indicators of habitat quality. Fourteen variables are assessed and grouped into four ecological functions (Neale *et al*., 2016):

- Hydraulic – assesses natural flow regime, floodplain effectiveness and connectivity for natural species migration and groundwater of the stream reach;
- Biogeochemical – assesses in-stream water chemistry, the processing of pollutants and the in-stream particle retention and organic matter inputs to the stream reach;
- Habitat provision – assesses suitability of the stream reach for aquatic fauna and spawning habitat of indigenous fish; and
- Biodiversity – assesses the condition of aquatic fauna, including fish and macroinvertebrates and the intactness of the riparian yard.

The SEV method assigns a score between 0 (low quality) and 1 (high quality) to each attribute, weighted according to its contribution to overall stream value. These are then combined to produce an overall SEV score on a scale of 0 to 1.

[3] Storey, R.G., Neale, M.W., Rowe, D.K., Collier, K.J., Hatton, C., Joy, M.K., Maxted, J.R., Moore, S., Parkyn, S.M., Phillips, N. and Quinn, J.M. (2011) Stream Ecological Valuation (SEV): a method for assessing the ecological function of Auckland streams. Auckland Council Technical Report 2011/009.

Macroinvertebrate communities, including their structure, abundance, and diversity, are widely recognised indicators of long-term stream health and water quality. Different taxa exhibit varying tolerances to pollutants, and their presence or absence provides insight into stream condition. Macroinvertebrates were sampled from in-stream habitats within each SEV reach to obtain semi-quantitative data, in accordance with the Ministry for the Environment's Protocols for Sampling Macroinvertebrates in Wadeable Streams (Stark et al., 2001).

Sampling was undertaken along each SEV reach using protocol 'C1: hard-bottomed, semi-quantitative' for Shepherd's Creek and Rise and Shine Creek (an upstream tributary to the Bendigo Creek), and 'C2: soft-bottomed, semi-quantitative' for for Bendigo Creek. Samples were preserved in 70% ethanol, returned to the laboratory, and sorted using protocol 'P3: full count with sub-sampling option' (Stark et al., 2001). Macroinvertebrates were identified to the lowest practicable taxonomic level and counted to enable calculation of biotic indices.

Fish communities were sampled prior to stream assessments to minimise disturbance and reduce the likelihood of fish retreating from the sample reach. At each survey location, electric fishing was conducted using an EFM300 backpack electrofishing unit. This method temporarily stuns fish, allowing them to be captured. All captured fish were identified, counted, measured, and assessed for general condition before being returned to their habitat.

3. Stream Ecological Valuation

This section summarises the outcomes of the SEV assessments undertaken across four stream reaches, as shown in Figure 2. The SEV excel calculator has been provided within the assessment package.

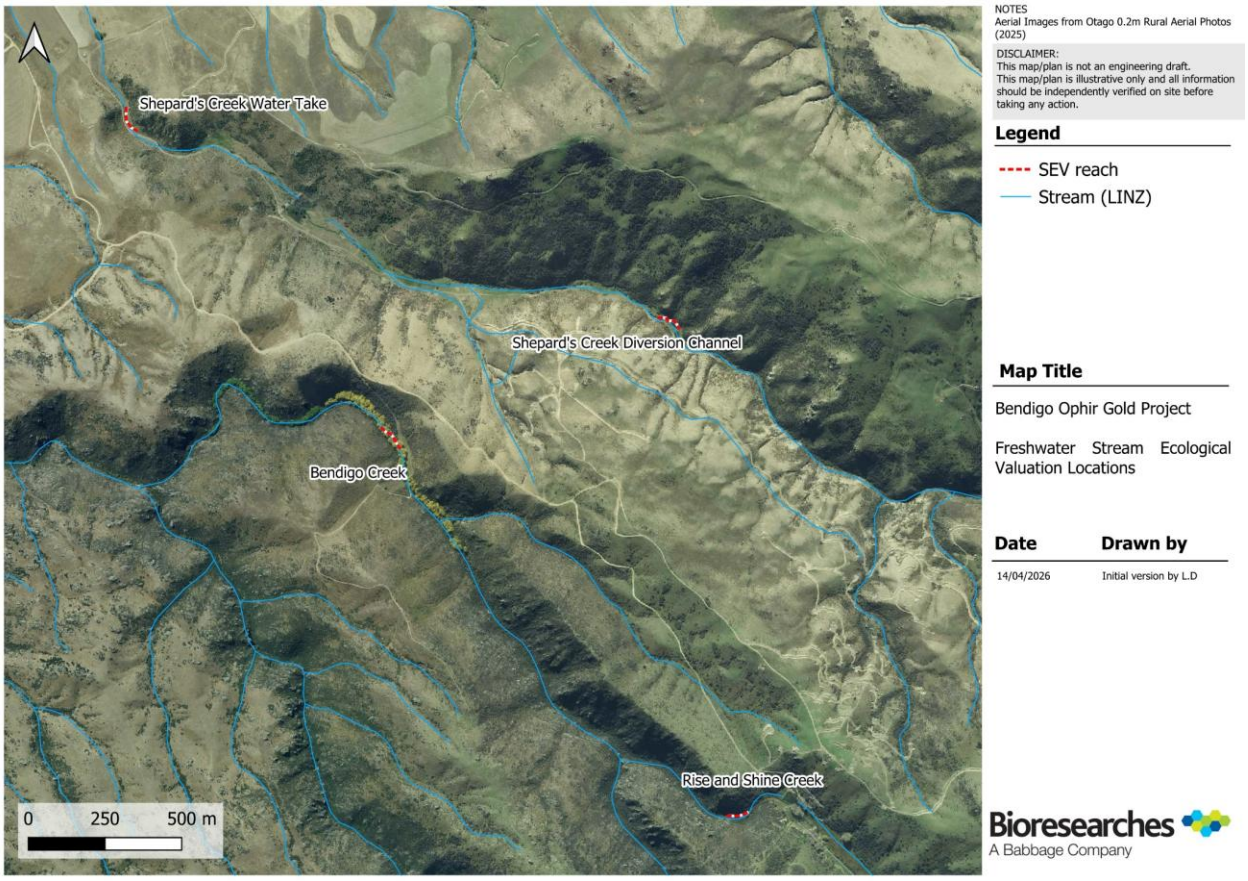

Figure 2. Location of the four SEV assessments undertaken.

3.1 Shepherd's Creek

Two SEV assessment was undertaken within Shephard's Creek, each over a 100 m of stream reach. One assessment was conducted within the central area of the proposed permanent diversion channel (located around and downgradient of the Shepherd's Engineered Landforms (ELF)).

The second SEV assessment was intended to be undertaken downstream of the diversion channel, within a reach unaffected by direct impacts, to act as a monitoring point for any changes in ecological value resulting from the permanent stream diversion. However, due to the presence of an existing water take, the streambed at this location was dry. Consequently, the second SEV was undertaken upstream of the water take, where permanent flow was present, although this reach is still within the section proposed for permanent diversion.

Shepherd's Creek recorded an SEV score of 0.49 within the proposed diversion reach site and 0.36 at the water take site. These relatively low scores are primarily driven by limited shading due to the pasture-dominated riparian margins and stock access, which has damaged stream banks and increased fine sediment loading, thereby reducing biogeochemical function. Riparian vegetation is dominated by pasture species, with scattered mingimingi (*Coprosma propinqua*), matagouri (*Discaria toumatou*), sweet brier (*Rosa rubiginosa*), and thistles (*Carduus* sp.).

The sections below summarise the outcomes for each of the four ecological functions assessed across the two reaches of Shepherd's Creek.

3.1.1 Hydraulic (Vchann, Vlining, Vpipe, Vbank, Vrough, Vbarr, Vchanshape, Vlining)

Overall, Shepherd's Creek is a relatively natural channel with minimal modification. However high macrophyte growth and in-stream structures (such as the water take structure, road crossings) have modified approximately 30–40% of the channel. Despite this, overall bank condition is considered good, with no significant obstruction to floodplain connectivity.

Livestock pugging has widened the wetted channel, meaning that smaller flood events, which would typically be contained within the channel, are more likely to extend into the floodplain. The floodplain is predominantly vegetated with long and short grasses, with some low shrubs present. In addition to localised bank damage, it is estimated that up to 60% of the channel is affected by elevated fine sediment loading.

No piped inlets were identified within either representative reach; however, one barrier to fish passage is present in the lower section.

3.1.2 Biogeochemical (Vshade, Vdod, Vripar, Vdecid, Vmacro, Vretain, Vsurf, Vripfilt)

Shepherds Creek had an average depth of 0.06 m at the diversion reach and 0.09 m at the water take site. Substrates at both locations comprised a mix of gravels, cobbles, and organic material; however, stock access has increased the proportion of fine sediments, which account for approximately 53–71% of the substrate.

Macrophytes, primarily watercress (*Nasturtium officinale*), covered approximately 30–40% of the channel surface, with submerged macrophytes occupying 15–30% of the channel bed. Flow velocity was generally moderate across both reaches, although the lower reach exhibited slower flows than the upper reach. A small area of stagnant water was observed in the upper reach, likely resulting from streambed pugging. Evidence of bubbling was observed, and the high abundance of macrophytes suggests sub-optimal oxygen conditions, indicating some depletion of dissolved oxygen.

Riparian shading is generally low, with most shade provided by matagouri. Site topography provides some additional shading during the morning; however, overall shade is patchy. The limited extent of evergreen vegetation reduces the persistence of shading, and the riparian margin contains very little woody vegetation. As a result, organic matter inputs and filtration capacity are low.

3.1.3 Habitat Provision (Vgalspwn, Vgalqual, Vgobspwn)

Across both reaches, Shepherd's Creek has relatively low-gradient banks that are likely to be inundated during high flows, providing some potential spawning habitat. However, limited shading and sparse ground cover result in low-quality galaxiid spawning habitat. The limited presence of cobbles and larger woody debris also restricts the availability of suitable spawning habitat for bully species (*Gobiomorphus* spp.).

3.1.4 Biodiversity (Vfish, Vmci. Vept, Vinvert, Vripcond, Vripconn)

Aquatic habitat within both reaches is limited, consisting primarily of undercut banks, rooted aquatic vegetation, root mats, and minor riffles. These habitat features are sparse and limited in overall extent.

No fish were observed during electrofishing surveys, and no large macroinvertebrates (kōura or kākahi) were recorded. Macroinvertebrate communities included both pollution-tolerant and pollution-sensitive taxa, with the free-living caddisfly *Hydroboisella* and mayfly *Delatidium* identified.

Riparian vegetation across both reaches is dominated by pasture grasses and low-diversity shrubs, primarily matagouri. Bare and disturbed soils are present throughout. Due to low bank height and minimal incision, there is good connectivity between the stream and the adjacent floodplain/riparian zone.

Photo 1. Downstream reach of the Diversion Channel section of Shepherd's Creek

Photo 2. Upstream reach of the Diversion Channel section of Shepherd's Creek

Photo 3. Downstream reach of the water take section of Shepherd's Creek

Photo 4. Upstream reach of the water take section of Shepherd's Creek

3.2 Rise and Shine Creek

The representative reach of Rise and Shine Creek was assessed immediately downstream of the proposed permanent diversion channel around the Rise and Shine Pit. The assessed channel reach supported hydric vegetation, likely influenced by the presence of an upstream sediment retention pond within the reach.

The assessed section of Rise and Shine Creek contained a thick cover of matagouri and sweet brier, with a weedy understory and evidence of wild goat and/or pig tracks. Due to the dense vegetation, the SEV assessment was undertaken over a 70 m reach, with the upstream extent including a short section of willow-dominated vegetation. This reach is characterised by scrub vegetation similar to that present in the upper diversion reaches, and the selected length was considered appropriate to capture the baseline stream characteristics.

Rise and Shine Creek recorded an SEV score of 0.63. This relatively high score is largely attributed to the natural channel form, the presence of an indigenous, evergreen riparian zone extending more than 20 m from the stream banks, which provides consistent shading, and a predominantly hard-bottomed streambed supporting a healthy macroinvertebrate community.

The sections below summarise the outcomes for each of the four ecological functions assessed as part of the SEV methodology for Rise and Shine Creek.

3.2.1 Hydraulic (Vchann, Vlining, Vpipe, Vbank, Vrough, Vbarr, Vchanshape, Vlining)

Rise and Shine Creek comprise a largely natural channel with minimal modification to channel shape or lining. Minor inputs of fine sediment and some channel incision were observed. Although the channel remains relatively natural, incision of the banks may restrict flood flows from overtopping and connecting with the floodplain.

The floodplain is vegetated with low shrubs, predominantly matagouri and mingimingi, with some exotic willow present in the upper extent and patches of long grass. No barriers to fish migration or piped inflows were identified.

3.2.2 Biogeochemical (Vshade, Vdod, Vripar, Vdecid, Vmacro, Vretain, Vsurf, Vripfilt)

Rise and Shine Creek had an average depth of 0.10 m and contained a range of substrates, including gravels, cobbles, small woody material, and bedrock. Fine sediments (silt and sand) comprised approximately 20% of the substrate. Organic matter, such as leaf litter, was relatively low despite the well-vegetated riparian zone.

The riparian zone provides a high degree of shading, which in turn limits macrophyte growth. Flow velocity was generally good throughout the reach, with no areas of slow or stagnant flow observed. No factors indicating reduced stream oxygenation were identified.

Dense indigenous vegetation covers the majority of the 20 m riparian zone, providing consistent year-round shading. However, the relatively sparse understory limits the overall filtration function of the riparian margin.

3.2.3 Habitat Provision (Vgalspwn, Vgalqual, Vgobspwn)

At the assessed reach, Rise and Shine Creek has incised banks, which limit the availability of suitable galaxiid spawning habitat. Additionally, sloped banks and limited ground cover further reduce spawning suitability. Although cobbles are present within the stream, their overall abundance is relatively low, limiting the availability of suitable spawning habitat for bully species.

3.2.4 Biodiversity (Vfish, Vmci. Vept, Vinvert, Vripcond, Vripconn)

Aquatic habitat within the reach includes woody debris, undercut banks, rooted aquatic vegetation, and cobbles, with runs and short waterfalls also present. However, these habitat features are limited in extent and overall coverage within the reach.

No fish were observed during electrofishing surveys, and no large macroinvertebrates (kōura or kākahi) were recorded. Macroinvertebrate communities included both pollution-tolerant and pollution-sensitive taxa, including the swimming mayfly *Oniscigaster* and the green stonefly (*Stenoperla*), both of which are sensitive to environmental disturbance.

Riparian vegetation is dominated by dense matagouri, with some exotic species present. However, channel incision reduces connectivity between the stream and the floodplain.

Photo 5. Stream bed condition within Rise and Shine Creek

Photo 6. Riparian yard within Rise and Shine Creek.

3.3 Bendigo Creek

The assessed Bendigo Creek reach was located within the proposed Willow Control Area. Within this representative reach, dense willow growth has created a braided flow pattern, with multiple chutes and channels and areas of wetland habitat. The main channel was assessed over a 100 m reach.

The Bendigo Creek is predominantly soft-bottomed, with limited hard substrates present. Willow root systems are likely covering the underlying natural hard-bottomed streambed. A low-profile ford located immediately upstream of the assessed reach (i.e. where willows are absent) contains a mix of gravel sizes and some small cobbles.

This reach recorded an SEV score of 0.65 reflecting the overall natural appearance of the stream channel, despite modification from willow growth and generally undisturbed bank form.

The sections below summarise the outcomes for each of the four ecological functions assessed as part of the SEV methodology for Bendigo Creek.

3.3.1 Hydraulic (Vchann, Vlining, Vpipe, Vbank, Vrough, Vbarr, Vchanshape, Vlining)

Bendigo Creek is characterised by a largely natural channel, with no significant bank incision or widening that would alter floodplain connectivity or flow regime within the main channel. Although the stream is likely naturally hard-bottomed, the presence of willows has resulted in a soft-bottomed channel. As a result, the reach exhibits a low overall loading of fine sediments.

The floodplain and riparian margins are dominated by mature willow, with an understory of long grasses. No piped inflows or barriers to fish migration were observed.

3.3.2 Biogeochemical (Vshade, Vdod, Vripar, Vdecid, Vmacro, Vretain, Vsurf, Vripfilt

Bendigo Creek had an average depth of 0.08 m, with the channel bed dominated by fine sediments, small woody material, and root mats, along with some leaf litter. No hard substrates, such as gravels or cobbles, were observed within the assessed reach.

Due to dense willow cover, the riparian zone provides a high degree of shading (assuming summer conditions in accordance with SEV guidelines). However, the deciduous nature of willow results in seasonal variability in shading and organic matter inputs. This level of shading limited macrophyte growth, which averaged approximately 13% of the channel surface at the time of assessment.

Flow velocity was generally good throughout the reach, with some areas of slightly slower flow; however, no stagnant areas were observed. No factors indicating reduced stream oxygenation were identified.

Vegetation covers the majority of the 20 m riparian zone, providing substantial shading, while the grassy understory contributes a moderate level of filtration function.

3.3.3 Habitat Provision (Vgalspwn, Vgalqual, Vgobspwn)

The stream contains low-sloping banks throughout the assessed reach, providing a relatively high extent of potential galaxiid spawning habitat. In addition, the vegetated floodplain and shading contribute to generally favourable spawning conditions. However, the absence of larger hard substrates limits the availability of suitable spawning habitat for bully species.

3.3.4 Biodiversity (Vfish, Vmci. Vept, Vinvert, Vripcond, Vripconn)

Aquatic habitat consisted of woody debris, and rooted aquatic vegetation with hydrological habitat features consisting of runs, riffles, pools, chutes and waterfalls. While there is a diversity of habitat types, these features collectively cover only approximately 30–50% of the channel, limiting overall habitat availability. No fish were observed during electrofishing surveys, and no large macroinvertebrates (kōura or kākahi) were recorded. Macroinvertebrate communities were dominated by pollution-tolerant taxa, although some sensitive taxa, including Megaloptera and stoneflies, were also present.

Photo 7. Upstream reach of Bendigo Creek

Photo 8. Downstream reach of Bendigo Creek

3.4 Reference Streams

As the SEV methodology has not been adapted for the Otago region, representative SEV reaches are typically required to provide appropriate bioclimatic comparisons. Due to time constraints associated with this assessment, reference SEV reaches were not assessed. Instead, surrogate reference scores have been estimated based on the *potential* condition of Shepherd's Creek, Rise and Shine Creek and Bendigo Creek.

These potential scores are based on the predicted state of the streams approximately 10 years following the implementation of enhancement measures, including stock exclusion, establishment of a 20 m riparian zone, and removal of fish barriers, and the assumption fish would be present throughout the reaches.

The justification for the potential SEV scores is presented in Table 1.

Table 1. Justification behind theoretical SEV reference scores for the three streams.

Function and Variable	Potential SEV score justification
Hydraulic	
Vchann	Naturalisation with reduction of excess roughness and riparian vegetation.
Vlining	Significant decrease in heavy load of silt. Greater presence of gravel and cobbles. In regards to Bendigo Creek, upstream of the willow control area, hard substrates dominated the streambed
Vpipe	No change.
Vbank	Naturalisation of banks following removal of stock
Vrough	Changed to reflect riparian margins, with regenerating indigenous vegetation and fenced, to 20m on both banks. Enhancement of wetland habitat on Bendigo Creek to a natural and diverse wetland.
Vbarr	Removal of fish barriers where applicable
Vchanshape	No data entry required.
Biogeochemical	
Vshade	Increased to reflect change in riparian margins.
Vdod	Increase with stock removed and reduction in macrophytes.
Vveloc	Removal of stagnant areas due to reduction in macrophytes.
Vdepth	Increase in depth on the 10% and 90% intervals due to the removal of stock impacts for Shepherd's Creek.
Vripar	Changed to reflect riparian margins 20 m on each bank.
Vdecid	Increase in evergreen vegetation
Vmacro	Reduction in macrophytes with increased shading
Vretain	No data entry required.
Vsurf	Increase in wood, gravel and cobbles, organic matter and reduction of silt.
Vripfilt	Changed to reflect riparian margins.
Habitat provision	
Vgalspwn	No change due to topography.
Vgalqual	Increase with shading and provision of overhanging vegetation.
Vgobspawn	No data entry required
Vphyshab	Increase in parameters associated with riparian planting and formation of aquatic habitats following stock removal and planting.
Vwatqual	No change.
Vimperv	No change.
Biodiversity	
Vfish	NPS Attribute Band B for fish IBI scores in Otago presumed considering the distance inland[4], altitude of the streams and potential of fish barriers throughout the downstream catchment
Vmci	No change compared to existing values
Vept	No data entry required
Vripcond	No data entry required
Vinvert	No change compared to existing values
Vripconn	Changed to reflect riparian margins.

While this represents a relatively bespoke approach to generating SEV scores reflective of the Otago region, it is considered that future collection of reference stream data would not fundamentally alter the baseline values obtained during this assessment.

[4] Ministry for the Environment. 2019. Fish Index of Biotic Integrity in New Zealand Rivers 1999–2018. Wellington: Ministry for the Environment.

If and when these practicable reference scores are incorporated into the SEV calculator, the inputs used to inform this memorandum are expected to remain accurate and representative of Shepherd's Creek, Rise and Shine Creek and Bendigo Creek.

4. Conclusion and Recommendations

Bioresearches has not reviewed the updated stream diversion design; therefore, comments on the feasibility of achieving or exceeding the current SEV scores within the diversion channels are limited to the design details provided in the *Freshwater Ecological Management Plan*[5], and assumed best-practice approaches. The proposed stream diversions are intended to replicate substrate composition and habitat features from the impact reaches, with additional design elements such as low-flow channels and embedded logs to enhance flow complexity.

Based on the relatively low SEV scores recorded for Shepards Creek to be diverted, it is considered likely that the diversion channels will be capable of achieving equivalent ecological values over time. Rise and Shine Creek SEV scores indicated greater ecological values than Shepard's Creek, however ensuring the stream features, particularly shade, substrate and hydrology are appropriately implemented, it is likely the diversion channel will achieve similar ecological values but will likely take a longer time period to establish than Shepard's Creek. We note that full recovery of all ecological functions (particularly biotic components such as fish and invertebrates) cannot be assumed and will depend on post-construction conditions and timeframes The outcome for both creeks is dependent on the diversion channels being constructed and implemented appropriately, under the guidance of a suitably qualified and experienced freshwater ecologist.

For Bendigo Creek, a temporary decline in freshwater ecological values is expected within the Willow Control Area due to the removal of a substantial portion of the riparian zone dominated by crack willow, and the associated reduction in shading during the warmer summer months. However, the replacement of exotic, deciduous vegetation with indigenous, evergreen riparian planting is expected to provide a long-term ecological benefit to the creek and downstream receiving watercourses.

In terms of future monitoring, given the absence of fish recorded within the assessed reaches (as documented in this memorandum and supporting aquatic values reports), it is recommended that environmental DNA (eDNA) methods be used in place of electrofishing or netting/trapping during routine monitoring for efficiency. Should eDNA detect the presence of native or exotic fish species, targeted physical sampling (e.g. electrofishing) should be undertaken during subsequent monitoring events, alongside continued eDNA sampling, to better characterise fish populations within the streams.

[5] Boffa Miskell (2025). Bendigo Ophir Gold Project. Freshwater Ecological Management and Monitoring Plan.