



Macraes MP4 Project

Assessment of Aquatic Environmental Effects

Prepared for: OceanaGold (New Zealand) Limited

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1 INTRODUCTION

1.1 Overview

OceanaGold (New Zealand) Limited ('OGNZL') currently undertakes open pit and underground gold mining operations at the Macraes Operation located at Golden Point Road, Macraes Flat, East Otago ('the site'). As part of ongoing operations, OGNZL continually reviews the remaining life of the Macraes Operation in light of updated knowledge of the gold resource and the economics of mining.

Reflecting recent exploration success and optimisation work, together with higher gold prices, the Macraes Phase Four Project ('MP4' or 'the Project') seeks to extend the life of mining at the Macraes Operation until at least 2039. The Project, which will enable ongoing gold production at a rate of approximately 130,000 ounces per annum, is identified as a Listed Project in Schedule 2 of the Fast-track Approvals Act 2024 ('FTAA') as a project providing significant national or regional benefits.

To support the development of the substantive application for the Project, OGNZL has engaged Viridis Limited (Viridis) to provide an assessment of the Project's effects on freshwater quality and instream ecology and, to the extent required, identify any necessary management and operation measures to address any such effects.

1.2 Site Location and Description

OGNZL owns and operates the Macraes Operation in Macraes Flat, approximately 30 km northwest of Palmerston in the Otago Region. The Macraes Operation is the largest gold mine in New Zealand and, since commissioning in 1990, has produced more than 6 million ounces of gold.

Macraes Flat is situated on an elevated plateau at approximately 500 m above sea level. The plateau is flanked by the Taieri Ridge to the northwest, Shag Valley and Horse Range to the east, and the coastal hills and extinct volcanic cones of Palmerston and Waikouaiti to the southeast. Macraes Road provides access to Macraes Flat and the Macraes Operation, connecting to State Highway 85 to the east and State Highway 87 (SH87, the Middelmarsh-Hyde Road) to the west.

The environment within and surrounding the Macraes Operation has been shaped by historic and current mining activities undertaken in accordance with existing resource consents. Figure 1 shows the current arrangement of the major mine features at the Macraes Operation. In summary, the current components of the Macraes Operation include:

- Numerous open pits (both operational and non-operational).
- Two underground mines (Fraser's, now closed, and Golden Point, which is actively mined).
- Waste rock stacks at various stages of operation and rehabilitation.
- A network of haul roads and general mine service tracks.
- A processing plant.
- Five tailings storage facilities (three inactive, one active but nearing capacity, and one under construction and currently receiving tailings).
- An extensive network of water management infrastructure, including diversion drains, silt ponds, sumps, pit lakes, pumps, pipelines and freshwater storage reservoirs.

- Two consented but not yet constructed water storage reservoirs (Camp Creek Dam and Coal Creek Dam).
- Associated infrastructure supporting ongoing operations, including district roads, powerlines, workshops, offices, and associated water and amenity facilities.

As part of operations, OGNZL holds a suite of resource consents¹ issued by Otago Regional Council (ORC), which authorise various discharges to surface water bodies within three key receiving catchments: the Shag/Waihemo, Waikouaiti and Taieri River catchments. In accordance with schedule requirements under these consents, OGNZL monitors surface water quality and aquatic ecology at several compliance sites within the three catchments, and where relevant, assesses these against consent limits.

1.3 Purpose and Scope

Building on the existing Macraes Operation, MP4 seeks to extend and modify mining activities and associated infrastructure across the Shag/Waihemo, Waikouaiti and Taieri River catchments. Potential effects on rivers and streams may arise from physical works within or near watercourses, including earthworks, vegetation clearance, stream reclamation or realignment, and culvert installation, as well as from changes in runoff, seepage, dewatering and discharges associated with the mine-water management system.

This report considers these effects in relation to surface-water quality and instream ecology within the MP4 footprint and downstream receiving environment. Groundwater and wetland effects are outside the scope of the assessment, except where they are relevant to understanding effects on connected surface-water environments.

The purpose of this report is to:

- Characterise the existing surface-water quality and ecological values of streams within the MP4 footprint and downstream receiving environment.
- Identify and assess the actual and potential effects of the proposed works on receiving-water quality and instream ecology.
- Identify measures to avoid, minimise, remedy or mitigate potential adverse effects and assess the significance of residual effects following implementation of those measures.

¹ 96808, 2002.491, 2002.759, 2002.763, 2003.640, 2004.359, 2005.341, 2006.303-308, RM10.351, RM12.378, RM16.138, RM19.085 and RM20.024.

68,000 mE

70,000 mE



OCEANA GOLD

MACRAES OPERATION

0 1,000

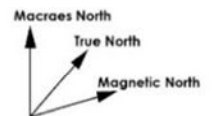
Metres

Datum: Macraes Local Grid

Date created: 23/07/2026

Imagery: Aerial Surveys Ltd (01/26)

LINZ (2014)



22,000 mN

20,000 mN

18,000 mN

16,000 mN

14,000 mN

12,000 mN

20,000 mN

18,000 mN

16,000 mN

14,000 mN

6,000 mN

5,500 mN

Horse Flat Rd

Coronation North
WRSCORONATION NORTH
PITCoronation
WRS

Trimbells WRS

CORONATION PIT

CORONATION
HAUL ROADDEEPELL
NORTH PITDeepdell
West WRSDeepdell
East WRSLone Pine Water
Storage Dam

Golden Point UG Portal

GOLDEN POINT PIT

Processing Plant

Northern Gully
North WRSMixed Tailings
Impoundment

Southern Pit 11A TSF

Northern Gully
South WRS

Golden Point

Open Pit Workshop

Underground
OfficesOpen Pit
OperationsMACRAES
TOWNSHIPINNES MILLS
PIT

Macraes - Dunback Rd

Redbull
Explosives
Facility

FRASERS PIT

Fraser's
TSF

Fraser's East WRS

Fraser's West WRS

Fraser's South
WRS

72,000 mE

68,000 mE

70,000 mE

71,000 mE

Golden Bar
WRSGOLDEN
BAR PIT

Golden Bar Rd

6,000 mN
5,500 mN

71,000 mE

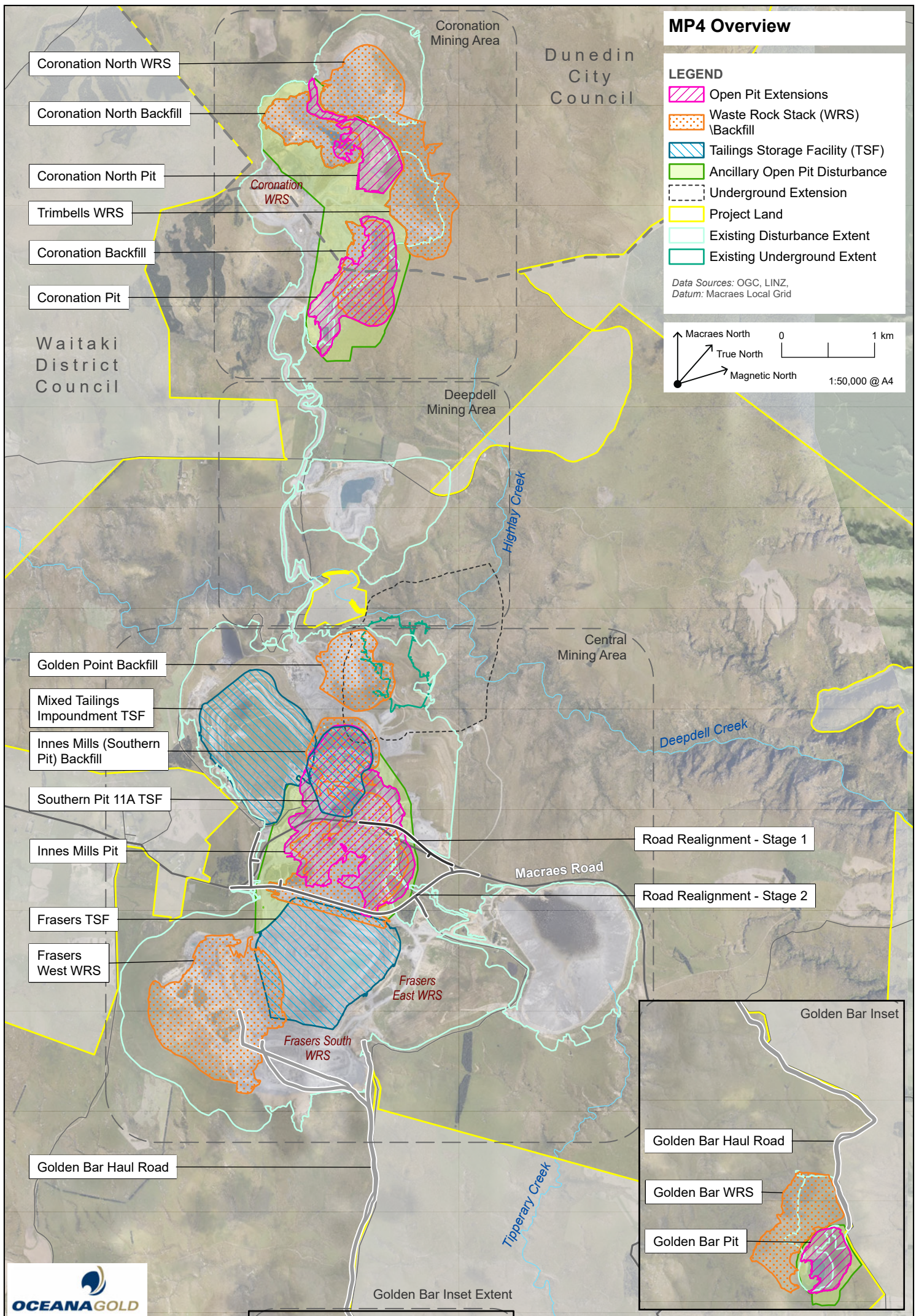
2 MP4 PROJECT PROPOSAL

2.1 Overview

The Project is made up of the following proposed key activities:

- **Open pit extensions** at Coronation, Coronation North, Innes Mills, and Golden Bar.
- **Underground mine expansion** through further development of the Golden Point Underground mine (“GPUG”).
- **Tailings management**, including:
 - Construction of the Frasers Tailings Storage Facility (“FTSF”) Stage 3 to accommodate a total tailings storage of up to 153 Mt.
 - Hydraulic mining and relocation of tailings from the Mixed Tailings Impoundment (“MTI”), Southern Pit Option 10 TSF (“SP10”), and Southern Pit Option 11A TSF (“SP11”) to FTSF.
- **Waste rock disposal**, including increased storage capacity within open pits and at existing waste rock stacks (WRS) at Coronation, Coronation North, Innes Mills, Golden Bar, Golden Point, and Frasers.
- **Water management infrastructure and operations**, including:
 - Construction of Camp Creek and Coal Creek dams for flow and water quality management.
 - Construction, operation and maintenance of a Water Treatment Plant.
 - Ongoing construction, operation and maintenance of the Mine Water Management System (“MWMS”).
- **Infrastructure and roading works**, including:
 - Realignment of Macraes Road in two stages; and
 - Relocation of the Open Pit Mining Workshop.
- **Ecological enhancements**, including establishment of:
 - Murphys Ecological Enhancement Area (“MEEA”) near Murphys Creek, including predator-proof fencing, access tracks, and site facilities.
 - Mt Highlay restoration area.
 - Cranky Jims Link shrubland enhancement area.
 - Murphys Link tussock protection area.
 - Additional compensation measures for residual ecological impacts.
- **Mine closure and rehabilitation activities**, including rehabilitation of mining landforms, creation of pit lakes, dry capping of tailings storage facilities, and revegetation in accordance with existing closure objectives.

An overview of the proposed activities which make up the Project is shown in Figure 2. A more detailed description of elements of the Project which are expected to potentially impact the downstream aquatic environment is discussed in Sections 2.2 and 2.3.



2.2 Sequencing of Activities and Proposed Work Dates

The Project is not being progressed in stages. Rather, all activities that comprise the MP4 project are included in this substantive application. Those activities are anticipated to occur across a period of 13 years, with OGNZL proposing to commence the MP4 project as soon as the necessary approvals are obtained.

The activities described herein are expected to be generally sequenced as follows:

- The continuation of Innes Mills Pit mining from Year 1 to Year 12.
- The continuation of Coronation Pit mining from Year 2 to Year 6.
- Relocation of tailings from Southern Pit TSF and MTI from Year 2 to Year 12 to facilitate mining of Innes Mills Stage 13 (IM13).
- The continuation of Golden Bar Pit mining mostly in Year 3 and in Year 7.
- The continuation of GPUG mining from Year 1 to Year 10.
- The continuation of Coronation North mining from Year 1 to Year 2 and then from Year 7 to Year 10.
- Associated replenishment of stockpiles throughout the MP4 mine life.
- Full site rehabilitation to commence in Year 11 and be completed by approximately end of Year 13.

Mine planning is fluid at complex multi-pit operations such as the Macraes Operation. Precise timing of activities depends on a range of factors and operational requirements may facilitate changes to the sequencing of some activities.

Table 1 shows the anticipated sequencing of the proposed MP4 activities across the life of the project.

Table 1. Anticipated sequencing of MP4 activities.

		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13
Pit	Stage													
Innes Mills	IM8													
	IM9													
	IM10													
	IM11													
	IM12													
	IM13													
Coronation North	CN5													
	CN6													
Coronation	C06													
	C07													
	C08													
Golden Bar	GB2													
	GB3													
Underground	GPUG													
Stockpiles														

2.3 Mine Water Management

2.3.1 Overview

The principal changes to mine-water management under MP4 are described in GHD (2026). These include dewatering of the Golden Bar, Coronation, Coronation North and Innes Mills pits, and new or altered seepage and runoff associated with the proposed pit extensions, FTSF Stage 3, expanded WRS and future pit lakes.

While dewatering water and collected seepage will be reused onsite where practicable, GHD (2026) identifies several pathways through which the Project could introduce, alter or continue to interact with downstream surface water bodies. These include direct discharges and groundwater seepage from the Innes Mills pit lake to tributaries of the Shag/Waihemo River and Waikouaiti River catchments. Seepage from FTSF and Frasers South WRS may also reach these catchments. Following closure, residual seepage from tailings-storage underdrains will be captured, treated and discharged through the site water-management system.

The nature and timing of these discharges will change over the life of the Project. GHD (2026) models downstream water quality during five representative phases:

- Early mining, up to no later than seven years following consent commencement (Phase A).
- Later mining, from no later than seven years following consent commencement through to site decommissioning and completion of rehabilitation (Phase B).
- Closure.
- The onset of pit-lake overflows.
- Long-term conditions.

These phases capture key changes in mine-water management and mitigation, peak WRS seepage concentrations and pit-lake overflow.

2.3.2 Mitigation measures

The physical water mitigation infrastructure that will be progressively constructed over the life of the mine includes:

- Construction of seepage capture drains and toe bunds, during Phases A and B.
- Construction of the Camp Creek and Coal Creek augmentation dams during Phase A.
- Progressive implementation of an active mine water treatment plant (WTP) that will consist of pretreatment systems (lime dosing and settling) followed by reverse osmosis (RO) technology to treat captured seepage waters (as described in GHD (2026)).

In addition to this infrastructure, the following operational and monitoring measures are proposed:

- Monitoring and water treatment of pit lakes, through ferric chloride dosing to manage concentrations of dissolved metals.
- Implementation of a flushing regime (where motivated by periphyton monitoring programmes), involving controlled release of three times the median flow into affected waterways, over up to six cycles at approximately 20-day intervals during the summer months (GHD 2026).

- Improvements to current and future WRS construction methodology to minimise infiltration rates.
- Continuous monitoring of flow and key water quality parameters at representative discharge and receiving environment locations, to support early identification of changes in mine water discharges and potential water quality impacts.
- Proportional return of treated water to receiving catchments, with flexibility to redirect discharges between catchments where appropriate to support adaptive management of dilution flows.

The existing consented (but yet to be constructed) Camp Creek and Coal Creek freshwater augmentation dams will be constructed during the early mining phase of the MP4 Project, and will serve as a mitigation measure for flow and quality in the Shag/Waihemo and Waikouaiti River catchments.

The active WTP will be constructed for use during operations and post-closure and will be designed to treat an average of approximately 45 L/s of captured seepage waters that would otherwise contribute significantly to the contaminant load within the receiving surface water environment.

The proportion of treated water returned to each catchment will generally reflect the volume of water captured and treated from that catchment, recognising that approximately 15% of influent volume is managed as a brine waste stream discharged to FRUG rather than returned to the surface water environment (GHD 2026). Treated water return flows, including any future redirection, will be managed within an operating envelope. The upper limit is approximately three times the median flow of the receiving waterway at the point of discharge - at headwater locations dominated by treated seepage, this is essentially three times the capture rate. Where the combined upstream seepage capture rate exceeds this threshold, the upper limit is instead the peak daily capture rate over the preceding seven days, reflecting water that would otherwise have discharged to the receiving waterway. Return flows will not be reduced or redirected to a point that causes a naturally continuous waterway to lose flow continuity. Naturally intermittent or ephemeral waterways are not subject to this limit.

2.3.3 Surface water quality compliance framework

A new surface water quality compliance framework is proposed to manage the mine water impact of the Macraes Operation and MP4 Project. The framework comprises trigger values and compliance criteria for key constituents of potential concern, being water-quality parameters that may be influenced by the Project and are relevant to freshwater ecology or drinking-water use. For existing resource consents within the scope of the MP4 Project, it is intended to replace the surface-water compliance limits currently applying to those consents.

The framework and its intended application are described in Viridis (2026a), included as Appendix A. It draws on national and international guidance, including the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018), together with site-specific water chemistry and historical monitoring data, to derive locally appropriate protection for aquatic ecological health and potential downstream water uses. Ecological trigger values are supported by compliance criteria addressing acute, chronic and eutrophication-related effects, including the frequency or duration of exceedance required to trigger a management response. Where relevant, trigger values and compliance criteria are also provided to protect human health, livestock, crops, and aesthetic values associated with downstream users. Compliance with these values supports effects-based water quality management and provides a high standard of protection for aquatic ecosystem values.

The framework is anticipated to become operative on a staged basis from Phase B, following implementation of the proposed water-quality mitigation measures (refer Section 2.3.2) with the timing of transition for each parameter confirmed based on Phase A monitoring. During the preceding transition period, compliance will continue to be assessed against the applicable existing consent limits.

2.4 Physical Works

To facilitate the footprint of the Project, the following physical works associated with aquatic environments are anticipated:

- Partial reclamation of Trimbells Gully and a tributary of Clydesdale Creek, including realignment of part of Trimbells Gully. A tributary of Trimbells Gully will be impacted through the construction of a sediment retention pond.
- Works associated with the reclamation and realignment including earthworks in and around the streams, and removal of riparian vegetation.
- Installation of sediment ponds on the realigned Trimbells Gully channel and on the Trimbells Gully tributary, both intermittent streams.
- Installation of culverts associated with the construction of the MEEA predator-proof fence.

3 ASSESSMENT METHODOLOGY

3.1 Surface Water Quality Assessment

Historical surface water quality and ecology data for key monitoring sites situated within the Shag/Waihemo, Waikouaiti and Taieri River catchments were reviewed to characterise the existing quality of the receiving environment and to provide a baseline for understanding the potential water quality effects of the Project. These sites are presented in Figure 3.

The available data were compared with OGNZL's proposed surface water quality compliance framework for the Project (Section 2.3.3), which uses ecological trigger values and associated compliance criteria, to identify an elevated risk of adverse effects on freshwater ecology. Comparison with the framework therefore provides a suitable basis for characterising existing conditions and identifying parameters that already approach or exceed a level at which adverse effects may begin to occur.

To assess the Project's potential effects on surface water quality, GHD (2026) modelled downstream concentrations of key constituents of concern for representative phases of MP4 (refer to Section 2.3.1). The modelled outcomes from Phase B onward (post implementation of key mitigation measures) were assessed against the proposed compliance framework, on the basis that the framework is anticipated to apply from Phase B². The potential effect on surface water quality was evaluated based on the predicted magnitude, frequency and duration of trigger-value exceedances relative to existing conditions.

3.2 Freshwater Ecology

3.2.1 Overview

Ecological investigations for the MP4 project occurred in two stages. The first stage included a classification of all waterways within the MP4 footprint to determine which waterways (if any) would be directly impacted by the proposed works. The second stage involved assessments and specific investigations to determine the values within waterways to be altered through reclamation or realignment. Values of waterways not subject to direct physical works were determined from existing data collected under the Macraes Operation annual biological monitoring programme (refer Section 1.2), with methodologies set out in the most recent annual report (Viridis 2026b).

3.2.2 Waterway classification assessment

The waterway classification assessment began with a desktop review of the site to identify potential reaches of stream located within the proposed MP4 footprint, but outside of any areas currently consented for works. Reaches located within areas subject to existing consents permitting physical works or reclamation were not considered further.

The desktop review included an examination of current and historical aerial imagery, as well as existing monitoring data, during which factors such as changes in vegetation and presence of surface water were noted. A review of data on local (Dunedin City Council and Waitaki District Council) and regional (Otago Regional Council) council GIS (such as biodiversity layers, mapped waterways and site topography) was also undertaken. The results of the desktop assessment informed the areas requiring field inspection to determine whether they constitute natural waterways. Any location where aerial imagery suggested the presence of a formed channel required physical on-site inspection to classify the waterway as either permanent, intermittent or ephemeral.

² Noting that timing of implementation may vary by parameter and will be confirmed based on Phase A monitoring data.

Macraes MP4 footprint and key water quality monitoring sites.

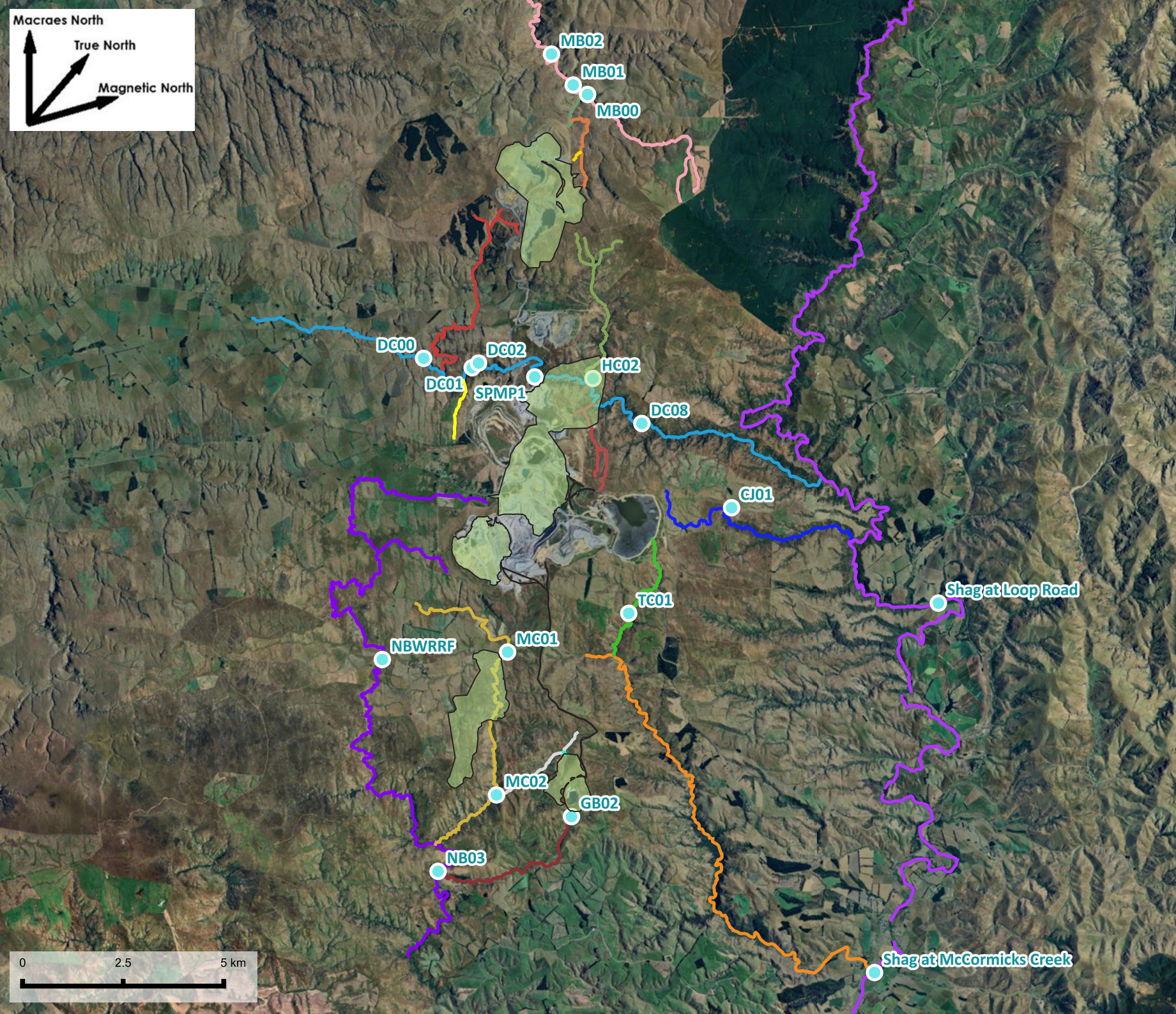
-  Proposed footprint
-  Water quality sites
-  Clydesdale Creek
-  Trimbells Gully Creek
-  Tipperary Creek
-  Shag River
-  North Gully Creek
-  Murphys Creek
-  McCormicks Creek
-  Mare Burn
-  Maori Hen Creek
-  Highlay Creek
-  Golden Bar Creek
-  Deepdell Creek
-  Waikouaiti River NB
-  Crank Jims Creek
-  Camp Creek

SOURCES
Google Satellite 2023

DISCLAIMER: This map/plan is not an engineering draft. This map/plan is illustrative only and all information should be independently verified on site before taking any action.

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DATE: 12/08/2026



Site visits were undertaken to classify relevant waterways within the MP4 Project footprint between 9 and 11 December 2025. The Regional Plan: Water for Otago (ORC 2026) does not include definitions for different types of waterways. Rather, it refers to the Resource Management Act 1991 (RMA) definition of a river:

“A continually or intermittently flowing body of fresh water; and includes a stream and modified waterway; but does not include any artificial waterway (including an irrigation canal, water supply race, canal for the supply of water for electricity power generation, and farm drainage canal).”

In the absence of plan-based definitions, waterways were classified in accordance with the Auckland Council Practice and Guidance note - River / Stream Classification (Auckland Council 2021). Waterways were classified as either permanent, intermittent or ephemeral, with permanent and intermittent waterways considered to align with the RMA definition of a river.

Maps were produced identifying the location and classification of waterways within the MP4 footprint and are provided in Appendix B.

3.2.3 Stream Ecological Valuation

Stream ecological valuation (SEV) assessments were undertaken at six locations within the site, on five separate waterways to assess the current ecological values of intermittent and permanent waterways present within the MP4 footprint, at potential mitigation/enhancement sites, and to determine the likely state of waterways in the absence of mining (i.e., reference locations). SEVs were completed on the permanent and intermittent channels that will be subject to physical works, where the stream was long enough to allow a full SEV to be completed. SEV is a comprehensive method for quantifying the value of aquatic ecosystems and can be used to estimate future value. Future values can be estimated by considering aspects such as proposed works, changes in flow regime, realignments, naturalisation, and riparian planting, as relevant. The background and basis for the method are described in Storey *et al.* (2011) and details of its application are provided in Neale *et al.* (2016).

SEV field assessments include a range of quantitative and qualitative measures of the stream and riparian environment to characterise the main ecological functions of streams. Data collection involves flow estimation and analysis of stream channel morphology (width, depth and substrate particle size, or roughness) from ten transects across the reach. Due to the small size of the streams, 50 m survey reaches were used. Field data is complemented by desktop information such as the area of impervious surfaces, flooding frequency and catchment size. The data is manipulated using a series of formulae in order to produce an SEV score between 0 (severely degraded with no ecological value) and 1 (a pristine stream with very high ecological value).

Existing biological monitoring data, collected for the subject waterways, or similar waterways under the existing aquatic biomonitoring programme (refer Section 1.2), was applied to quantify the resident macroinvertebrate and fish communities. Fish and macroinvertebrate sampling methods are described in the latest annual monitoring report (Viridis 2026b). This was supplemented by sampling environmental DNA (eDNA) at six locations (noting two SEVs were undertaken on the same waterway and thus one eDNA sample covers both sites).

eDNA is genetic material that organisms shed into their environment, such as skin cells, mucus, or waste. Analysis of water samples allows detection of a wide range of species present within an ecosystem. eDNA was an effective tool for the SEV sites given their location in the upper reaches of their

catchments. As eDNA is transported by water, it can travel significant distances before being degraded or filtered out. This issue is mitigated through sampling high in the catchment.

Where historic invertebrate data were unavailable, macroinvertebrate community index (MCI) values were calculated from the eDNA results. Recent studies have shown MCI values calculated from eDNA are comparable to MCI values determined through traditional macroinvertebrate sampling, when eDNA results are considered at the same taxonomic level as MCI identification levels (White *et al.* 2025).

A fish index of biotic integrity (IBI) was also calculated for assessed reaches based on fish species present, altitude and distance inland (Joy & Henderson 2004). Fish IBI is a multi-metric indicator of taxonomic richness which considers habitat guilds, such as altitude and distance from the coast, using quantile regression scoring. The NPS-FM (MfE 2025) specifies Attribute Bands (A-D) for fish IBI scores, which aid in the interpretation of these data.

3.3 Ecological Impact Assessment

The overarching approach of this analysis and reporting is to ascertain the existing ecological values present within and downstream of the Project site and determine the impact of the proposed works on those values.

The ecological values of the key aquatic environments, relating to species, communities and systems, were determined in general accordance with the Environment Institute of Australia and New Zealand Ecological Impact Assessment guidelines (EclAG) for use in New Zealand (Roper-Lindsay *et al.* 2018). This report also identifies statutory guidelines and regulation with respect to ecology (such as waterways, wetlands, high value vegetation and habitats) where relevant to the proposed development. Using this framework, the EclAG describes a simple ranking system to assign value to species as well as other matters of ecological importance such as species assemblages and levels of organisation. The overall ecological value is then determined on a scale from 'Negligible' to 'Very High'.

Criteria for describing the magnitude of effects are given in Chapter 6 of the EclAG. The level of effect can then be determined through combining the value of the ecological feature/attribute with the score or rating for magnitude of effect to create a criterion for describing level of effects (Table 2). A moderate level of effect or higher requires careful assessment and analysis of the individual case. For moderate levels of effects or above, measures need to be introduced to avoid effects through design, or appropriate mitigation needs to be addressed (Roper-Lindsay *et al.* 2018).

Table 2. Criteria for describing the level of effects (from Roper-Lindsay *et al.* 2018).

Magnitude of Effect	Ecological Value				
	Very High	High	Moderate	Low	Negligible
Very High	<i>Very High</i>	<i>Very High</i>	<i>High</i>	<i>Moderate</i>	Low
High	<i>Very High</i>	<i>Very High</i>	<i>Moderate</i>	Low	Very Low
Moderate	<i>High</i>	<i>High</i>	<i>Moderate</i>	Low	Very Low
Low	<i>Moderate</i>	Low	Low	Very Low	Very Low
Negligible	Low	Very Low	Very Low	Very Low	Very Low
Positive	Net Gain	Net Gain	Net Gain	Net Gain	Net Gain

Notes: Where text is italicised, it indicates 'significant effects' where mitigation is required.

4 EXISTING ENVIRONMENT

4.1 Ecological Context

The Macraes Operation and MP4 footprint is situated in the Macraes Ecological District (ED) of the Lammerlaw Region. The district is characterised by a series of faulted, gently sloping ridges around 600 m above sea level (asl), extending to 800 m asl. The climate is generally cool and dry, and snow can remain in place for weeks during winter. Historically (pre-human), vegetation in the area would have included podocarp, broadleaf, hardwood forest, however post-human arrival areas of forest have significantly decreased and tussock land with areas of coprosma-flax scrubland have proliferated. Review of historic aerial images shows the site has been devoid of significant areas of vegetation for the duration of the available record.

The site itself has been subject to various scales of gold mining activity for more than a century. The Macraes Operation in its current form was first established in 1990, and it has expanded over time to occupy its current footprint. Prior to establishment of the current mining operation, the area was characterised as extensive agricultural land (sheep and beef), and this activity continues on site where mining operations do not currently occur.

4.2 Key Catchment Descriptions

4.2.1 Overview

The wider mine footprint, both current and proposed, sits across three main river catchments – the Shag/Waihemo, Waikouaiti and Taieri River catchments. These are described in broad, general terms in the sections below, to prescribe an overall value of the main receiving environments for MP4 activities. Where specific tributaries, or reaches of these catchments are relevant to a specific assessment of effect, the value of these reaches is described in more detail in Sections 4.3 through 4.5.

4.2.2 Taieri River

The Taieri River is the fourth longest river in New Zealand. It originates on the northern side of the Lammermoor Range, flowing northeast, then southwest around the Rock and Pillar Range. It discharges to the coast south of Dunedin. Within the site, Mare Burn and Trimbells Gully are tributaries of the Taieri River. The catchment of these two waterways includes the mine footprint, extensive agricultural land, and recently established plantation forestry.

The Taieri River has a distinctive natural brown tea-colour, a result of tannins leached from the scroll plain wetland and tussock covered soils in the upper reaches of the river and its tributaries (Taieri Wai 2025). The mid reaches are generally characterised by low nutrient content compared with many rural rivers. However, the river is subject to ongoing pressures from fine sediment, reduced water clarity, faecal contamination, and temperature stress.

The ecological value of the Taieri River, as a whole, is considered to be high to very-high, due to its size and provision of extensive, variable and high-quality instream habitat. The river and wider catchment provides habitat for various fish species classified as Threatened or At Risk under the New Zealand Threat Classification System (NZTCS; Dunn et al. 2023), including Taieri flathead galaxias (*Galaxias depressiceps*), bluegill bully (*Gobiomorphus hubbsi*), dusky galaxias (*Galaxias pullus*), Eldon's galaxias (*Galaxias eldoni*), giant kōkopu (*Galaxias argenteus*), īnanga (*Galaxias maculatus*), koaro (*Galaxias brevipinnis*), roundhead galaxias (*Galaxias anomalus*), longfin eel (*Anguilla dieffenbachii*), upland bully (*Gobiomorphus breviceps*) and torrentfish (*Cheimarrichthys fosteri*).

4.2.3 Shag/Waihemo River

The Shag/Waihemo River originates on the southern side of the Kakanui Mountains. It flows predominantly south eastwards following the general alignment of SH85, before discharging to the coast at Shag Point.

The land use within the Shag/Waihemo catchment is predominantly agricultural, with areas of plantation forestry. Deepdell Creek is a significant tributary of the Shag River. Deepdell Creek flows predominantly eastwards, transecting the mine site. It is intermittent and significant reaches cease flowing during summer months. Camp Creek and Highlay Creek are minor tributaries of Deepdell Creek. Land use within the Camp Creek sub-catchment is mainly agricultural, with parts of the catchment also used for hay making. The Highlay Creek catchment includes a covenanted area where stock have been excluded. Highlay Creek is also known to dry during warmer summer months.

Cranky Jims Creek and McCormicks Creek are minor tributaries of the Shag River. Cranky Jims Creek originates on the eastern side of the Top Tipperary tailings storage facility (TTTSF) with significant portions of the creek contained within covenants that support some of the best examples of regenerating native vegetation in the area. Tipperary Creek, which also originates east of the TTTSF, flows into McCormicks Creek downstream of the site, which subsequently discharges to the Shag River.

The Shag River is generally characterised by good water quality, although it has been affected by historical and ongoing agricultural land-use pressures (ORC 2014). Water quality is typically better in the upper catchment and declines downstream, with some lower-catchment sites showing pressures associated with nutrients, faecal indicator bacteria, sediment, reduced summer flows, and riparian modification.

The ecological value of the Shag River, as a whole, is considered to be high due to its provision of extensive, variable and high-quality instream habitat. The river, and wider catchment, provides habitat for various fish species classified as Threatened or At Risk under the NZTCS (Dunn et al. 2023), including Taieri flathead galaxias, bluegill bully, īnanga, koaro, torrentfish, longfin eel, and upland bully.

4.2.4 North Branch Waikouaiti River

The Waikouaiti River consists of two main branches. The North Branch originates within the mine site itself, with the current headwaters located just to the east of Macraes township. Historically, it originated further east, however the channel has been interrupted by the development of the Innes Mills and Frasers pits. It currently flows generally southwards before joining with the South Branch and then discharging to the coast through the estuary at Karitane. The catchment includes the mine site, extensive agricultural activities as well as an area of native vegetation in the lower catchment. Within the site, Murphys Creek forms one of the main tributaries of the upper reaches of the North Branch. It originates south of the mine site, continuing to flow predominantly southwards. Clydesdale Creek and an unnamed tributary discharging from near the Golden Bar pit (referred to in this report as the Golden Bar tributary) round out the main waterways within the site. Both discharge to the North Branch south of the Murphys Creek-North Branch confluence.

The North Branch Waikouaiti River generally has good water quality. The catchment is relatively dry and can experience low summer flows, making water quality and aquatic habitat sensitive to flow reduction and land-use pressures (ORC 2008). Overall, the North Branch is best described as a rural headwater system with some sensitivity to low flows, sediment, nutrients, and catchment disturbance.

The ecological value of the North Branch Waikouaiti River is considered to be high due to its provision of extensive, variable and high-quality instream habitat. The river, and wider catchment, provides habitat for various fish species classified as Threatened or At Risk under the NZTCS (Dunn et al. 2023) including Taieri flathead galaxias, bluegill bully, īnanga, koaro, torrentfish, longfin eel, upland bully, banded kōkopu (*Galaxias fasciatus*) and lamprey (*Geotria australis*). However, the upper reaches within the site currently hold low ecological values due to the lack of permanent water, modified status, compromised water quality and lack of instream habitat. These areas are discussed further in Section 0.

4.3 Receiving Water Quality

4.3.1 Overview

OGNZL measures water quality at several compliance and control sites within the Shag/Waihemo, Waikouaiti and Taieri River catchments. Of these, HC02, CJ01 and TC01 fall outside the proposed framework, as the associated watercourses are not subject to new or modified discharges under MP4 (Appendix A), though they remain relevant to characterising the existing receiving environment.

The surface water quality measured at sites within these catchments is presented in the Surface Water Quality Compliance Framework report (Appendix A) alongside the relevant trigger values proposed under this framework. These proposed trigger values, which reflect current national guidance and site-specific toxicity modifiers, provide a more appropriate and ecologically robust basis for assessing effects than the existing consent limits, several of which are based on superseded guidance (refer Appendix A for full derivation and rationale).

Supporting aquatic biomonitoring data, such as macroinvertebrate indices and periphyton cover, is also presented in Appendix A. Receiving water quality data are discussed in Sections 4.3.2 through 4.3.4.

4.3.2 Physicochemistry

Historical physicochemical monitoring of the Macraes Operation receiving environment shows:

- In-stream pH has remained relatively stable and circumneutral across the monitored catchments. Departures from the proposed trigger range of 6.5-9.0 have been uncommon, limited to isolated instances at a small number of compliance sites (Shag at Loop Road, MC02, NB03, NBWRRF) and one control site (MB00). As the proposed trigger range reflects pH values considered suitable for aquatic life (USEPA 1986), pH conditions in the receiving environment are considered unlikely to cause stress to aquatic organisms.
- Turbidity concentrations were generally low at monitored compliance sites, indicating limited suspended sediment or particulate matter in the water column. Where upstream control data were available, downstream compliance sites were broadly comparable with background conditions. Exceedances of the proposed 5 NTU trigger value, informed by the ORC Regional Plan for Water (ORC 2026), were infrequent across the monitoring record and therefore unlikely to present a chronic health risk to aquatic organisms.
- Sulphate concentrations varied substantially between sites. Background concentrations at control sites DC00 and MB00 were generally low, while repeated exceedances of the proposed hardness-adjusted trigger value occurred at compliance sites such as CJ01, SPMP1 and MC01. However, sulphate concentrations at SPMP1 have improved since 2017, with no further exceedances recorded. Elevation at CJ01 and MC01 coincides with reduced abundance of single-gill mayflies (Appendix A), a taxon considered a useful indicator group given its known sensitivity to sulphate (NIWA 2024).

Overall, the existing physicochemical condition of the receiving environment is generally stable with respect to pH and turbidity. Sulphate represents the main localised physicochemical pressure, particularly in Cranky Jims and Murphys Creek, where elevated concentrations coincide with reduced abundance of a sensitive taxon.

4.3.3 Nutrients

The key findings from historical measurement of nutrient concentrations in the Macraes Operation receiving environment were:

- Ammoniacal nitrogen concentrations were low across all monitored catchments, with many results below laboratory detection limits ($<0.01 \text{ g/m}^3$). Exceedances of the proposed pH- and temperature-adjusted trigger value (equivalent to the ANZG DGV at a 95% species protection level) have been limited to isolated occasions at CJ01, MB01 and MB02. These data do not indicate widespread or persistent ammoniacal nitrogen elevation in the receiving environment.
- Nitrate nitrogen concentrations were generally low in the Shag River catchment, below levels of environmental concern (i.e., the hardness- and chloride-adjusted trigger value, equivalent to the ANZG DGV for a 95% species protection level). In contrast, concentrations were frequently elevated in parts of the Taieri and Waikouaiti catchments, particularly in Mare Burn and Murphys Creek, with exceedances persisting at some sites through to 2025. These locations generally correspond with lower MCI and QMCI scores (Appendix A). While ecological condition cannot be attributed solely to nitrate, given the potential influence of other constituents and habitat factors, the coincidence of elevated nitrate and reduced macroinvertebrate indices indicates that ecological communities may be constrained at these locations.
- Dissolved reactive phosphorus (DRP) has been monitored less frequently than nitrogen species, but available data indicate that concentrations are generally very low across the receiving environment, often below laboratory detection limits, with mine-related contributions considered minimal.
- Nutrient supply, particularly nitrogen and phosphorus, can contribute to eutrophication effects such as increased periphyton growth. However, historical monitoring indicates no clear relationship between nutrient concentrations and periphyton cover across the Macraes Operation receiving environment, with high variability in cover observed even at low nutrient concentrations (Appendix A). This suggests that periphyton growth in these catchments is more heavily influenced by other factors, such as flow regime, light availability and invertebrate grazing pressure.
- Evidence of nutrient-related enrichment is limited to DC08 and MB01, where soluble inorganic nitrogen³ (SIN) trigger value exceedances ($>0.075 \text{ g/m}^3$ as a rolling annual median) corresponded with elevated periphyton growth ($>30\%$ cover of long filamentous algae). This indicates that nutrient-drive eutrophication is localised in the receiving environment.

Overall, the existing nutrient condition of the receiving environment is characterised by low ammoniacal nitrogen and DRP concentrations, with localised nitrate/SIN enrichment evident in parts of the monitoring network. Eutrophication-related degradation appears limited to sites where elevated nitrogen coincides with suitable physical conditions for periphyton growth.

³ SIN is the sum of ammoniacal nitrogen and total oxidised nitrogen, comprising nitrate nitrogen and nitrite nitrogen.

4.3.4 Inorganic toxicants

The key findings from historical measurement of key inorganic toxicants within the Macraes Operation receiving environment were:

- In the absence of arsenic speciation data, historical dissolved arsenic concentrations were reviewed as a conservative indicator of potentially bioavailable arsenic, noting that arsenic is expected to occur mainly as arsenate, As(V), under oxic surface water conditions. Specifically:
 - Elevated dissolved arsenic concentrations in lower Deepdell Creek and Battery Creek have frequently exceeded the 95% species protection trigger value proposed under the framework for most sites. These elevated concentrations pre-date the commencement of Macraes Operation in the mid-1990s, indicating that they are at least partly associated with local mineralisation and legacy mining features (from the late 1800s), including the historical Golden Point adit (as discussed in Appendix A).
 - On this basis, concentrations at DC08 (in lower Deepdell Creek) and SPMP1 (in Battery Creek) were assessed against a 90% species protection trigger value of 0.042 g/m³ (Appendix A). This trigger value was consistently met at DC08 but occasionally exceeded at SPMP1.
 - For the remaining compliance sites, where a 95% species protection trigger value of 0.013 g/m³ is proposed (Appendix A), exceedances were limited to HC02, MC01, NBWRRF and GB02. Golden Bar Creek had the most frequent exceedances, particularly in recent years, at concentrations where chronic effects on sensitive aquatic species may occur.
- Although boron monitoring was limited to a single sampling round in January 2026, dissolved boron concentrations were below laboratory detection limits at most sites. The only detections were low-level results recorded at CJ01. All concentrations were well below the proposed trigger value of 0.94 g/m³, equivalent to the ANZG DGV for 95% species protection.
- Dissolved copper concentrations were consistently low across the monitoring network, frequently at or below laboratory detection limits. Exceedances of the dissolved organic carbon (DOC) adjusted chronic trigger value were rare, occurring only once at DC08, MC01 and MC02 over the monitoring record. A single exceedance of the DOC-, pH- and temperature-adjusted acute trigger value was recorded at GB02 in 2009; however, this was not repeated in subsequent monitoring.
- Total iron data⁴ were limited to several sites, but most results were below the proposed trigger value of 0.28 g/m³. Isolated exceedances were recorded at MB02 and NB03, while the most consistent exceedances occurred at NBWRRF, where concentrations were variable and reached up to 0.65 g/m³. Dissolved iron data, reviewed as a proxy for total iron where total data were unavailable, indicate exceedances likely occurred at several further sites, including control sites DC00 and MB00. Elevated iron concentrations were therefore variable across the monitoring network rather than confined to specific sites, or showing a consistent downstream increase, reflecting a wider geological influence and the potential contribution of mineralised sedimentary iron.
- Dissolved lead concentrations were consistently low across each catchment, with most results at or near analytical detection limits. All recorded detections were below the proposed hardness-

⁴ Total iron was reviewed as the ecologically relevant measure, as iron effects extend beyond dissolved toxicity. ANZG (2025b) notes that precipitated iron can coat respiratory and digestive surfaces and can alter benthic habitat and food resources.

adjusted trigger value, equivalent to the ANZG DGV for 95% species protection. As such, lead concentrations were not elevated to levels expected to pose a risk to aquatic ecosystems.

- Nickel concentrations were generally low across most catchments, although the available dataset was limited and largely recent (July 2025 through January 2026). Exceedances of the DOC-, pH- and hardness-adjusted trigger value were confined to the Mare Burn catchment, primarily at MB01 and, to a lesser extent, MB02. Concentrations at the upstream control site, MB00, were consistently low, indicating minimal background nickel. The pattern of elevated concentrations at MB01, followed by lower concentrations at MB02, suggests a localised nickel source downstream of MB00, with some dilution provided downstream of this source.
- Dissolved zinc concentrations were generally low across most monitored sites, although localised exceedances occurred in the Shag and Taieri River catchments:
 - In the Shag River catchment, occasional trigger value exceedances were recorded at a small number of sites, including the control site DC00, where both the chronic and acute trigger values were exceeded on a one-off occasion. The infrequency of exceedances in this catchment and their occurrence at a control site suggest some background or upstream influence, rather than a persistent condition of concern.
 - The most persistent zinc elevation occurred at MB01, downstream of the Mare Burn control site, where concentrations frequently exceed the proposed chronic trigger. Macroinvertebrate community metrics (MCI/QMCI) at this site have fluctuated without a clear long-term trend, indicating no consistent ecological response associated with these exceedances (Appendix A).
- Historical WAD cyanide results, used as a surrogate for free cyanide, were compared against a pH-adjusted free cyanide trigger value. This approach likely overestimates ecological relevance under the mildly alkaline conditions typical of Macraes Operation waters, so most detected WAD cyanide concentrations were interpreted as exceedances, including isolated detections at control sites DC00 and MB00. CJ01 and TC01 most frequently exceeded the trigger value (Appendix A). The apparent frequency of exceedances is therefore considered to reflect limitations of WAD cyanide as a surrogate, rather than a clear indication of ecological risk.

Overall, the inorganic toxicant data indicate that most measured parameters were not present at concentrations likely to pose ongoing ecological risk across the wider Macraes Operation receiving environment. The key exceptions were localised elevations of arsenic in Battery Creek and Golden Bar Creek, total iron at NBWRRF, nickel and zinc elevation in the Mare Burn catchment, and WAD cyanide detections that exceeded trigger values under a conservative free-cyanide assessment.

4.4 Aquatic Ecology

4.4.1 Overview

Annual biological monitoring has occurred at various sites within and around the Macraes Operation since 2002. Monitoring of macroinvertebrates, sediment coverage (at select sites), periphyton and macrophytes occurs quarterly, and monitoring of fish populations occurs once per year in late summer/early autumn. The following sections provide an overview of the receiving environment ecology, as monitored over the years by OGNZL.

4.4.2 Aquatic flora

Filamentous and mat forming algae occur throughout the monitored catchments, although their abundance varies considerably among sites and sampling occasions. Filamentous algae cover is generally low, although higher cover occurs periodically at some sites and tends to be more common during the warmer months. At HC02, DC03 and DC08, where the existing consents specify a 30% cover limit for filamentous algae greater than 2 cm long, filamentous algae cover is typically low. However, the limit has occasionally been exceeded historically at DC03 and DC08, but not at HC02. Mat-forming algae show a stronger catchment-specific pattern, with generally higher cover in Deepdell Creek, Mare Burn and Trimbells Gully, and lower cover in Battery Creek, Golden Bar Creek, the Waikouaiti River.

Macrophytes are most abundant in the North Branch Waikouaiti River catchment, which is likely associated with the surrounding agricultural land use and limited riparian vegetation and shading, providing conditions favourable for macrophyte growth.

4.4.3 Macroinvertebrates

Long term seasonal monitoring of macroinvertebrates suggests the majority of the receiving waterways sit within Attribute Band C (as per the NPS-FM; MfE 2025), indicating moderate organic pollution or nutrient enrichment, with several results falling below the national bottom line (in Attribute D). Results are consistent across control sites which suggests there are wider influences on the macroinvertebrate population rather than just mining activities. All sites are influenced by current and historical agricultural practices, with legacy mining also likely to have influenced the waterways and therefore the macroinvertebrate population.

The macroinvertebrate communities are relatively variable, reflecting the range of habitats present across the Macraes Operation area. Percent EPT (Ephemeroptera, Plecoptera, Trichoptera) abundance, an indication of a community's abundance of more sensitive taxa, is generally lowest in the North Branch Waikouaiti River catchment. Sites in this catchment are highly modified, subject to agricultural pressure, and often lack the hard bottom riffle habitat favoured by EPT taxa. Sensitive EPT taxa are consistently more abundant in the Taieri catchment, likely due to more favourable instream habitat conditions. In the Shag catchment, abundance in the main tributary, Deepdell Creek, varies with both distance downstream and season. Deepdell Creek is intermittent, with large drying reaches which can result in significant increases in water temperature during summer, and decreased flow - conditions which are better tolerated by less sensitive (non-EPT) taxa.

Overall, the macroinvertebrate communities in waterways within and around the Macraes Operation are considered typical of moderately impacted, rural dominated streams.

4.4.4 Fish

The fish community in all catchments is dominated by Taieri flathead galaxias. Infrequent records of eels and brown trout occur at some sites, mostly in the larger tributaries such as Deepdell Creek. Bullies are only recorded in the North Branch Waikouaiti River at a single site (NBWRRF). Freshwater crayfish/koura are also abundant in sites where suitable habitat is present. Population densities have fluctuated over time but are generally considered to be stable. Natural barriers to fish passage are present on most streams, generally associated with intermittent flows and periods of drying. Fish barriers only influence the distribution of migratory species such as eels and trout.

4.5 Waterways Subject to Works

4.5.1 Waterway classification

The results of the waterway classification (Section 3.2.2) indicated two streams (Trimbells Gully and Clydesdale Creek tributary) within the MP4 footprint (refer Figure 4 and Appendix B), each of which is discussed below. An intermittent stream (Trimbells Gully tributary) outside the MP4 footprint will be impacted by a proposed sediment pond and is therefore also described below. The other channels and gullies within the footprint were classified as ephemeral (Appendix B) and contained no freshwater habitat or instream values. Streams identified for compensation or enhancement mitigation measures outside of the MP4 footprint are also discussed (Murphys Creek and North Branch Waikouaiti River).

Trimbells Gully

The ecological value of Trimbells Gully was considered to be low.

Trimbells Gully originates to the east of the current Trimbells Gully WRS, draining from the north-western face of Highlay Hill. It flows in a generally north-western direction, around the base of the Trimbells WRS before joining Maori Hen Creek and discharging to Mare Burn. It ultimately sits within the Taieri River catchment.

A sediment pond at the base of the Trimbells WRS divides the reach into two stream classifications. Downstream of the sediment pond, the stream was classified as permanent due to the permanent discharge from the pond. Upstream of the pond, it was classified as intermittent, with portions where flow was absent or significantly reduced during the site visits, suggesting flow would cease during drier periods of the year. The intermittent reaches included the mainstem of the tributary and two smaller tributaries, one fed by a seep discharging from the Trimbells Gully WRS. Further upstream, and partly outside the MP4 footprint, the upper reaches of the mainstem were classified as wetland and are addressed in the wetland impact assessment report (Bioresarches 2026). Above the wetland, the channels were dry and were classified as ephemeral.

Permanent reach

The permanent reach of Trimbells Gully (waterway 5; Appendix B), downstream of the sediment pond, ran through a moderately incised channel, with banks formed by natural soil substrates and large tussocks (Figure 5a). The channel appeared very stable, with no scour or erosion identified. Substrates were heavily dominated by fine sediment, though not deep, with a relatively firm base beneath. Periphyton and macrophyte growth formed a moderate component of the channel, with macrophytes generally limited to areas of thinner tussock and including emergent exotic grasses such as *Glyceria* sp. and creeping bent (*Agrostis stolonifera*) (Figure 5b). Flow was low-moderate during the SEV surveys, though visits by Viridis during and after rainfall as part of annual monitoring have shown flow can increase rapidly, with the relatively small upstream catchment suggesting flashy, rapidly rising and falling flow following rainfall.

Results from eDNA sampling showed the invertebrate community within the stream included common invertebrate species, generally tolerant of pollution and elevated sediment levels. No fish were detected in the eDNA sampling. Taieri flathead galaxias (At Risk – Declining; Dunn et al. 2025) are known to be present downstream of the reach at TG01 (Appendix A). They may periodically move upstream to the sample reach; however, the lack of any detection, and the reach's position high in the catchment suggest fish are generally not present at the site.

Additional data resulting from the SEV assessments are interpreted in Section 4.5.2.

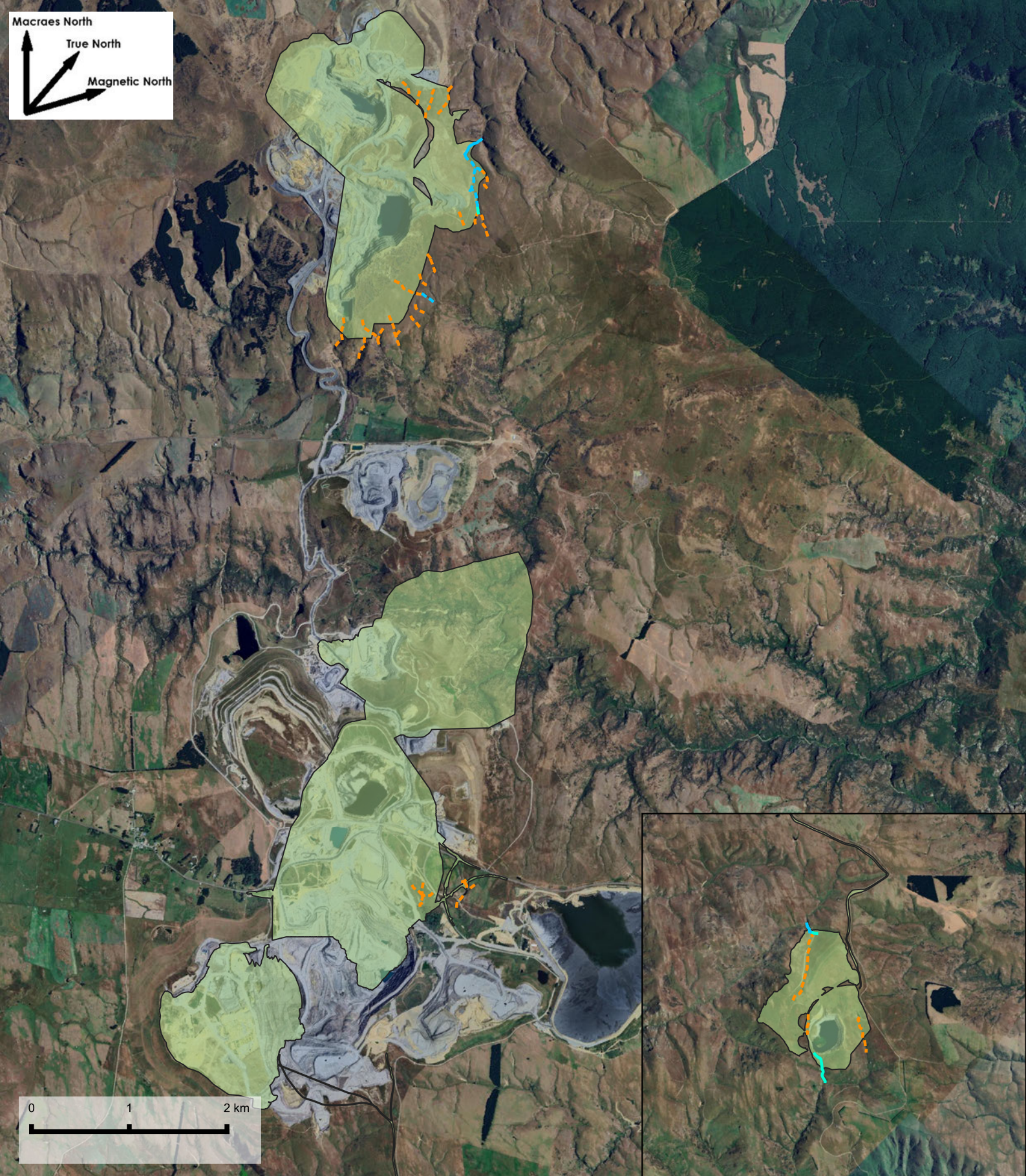


Figure . Waterway classification overview

PROJECT NO. 10023
 DRAWN BY: AJC
 DATE: 27/05/2026
 SCALE **1:50,000** @ A4

Proposed footprint

Waterways

- Permanent
- Intermittent
- Ephemeral
- Wetland*

* Classified as a wetland rather than a stream and addressed by Bioresearches. Illustrated here for completeness.



SOURCES
 Nearmap.com 2023

DISCLAIMER: This map/plan is not an engineering draft. This map/plan is illustrative only and all information should be independently verified on site before taking any action.

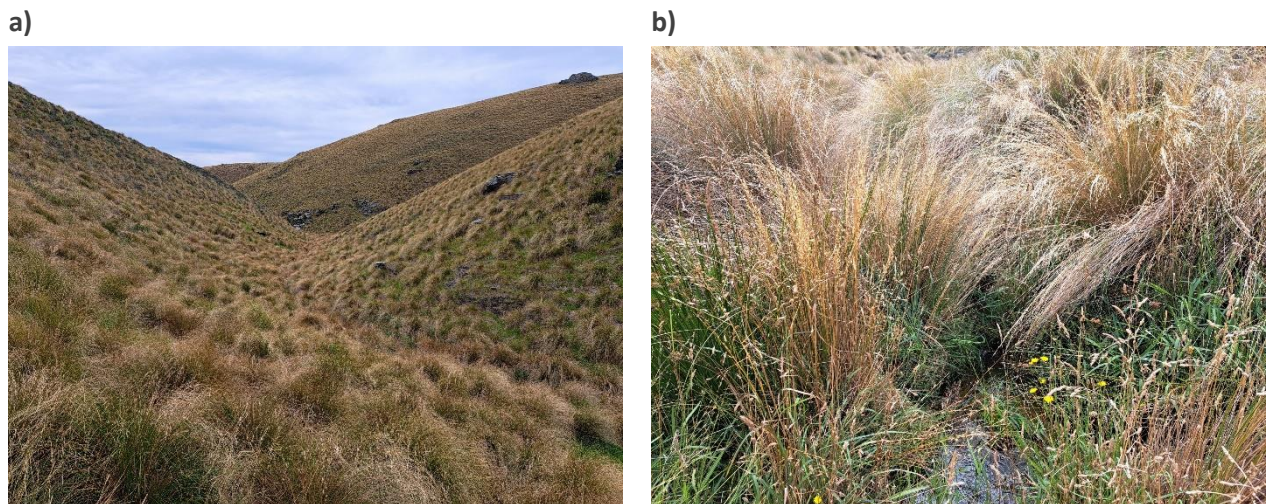


Figure 5. a) Trimbells Gully containing the permanent reach and b) close up view of permanent channel amongst tussocks.

Intermittent reach

The wetted channel in the intermittent reach upstream of the pond (waterway 6; Appendix B) was narrower and shallower than the permanent reach, with portions where water flowed just below ground level (Figure 6a). Substrates were more variable in this reach with gravels and small cobbles present as well as fine sediment. Flow was also variable, generally depending on water depth. As with the permanent reach, macrophytes were present and included both *Glyceria* sp. and creeping bent. Small amounts of exotic monkey musk (*Erythranthe guttata*) were also present where tussock growth was lower and less dense.

eDNA results showed the invertebrate community within the stream included common invertebrate species, generally tolerant of pollution and elevated sediment levels. No fish were detected. The sediment pond's outlet that separates the intermittent reach from the permanent reach is a perched pipe. The pipe, and the pond's bund, together form a complete barrier to fish passage (Figure 6b). Eels may periodically be able to negotiate the barrier, but the lack of eDNA detection, combined with the absence of any eel captures at downstream monitoring sites (MB01, MB02, TG01) since monitoring began in 2017, suggests their presence here is highly unlikely.

Additional data resulting from the SEV assessments are interpreted in Section 4.5.2.



Figure 6. a) Intermittent reach of Trimbells Gully and b) perched outlet and bund containing the Trimbells Gully sediment pond.

Trimbells Gully tributary

The ecological value of the Trimbells Gully tributary was considered to be low.

Trimbells Gully has various tributaries along its length. The tributary described as waterway 36 in Appendix B originates as an ephemeral channel on the northern side of the existing Coronation North WRS, flowing northwards for a short distance before discharging to Trimbells Gully. The channel transitions from ephemeral to intermittent at a constructed vehicle access track which acts as a bund across the channel. A small culvert/pipe is present here too that conveys overland flow from the upper catchment into the intermittent channel.

The characteristics of the intermittent channel were identical to the intermittent reaches of Trimbells Gully. The intermittent reach was approximately 260 m in length and was characterised by areas of obvious channel with gravel substrates interspersed by reaches where flow appeared to go subsurface and no clear channel was present.

There was no fish barrier below the track and therefore, like the permanent reach of Trimbells Gully, it is possible Taieri flathead galaxias may periodically be present. However, the lack of any detection in the permanent, adjacent Trimbells Gully, and the reach's position high in the catchment suggest fish are generally not present at the site.

Clydesdale Creek tributary

The ecological value of the Clydesdale Creek tributary was considered to be low.

A short reach (22 m) of stream (waterway 31; Appendix B) is present on the northwest side of the Golden Bar WRS, fed by seepage from the WRS and an area of wetland in the upper reaches of the channel (Figure 7a). The channel discharges to the Clydesdale Creek sediment pond (Figure 7b) which, in turn, discharges to Clydesdale Creek. Review of aerial imagery shows a small gully was present here prior to the construction of the Golden Bar WRS (i.e. prior to 2003). Despite originating from the artificial landscape of the Golden Bar WRS, the water is sourced naturally through infiltration of rainwater. It is therefore considered to be a natural channel, albeit modified.

At the time of the site visit, the stream was heavily pugged. Sheep were present in the paddock, though it is expected cattle are also periodically present. The upper reaches of the channel were difficult to define due to the pugging, though the lower reaches were more defined and appeared to contain a permanent flow of water. Substrates were entirely soft sediment. Riparian vegetation was limited to grazed pasture grass and some tussocks in the upper reaches, which provided minimal shading.

The receiving sediment pond was contained by a bund. The discharge point from the pond was a perched culvert which combined with the bund, presented a total barrier to fish passage, even for strong climbing species such as eels. Given the very small amount of stream upstream of the pond (about 22 m), the lack of access for fish past the pond is not considered an issue ecologically. The macroinvertebrate community is expected to be characterised by common, tolerant species, capable of persisting in small stock-impacted waterways.

No SEV assessment was undertaken for this reach, as its length (22 m) is below the 50 m minimum specified in the methods (Storey et al. 2011). The Trimbells Gully permanent SEV is instead considered representative, based on physical inspection confirming comparable characteristics. If anything, the Trimbells Gully permanent SEV is likely to be slightly higher, providing a conservative estimate of ecological value for this reach.

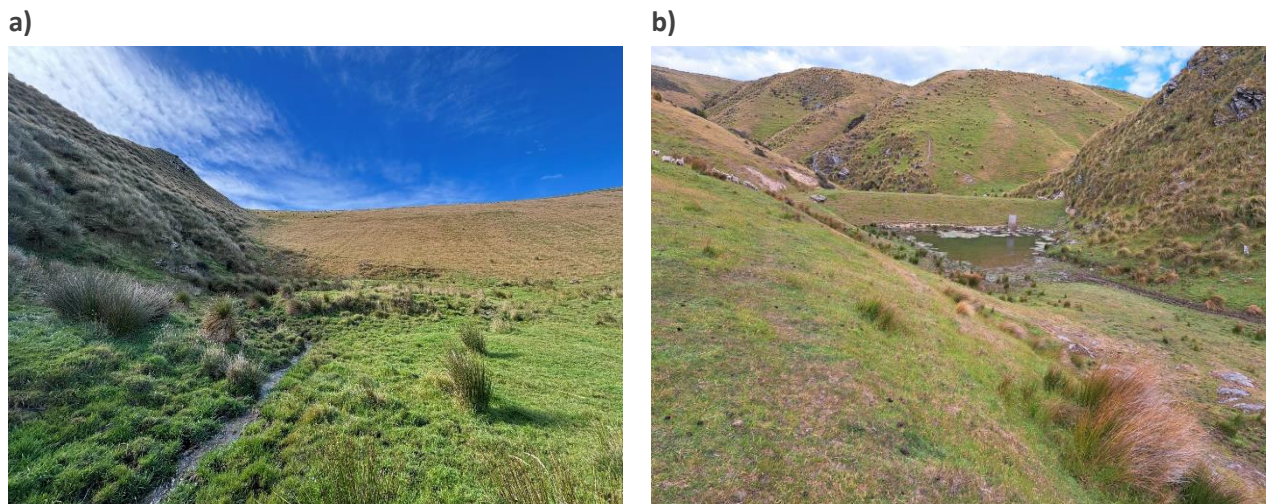


Figure 7. Clydesdale Creek tributary a) looking upstream to the WRS and wetland area and b) looking downstream to the sediment pond.

Ephemeral channels

The remainder of the channels within and around the MP4 footprint have been classified as ephemeral. They were characterised as dry gullies or depressions, lacking clear channels, evidence of erosion and substrate sorting, and were entirely vegetated with terrestrial vegetation (Figure 8). All channels have been physically inspected, and they did not meet more than two of the criteria listed in the Auckland Council Practice and Guidance note – River / Stream Classification. Appendix B provides the results of the classifications of all waterways, including specific comments, where appropriate.



Figure 8. Examples of ephemeral channels within the site.

Murphys Creek

The ecological value of Murphys Creek is considered to be moderate.

Murphys Creek originates south of the current active mining area, near the southern end of Red Bank Road. It flows through a steep gully system, in a generally south easterly direction, before discharging to the North Branch Waikouaiti River.

The upper reaches flow through a relatively flat area. The flatness, coupled with pugging from stock has allowed the stream to widen significantly and become more diffuse (Figure 9a). A lack of shading in this area has resulted in significant growth of *Glyceria sp.* Within and below the heritage covenant, the creek

was much more defined. Flow was variable, with deep still pools, and shallow riffles (Figure 9b). Substrates were also variable and ranged from areas of exposed bedrock to areas dominated by silt. Macrophyte coverage was present, though it is seasonally influenced. Significant growths of exotic water buttercup (*Ranunculus trichophyllus*) were present during the site visit.

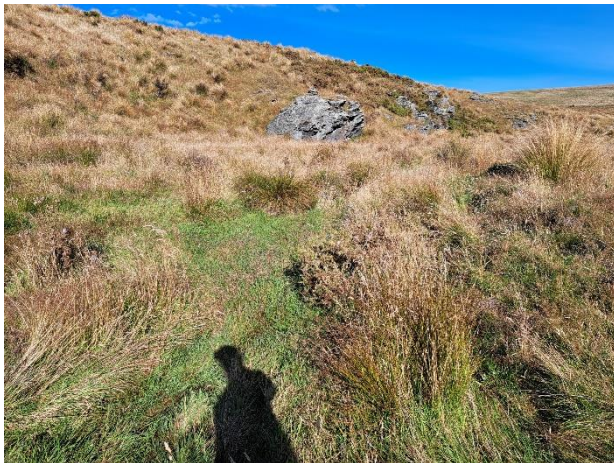
Riparian vegetation was reflective of the extensive agricultural landscape. Stock were able to access most of the creek. Areas of mixed native and exotic scrub provided low to moderate levels of shading. Shade was also provided by the topography of the gully the creek is contained within. Tussocks and sedges were also common along the stream edge, with grazed pasture grass forming the remaining vegetation.

An eDNA sample collected from the creek indicated the presence of Taieri flathead galaxias, shortfin eel (*Anguilla australis*; Not Threatened) and longfin eel (At Risk - Declining). The macroinvertebrate population included a combination of sensitive and tolerant species, reflective of the agricultural use of the catchment.

While At Risk – Declining Taieri flathead galaxias are present in Murphys Creek, which would typically indicate a high ecological value, the assessed reach is considered moderate. This reflects the distinction between species value and habitat condition under the EclAG framework. Ongoing pressures including stock access, limited riparian management, and reduced habitat quality as described above, constrain the expression of ecological values. The rating assigned here therefore relates specifically to the current condition and functional habitat value of the reach, rather the presence of At Risk species alone.

Additional data resulting from the SEV assessments are interpreted in section 4.5.2.

a)



b)



Figure 9. Murphys Creek showing a) flatter upper reaches with lack of defined channel, and b) within the reach where values assessments were completed.

North Branch Waikouaiti (within OGNZL owned land)

The ecological value of the North Branch Waikouaiti River, within land owned by OGNZL, is considered to be low.

The upper reaches of the North Branch Waikouaiti River are contained within land owned by OGNZL. As described in Section 4.2.4, the river originates just to the east of the Macraes township. Within the site, it flows through a highly modified, straightened channel, before leaving OGNZL land via a culvert under Red Bank Road, and continuing its flow downstream (Figure 10).

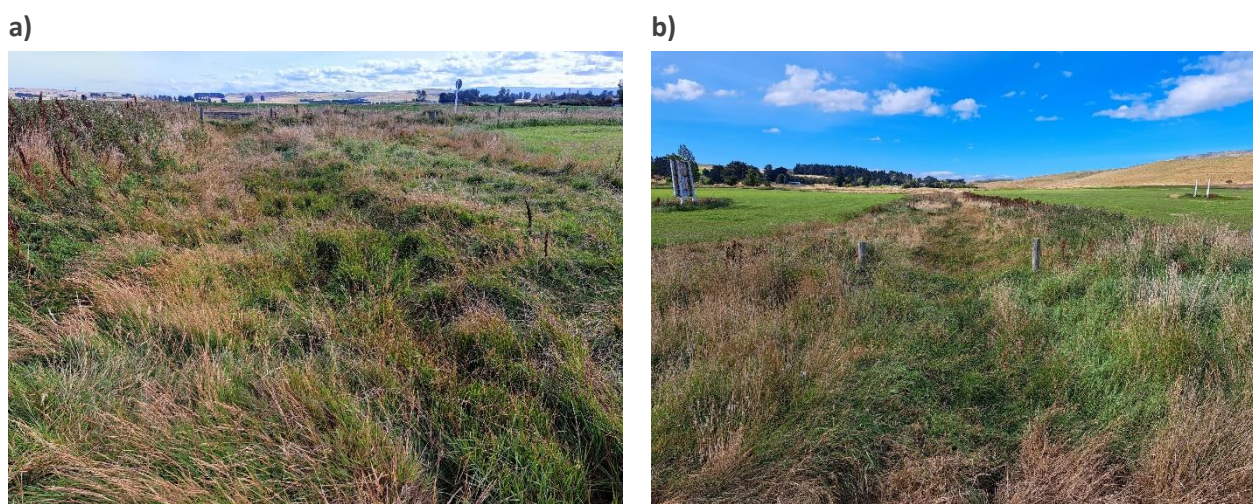


Figure 10. North Branch Waikouaiti River within OGNZL land a) looking downstream towards Red Bank Road and b) looking upstream towards the headwaters.

Within the site the river is intermittent, generally only containing water during wetter winter months. Even when water is present, flow is generally absent, with the water stagnant and anoxic. The channel is subject to excessive macrophyte growth year-round. Substrates are dominated by soft, fine sediment, beneath the macrophyte growth. Native riparian vegetation is absent, with pasture the only vegetation type along its length. Stock, when present in the adjacent paddocks, have direct access to the channel.

North Branch Waikouaiti River at Red Bank Road has been surveyed as part of the annual monitoring programme since 2018, with sampling dependent on the watercourse's intermittent flow and occurring only when water is present. No fish have been caught in this reach. The macroinvertebrate community, when sampled, has consisted of a low diversity community dominated by common, tolerant taxa.

Additional data resulting from the SEV assessments are interpreted in Section 4.5.2.

4.5.2 Stream ecological valuation

Quantitative SEV assessments were undertaken on six separate reaches of stream (Figure 11). Two were undertaken on Trimbells Gully (one on the permanent reach and one on the intermittent reach). Two were undertaken on waterways identified as options for mitigation enhancement works (Murphys Creek and North Branch Waikouaiti River), and two were undertaken on 'reference' streams (Cranky Jims Creek and Highlay Creek). The reference SEVs provide a locally relevant benchmark of ecological condition, illustrating the level of function that may be achievable under improved management, including stock exclusion, riparian planting and other forms of habitat enhancement.

The SEV scores for each assessed reach are provided in Table 3. A summary of the SEV scores for each SEV variable, and assumptions, are provided in Appendix C.

Table 3. Biological metrics for impact, potential compensation sites and reference sites.

Stream	Trimbells permanent	Trimbells intermittent	Murphys Creek	North Branch Waikouaiti	Cranky Jims Creek	Highlay Creek
Type	Impact reach	Impact reach	Compensation reach	Compensation reach	Reference	Reference
SEV score	0.544	0.482	0.574	0.250	0.802	0.740
MCI	94	94	87	68	100	93
Fish IBI	0	0	34	0	20	34

Figure . SEV investigation locations

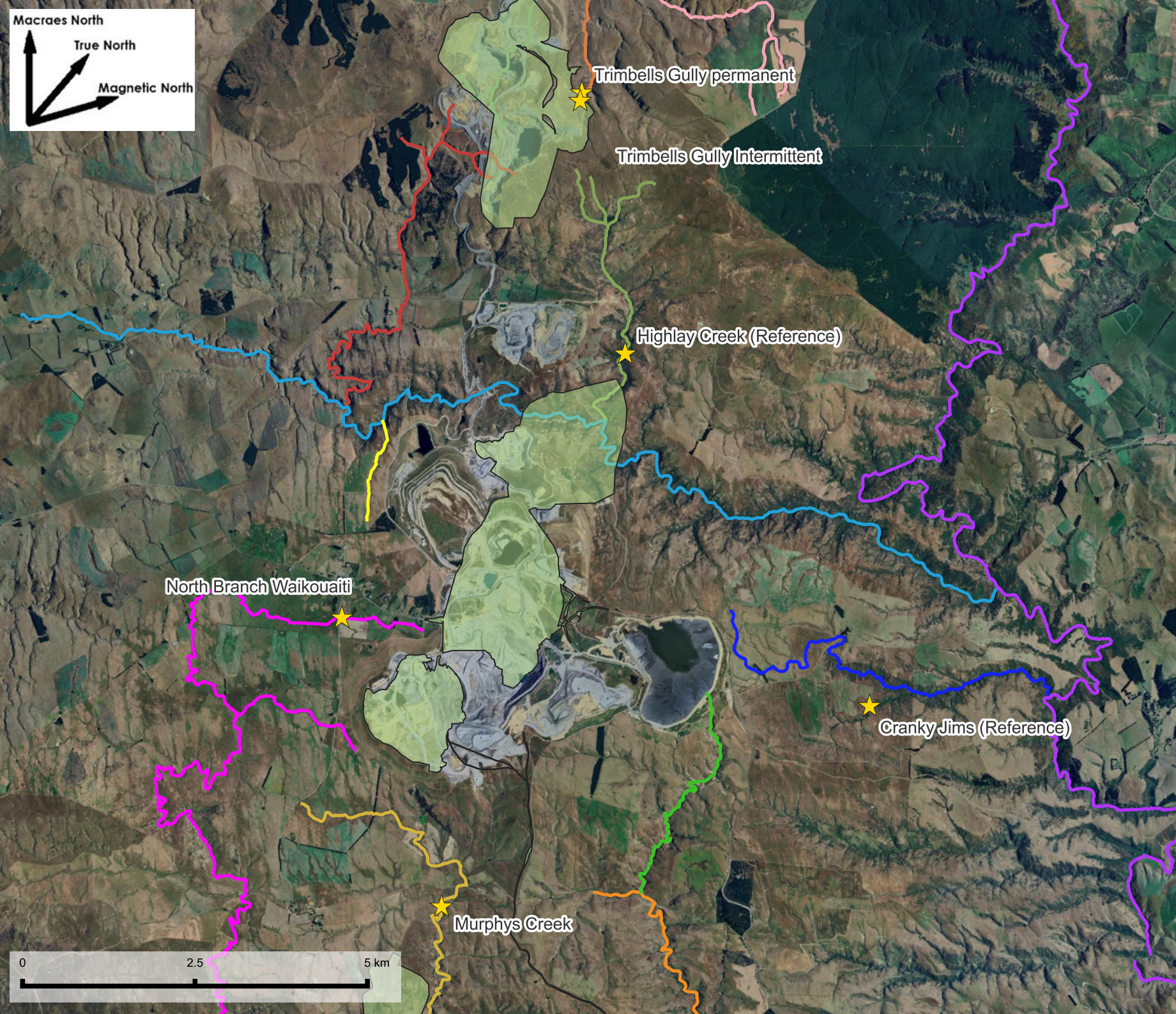


SOURCES
Google Satellite 2023

DISCLAIMER: This map/plan is not an engineering draft. This map/plan is illustrative only and all information should be independently verified on site before taking any action.

SCALE 1:70,000 @ A4

PROJECT NO. 10023
DRAWN BY: AJC
DATE: 28/05/2026



Trimbells Gully permanent and intermittent reaches had SEV scores of 0.544 and 0.482 respectively. These indicate moderate habitat values, however they were compromised by limited shade, fine sediment and, in the case of the intermittent reach, a fish barrier. MCI scores indicated the sites fell within Attribute Band C as per the NPS-FM. These scores suggest moderate organic pollution or nutrient enrichment, and are generally indicative of a rural catchment. The fish IBI score of 0 was reflective of the lack of fish present within the site.

Murphys Creek yielded an SEV score of 0.574. At the assessment reach, it was similar in nature to the permanent reach of Trimbells Gully, however the presence of a more diverse riparian vegetation community, and the presence of fish, increased the scores when compared against Trimbells Gully. Instream habitat was also more diverse, with coarser substrates creating riffles, runs and pools. The site MCI score of 87 fell in Attribute Band D, which is also below the National Bottom Line as per the NPS-FM. The rural nature of the catchment, coupled with direct stock access to the stream had a strong influence on the macroinvertebrate community. The Fish IBI score for Murphys Creek was 34, which falls in Attribute Band A of the NPS-FM. It suggests there are no major barriers to fish passage and habitat for fish is generally of good quality.

The North Branch Waikouaiti River scored 0.25 in the SEV assessment, indicative of a poor quality, highly impacted waterway. The river at the SEV reach was intermittent, and was dry at the time of the assessment. Macrophyte growth was prolific, stock had direct access to the channel, substrates were entirely fine sediment and released a strong sulfuric smell when disturbed, indicating anoxic conditions. This site forms part of OGNZL's quarterly biological monitoring programme. As a result, the MCI scores were calculated from the most recent quarterly monitoring results (September 2025). The MCI score of 68 was very low, and fell well below the National Bottom Line as per the NPS-FM. The macroinvertebrate community included only a small number of highly tolerant species. The fish IBI score of 0 was reflective of the lack of permanent water present and the fact no fish have ever been captured at this site during annual monitoring.

The Cranky Jims Creek SEV reach was within the Cranky Jims bush covenant. The high SEV score of 0.802 was reflective of the native dominant riparian vegetation, high levels of shading, natural flow patterns, good quality instream habitat and exclusion of stock. The MCI score of 100 fell in Attribute Band C as per the NPS-FM. The upper catchment of Cranky Jims Creek is subject to agricultural activities which is likely reducing the number of sensitive taxa within the stream itself. The Fish IBI of 20 fell within Attribute Band C of the NPS-FM. The lower score was likely the result of periods where reaches downstream flow subsurface, preventing ready movement of fish.

The Highlay Creek SEV reach was within the Highlay covenant area. Stock were excluded from this area however riparian vegetation appeared to be naturally regenerating meaning tussock and scrub were the dominant vegetation types. The SEV score of 0.74 was indicative of a moderately good quality aquatic environment. The regenerating scrub provided moderate to high levels of shade and instream habitat, which was variable with pools, riffles, and runs all present. The MCI score of 93 fell within Attribute Band C as per the NPS-FM. The upper parts of the catchment are subject to agriculture and mining activities. The fish IBI score of 34 falls in Attribute Band A of the NPS-FM (MfE 2025). The score indicates good quality habitat and no significant barriers, despite Highlay Creek being known to dry in the lower reaches during summer.

4.6 Summary of Ecological Values

Table 4 provides a summary of the ecological value of the waterways within and around the Project site. Reach-scale values have been assigned to waterways within the MP4 footprint that will be physically altered through reclamation, realignment or enhancement activities, based on the specific attributes of each reach. This includes the North Branch Waikouaiti River and Murphys Creek reaches identified as potential enhancement sites, each shown in Table 4 alongside a separate catchment-scale value for the wider waterway.

For the remainder of the surface water receiving environment, including monitored reaches of Deepdell Creek that are not subject to physical works, values have been assigned at the catchment scale, inclusive of tributaries. These values are driven primarily by the presence of Threatened or At Risk fish species within the wider catchment and are therefore inherently conservative when applied to individual reaches. Effects are nevertheless assessed with regard to the characteristics and ecological values of the particular reaches affected. For example, the North Branch Waikouaiti River is assigned a High value at the catchment scale, reflecting the presence of Threatened or At Risk fish, whereas the reach within the Project site is assigned a Low value due to its modified condition, long periods of no flow, anoxic conditions and absence of fish.

Table 4. Summary of ecological values of waterways within and around the site.

Feature	Value	Comments
Reach scale values		
Trimbells Gully	Low	Small size, high in catchment, does not support fish
Trimbells Gully tributary	Low	Small size, high in catchment, does not support fish
Clydesdale Creek tributary	Low	Small size, at top of catchment, does not support fish
Ephemeral channels	Negligible	No instream habitat value
Murphys Creek	Moderate	Moderate size, moderate habitat variability, value impacted by surrounding landuse
North Branch Waikouaiti River (within site)	Low	Long periods of no flow, anoxic conditions, modified reach, does not support fish
Catchment scale values		
North Branch Waikouaiti River (rest of catchment)	High	Supports various Threatened and At Risk fish
Shag River	High	Supports various Threatened and At Risk fish
Taieri River	High to Very High	Supports various Threatened and At Risk fish

5 ASSESSMENT OF ENVIRONMENTAL EFFECTS

5.1 Introduction

The actual and potential effects of the MP4 Project on the aquatic environment are principally associated with:

- Changes to mine water management, including dewatering, seepage and direct discharges and future pit-lake overflows, which may alter downstream flows and water quality.
- Physical works within or near waterways, including stream realignment and reclamation, earthworks and vegetation clearance, and the installation of sediment ponds and culverts.

An assessment of these key activities is discussed by effects in Sections 5.2 and 5.3, with a summary of effects provided in Section 5.4.

5.2 Effects of Mine Water Management

5.2.1 Effects on stream flow

The MP4 Project is expected to alter receiving environment flows through:

- Reductions in groundwater and seepage contributions to some streams as a result of dewatering and seepage capture associated with Golden Bar, Coronation and the central mining area, including Frasers Pit, Innes Mills and GPUG. These effects will primarily occur during the active mining stages (Phase A and B) of the Project.
- The collection, treatment and managed return of seepage water, generally proportional to the volume captured and treated from each catchment, with flexibility to redirect treated water between catchments where appropriate (refer Section 2.3.2), which will restore or increase flows in several receiving catchments during the active mining and post-closure periods.
- Managed discharges from the Coal Creek and Camp Creek flow-augmentation dams and water treatment plant, commencing in Phase B, and including the use of flushing flows during summer periods to manage periphyton growth.
- Pit-lake overflows during the long-term post-closure period, from approximately 2100 onwards.

The timing and magnitude of these changes will vary by catchment and mine phase, as modelled and discussed in GHD (2026). At most receiving water sites, modelled median and low-flow statistics (i.e., Q90 and Q95, representing flows equalled or exceeded 90% and 95% of the time, respectively) are predicted to increase relative to estimated baseline conditions. In Mare Burn, initial flow reductions are expected during Phase A of mining, primarily a result of new seepage capture, followed by recovery and substantial increases once the augmentation dams and treated discharges are operational. Long-term contributions are expected from pit lakes post-closure, though smaller reductions may persist in some locations (e.g., Camp Creek above the dam), depending on the final configuration of the treated water return systems.

However, some locations depart from this general pattern. In the upper reaches of Murphys Creek and Golden Bar, flows are predicted to decrease relative to baseline, across all mine phases, including the long-term scenario. These reductions are associated with reduced infiltration from the Golden Bar WRS, increased evaporative losses from the larger Golden Bar pit lake, and improved seepage capture within the respective catchments.

The potential aquatic environment effects associated with these changes in flow include:

- Reductions in wetted habitat, flow continuity and habitat connectivity where groundwater or seepage contributions are intercepted. In susceptible waterways, this could increase the frequency or duration of low-flow or dry conditions and associated effects such as elevated water temperatures, reduced dissolved oxygen and loss of aquatic habitat. Such effects are restricted to Murphys Creek, Golden Bar and Mare Burn, the latter for which are considered temporary (i.e., limited to Phase A).
- Increased flow permanence in waterways once augmentation dams and treated discharges become operational, particularly during dry weather conditions for parts of Deepdell Creek. This is expected to improve instream habitat consistency and reduce stagnant conditions that promote nuisance algal growth, low dissolved oxygen and elevated water temperatures.
- Increased erosion, scour and sediment transport, particularly near discharge points (where increased flow velocities interact with unstable banks or bed material) or in waterways that will experience increased frequency of elevated flows. This could generate excess fine sediment which can smother benthic habitat, disturb channel morphology and contribute to secondary water quality effects such as increased turbidity. Specific effects associated with increased sediment loads are discussed further in Section 5.3.6.
- Periodic mobilisation of accumulated fine sediment and periphyton associated with increased flows may provide ecological benefits by reducing substrate smothering, increasing interstitial spaces available for invertebrate colonisation, and improving exchange of oxygenated water through the streambed. For example, the flushing flows proposed for periphyton management are expected to contribute to these processes where appropriately timed and managed.
- Changes in wetted width, depth and velocity. While increased flow may expand the total area of aquatic habitat, it could also alter habitat type and heterogeneity, for example by converting shallow riffles or margins into deeper, faster-flowing runs. Over time, such changes may be reflected in aquatic community composition, through a shift towards or dominance of taxa better adapted to deeper or faster-flowing conditions.
- Cumulative effects of repeated flushing flows (as proposed for periphyton management) on benthic invertebrate communities and food-webs. The proposed flushing flows (approximately three times median flow for an affected waterway; GHD 2026) could, if repeated at short intervals, prevent some invertebrate species from re-establishing or maturing. Aquatic invertebrate communities can generally recolonise following disturbance; however, repeated removal of some species, along with periphyton and other food resources, may constrain recovery and reduce food availability for fish. This may, in turn, affect fish populations.

The potential effects described above are expected to be effectively mitigated and managed, such that significant adverse effects are not anticipated, for the following reasons:

- In large part, the proposed augmentation and treated water return systems will offset initial reductions and restore or increase flows in several affected catchments. Some residual flow reductions are predicted at select locations, including the upper reaches of Golden Bar (at site GB02) and Murphys Creek (at MC01 and MC02). GB02 is near active mine operations and represents a highly modified waterway with comparatively low existing ecological value, including a tolerant macroinvertebrate community and no fish recorded in monitoring undertaken since 2004

(Viridis 2026b). In Murphys Creek, the predicted reductions are largely restricted to dry periods and are not expected to result in a loss of flow continuity. These reductions are also a consequence of improved WRS management practices. Reduced infiltration lowers seepage contributions to the waterway, but is necessary to achieve the water quality outcomes described in Section 5.2.2.

- The ability to vary the direction of treated mine water between receiving catchments provides flexibility to respond to observed flow conditions and ecological requirements. Redirected flows, like all treated water returns, remain subject to the same operating envelope described in Section 2.3.2, so any change in the magnitude of flow augmentation within individual waterways resulting from redirection remains within those bounds.
- The predicted flow increases from augmentation and treated water returns, including where redirected between catchments, are not anticipated to impact the ecological function of higher flushing flows or result in a fundamental change in riverine habitat. Rivers are naturally dynamic systems, and while some adjustment in wetted width, depth, velocity and habitat distribution would be expected as flows increase, the receiving waterways are expected to progressively adjust to the modified flow regime overtime. As such, the proposal is not expected to result in a significant adverse change to the overall hydrological character of the receiving environments. The ecological function of flushing flows specifically, as a periodic high-flow disturbance event distinct from general flow augmentation, is addressed further below.
- Potential erosion and scour effects would be managed through discharge design, including appropriate outlet configuration, energy dissipation and erosion protection such as riprap where required (GHD 2026). In some locations, interaction with waterways would occur primarily through groundwater infiltration rather than direct surface discharge, further reducing the potential for localised hydraulic disturbance.
- Continuous flow monitoring, providing robust gauged flow records, is already undertaken at Deepdell Creek, with additional key sources proposed (GHD 2026), providing a basis for confirming actual receiving-environment flow responses and identifying any unexpected changes following implementation of the Project. Flushing-flow magnitudes for other waterways will be based on modelled or scaled flow estimates, which may be refined as further monitoring becomes available.
- The proposed flushing-flow magnitude (approximately three times the median flow; GHD 2026), reflects the flow magnitude used to define FRE3, a New Zealand flow-variability metric describing high-flow events capable of removing periphyton from the streambed (Clausen & Biggs 1997). Because this magnitude comes from each waterway's own natural flow variability rather than a fixed discharge value, it should fall within the disturbance range resident communities already experience, rather than introducing a new type or scale of disturbance. Clausen and Biggs (1997) also found that streams with moderate FRE3 values supported higher invertebrate densities than streams with substantially higher or lower values, indicating that periodic disturbance of this kind is consistent with, rather than harmful to, healthy instream communities.
- GHD (2026) identifies up to six flushing cycles at approximately 20-day intervals during summer months, as a means of controlling periphyton. As flushing flows can themselves affect benthic invertebrate communities and fish populations, ecological response to these flushes, distinct from periphyton control outcomes, would be reviewed after three cycles. Where recovery of the invertebrate community and fish populations appears limited, a longer recovery period (for

example, approximately six weeks) may be provided before further flushing is considered, irrespective of whether periphyton control objectives have been met, allowing communities to re-establish between events. The review should also consider whether limited improvement reflects conditions or sources elsewhere in the catchment that warrant further investigation, rather than the flushing regime itself. This adaptive approach to flushing frequency is intended to minimise the potential for longer-term changes to local invertebrate communities and fish populations.

Overall, while the MP4 Project is expected to alter flows in parts of the receiving environment, the predicted changes are expected to be appropriately managed to avoid adverse effects on instream habitat or aquatic community values. The proposed mine water management plan (WGA 2026) will provide a framework for adaptive management, allowing flow management measures to respond to observed conditions and ecological outcomes. Subject to the implementation of these measures, the overall level of adverse effect on the aquatic environment from flow changes is expected to be low, rising to moderate only if flushing continues without adequate recovery of affected invertebrate and fish populations.

5.2.2 Effects on water quality

Overview

The MP4 Project is expected to alter receiving-water quality over the active-mining (Phases A and B), closure, pit-overflow and long-term phases. GHD (2026) modelled receiving-water concentrations during each of these stages at key sites within the Shag/Waihemo, Waikouaiti and Taieri River catchments using a water balance model (WBM). Predicted concentrations were assessed against existing conditions (as measured between 2020 and 2026), the existing consent framework (during Phase A), and the proposed surface water quality framework (applying from Phase B onwards). Compliance was assessed using the recommended criteria for each trigger value, reflecting the potential for adverse effects.

Full details of the model methodology, assumptions and results are provided in GHD (2026). Table 5 summarises predicted compliance, by constituent and Project phase, for each compliance site expected to be affected by MP4. HC02, CJ01 and TC01 are not included, as these existing compliance sites fall outside the proposed framework and are not subject to new or modified discharges under MP4.

GB01, located immediately downstream of the Clydesdale Silt Pond, is not subject to compliance limits and is therefore not included in Table 5. The Clydesdale Creek tributary discharging to this pond is fed by seepage from the Golden Bar WRS, meaning GB01 represents an existing, highly modified receiving environment rather than an unimpacted waterway. This reach discharges to Murphys Creek about 2 km downstream (GHD 2026), upstream of MC02, where the effects of the proposed works on downstream water quality are assessed.

Table 5. Compliance summary of water quality outcomes in receiving environment during different phases of the MP4 Project. Reproduced from GHD (2026).

Parameter	Deepdell Creek					Shag River					McCormicks Creek					Mare Burn					MB02				
	DC08					Loop Road					McCormicks Creek					MB01					MB02				
Sulphate																									
Nitrate-N	▼																								
Ammoniacal-N																									
Arsenic						▼	▼	▼	▼	▼	▼	▼	▼	▼	▼						▼				
Copper																▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
Iron						▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▼	▼	▼	▼		▼	▼	▼	▼
Lead																									
Zinc																									
pH																									

Parameter	Waikouaiti River North Branch					NB03					GB02					Murphys Creek					MC02				
	NBWRRF					NB03					GB02					MC01					MC02				
Sulphate																									
Nitrate-N																									
Ammoniacal-N																									
Arsenic																									
Copper		▼																							
Iron	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼						▼	▼	▼	▼	▼		▼			
Lead																									
Zinc																									
pH																									

Mining Ph.A	Mining Ph.B	Closure	Pit OF	Long-Term
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Notes: The table is colour-coded based on modelled risk of non-compliance, based on existing limits in Phase A and the new proposed framework from Phase B onward; grey indicates no risk, yellow indicates low risk / non-compliances are rare (<5%), orange indicates medium risk/ occasional non-compliance (5-25%), red indicates high risk/periodic non-compliance (25-50%), and purple indicates very high risk/frequent non-compliance (≥50%). Icons indicate model limitations and likelihood of under- or over-estimating risk; ▼ indicates model likely overstates risk, due to conservative assumptions or input values, ▲ indicates model likely understates risk, true value expected to be higher, ▽ model likely overstates risk due to historical data suggests natural attention is afforded in the environment, ■ indicates risk is plausible, but that further (unmodelled) mitigation options are available to reduce this risk, Pit OF = pit overflow.

Predicted outcomes

In summary, the WBM predicted the following outcomes over the duration of the Project:

- Sulphate concentrations generally increased relative to existing conditions. It was principally an issue during early mining (Phase A), before the augmentation dams become operational (refer Section 2.3.2), and more consistently in the North Branch of the Waikouaiti River. At NB03, non-compliances were related to the drinking-water aesthetic trigger value (250 g/m³) rather than a health-based values or ecological toxicity triggers, with a maximum predicted frequency of approximately 35% in Phase B. At NBWRRF, modelling indicated a moderate to high risk of being non-compliant the applicable ecological trigger, peaking at approximately 18% during Phase B before reducing following closure.
- Although nitrate nitrogen and ammoniacal nitrogen concentrations increased relative to existing conditions, they were mostly expected to comply with the proposed framework. A moderate risk of localised non-compliance was predicted in the Mare Burn and Deepdell Creek catchments during Phase A (when existing limits apply), with maximum frequencies of 7.5% for nitrate nitrogen and 15% for ammoniacal nitrogen at MB02 in the Mare Burn catchment, and 6.8% for nitrate nitrogen at DC08 in the Deepdell Creek catchment. Concentrations were modelled to generally improve once the mitigation and water-management measures are established (refer Section 2.3.2).
- Receiving-water pH remained circumneutral at each of the key assessment sites, representing little to no change from existing conditions. Under each phase of the Project, pH remained within the ranges for the protection of aquatic ecological health (6.5-9) and drinking-water value (7-8.5).
- Modelled arsenic concentrations were generally higher than existing conditions, with non-compliances predicted across several catchments and varying from rare (<5%) to frequent (≥50%) depending on the site and Project phase. The greatest risk was associated with pit overflow during the post-closure period, when the predicted non-compliance frequency peaked at 69% at GB02. Risks of framework non-compliance at other sites were substantially lower.
- The principal increases in copper concentrations were within the Mare Burn catchment, across most of the Project phases. The highest predicted chronic-trigger non-compliance frequency was 84% at MB01 during Phase B; elsewhere, elevated concentrations were generally predicted to be limited to Phase B or were expected to remain similar to or lower than existing concentrations.
- Iron concentrations were predicted to pose a low to high risk of non-compliance at several sites, peaking at 85% at MC01 during Phase B. However, iron is known to be naturally elevated across the receiving catchments (refer to Section 4.3), and predicted concentrations, although generally higher than under existing conditions, remained within the same order of magnitude as concentrations recorded upstream.
- Lead concentrations generally decreased or remained at similarly low concentrations across the assessed catchments, often at or near the standard laboratory detection limit of 0.0001 g/m³. At each modelled site, lead concentrations were expected to comply with the existing consent limits in Phase A and the proposed trigger values from Phase B onward.
- Zinc concentrations increased above existing conditions, principally during Phase B, though the elevation persisted for a greater proportion of the Project at NBWRRF. Compliance issues were greatest in Murphys Creek under the proposed framework, with the highest non-compliance frequency of 72% at MC01 during Phase B.

Receiving-water concentrations of turbidity, SIN, boron, nickel and cyanide were not modelled because of insufficient source data, limitations in the available datasets or the suitability of parameters for inclusion in the model (GHD 2026). Their likely responses to increased mining activity under MP4 were therefore inferred from the existing water-quality trends described in Section 4.3, as set out below:

- Historical turbidity concentrations have generally been low and broadly comparable to upstream conditions. The Project is therefore considered to have the greatest potential to increase turbidity in the downstream environment during periods of more intensive earthworks or significant rainfall events. The magnitude and duration of any such increase will depend on the effectiveness of the proposed sediment-control measures.
- SIN was considered likely to increase further in catchments where elevation was already evident, with Mare Burn and Murphys Creek identified as particularly susceptible.
- Limited historical boron monitoring in the receiving environment indicated that existing concentrations were very low; sites expected to be influenced by the MP4 footprint had concentrations below the standard laboratory detection limit. However, localised increases remain possible based on the WRS predictions identified in MWM (2026a).
- Nickel concentrations were considered likely to remain elevated or increase locally within the Mare Burn, as historical monitoring showed low upstream concentrations and higher downstream concentrations. This pattern indicates a localised source within the Mare Burn catchment, downstream of MB00, with lower concentrations at MB02 consistent with downstream dilution. This pattern may continue under MP4.
- Under current operations, WAD cyanide concentrations in the receiving environment are often below detection limits. Given these historically low concentrations and the mildly alkaline conditions typical of Macraes Operation waters, the potential for MP4 to result in meaningful increases in ecologically relevant free cyanide is considered low.

The modelled and inferred changes described above indicate water quality may respond to MP4. How these changes may translate into effects on ecological and drinking-water values is discussed below.

Interpretation of effects

The significance of the modelled and inferred changes in water quality depends on their magnitude, frequency, duration, and location, as well as the sensitivity of the receiving environment. On this basis, the changes translate to varying degrees of potential effect on ecological and drinking-water values. Under the Project, these include the following effects:

- Positive where water quality improves relative to baseline (e.g., lead at most sites).
- Negligible to very low where conditions remain comparable to baseline (e.g., pH).
- Negligible to very low where ecological and drinking-water triggers are met, despite increases relative to existing conditions (e.g., nitrate and ammonia across most sites). This reflects that the surface water quality framework was developed specifically to provide a sufficient, locally appropriate level of protection for the receiving environment (refer Appendix A).
- Low to moderate where increases are uncertain or unmodelled (e.g., turbidity, SIN, boron, nickel and cyanide), or where risk of framework non-compliance was rare to occasional (e.g., sulphate for most sites, and iron in Shag River and Mare Burn).

- Moderate to high where chronic ecological non-compliance persists, with periodic or frequent modelled elevation (e.g., arsenic, copper in the Mare Burn, iron and zinc in Murphys Creek). Sustained exposure at these levels could alter macroinvertebrate community composition, reduce sensitive taxa abundance and, where fish are present and toxicity is sufficiently elevated, affect fish recruitment.
- Exceedance of drinking-water criteria may also reduce the suitability of water for that use (e.g., sulphate at NB03), with the significance depending on whether the criterion is health-based (e.g., the maximum allowable value (MAV) for arsenic), aesthetic (e.g., sulphate) or irrigation-based for long-term use (e.g., iron).

These effect ratings describe the potential effects of the Project on water quality, ecology and drinking-water health, as indicated by the modelling or, where parameters were not modelled, inferred from historical monitoring data as an indicative proxy. However, they represent a conservative potential outcome rather than the likely outcome in practice. Monitoring, mitigation and adaptive management is proposed to identify and address emerging water-quality issues before they develop into sustained effects of the magnitude described above.

The modelling also has several limitations, assumptions and unavoidable conservative elements that may overstate the frequency, duration or significance of predicted non-compliances (GHD 2026), as demonstrated by the icons in Table 5. Actual effects are therefore expected, in large part, to be lower than those indicated by the modelled scenarios, with the overall residual risk following mitigation and management assessed as low.

The basis for expecting lower effects in practice than those indicated by the modelled non-compliance scenarios is set out below:

- The model does not represent the natural attenuation processes expected within the mine-water and receiving-water systems, indicated by differences between modelled and historically measured receiving-water concentrations, particularly for arsenic, copper, zinc and nitrogen species (GHD 2026). Although the mechanisms are not fully understood, they may include plant and soil uptake, filtration, and absorption. Arsenic in the slow-moving groundwater plume, for example, is understood to attenuate as groundwater moves through the surrounding rock, potentially through adsorption onto mineral surfaces. The model therefore likely overstates non-compliance risk for contaminants subject to these attenuation processes. These mechanisms will be further investigated at a catchment scale during Phase A, contributing to the evidence base used to inform the Phase B transition (Appendix A).
- Some predictions rely on conservative assumptions regarding pit-lake concentrations, seepage quality (particularly from TTTSF), background concentrations in groundwater, and the proportion of streamflow derived from mine-related sources during low-flow periods, in large part reflecting the limited data available to characterise these inputs (GHD 2026).
- Compliance with the existing consent limits (during Phase A) and the proposed framework (from Phase B) was assessed using daily modelled concentrations rather than the monthly sampling regime required under existing consents and specified in the proposed framework (Appendix A) and monitoring programme (Appendix D). The modelled dataset therefore provides up to 365 assessment values annually, compared with the 12 samples collected under monthly monitoring. This greater temporal resolution makes the modelled assessment more sensitive to short-duration

variability and concentration peaks, which may increase the apparent frequency of non-compliance relative to the monitoring regime for which the proposed framework was designed.

- The modelling does not incorporate the proposed compliance-reset periods (refer Appendix A). These periods are intended to ensure that chronic triggers are assessed over appropriate timeframes and that management responses are proportionate to the level of risk. As these reset periods are not represented in the modelling, discrete events may be represented as part of a continuing pattern of non-compliance.
- The modelling does not explicitly account for variability in background contaminant concentrations and loads originating upstream of the mine. For example, iron concentrations are known to be elevated and variable at the upstream monitoring sites MB00 and DC00 (refer Appendix A).
- Site mean or standard values were applied for some toxicity-modifying factors, such as pH and temperature, while hardness and dissolved organic carbon were modelled where practicable. Actual site- and event-specific conditions are likely to be more variable and may reduce contaminant bioavailability and toxicity relative to the assumptions used in the assessment.
- The modelling does not account for corrective actions that would be implemented in response to emerging trends or confirmed non-compliances. In practice, source (e.g., pit lakes, WTP), receiving-water, and biological monitoring (as recommended in Appendix D) would be used to identify elevated concentrations and initiate investigation and management before they developed into sustained high-frequency non-compliances, in accordance with a site water management plan (WGA 2026). Treatment systems, operational controls, or other mitigation measures would be refined where monitoring indicated that concentrations were approaching levels of potential ecological concern. For example, while not currently proposed, field trials of passive water treatment systems are being conducted with the aim of expanding array of mitigation options available for implementation (GHD 2026).
- Some proposed mitigation measures could not be fully represented in the model, including the progressive implementation of seepage capture, refinement of treatment systems, and operational changes informed by monitoring results. For example:
 - Modelling by MWM (2026b) indicates that higher removal rates of arsenic and zinc from pit lakes may be feasible by adjusting ferric chloride dosage.
 - GHD (2026) identifies that, during particularly dry or high-risk periods, pit lake discharges could be reduced (via selective pumping) or diverted to the WTP, which is likely to have greater available treatment capacity under lower-flow conditions.
 - Proposed interim management practices for WRS surfacing (which were not modelled) is expected to reduce infiltration rates, likely resulting in reduced contaminant loads to the receiving environment. These measures include improved construction sequencing, enhanced erosion protection, localised contouring, and completion of unfinished capping (GHD 2026).

Summary

Overall, the potential effects of MP4 mine water management on water quality range from positive or negligible to moderate-to-high where non-compliances are predicted to persist. The more substantial potential effects are generally localised to particular contaminants, catchments and Project phases, rather than representing a consistent deterioration across the wider receiving environment.

These ratings represent conservative potential outcomes rather than the effects considered most likely to occur in practice. The modelling does not fully account for natural attenuation, the progressive refinement of mitigation measures or the corrective actions that would be implemented in response to emerging trends or confirmed non-compliances. Source, receiving water and biological monitoring would provide an early indication of deteriorating conditions, allowing treatment and operational controls to be adjusted before non-compliance developed into sustained effects of ecological or drinking water significance.

Phase A will also provide an important transition period during which the existing consent limits remain in place and intensive monitoring, including catchment scale investigation of natural attenuation, is undertaken. The information will confirm which parameters can transition to the proposed framework at Phase B and which require a longer transition while mitigation is refined. Taking the proposed mitigation, monitoring and adaptive-management measures into account, the residual risk of sustained adverse effects on aquatic ecological and drinking-water values is assessed as low.

5.3 Effects of Physical Works

5.3.1 Overview

This section addresses the effects on instream habitat and values associated with physical works in waterways, including stream diversions, riparian disturbance, fish passage and sediment generated during physical works.

5.3.2 Stream works

Two waterways, Trimbells Gully and the Clydesdale Creek tributary, will be directly impacted through instream works including reclamation and realignment. Trimbells Gully will also be impacted by the installation of a sediment pond on the realigned channel. An additional waterway, Trimbells Gully tributary, will be impacted through the creation of a separate sediment pond.

The magnitude of effect of works in the streams is considered to be high but reduces to moderate when considered at the scale of the wider landscape, mitigated to low following the proposed stream enhancement compensation works. The overall level of effect of the proposed stream works will be low.

The main effects associated with the physical works are the loss of instream habitat, as well as the impact of sediment generated during physical works. Effects of sediment on streams are considered separately below.

Trimbells Gully

The reclamation and partial realignment of Trimbells Gully is necessary to accommodate the expanded Trimbells WRS. Earlier design iterations required full reclamation of the stream channel, resulting in a complete loss of ecological values within the upper catchment. Through the design process, the footprint of the Trimbells WRS has been refined to avoid this outcome to the extent practicable. As a result, the stream channel will be retained and realigned around the base of the Trimbells WRS, reducing the extent of direct stream bed and habitat loss.

Approximately 180 m of permanent stream will be lost, and 670 m of intermittent stream will be impacted, as part of the works within Trimbells Gully (Figure 12). An online artificial sediment pond, incorporating approximately 30 m of lineal stream length is included in the permanent stream measurements. The impact is required to accommodate the expansion of the Trimbells Gully WRS.

Figure . Trimbells Gully impacted waterways

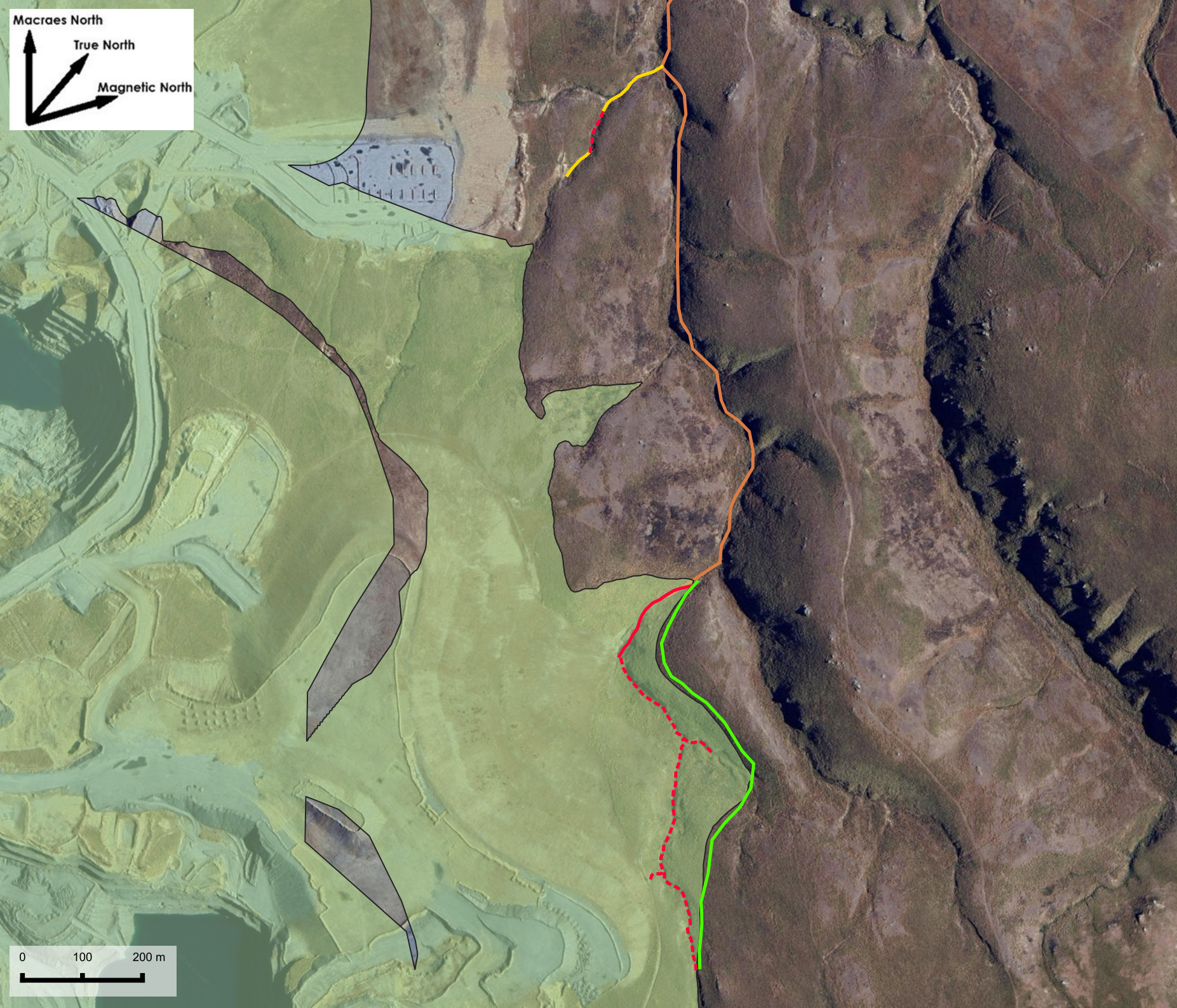
-  Proposed footprint
-  Trimbells Gully Creek
-  Trimbells Gully tributary
-  Lost permanent channel
-  Lost intermittent channel
-  Trimbells Gully realignment

SOURCES
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Further refinements to the design were made during the assessment process. Initially, 410 m of stream was expected to be lost through reclamation, with the new alignment around the base of the WRS being significantly shorter than the current, natural stream alignment. The impacted reach will instead be realigned around the toe of the expanded Trimbells Gully WRS, resulting in a new channel of approximately 745 m. Some variation on length may occur during construction, where local ground conditions, including areas of steeper gradient, require additional cutting or earthworks to accommodate the channel. The point where stream conditions begin, i.e. the transition from ephemeral to intermittent channel, is assumed to remain in the same location. Upstream of this point, the channels are ephemeral and will remain so.

As a result of the additional refinements, the new alignment of Trimbells Gully has been significantly increased in length, to a point where only 105 m of lineal stream length will be lost.

It is difficult to predict how much of the new alignment will be considered a permanent stream and how much will be intermittent. As the existing stream channel contains more than three times as much intermittent stream compared to permanent stream, and the permanent channel is only present downstream of the permanent sediment pond, it is considered likely the habitat that will be lost is permanent stream. A sediment pond will be reinstated on the channel, near the downstream extent of the realignment. While detailed design of the sediment ponds has not yet been undertaken, indicative design suggests only minimal diversion channel (about 20 m) will be located downstream of the pond.

Based on the survey, the average width of the permanent reach was 0.7 m, while the average width of the intermittent reach was 0.48 m. As a result, approximately 74 m² of permanent stream in Trimbells Gully will be impacted. Detailed design of the channel itself has not yet been undertaken. However, indicative designs include the channel consisting of an approximately 1 m wide channel, capable of conveying flows up to the 1% AEP event. The wider channel will mean the diversion will contain 745 m² of instream habitat, an increase from what is currently present. However, as discussed, it is difficult to determine if this habitat will be intermittent or permanent and it is conservatively considered that realignment will result in intermittent habitat only.

Clydesdale Creek tributary

A total of 22 m of the permanent Clydesdale Creek tributary will be reclaimed to accommodate the expansion of the Golden Bar WRS (Figure 13). There is no opportunity to reinstate the channel due to the existing and proposed topography. Upstream of this reach, the channel includes a wetland area, which is assessed separately by Bioresarches (2026). Above the wetland, the channel is ephemeral.

15 m² of permanent stream on the Clydesdale Creek tributary will be lost through proposed works.

Trimbells Gully tributary

A sediment retention pond will be constructed in the gully holding the Trimbells Gully tributary, as part of the site's sediment management plan. Detailed design is incomplete, but the pond will sit in the upper intermittent channel and is expected to result in the loss of 80 m of stream. While water will remain in the gully, the stream will change from a natural, intermittent channel to an artificial pond, and is therefore conservatively considered a reclamation.

The reach is almost identical to the intermittent reach of Trimbells Gully, and the same characteristics have therefore been applied to calculations.

38 m² of intermittent stream on the Trimbells Gully tributary will be lost through construction of the sediment retention pond.

Figure . Golden Bar impacted waterways

-  Proposed footprint
-  Clydesdale Creek
-  Clydesdale Creek tributary
-  Lost permanent channel

SOURCES
Google Satellite 2023

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0 100 200 m

Summary of impacted areas

Realigned stream lengths are summarised in Table 6. A total of 141 m² of permanent stream and 38 m² of intermittent stream will be lost through the proposed works. A total of 423 m² of new intermittent habitat will be created through realigning a portion of Trimbells Gully.

Table 6. Summary of impacted stream lengths.

Metric	Trimbells Gully (permanent)	Trimbells Gully (intermittent)	Clydesdale Creek tributary	Trimbells Gully tributary (intermittent)
Current length (m)	180	670	22	140
Proposed new length (m)	0	745	0	60
Stream length lost (m)	180	75 gained	22	80
	105 (total combined permanent and intermittent)			
Current habitat area (m²)	126	322	15	67
Proposed new habitat area (m²)	0	745	0	29
Habitat lost (m²)	126	423 gained	15	38
	297 gained (total combined permanent and intermittent)			

Notes: The proposed realignment of intermittent stream in Trimbells Gully will be 1 m in width. As a result, the habitat areas lost and created do not combine to equal the current habitat of the entire reach.

Trimbells Gully reinstatement

The existing streams have been impacted through land use practices (e.g., agriculture, mining), however they have moderate levels of habitat diversity, abundance, and hydrologic heterogeneity as discussed in Section 4.5.2. Despite this, no fish are present in the streams subject to works, and macroinvertebrates present are a combination of tolerant and moderately sensitive species. The realignment of Trimbells Gully allows for the ability to recreate aquatic habitat.

It is expected that the new Trimbells Gully channel will comprise a single channel, replicating the current natural channel. The channel is expected to contain an intermittent water flow as it will remain in the upper part of the catchment. The permanent, lower reaches of the catchment will be lost from its length. A single channel contains all water under baseflow conditions. Water may spill out of the channel given sufficient rainfall; however, the channel will be designed to accommodate flows up to the 1% AEP event. The current channel has good connection with the wider gully floor and flood plain. The realigned channel will result in some loss of connection through restraining flows to the channel. However, it is expected natural processes will allow a narrower low flow type channel to form in the constructed alignment, replicating the current situation where a narrow channel can overtop to the gully floor flood plain. The true right will comprise unimpacted, existing land, shaped by the flow of water through shallow gullies. The WRS will be set back from the channel on the true left bank to ensure stream flow does not undermine the stability of the WRS, creating a relatively flat flood plain.

The channel will be designed to provide enhanced hydrological variation and habitat diversity. The addition of some hard substrates (e.g., boulders and large wood) will provide eddies, velocity changes,

and interstitial spaces and pools at intervals which will provide habitat for aquatic macroinvertebrates and increase hydraulic heterogeneity. Due to the lack of fish, providing fish habitat is not considered a priority. However, the hydraulic heterogeneity will provide habitat for fish, should they ever be able to reach the site. Direct transfer of tussocks excavated from the current Trimbells Gully alignment will be undertaken, to where gaps in the riparian vegetation are present on the new alignment. As the location of the new alignment is currently vegetated with tussocks, it is anticipated vegetation transfer will only need to occur to areas that are disturbed by earthworks to create the new channel. As tussocks are slow growing, this allows significantly more rapid revegetation of the new alignment to occur, providing shade, bank stability and habitat. The proposed realignment will recreate habitat of similar quantity and quality to what is currently present, largely replicating substrates, shade, ground filtration, organic matter inputs and instream habitat. A sediment pond will be constructed on the lower reaches of the realignment, replicating what is currently present on Trimbells Gully. While designs have not been confirmed, it is expected to present at least a partial barrier to fish passage consistent with the complete barrier currently present at this location. As no fish are present in this reach of Trimbells Gully, maintaining fish passage is not considered necessary.

Current, potential and post-enhancement SEV scores, providing a quantitative assessment, are summarised in Table 7. The assumptions used for the SEV scores are provided in Appendix C. The potential SEV score reflects typical 'best practice' stream management in rural Otago hill country, i.e., stock exclusion, retention/development of riparian tussock and scrub, and no instream enhancements. The post-enhancement SEV score represents the condition five or more years after the proposed enhancement works, including 10 m of riparian planting on North Branch Waikouaiti and 20 m of riparian planting on Murphys Creek.

The current and potential SEV scores for the permanent reach of Trimbells Gully and Clydesdale Creek tributary are 0.544 and 0.547, respectively, while the intermittent reaches of Trimbells Gully and Trimbells Gully tributary both score 0.482. For the impacted reaches, the potential SEV scores, reflecting best-practice stream management, are marginally higher than current scores, indicating no significant residual reduction in ecological value. For the compensation reaches, comparison of current SEV scores with the post-enhancement scores indicates a substantial increase in ecological value.

Overall, the proposed realignment is expected to maintain or enhance habitat quality, and no significant residual adverse effects on ecological function are anticipated.

Table 7. Current, potential and post-enhancement SEV scores for impact and compensation reaches.

Stream	Current SEV	Potential SEV	Post-enhancement SEV
Impacted reaches			
Trimbells Gully Permanent	0.544	0.547	
Trimbells Gully Intermittent	0.482	0.482	
Clydesdale Creek tributary	0.544	0.547	
Trimbells Gully tributary	0.482	0.482	
Compensation reaches			
North Branch Waikouaiti River	0.250		0.551
Murphys Creek	0.574		0.811

Notes: Compensation reaches use the current SEV score as the baseline, therefore no 'potential' scores have been calculated for compensation reaches; grey shaded cells do not have a SEV score.

Stream compensation

The realigned Trimbells Gully will result in a net loss of 105 lineal metres of stream, the works at Golden Bar will result in a net loss of 22 lineal metres of permanent stream (Clydesdale Creek tributary) and the installation of a sediment retention pond will result in the loss of 80 lineal metres of the intermittent Trimbells Gully tributary. Topographic constraints prevent the realignment being lengthened in Trimbells Gully and prevent any reinstatement of stream at Golden Bar and the Trimbells Gully tributary. Therefore, it is proposed to enhance alternative streams to compensate for the loss of stream habitat in Trimbells Gully, Golden Bar and Trimbells Gully tributary.

To compensate for the loss of stream habitat, it is proposed to restore and enhance the North Branch Waikouaiti River, upstream of Red Bank Road, and enhance Murphys Creek. The loss of permanent habitat in Trimbells Gully and Clydesdale Creek tributary will be compensated through enhancing the permanent Murphys Creek. Compensation for the loss of intermittent habitat in Trimbells Gully and its tributary will be achieved through enhancing the intermittent North Branch Waikouaiti River.

The proposed compensation site on the North Branch Waikouaiti River currently has very low ecological values. It is artificially channelised, subject to excessive macrophyte growth, has direct stock access, and no riparian shading or vegetation. The instream conditions are intermittent, and very anoxic when water is present. It has a current SEV score of 0.250 indicating very low habitat values.

Enhancing the North Branch Waikouaiti River has been selected for several reasons, including:

- The enhancement site is at the top of the catchment meaning improved habitat and water quality will have an influence on the entire river.
- The reach of the river has been historically modified and returning it to a more natural condition is inherently positive.
- An engineered groundwater seepage collection drain will be installed around the base of the Frasers West WRS, preventing contaminated water from entering the river.
- At completion of mining, it is intended to reinstate the upper reaches of the river that were reclaimed at the commencement of the Macraes operation. Ultimately, it is intended a channel will be constructed across the completed Frasers tailings storage facility reconnecting the spring-fed upper catchment of the North Branch Waikouaiti River near the intersection of Macraes and Golden Bar Roads, to the remaining channel. The enhanced compensation reach would complement any recreated channels, but enhancement is not reliant on the reinstatement of the historically reclaimed reaches (note the recreation of the upper reaches is not included in MP4 proposed works but are discussed to provide context only). If mining plans and conditions change, and the upper channel is not reinstated, the reach enhanced as part of MP4 will act as the headwaters for the North Branch, still providing significant ecological benefits for lower reaches.

The proposed Murphys Creek enhancement reach currently has moderate values. It is subject to direct access by stock, contains areas of excessive macrophyte growth greatly limiting the streams ability to provide fish habitat in this area, and generally lacks riparian vegetation. Enhancing Murphys Creek has been selected for several reasons:

- The site is located near the top of the catchment meaning any enhancements will influence downstream values.

- The site is located downstream of a sediment pond. Enhanced riparian planting will assist with management of sediment in overland flow.
- It is in proximity to terrestrial enhancement areas providing connection to these habitats, particularly the MEEA.
- It is subject to current and historical pressures from mining, creating room for enhancements and returning to a more naturalised state.

Summarised current, potential and post-enhancement SEV scores for the compensation reaches, and the assumptions used to derive them, are provided in Appendix C. The potential SEV scores were based on typical 'best practice' stream management in rural Otago flat land, i.e., stock exclusion, 10 m of riparian planting on each bank and no instream enhancements. The post enhancement SEV scores are based on the condition more than five years after the proposed works, including some instream habitat enhancement and stream works such as recreation of meanders (for North Branch Waikouaiti River only), fencing from stock, and 10 m of riparian planting on both banks of the North Branch Waikouaiti River and 20 m on both banks of Murphys Creek), have been implemented.

An ecological compensation ratio (ECR) (Storey et al. 2011) was then calculated using the impact stream potential score (SEVi-P), impact stream post works score (SEVi-I), mitigation stream enhanced score (SEVm-E) and mitigation stream current score (SEVm-C). As the affected permanent reaches are conservatively assumed to be entirely lost, SEVi-I is taken as zero for these calculations. The ECR calculation is: $ECR = [(SEVi-P - SEVi-I) / (SEVm-E - SEVm-C)] \times 1.5$.

Table 8 provides a summary of compensation ratios and the corresponding lengths and areas necessary to compensate for stream losses. As design refinements have occurred during the reporting process, initial calculations for compensation were significantly higher. While less compensation is now required to address actual loss, the decision was made to continue with the initial planned compensation reaches. As it is not possible to accurately predict how much of the new alignment, if any, will contain permanent flow, it is conservatively assumed that all permanent habitat will be lost. For the loss of the permanent habitat in Trimbells Gully and Clydesdale Creek tributary, the ECR yielded a compensation ratio of 3.5:1 requiring a minimum compensation of 605 lineal metres on Murphys Creek (assuming a minimum of 20 m of planting on each bank). No intermittent habitat on Trimbells Gully will be lost; rather, there will be a gain of approximately 75 m of intermittent habitat. For the intermittent Trimbells Gully tributary, the ECR yielded a compensation ratio of 2.4:1, requiring a minimum compensation length of 31 m on North Branch Waikouaiti River. As the compensation reach should not be shorter than the impact reach, this value has been rounded up to a minimum compensation length of 80 m on the North Branch Waikouaiti River.

Final compensation reach lengths have been determined to fit most appropriately around existing property boundaries and stream crossings (Figure 14 and Figure 15), meaning significantly more of North Branch Waikouaiti River will be enhanced than is strictly necessary for compensation. As the realignment of Trimbells Gully intermittent reaches will result in a temporary loss of ecological values while the realignment works are completed, this additional enhancement will also compensate for that temporary loss. Once both the Trimbells Gully realignment and the North Branch Waikouaiti River enhancement activities have been completed, there will be gains in the value of intermittent stream habitat across the wider site.

Table 8. Summary of stream impact and proposed compensation quantities.

Metric	Trimbells Gully permanent	Clydesdale Creek tributary permanent	Trimbells Gully intermittent	Trimbells Gully tributary intermittent
Stream length lost (m)	180	22	0*	80
Stream area lost (m ²)	126	15	0*	38
Compensation stream	Murphys Creek (20 m riparian planting)		North Branch Waikouaiti River (10 m riparian planting)	
Compensation ratio	3.5 : 1		2.4 : 1	
Compensation reach area (m ²)	436	54	0	92
Compensation reach length (m)	539	66	0	31 (increased to 80) +
Final compensation reach length (m)	640		950	

Notes: * All lost intermittent stream will be reinstated through the stream diversion. + Compensation reaches cannot be smaller than the impact reach, therefore minimum length is rounded to the same length as the impact reach.

Overall, the proposed stream compensation and enhancement activities are expected to result in no net loss, and potentially net ecological benefit, to freshwater ecological values, provided that the proposed stream realignment and compensation measures are implemented as designed. This conclusion is based on the application of ecological compensation ratios, the scale of the proposed enhancement works, and the anticipated improvement in habitat condition, and is contingent on successful plant establishment and ongoing monitoring.

The effectiveness of the proposed stream realignment, compensation measures and direct transfer of riparian vegetation is dependent on detailed design, implementation and follow-up management. Detailed design should be undertaken by suitably qualified freshwater ecology and geomorphology specialists, and incorporate appropriate staging, erosion and sediment control measures, and fish salvage where required. Clear riparian establishment targets should be defined and a programme of monitoring and adaptive management implemented, including contingency measures where performance outcomes are not achieved. These details are included in the stream compensation plan provided as Appendix E.

An assessment of the proposed compensation against the principles of biodiversity compensation is provided in Appendix F, as per Appendix 4 of the National Policy Statement for Indigenous Biodiversity.

Figure . Proposed compensation footprint - North Branch Waikouaiti River

-  Proposed footprint
-  North Branch Waikouaiti River
-  Compensation reaches
-  Riparian enhancement

SOURCES
Google Satellite 2023

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Figure . Proposed compensation footprint - Murphys Creek

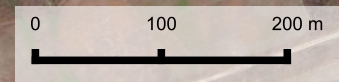
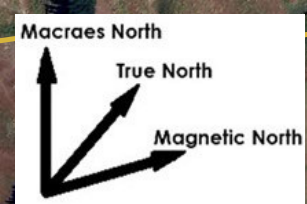
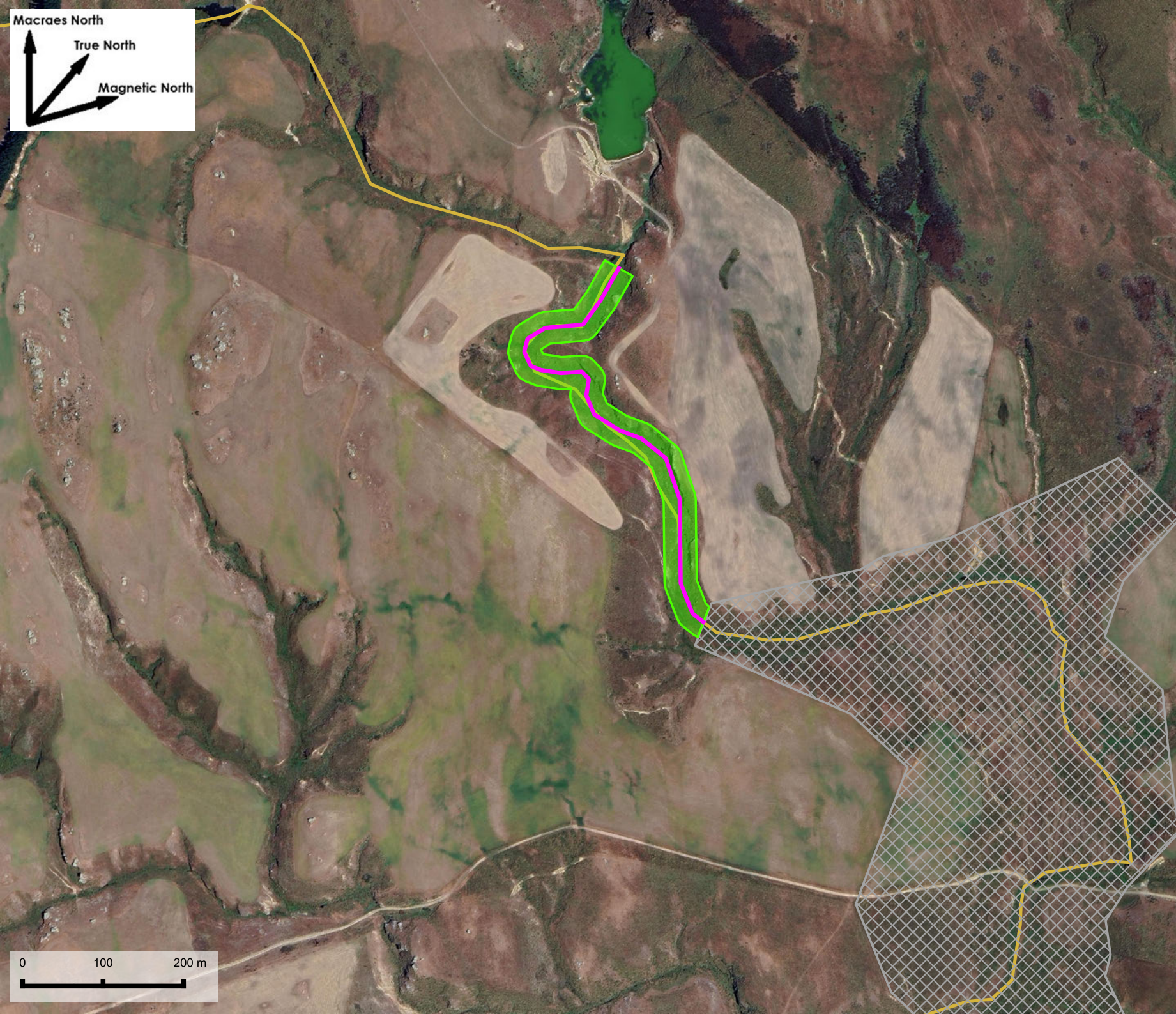
-  Murphys Creek
-  Compensation reaches
-  Riparian enhancement
-  Murphys Creek Heritage Reserve

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5.3.3 Impact on fish

The magnitude of effect on fish as a result of stream reclamation works is considered to be moderate, mitigated to low. The overall level of effect following mitigation will be very low.

Physical works in streams, including reclamation and realignment, have the potential to result in death or injury to any fish present in the impacted reach at the time of works. The impacted reaches of streams are in the upper parts of catchments. Results of eDNA sampling suggest no fish are present in Trimbells Gully, and the presence of a complete fish barrier in the sediment ponds in both Trimbells Gully and the Clydesdale Creek tributary, means the likelihood of fish being present in the impacted reaches is very low. Effects on fish habitat are therefore considered to be negligible, with a higher impact on fish resulting from elevated sediment levels in the downstream reaches, where fish are known to be present, during works. Effects of sediment on streams are considered separately below.

Despite the unlikelihood of fish being present in the works reach, fish salvage is recommended for works to reclaim the permanent reach of Trimbells Gully, downstream of the sediment pond, as a precaution against any fish that may periodically move upstream from TG01. Fish salvage is not considered necessary upstream of the sediment pond barriers in either Trimbells Gully or the Clydesdale Creek tributary, given the complete barrier to fish passage at both locations. A draft Fish Management Plan (FMP) has been prepared and is provided in Appendix G. Providing works occur as per the FMP, effects on fish are expected to be low.

5.3.4 Impact on invertebrates

The magnitude of effect on aquatic invertebrates as a result of stream reclamation works is considered to be low. The overall level of effect will be very low.

Physical disturbance and instream works have the potential to impact aquatic macroinvertebrates through removal of habitat and changes to instream habitat which can make it unsuitable for species that may currently be present. The macroinvertebrate community present in the Trimbells Gully permanent and intermittent reaches was characterised by common, relatively tolerant species, with an MCI value of 94 for both reaches. This is indicative of moderate organic pollution or nutrient enrichment and is only slightly above the national bottom line in the NPS-FM of 90. The Trimbells Gully tributary and Clydesdale Creek tributary are considered likely to support broadly comparable communities to those in Trimbells Gully, given their similarly modified, tolerant-species-dominated conditions (see Trimbells Gully tributary and Clydesdale Creek tributary sections in Section 4.5.1). Macroinvertebrates have a relatively short life cycle, and are capable of rapidly recolonising a disturbed habitat, providing a source population is available. It is expected the realigned reach will be recolonised, providing water is present, rapidly after construction, with the source population provided by the lower reaches of Trimbells Gully.

5.3.5 Impact on riparian vegetation

The magnitude of effect of the proposed works on riparian vegetation is considered to be moderate, mitigated to low. The overall level of effect on riparian vegetation will be very low.

Vegetation along Trimbells Gully was predominantly native red tussock (e.g. *Chionochloa rubra*) with lesser amounts of exotic pasture grasses, likely remaining from pre-mine land uses. The tussocks provided various ecosystem services including shading of the stream, organic matter input and bank stability. As the footprint of the WRS will extend over the current Trimbells Gully alignment, riparian vegetation will be lost. It is proposed to undertake direct transfer of the existing riparian tussocks to the new alignment/diversion. Direct transfer allows a more rapid establishment of riparian vegetation,

through planting mature individuals along with their roots, soil structure and complementary biological communities such as fungi and invertebrate communities.

There was no riparian vegetation along the stream reach of the Clydesdale Creek tributary. Vegetation present on this waterway was limited to the upper reaches, where wetland conditions were present, and is therefore considered in Bioresarches (2026).

Direct transfer of tussocks will be undertaken as far as practicable within areas of the new alignment disturbed by earthworks, prioritising tussocks within 10 m of the constructed channel where sufficient bare ground is created to support their establishment. The extent of direct transfer required will depend on the degree to which the riparian zone of the new alignment is disturbed during construction; where earthworks are limited, correspondingly less transfer will be necessary.

Additional mitigation will be achieved through the enhancement measures, including riparian planting of the North Branch Waikouaiti River, as per the discussions above.

5.3.6 Effects of sediment

The magnitude of effect of sediment generated by the proposed MP4 works on stream environments is considered to be moderate, mitigated to low. The overall level of effect of sediment on stream environments will be low.

Earthworks within and in the vicinity of rivers and streams have the potential to introduce excess loads of fine sediment to the aquatic environment. High sediment loads in streams can have significant detrimental effects on ecology, including through smothering of food resources and interstitial spaces, reducing light penetration and clogging the gills of fish and invertebrates. All aquatic biota have some level of adaptation to short periods of high sediment, as would be experienced following periods of rainfall. However, it is the chronic, long term exposure to high sediment loads that has the potential for the most significant negative impact.

Physical works associated with MP4, including stream realignment and enhancement works, will generate sediment that is likely to enter the streams if not properly managed. All works will occur under an erosion and sediment control plan prepared and implemented to current industry best practice.

Various sediment ponds are located around the wider mine site that function to trap sediment flowing off works areas before it enters natural waterways. Additional erosion and sediment control measures will be located around the site associated with the MP4 works. Providing all erosion and sediment control measures function as intended, the impact of sediment on freshwater environments is considered to be low.

Quarterly monitoring occurs around the site, including percentage cover of fine sediment, and sampling of invertebrates. This monitoring is proposed to continue to cover the MP4 project (refer Appendix D). Any increases in fine sediment in the environment will be detected through monitoring, and any changes in habitat and water quality will be detected through changes in the macroinvertebrate community. The monitoring allows identification of issues that require remediation, such as sediment control measures not working as intended.

5.3.7 Effects of sediment retention ponds

The magnitude of effect of installing sediment retention ponds is considered to be moderate where the ponds are located on streams, and negligible where they are located on ephemeral channels. The overall level of effect will be low.

Ten sediment retention ponds are proposed as part of MP4. Of these, eight are located either outside of stream channels or on reaches that have been classified as ephemeral. The construction and operation of these eight ponds will have no impact on aquatic ecology beyond the impact of sediment generated during construction, the effects of which have been covered above.

Two sediment retention ponds (Trimbells SRP 1 and 3) will be constructed on intermittent reaches of Trimbells Gully and its tributary (Section 2.4). The impacts of this have been covered in Section 5.3.2 and appropriate mitigation in the form of stream compensation has been proposed.

Providing the ponds function as intended, their presence and operation is likely to have positive impacts on stream function and value through the interception and retention of excess fine sediment before it enters natural waterways.

5.3.8 Effects of predator-proof fence

The magnitude of effect of the proposed predator-proof fence on Murphys Creek is considered to be moderate, mitigated to low. The overall level of effect of the predator-proof fence on aquatic values, namely fish, will be low.

As part of the construction of the predator-proof fence associated with the MEEA, Murphys Creek itself will be crossed by the fence in two separate locations. In addition, smaller tributaries flowing into Murphys Creek are also likely to require culverts. To prevent the creek crossings becoming points of incursion by pests into the MEEA, it is necessary to construct culverts with exclusion gates or similar.

Culverts associated with permanent and intermittent fish-bearing streams will be designed to maintain fish passage in accordance with the New Zealand Fish Passage Guidelines (Franklin et al., 2018) while also maintaining the integrity of the predator exclusion fence. Similar approaches have been successfully implemented at a number of mainland predator-fenced sanctuaries in New Zealand, including Maungatautari, Rotokare Scenic Reserve, Brook Waimārama Sanctuary and Zealandia, demonstrating that fish passage and mammalian pest exclusion can be achieved simultaneously through appropriate engineering design.

Where practicable, maintenance of the natural streambed through the culvert will be maintained and velocities will be suitable to allow passage of indigenous fish. The culverts are expected to contain removable inspection panels to easily facilitate maintenance and debris removal. They will also include measures to prevent scour, sediment accumulation and preferential flow paths that could compromise either fish passage or fence integrity.

The culverts are expected to act as partial barriers to fish passage as certain design restrictions are required to ensure the integrity of the predator exclusion functions. Fish present in Murphys Creek include Taieri flathead galaxias, upland bully, longfin eel and shortfin eel. Taieri flathead galaxias and upland bully are non-migratory species that complete their lifecycle within relatively small reaches of stream. As such, their populations are less dependent on longitudinal connectivity, and the proposed culvert structures are unlikely to result in a significant effect on these species.

In contrast, both longfin and shortfin eels are diadromous and rely on movement between freshwater and the marine environment to complete their lifecycle. While both species were detected in the eDNA samples from Murphys Creek, longfin eels have only been recorded at Murphys Creek monitoring sites on two occasions during annual surveys (once at MC01 in 2007, and once at MC100 in 2013). This suggests eels are not abundant in the catchment. Migration of eels up and downstream will be incorporated into the culvert design, however passage is expected to be reliant on certain flow velocities

and therefore may not be available continuously. While passage is likely to be constrained under typical flow conditions, ecological connectivity is not entirely lost. Given the low abundance of eels and the upper catchment location of the site, the overall effect on eel passage is considered to be low.

Overall, the proposed culverts are expected to have a minor effect on fish communities within Murphys Creek. Non-migratory species such as Taieri flathead galaxias and upland bully are unlikely to be affected, while diadromous species such as eels may experience some constraint to passage under typical flow conditions. However, periodic passage, combined with the low abundance of eels, and the upper catchment location, means ecological connectivity is not lost and population-level effects are expected to be minor.

It is recommended fish management occurs if the culverts are required to be constructed 'in the dry'. A draft fish management plan is provided in Appendix G.

5.3.9 Effects of mine subsidence

The magnitude of effect of underground mine subsidence on Deepdell Creek is considered to be very high, mitigated to low. The overall level of effect will be low.

GPUG will extend beneath the alignment of Deepdell Creek. Modelling indicates that stoping directly below the creek is likely to cause *"significant subsidence (in the order of >1,000 mm) that may lead to dilation of existing fractures in the rock mass and fault zones and/or opening of new cracks"* (PSM 2026). Conservative base-case modelling of a full, unmitigated mine plan predicts *"subsidence up to 5 m and tensile strain up to 1.5% at Deepdell Creek - an order of magnitude greater than measured subsidence"*, which PSM (2026) attributes to *"conservative DDFZ [Deepdell Fault Zone] characterisation requiring refinement"*. If a crack should open at surface level, there is the potential for the flow of Deepdell Creek to be drained to ground, which could result in the loss of aquatic habitat within the creek for a significant distance downstream, as well as very reduced flows in the lower reaches of the catchment.

The risk is managed through a stand-off line around the creek, within which only limited works (i.e., declines, access tunnels, cross cuts, but no stoping) can occur (PSM 2026). Stopping within this zone may proceed once the geotechnical model is refined with additional data and detailed analyses demonstrate the risk to the creek is low. As a result, the risk of mine subsidence on Deepdell Creek is considered to be mitigated.

5.4 Summary

Table 9 provides a summary of expected effects on water quality and aquatic ecological values as a result of the Project. It considers the ecological value of all impacted features, summarised in Table 4, and the magnitude of effect of proposed works on those features, both before and after planned mitigation has been applied. The overall level of effect illustrates where residual effects are expected following all mitigation.

Table 9. Summary of magnitude and overall level of effects on aquatic values.

Effect	Ecological value*	Magnitude of effect before mitigation	Magnitude of effect after mitigation	Level of effect	Proposed mitigations
Catchment scale impacts					
Effects on stream flow	High-Very High	Moderate	Low	Low**	Augmentation dams, treated water returns, erosion/scour protection, flow monitoring
Effects on water quality	Moderate-High	Variable; ranging from positive to High	Low	Low	Augmentation dams, seepage capture, treatment refinement, source, receiving water and biological monitoring, adaptive management
Reach scale impacts					
Effect of stream works	Low	High/Moderate	Low	Very Low	Compensation activities on North Branch Waikouaiti River and Murphys Creek
Impact on fish from stream works	Low	Moderate	Low	Very Low	Fish management during works
Impact on invertebrates from stream works	Low	Low	Low	Very Low	No specific mitigations necessary
Impact on riparian vegetation from stream works	Low	Moderate	Low	Very Low	Direct vegetation transfer of tussocks on realigned Trimbells Gully, and enhancement works on compensation reaches
Effects of sediment	Low	Moderate	Low	Very Low	Erosion and sediment control measures
Effects of sediment retention ponds	Low	Moderate	Low	Very Low	Compensation activities on North Branch Waikouaiti River and Murphys Creek
Effects of the predator-proof fence	Moderate	Moderate	Low	Low	Fish passage to be incorporated into culvert design (NZ Fish Passage Guidelines); fish management during construction where required
Effects of mine subsidence	High	Very High	Low	Low	Exclusion zone until models can be updated

Notes: *Refers to ecological value of existing environment affected by proposed activity; **rising to moderate if flushing continues without adequate recovery of affected invertebrate and fish populations

6 RECOMMENDATIONS

The following recommendations are provided to ensure that the effects of the Project on instream aquatic values are appropriately avoided, mitigated, monitored and, where necessary, adaptively managed:

- Flow-management measures, including augmentation dams, treated-water returns, erosion/scour protection and continuous flow monitoring, are implemented to manage effects on the receiving environment's hydrological character.
- Refinement and adaptive management of flushing regimes for periphyton control, informed by ongoing flow, periphyton and ecological monitoring to ensure flushing remains effective and ecologically appropriate.
- Water-quality mitigation, including seepage capture, treatment refinement, monitoring and adaptive management, is progressively implemented and refined during the Project phases.
- OGNZL implements a consistent, network-wide water quality sampling and aquatic biomonitoring programme, as detailed in Appendix D.
- The proposed surface-water quality compliance framework is progressively implemented in accordance with Appendix A, using monitoring data to assess water-quality effects, test model assumptions and inform adaptive management.
- Underground mining beneath Deepdell Creek is managed in accordance with the stand-off line described in Section 5.3.8, informed by ongoing subsidence monitoring.
- Stream realignment, enhancement and compensation works are undertaken in accordance with the stream compensation plan in Appendix E.
- Works within the permanent reaches of Trimbells Gully (i.e., downstream of the sediment pond) are undertaken in accordance with a fish management plan (a draft plan is provided in Appendix G).
- Culverts associated with the predator-proof fence crossing Murphys Creek are designed in accordance with the New Zealand Fish Passage Guidelines, with fish management undertaken during construction where culverts are required to be constructed 'in the dry'.
- Direct transfer of riparian vegetation from the reclaimed reaches of Trimbells Gully should occur with transfer to the realigned channel where existing vegetation has not been able to be retained.
- All works as part of the Project should occur under an appropriately designed and implemented erosion and sediment control plan.

7 CONCLUSIONS

OGNZL is seeking to extend the life of the current Macraes Operation through the development of MP4. The project has been listed in the FTAA (2024). The MP4 project will include various activities including open pit and underground mine expansions, tailings management, waste rock disposal, water management, infrastructure works and specific ecological enhancements.

Viridis was engaged by OGNZL to undertake an assessment of the Project's effects on freshwater quality and instream ecology and, to the extent required, identify any necessary management and operation measures to address any such effects.

Within the wider receiving environment, several water quality parameters were identified to be historically elevated, with evidence of an associated ecological response. Assessments of the aquatic environment within the MP4 footprint identified a number of tributaries across three main catchments. The tributaries generally have moderately degraded water and habitat quality, typical of their setting within an extensive agricultural environment. Despite this, the ecological values of the three main catchments were considered high-very high due to the presence of At Risk and Threatened fish species. Values of stream reaches impacted by physical works as part of the Project, i.e. reclamation and/or realignment, were low, largely due to the lack of fish, location high in the catchment, stock access and a modified riparian zone.

The Project's mine water management is predicted to result in changes to both receiving-water flow and water quality. Flow effects are expected to be low following implementation of the proposed augmentation dams, treated-water return, erosion/scour protection and monitoring measures, rising to moderate only if flushing continues without adequate recovery of affected invertebrate and fish populations. Water-quality effects vary by contaminant, catchment and Project phase, ranging from positive or negligible to moderate to high where sustained non-compliances of the new framework are predicted, noting that some parameters may take longer than Phase B to achieve compliance as mitigation is refined. However, the modelling incorporates several conservative assumptions and does not fully account for natural attenuation, progressive refinement of mitigation or corrective management responses. With the proposed treatment, monitoring and adaptive-management framework in place, the residual risk of sustained adverse effects on aquatic ecological and drinking-water values, accounting for the staged transition, is assessed as low.

Impacts of physical works on streams cannot be avoided and as a result there will be a loss of 202 m of permanent stream, across two waterways (Trimbells Gully and Clydesdale Creek tributary), and a loss of 80 m of intermittent stream at the Trimbells Gully tributary (Table 6). The proposed realignment of Trimbells Gully will result in an increase in intermittent stream; however, there will be a lag between constructing this habitat and the stream functioning as a natural waterway. To compensate for this loss, it is proposed to enhance 950 m of the intermittent North Branch Waikouaiti River and 640 m of the permanent Murphys Creek (Table 8). Compensation lengths on both streams are larger than required by the calculated ECR.

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Appendix A

Recommended Surface Water Quality Framework

Macraes Phase 4 Project

Recommended Surface Water Quality Compliance Framework

Prepared for: OceanaGold (New Zealand) Limited

September 2026



DOCUMENT CONTROL AND REVISION HISTORY

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Author	
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Reference: Viridis 2026. Macraes Phase 4 Project: Recommended Surface Water Quality Compliance Framework. Report for OceanaGold (New Zealand) Limited by Viridis Limited. September 2026.

Cover photo: Water quality monitoring site MB01, pictured during the summer aquatic monitoring survey on 10 December 2025.

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1 INTRODUCTION

OceanaGold (New Zealand) Limited (OGNZL) currently undertakes open pit and underground gold mining operations at the Macraes Operation located at Golden Point Road, Macraes Flat, East Otago ('the site'). As part of their ongoing operations, OGNZL continually review the remaining life of the Macraes Operation in light of updated knowledge of the gold resource and the economics of mining.

Reflecting recent exploration success and optimisation work, together with higher gold prices, the Macraes Phase Four Project (MP4 or 'the Project') seeks to extend the life of mining at the Macraes Operation until at least 2039. The Project, which will enable ongoing gold production at a rate of approximately 130,000 ounces per annum, is identified as a Listed Project in Schedule 2 of the Fast-track Approvals Act 2024 (FTAA) as a project providing significant national or regional benefits.

To support the development of the substantive application for the Project, OGNZL has engaged Viridis Limited (Viridis) to develop a compliance framework for assessing surface water quality at key receiving environments. While compliance limits already apply at various downstream surface water sites under existing consents, these have been developed over time through multiple consenting processes and reflect differing methodologies. As such, they do not constitute a single, consistent approach aligned with contemporary guidelines. The proposed MP4 development provides an opportunity to implement a more coherent and up-to-date framework for assessing and managing surface water quality effects across the site, consistent with guideline values.

The framework is intended to provide a more integrated and transparent approach to water quality compliance assessment, aligned with current best practice and guidance, tailored to site-specific conditions at the Macraes Operation. It will enable the identification of potential water quality issues and facilitate timely management responses to avoid adverse effects.

This report outlines the proposed framework, its application at the Macraes Operation, and the rationale for the development of trigger values and compliance criteria. The framework draws on relevant national and international guidance and, where appropriate, considers site-specific water chemistry, monitoring data, and ecological information, including factors relevant to both contaminant toxicity and nutrient enrichment.

2 BACKGROUND

2.1 Site Location and Description

OGNZL owns and operates the Macraes Operation at Macraes Flat, approximately 30 km northwest of Palmerston in the Otago Region. The Macraes Operation is the largest gold mine in New Zealand and, since commissioning in 1990, has produced more than 6 million ounces of gold.

Macraes Flat is situated on an elevated plateau at approximately 500 m above sea level. The plateau is flanked by the Taieri Ridge to the northwest, Shag Valley and Horse Range to the east, and the coastal hills and extinct volcanic cones of Palmerston and Waikouaiti to the southeast. Macraes Road provides access to Macraes Flat and the Macraes Operation, connecting to State Highway 85 to the east and State Highway 87 (SH87, the Middlemarch–Hyde Road) to the west.

The environment within and surrounding the Macraes Operation has been shaped by historical and current mining activities undertaken in accordance with existing resource consents. Figure 1 shows the arrangement of the major mine features at the Macraes Operation. In summary, the current components of the Macraes Operation include:

- Numerous open pits (both operational and non-operational).
- Two underground mines (Fraser's, now closed, and Golden Point, which is actively mined).
- Waste rock stacks at various stages of operation and rehabilitation.
- A network of haul roads and general mine service tracks.
- A processing plant.
- Five tailings storage facilities (three inactive, one active but nearing capacity, and one under construction and currently receiving tailings).
- An extensive network of water management infrastructure, including diversion drains, silt ponds, sumps, pit lakes, and freshwater storage reservoirs.
- Two consented but not yet constructed water storage reservoirs (Camp Creek and Coal Creek Dams).
- Associated infrastructure supporting ongoing operations, including district roads, powerlines, workshops, offices, and associated water and amenity facilities.

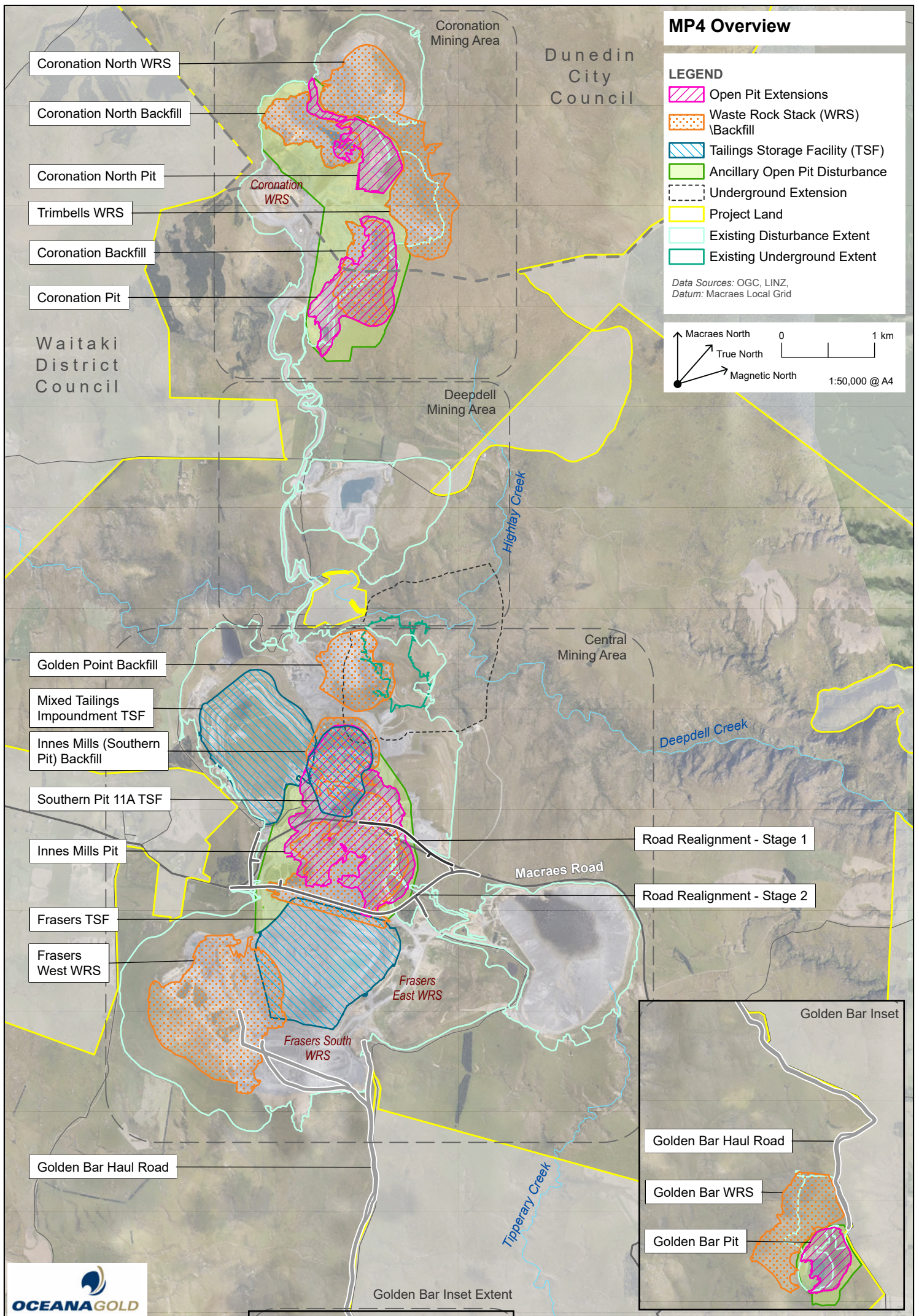
2.2 MP4 Project Overview

The MP4 Project comprises the following proposed key activities:

- Open pit extensions at Coronation, Coronation North, Innes Mills and Golden Bar.
- Underground mine expansion through further development of the Golden Point Underground mine ('GPUG').
- Tailings management, including:
 - Construction of the Fraser's Tailings Storage Facility ('FTSF') Stage 3 to accommodate a total tailings storage of up to 153 Mt.
 - Hydraulic mining and relocation of tailings from the Mixed Tailings Impoundment ('MTI'), Southern Pit Option 10 TSF ('SP10'), and Southern Pit Option 11A TSF ('SP11') to FTSF.

- Waste rock disposal, including increased storage capacity within open pits and at existing waste rock stacks at Coronation, Coronation North, Innes Mills, Golden Bar, Golden Point, and Frasers.
- Water management infrastructure and operations, including:
 - Construction of Camp Creek and Coal Creek dams for flow and water quality management.
 - Construction, operation and maintenance of a Water Treatment Plant.
 - Ongoing operation and maintenance of the Mine Water Management System ('MWMS').
- Infrastructure and roading works, including:
 - Realignment of Macraes Road in two stages; and
 - Relocation of the Open Pit Mining Workshop.
- Ecological enhancements, including establishment of:
 - Murphys Ecological Enhancement Area ('MEEA') near Murphys Creek, including predator-proof fencing, access tracks, and site facilities.
 - Mt Highlay restoration area.
 - Cranky Jims Link shrubland enhancement area.
 - Murphys Link tussock protection area.
 - Additional offset and compensation measures for residual ecological impacts.
- Mine closure and rehabilitation activities, including rehabilitation of mining landforms, creation of pit lakes, dry capping of tailings storage facilities, and revegetation in accordance with closure objectives.

An overview of the proposed activities which make up the Project is shown in Figure 2.



3 EXISTING COMPLIANCE FRAMEWORK

3.1 Overview

OGNZL currently holds resource consents¹ issued by Otago Regional Council (ORC) authorising discharges to surface water bodies within three key receiving catchments: Shag/Waihemo, Waikouaiti and Taieri. Compliance is assessed at prescribed monitoring sites in accordance with specified schedules, which define site locations, parameters, sampling frequency, consent limits, and how compliance is assessed. OGNZL also monitors supplementary sites to support interpretation of water quality within the wider receiving environment.

3.2 Monitoring Network

The monitoring network comprises sites located within key receiving environments downstream of mining activities, as well as at upstream control locations where available. These sites represent key locations for assessing the potential effects of discharges on receiving water quality.

Monitoring sites relevant to the Project are listed in Table 1 and shown in Figure 3. Table 1 lists compliance sites only, those carrying an applicable consent limit under Table 2. OGNZL voluntarily monitors control sites at DC00 in Deepdell Creek (Shag/Waihemo) and MB00 in Mare Burn (Taieri) to help distinguish potential project-related effects from background conditions. No upstream control sites exist in the Waikouaiti River catchment, as the Macraes Operation lies within its headwaters.

3.3 Consent Limits

A summary of existing consent limits in place at the Macraes Operation is provided in Table 2. These limits are applied at the compliance sites listed in Table 1, on a parameter-specific basis.

In general, the current consent limits have been informed by a range of national and international guideline values and standards available at the time of the relevant consenting, including:

- United States Environmental Protection Agency (USEPA) criteria for continuous concentration (CCC), representing concentrations protective of aquatic communities under chronic exposure.
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality trigger values (ANZECC 2000), which have largely been superseded by ANZG default guideline values (DGVs).
- National Policy Statement for Freshwater Management (NPS-FM 2020) national bottom lines (NBL).
- Drinking-water Standards for New Zealand 2005 (revised 2008) (MoH 2008), which have been superseded by the Water Services (Drinking Water Standards for New Zealand) Regulations 2022 and the Taumata Arowai (2022) Aesthetic Values for Drinking Water Notice 2022.

As a result of national and international guidance evolving and changing over time, consent limits at the Macraes Operation often reflect outdated guidance and, in some cases, vary in purpose (e.g., protection of aquatic ecology, human health or livestock) between sites. This is particularly evident at HC02, where the more recently approved consents for Highlay Creek (i.e., RM20.024.09 and RM20.024.14) specify a distinct set of limits and compliance requirements compared with other sites. Accordingly, there is merit to moving to a consistent, site-wide framework that aligns with contemporary guideline approaches.

¹ 96808, 2002.491, 2002.759, 2002.763, 2003.640, 2004.359, 2005.341, 2006.303-308, RM10.351, RM12.378, RM16.138, RM19.085, RM20.024

Macraes MP4 footprint and key water quality monitoring sites.

-  Proposed footprint
-  Water quality sites
-  Clydesdale Creek
-  Trimbells Gully Creek
-  Tipperary Creek
-  Shag River
-  North Gully Creek
-  Murphys Creek
-  McCormicks Creek
-  Mare Burn
-  Maori Hen Creek
-  Highlay Creek
-  Golden Bar Creek
-  Deepdell Creek
-  Waikouaiti River NB
-  Crank Jims Creek
-  Camp Creek

SOURCES
Google Satellite 2023

DISCLAIMER: This map/plan is not an engineering draft. This map/plan is illustrative only and all information should be independently verified on site before taking any action.

SCALE 1:120,000 @ A4

PROJECT NO. 10023
DRAWN BY: AJC
DATE: 12/08/2026

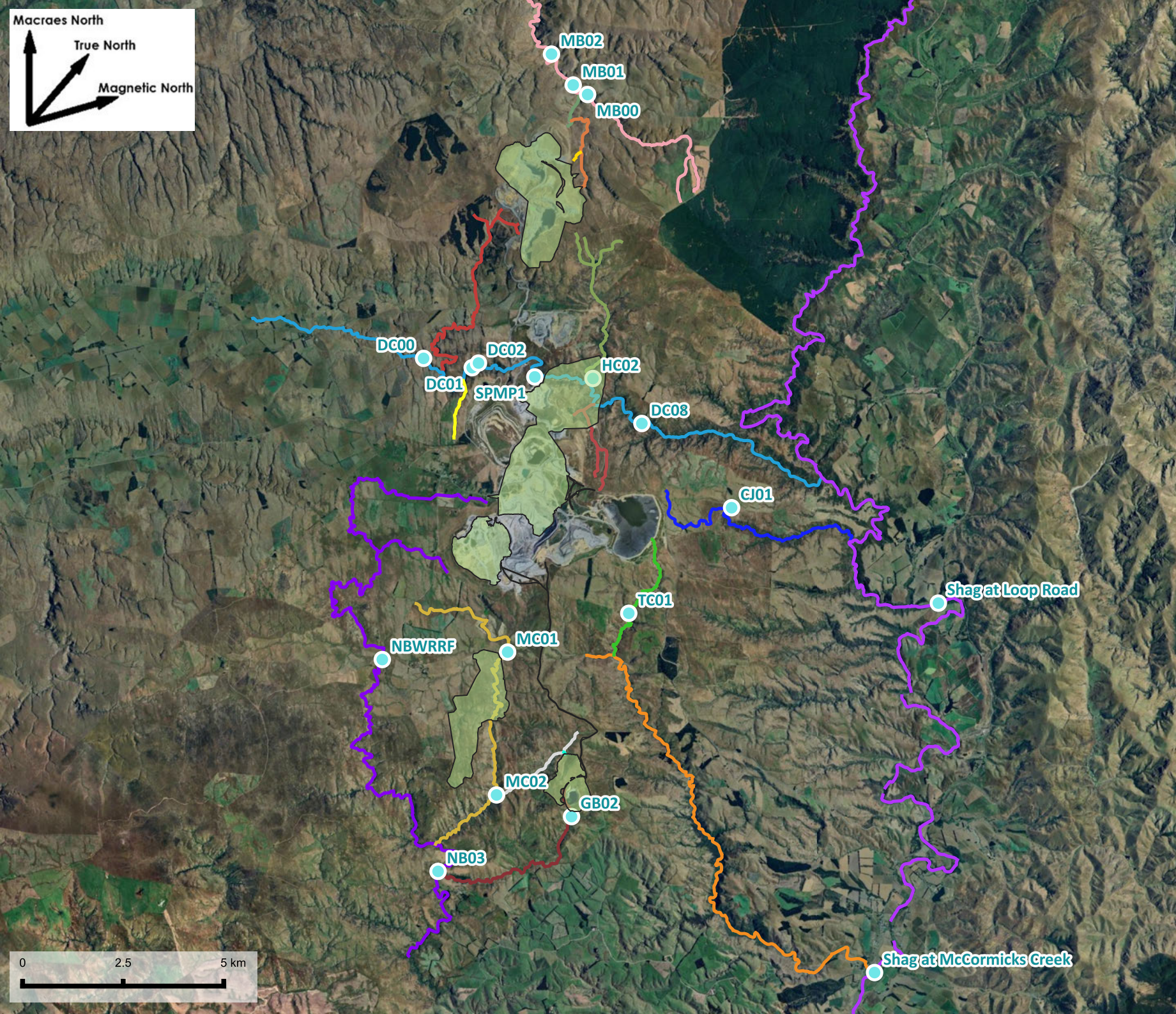


Table 1. Surface water quality compliance and control sites in existing Macraes Operation consents.

Site	Watercourse	Type
Shag/Waihemo River catchment		
DC00	Deepdell Creek	Control*
DC08	Deepdell Creek	Compliance
SPMP1	Battery Creek	Compliance
HC02**	Highlay Creek	Compliance
Shag at Loop Road	Shag/Waihemo River	Compliance
Shag at McCormicks	Shag/Waihemo River	Compliance
CJ01**	Cranky Jims Creek	Compliance
TC01**	Tipperary Creek	Compliance
Waikouaiti River catchment		
MC01	Murphys Creek	Compliance
MC02	Murphys Creek	Compliance
GB02***	Golden Bar Creek	Compliance
NBWRRF	North Branch of Waikouaiti River	Compliance
NB03	North Branch of Waikouaiti River	Compliance
Taieri River catchment		
MB00	Mare Burn	Control*
MB01	Mare Burn	Compliance
MB02	Mare Burn	Compliance

Notes: *Control sites are monitored by OGNZL on a voluntary basis; **these sites will not be affected by the Project and are therefore excluded from the new framework, as discussed in Section 4.3.1; ***GB02 is where the Golden Bar Pit lake standard (consent 2002.763) has been assessed since the pit lake began discharging in 2018.

3.4 Compliance Assessment

Under the existing framework, compliance is generally assessed through direct comparison of monthly monitoring results against applicable consent limits at each compliance site.

In most cases, exceedance of a consent limit on any sampling occasion constitutes non-compliance. However, consents RM20.024.09 and RM20.024.14 require that, at HC02, compliance with consent limits for nitrate nitrogen, arsenic, copper, lead, and zinc is assessed using rolling statistics². This contrasts with the single-sample exceedance approach applied at other sites and introduces a different basis for assessing compliance, incorporating longer-term exposure and site-specific considerations.

As a result, the existing framework applies a range of assessment approaches, including both instantaneous and rolling statistical measures, and does not provide a consistent, site-wide method for interpreting monitoring results or assessing ecological risk.

² Median or 95th percentiles, based on annual or 36 consecutive monthly samples, depending on parameter being assessed.

Table 2. Existing water quality compliance limits at Macraes Operation.

Parameter	Limit	Applicable sites	Source
pH (unitless)	7 - 8.5	Shag at Loop, Shag at McCormicks	MoH (2008) guideline value for aesthetic determinand
	6.5 - 9.5	MB02	
	6.0 - 9.5	CJ01, DC08, MB01, MC01, MC02, GB02*, HC02, NB03, NBWRRF, SPMP1, TC01	
Visibility (TSS / turbidity)	30-50% Δ	MB02	
Sulphate	1,000	CJ01, DC08, HC02, MB01, MC01, NBWRRF, TC01	ANZECC (2000) TV for livestock drinking water
	250	NB03, Shag at Loop Road, Shag at McCormicks	MoH (2008) guideline values for aesthetic determinands
Ammoniacal nitrogen (g N/m ³)	0.24	MB02	NPSFM (MfE 2025) NBL as annual median ^A
Nitrate nitrogen (g N/m ³)	2.4	DC08, HC02, MB02, Shag at Loop Road	NPSFM NBL (MfE 2025) as annual median ^{A,B}
	3.5	DC08, HC02, Shag at Loop Road	NPSFM NBL (MfE 2025) as annual 95th percentile ^{A,B}
Arsenic	0.15	CJ01, DC08, GB02, MB01, MB02, MC01, MC02, NBWRRF, SPMP1, TC01	USEPA (1995) CCC for As(III)
	0.013	HC02	ANZECC (2000) TV for As (V) at 95% protection level
	0.01	NB03, Shag at Loop Road, Shag at McCormicks	MoH (2008) maximum acceptable value
Copper	0.018**	CJ01, DC08, GB02, MB01, MB02, MC01, MC02, NB03, NBWRRF, Shag at Loop Road, Shag at McCormicks, SPMP1, TC01	USEPA (1984) CCC
	0.0076**	HC02	ANZECC (2000) HMTV 95% protection level
Iron	1	CJ01, DC08, GB02, MB01, MB02, MC01, MC02, NB03, NBWRRF, SPMP1, TC01	USEPA (1986) CCC
	0.3	HC02	ANZECC (2000) interim level from CCREM (1987)
	0.2	NB03, Shag at Loop Road, Shag at McCormicks	ANZECC (2000) long-term TV in irrigation water
Lead	0.0059**	CJ01, DC08, GB02, MB01, MB02, MC01, MC02, NB03, NBWRRF, Shag at Loop Road, Shag at McCormicks, SPMP1, TC01	USEPA (1985) CCC
	0.043**	HC02	ANZECC (2000) HMTV 95% protection level
Zinc	0.23**	CJ01, DC08, GB02, MB01, MB02, MC01, MC02, NB03, NBWRRF, Shag at Loop Road, Shag at McCormicks, TC01	USEPA (1995) CCC
	0.044**	HC02	ANZECC (2000) HMTV 95% protection level
Cyanide	0.1	CJ01, DC08, MB01, MB02, MC01, NB03, NBWRRF, Shag at Loop Road, Shag at McCormicks, SPMP1, TC01	

Notes: Units are in g/m³ unless stated otherwise; all metals are tested in the dissolved fraction unless stated; HMTV = hardness modified trigger value; DGV = default guideline value; NBL = national bottom line; ^A applied as fixed limit; ^B Calculated at pH of 8; * GB02 is the site at which the pit lake standard for Golden Bar Pit (consent 2002.763) is assessed, as set out in Note *** to Table 1; and ** adjusted here for a standard Macraes Operation hardness of 220 g/m³ as CaCO₃, though typically presented in consent schedules at a hardness of 30 or 100 g/m³ as CaCO₃.

4 PROPOSED COMPLIANCE FRAMEWORK

4.1 Overview

To support the MP4 development, a new compliance framework is recommended. The framework will consist of trigger values that, when exceeded, initiate defined response actions. In practice, the framework will operate as a stepwise process:

- Surface water quality is monitored monthly at defined locations.
- Monitoring results at compliance sites are compared against trigger values, adjusted for site-specific chemistry where appropriate.
- Where a trigger value is exceeded, it will prompt further assessment and, where appropriate, investigation and / or management response.
- Where exceedances occur at a defined frequency or duration and are demonstrated to be attributable to mine operations, this results in non-compliance.
- Non-compliance will trigger management intervention and, if appropriate, longer-term mitigation measures.

This structure distinguishes between early warning indicators (trigger value exceedances) and elevated likelihood of adverse effects (non-compliance), enabling a proportionate, risk-based response.

4.2 Key Definitions

4.2.1 Compliance site

A compliance site is a defined monitoring location within the receiving environment where water quality is formally assessed against trigger values under this framework. Compliance sites represent locations where potential project-related effects are expected to be measurable and form the basis for compliance assessment.

4.2.2 Control site

A control site is not influenced by mine-related activities and is used to characterise background receiving environment conditions. Control sites provide a reference against which compliance site results can be compared to help distinguish natural variability or background quality from potential mine-related effects.

In the Waikouaiti River catchment, where upstream control sites are not available due to the headwater location of the Macraes Operation, background conditions are inferred from temporal trends and comparison with adjacent or downstream monitoring sites.

4.2.3 Trigger value

A trigger value is a concentration or condition used to indicate potential ecological risk, adjusted where appropriate for site-specific water chemistry. Trigger values are intended to replace the compliance limits previously defined under the existing Macraes Operation consents (refer Section 3.3).

Trigger values are defined for:

- Acute exposure - concentrations that may cause adverse effects from short-term exposure.
- Chronic exposure - concentrations that may cause adverse effects from sustained exposure.

- Eutrophication assessment - nutrient and ecological response indicators used to identify and assess excessive plant or algal growth and related ecological effects.

Drinking water values are also adopted as trigger values at several compliance sites (NB03, Shag at Loop Road and Shag at McCormicks) where protection of water quality for downstream drinking water uses is relevant (refer Section 4.3.4).

4.2.4 Exceedance

An exceedance occurs when a measured concentration or monitored condition at a compliance site is greater than the applicable trigger value. Exceedance of a trigger value does not in itself confirm an adverse effect or constitute non-compliance but indicates an increased likelihood of adverse effects and signals the need for further assessment and, where appropriate, management response.

4.2.5 Non-compliance

Non-compliance identifies mine-attributable conditions where there is an elevated likelihood of adverse ecological effects and where additional management intervention may be required.

A compliance site is considered non-compliant where exceedances of trigger values occur at defined frequencies or durations specified within this framework, and are demonstrated to be attributable to mine operations, subject to the compliance assessment approach described in Section 4.3.3.

4.3 Application at Macraes Operation

4.3.1 Monitoring network

Water quality monitoring sites relevant to the proposed framework are consistent with the sites listed in Table 1, except for HC02, CJ01, and TC01, which will not be affected by the proposed development as the associated watercourses are not subject to new or modified discharges. The compliance framework for these sites will be reviewed for consistency following the FTAA process.

Consistent with OGNZL's existing consents, surface water quality monitoring will be undertaken monthly, with sampling in the same catchment carried out on the same day to ensure comparability of results. Final monitoring locations and aquatic ecological monitoring requirements, including assessment of eutrophication response indicators, will be specified in the monitoring schedule proposed for MP4.

4.3.2 Proposed trigger values

Trigger values were derived using a weight-of-evidence approach considering regulatory requirements, ecological sensitivity, site-specific geochemical context, and historical monitoring data. Parameters were selected based on their environmental relevance, association with mining-related processes, and potential to influence ecological health. In general, the trigger values align with a guideline protection level for 95% of species. Further methodology and rationale for trigger value derivation are provided in Section 5.

Proposed trigger values are presented in Table 3. Where adjustment for site-specific conditions is required, values are expressed as equations or refer to lookup tables in Appendix A. In these cases, trigger values are also presented for standard Macraes Operation receiving water conditions (pH 7.8, chloride 9.1 g/m³, dissolved organic carbon (DOC) 4.5 g/m³, hardness 220 g/m³ as CaCO₃ and temperature 20°C) to support consistent comparison and interpretation. Compliance assessment will use site-specific water chemistry measured at the time of sampling.

4.3.3 Compliance assessment

The basis for assessing exceedance frequency and duration for each trigger value is presented alongside the trigger values in Table 3. A compliance site is considered non-compliant when trigger values are exceeded at a defined frequency or duration and are demonstrated to be attributable to mine operations, assessed in accordance with the compliance criteria and attribution considerations set out in this section. Compliance criteria vary by parameter type and exposure condition and align with the intended level of ecological protection.

The compliance criteria are as follows:

- Acute trigger values - non-compliance occurs when a trigger value is exceeded on any sampling occasion.
- Chronic trigger values - non-compliance occurs when a trigger value is exceeded on more than two occasions within any rolling 12-month period, based on routine monthly compliance monitoring. This approach distinguishes repeated departures from trigger values from isolated exceedances arising from natural variability or analytical uncertainty.
- Eutrophication assessment criteria - non-compliance occurs when:
 - The nutrient trigger value is exceeded by the rolling annual median; and
 - The ecological response trigger value is exceeded on repeated monitoring occasions, such that a sustained nuisance plant or algal growth response is demonstrated.

The methodology used to determine a sustained ecological response will be refined through further technical review during the FTAA process.

For chronic and acute trigger values, a site returns to compliant status where monthly compliance monitoring demonstrates no further exceedances over a continuous six-month period.

For eutrophication trigger values, a site returns to compliant status where either:

- The rolling annual median nutrient trigger value no longer exceeds the applicable threshold; or
- Monitoring no longer demonstrates a sustained exceedance of the ecological response trigger value.

Exceedances at compliance sites are interpreted in the context of:

- Conditions observed at relevant upstream control sites during the same monitoring event, where available; and
- Whether the observed response reflects broader background catchment conditions rather than site discharges alone.

The rationale for the application of the compliance criteria is provided in Section 5.4.

Table 3. Proposed ecological trigger values, toxicity modifiers and exceedance frequency/duration criteria.

Parameter	Type	Toxicity modifiers	Proposed trigger value ^A	Source	Exceedance frequency/duration criteria ^B
pH (unitless)	Chronic	-	6.5-9.0	USEPA (1986) FW CCC	More than two exceedances within any rolling 12-month period
Turbidity (NTU)	Chronic	-	5	ORC (2026) Regional Plan	More than two exceedances within any rolling 12-month period
Sulphate	Chronic	Hardness	500 (when <100 g/m ³ hardness) 1,000 (when ≥100 g/m ³ hardness)	Adapted Iowa DNR (2009) guideline	More than two exceedances within any rolling 12-month period
Ammoniacal nitrogen ^C (g N/m ³)	Chronic	pH, temperature	Refer to lookup Table A1 in Appendix A for TV adjustment Equivalent to 0.52 when the pH is 7.8 and T is 20 °C.	ANZG (2026) DGV	More than two exceedances within any rolling 12-month period
Nitrate nitrogen ^C (g N/m ³)	Chronic	Hardness, chloride	1.1 (when <30 g/m ³ hardness) 2.6 (when 30-150 g/m ³ hardness or >150 g/m ³ with Cl <30 g/m ³) 29 (when >150 hardness with Cl ≥30 g/m ³)	ANZG (2025a) DGV	More than two exceedances within any rolling 12-month period
SIN (g N/m ³) ^D Ecological response indicator	Eutrophication	-	0.075 Periphyton-based trigger outlined in the water quality management plan	Biggs (2000) WGA (2026)	Rolling annual median exceeds the applicable nutrient trigger value; and Repeated exceedance of the ecological response trigger value, demonstrating sustained nuisance plant or algal growth
Arsenic ^E	Chronic	-	0.013 (0.042 at DC08 and SPMP1 for the reasons outlined in Section 5.3.3)	ANZECC (2000) TV	More than two exceedances within any rolling 12-month period
Boron	Chronic	-	0.94	ANZG (2021) DGV	More than two exceedances within any rolling 12-month period
Copper	Chronic	DOC	$TV = 0.00047 \times \left(\frac{DOC}{0.5}\right)^{0.977}$ Equivalent to 0.004 when DOC is 4.5 g/m ³	ANZG (2023a) draft DGV	More than two exceedances within any rolling 12-month period
	Acute	Hardness, pH, DOC	$TV = \frac{\exp(-6.6 + 0.78 pH + 0.58 \times \ln(hard.) + 0.70 \times \ln(DOC))}{1,000}$ Equivalent to 0.039 when DOC is 4.5 g/m ³ , pH is 7.8, and hardness is 220 g/m ³	Gadd <i>et al.</i> (2024) acute GV	Single exceedance
Iron ^F	Chronic	-	0.28	ANZG (2025b) DGV	More than two exceedances within any rolling 12-month period
Lead	Chronic	Hardness	$TV = 0.0034 \times \left(\frac{Hardness}{30}\right)^{1.27}$ Equivalent to 0.045 when hardness is 220 g/m ³	ANZECC (2000) TV	More than two exceedances within any rolling 12-month period
Nickel	Chronic	Hardness, pH, DOC	Refer to lookup Table A2 in Appendix A for TV adjustment Equivalent to 0.008 when DOC is 4.5 g/m ³ , pH is 7.8, and hardness is 220 g/m ³	ANZG (2024a) draft DGV	More than two exceedances within any rolling 12-month period
Zinc	Chronic	Hardness, pH, DOC	Refer to lookup Table A3 in Appendix A for TV adjustment Equivalent to 0.016 when DOC is 4.5 g/m ³ , pH is 7.8, and hardness is 220 g/m ³	ANZG (2024b) draft DGV	More than two exceedances within any rolling 12-month period
	Acute	Hardness, pH, DOC	$TV = \frac{\exp(2.5 - 0.12 pH + 0.6 \times \ln(hardness) + 0.13 \times \ln(DOC))}{1,000}$ Equivalent to 0.15 when DOC is 4.5, pH is 7.8 and hardness is 220 g/m ³	Gadd <i>et al.</i> (2024) acute GV	Single exceedance
Cyanide ^G	Chronic	pH, temperature	$TV = 0.007 \times (1 + 10^{(pH - (9.721 - 0.0194 \times T))})$ Equivalent to 0.0072 when the pH is 7.8 and T is 20 °C.	ANZECC (2000) TV	More than two exceedances within any rolling 12-month period

Notes: All units g/m³ unless stated; metals analysed in dissolved fraction unless stated; TV = trigger value; DGV = default guideline value; DOC = dissolved organic carbon; ^A applies to all compliance sites, unless stated; ^B compliance assessment is based on routine monthly compliance monitoring results; ^C Not considered protective of eutrophication effects; ^D SIN = soluble inorganic nitrogen, which is the sum of ammoniacal nitrogen, nitrate nitrogen and nitrite nitrogen; ^E proposed TV for arsenic applies to As(V) concentrations; in the absence of speciation testing, dissolved arsenic is used as a conservative surrogate for comparison; ^F proposed TV for iron is ideally applied to weak acid extractable concentrations; in the absence of an available analytical method, total iron is used as a conservative surrogate for comparison; ^G proposed TV applies to free cyanide, with pH and temperature adjustments accounting for proportion present as un-ionised HCN (bioavailable fraction). As free cyanide analysis is not readily available, weak acid dissociable (WAD) cyanide is used as a conservative surrogate for comparison.

4.3.4 Other applicable water guideline values

In addition to the proposed ecological trigger values, drinking water guideline values are also applied at NB03, Shag at Loop Road, and Shag at McCormicks, where protection of drinking water uses is relevant.

The applicable drinking water guideline values are summarised in Table 4. Table 4 includes parameters already subject to drinking water values under existing consents (refer Table 2) and additional parameters introduced to align with current guideline recommendations and the expanded parameter suite adopted under the proposed framework.

The drinking water values include both maximum acceptable values (MAVs), which are health-based limits that must not be exceeded at any time, and aesthetic or irrigation-based values relating to water acceptability and long-term use suitability. All parameters are assessed on the basis of a single exceedance, but a MAV exceedance constitutes non-compliance, whereas an aesthetic or irrigation-based value exceedance is treated as a trigger for further investigation.

Irrigation water quality guidelines were generally not adopted, as they are typically less stringent than the ecological trigger values and drinking water values. The exception is iron, where an irrigation guideline value of 0.2 g/m³, consistent with the existing consent limit at the relevant compliance sites, has been retained as an appropriate and conservative benchmark, as the applicable drinking water aesthetic value (0.3 g/m³) is less stringent. Whether the irrigation-based value remains appropriate at sites where irrigation use does not apply is noted for further discussion, with the drinking water aesthetic value potentially applied instead at such sites.

Table 4. Proposed drinking water values applicable to NB03 and Shag River sites.

Parameter	Value*	Source
Arsenic	0.01	New Zealand Government (2022) MAV
Boron	2.4	New Zealand Government (2022) MAV
Copper	2	New Zealand Government (2022) MAV
Iron	0.2	ANZECC (2000) irrigation guideline (long-term)
Lead	0.01	New Zealand Government (2022) MAV
Nickel	0.08	New Zealand Government (2022) MAV
Nitrate nitrogen	11.3	New Zealand Government (2022) MAV
pH (unitless)	7-8.5	Taumata Arowai (2022) aesthetic value
Sulphate	250	Taumata Arowai (2022) aesthetic value (taste)

Notes: Metals are in the dissolved fraction; *units are in g/m³ unless otherwise stated.

4.4 Performance Monitoring

The Project is expected to result in a managed change in receiving water quality, with implementation of the trigger values and compliance criteria detailed in Table 3 anticipated from 2033. Timing may vary by parameter and will be confirmed prior to Phase B based on Phase A monitoring data, including catchment scale investigation of natural attenuation. This reflects the time required to implement operational controls and mine water management measures, and for resulting improvements to be reflected in receiving water quality outcomes.

Performance monitoring will support this managed change through monitoring of water quality at source locations, including seeps, sump and pond discharges, as detailed in GHD (2026). The primary

objective of this approach is to identify changes in discharge quality at source, enabling issues to be detected and addressed before they propagate to the receiving environment.

Performance monitoring is intended to complement, but remain distinct from, instream compliance monitoring. Its purpose is to inform operational decision-making, support proactive management of discharge sources, and identify changes in water quality before they have the potential to affect the receiving environment.

4.5 Summary

Overall, the proposed framework provides a precautionary, risk-based approach to managing water quality, integrating established guideline values with site-specific modifiers and monitoring data. The use of trigger values and defined exceedance criteria enables early identification of potential ecological risks while maintaining a clear distinction between short-term variability and sustained adverse effects. The framework is fit-for-purpose for the Macraes Operation receiving environment and supports adaptive management in response to changing conditions.

5 SUPPORTING RATIONALE

5.1 Overview

This section provides the technical basis and supporting rationale for the compliance framework described in Section 4. It outlines the derivation of ecological trigger values, including justification for departures from guideline values, and their application within the compliance framework. The overall approach is technically robust, site-appropriate, and aligned with current best practice for protecting aquatic ecosystem health.

Drinking water values are not discussed in detail in this section, as they are adopted from established drinking water standards and aesthetic and irrigation-based guideline values, and will be applied within the framework as described in Section 4.3.4.

5.2 Methodology

5.2.1 Identification

Potential constituents of concern were identified in the light of regulatory requirements, known ecological sensitivities, site-specific geochemical context, and available monitoring data. Parameters selected for water quality trigger derivation met a combination of the following criteria:

- The parameter is currently regulated through existing consent limits for the Macraes Operation, or comparable mining operations (i.e., gold mining operations in similar geochemical environments).
- The parameter is well studied and widely recognised as an anthropogenic contributor to ecological deterioration in freshwater systems.
- The parameter is associated with local geochemical characteristics of the Macraes Operation or represents a process-related contaminant with an elevated likelihood of mobilisation, informed by process knowledge, leachate characterisation, and operational performance.
- Historical surface water monitoring data for Macraes Operation receiving water sites indicate elevated concentrations, temporal trends, or associations with observed ecological responses.

This structured screening process identified parameters of greatest environmental relevance and compliance risk for the proposed MP4 development.

5.2.2 Sources

For each identified parameter, relevant contemporary national and international guideline values and supporting ecotoxicological data were reviewed³. These included:

- Otago Regional Council Regional Plan for Water, Schedule 15 water quality targets (ORC 2026).
- ANZG DGVs for the protection of freshwater aquatic ecosystems, which superseded ANZECC (2000) trigger values.
- The Ministry for the Environment's (MfE) acute guideline values (GVs) developed to manage copper and zinc in freshwater environments (Gadd *et al.* 2024).
- USEPA national recommended aquatic life criteria.

³ Guidelines relating to human health and other water uses are discussed further in Section 4.3.4.

- The Iowa Department of Natural Resources criteria (Iowa DNR 2009).
- The New Zealand Periphyton Guidelines (Biggs 2000).

5.2.3 Application of guideline values

In developing the recommended trigger framework, priority was given to contemporary, ecologically derived guidance, with a primary focus on chronic protection values intended to manage longer-term exposure risks⁴. Where available and relevant, acute guideline values⁵ have also been recommended alongside chronic triggers to provide protection against short-duration, higher-concentration events. For eutrophication, a trigger value for soluble inorganic nitrogen (SIN⁶) has been identified, recognising that nutrient concentrations represent a pressure on the system. Assessment of ecological response is also required to determine whether nutrient enrichment is resulting in nuisance plant or algal growth. The assessment methodology is discussed in Section 5.3.2.

Where guideline frameworks incorporate toxicity-modifying factors, ancillary water quality parameters (e.g., pH, DOC, hardness, chloride and temperature) were incorporated into bioavailability-based assessments. Adjustment factors were derived from the relevant lookup tables or equations, to reflect site-specific water chemistry. For consistency in comparison and interpretation, standard index conditions were adopted for the Macraes Operation, corresponding to a pH of 7.8, chloride concentration of 9.1 g/m³, DOC of 4.5 g/m³, hardness of 220 g/m³ as CaCO₃, and a temperature of 20°C (refer Section 4.3.2).

An ecologically protective approach, appropriate to the condition and values of the receiving environment, was adopted in developing the proposed trigger framework. Many of the proposed inorganic toxicant trigger values are based on ANZG DGVs, which are available at four species protection levels (99%, 95%, 90% and 80%). ANZG recommends applying 95% species protection levels to slightly to moderately disturbed systems, which are defined as systems affected by human activity but retain ecological function.

The Macraes Operation receiving environment is considered to meet the definition of a slightly to moderately disturbed system. This reflects the historical and ongoing land uses within its catchments (i.e., mining and rural activities), while recognising that the watercourses continue to support functioning aquatic communities. The latter is demonstrated by the retention of diverse macroinvertebrate assemblages and at-risk galaxias species (Viridis 2026). On this basis, adoption of the 95% species protection level was considered suitable for the proposed framework.

Departure from the 95% protection approach is limited to physicochemical parameters, for which species protection levels are generally less clearly defined, and dissolved arsenic in Deepdell Creek and Battery Creek. In these watercourses, naturally elevated background levels and legacy mining influences cause arsenic concentrations to frequently exceed the ANZG 95% DGV. In this context, adoption of the 90% species protection level provides a more appropriate basis for distinguishing project-related effects from background conditions (refer Section 5.3.3).

⁴ Chronic guidelines are intended to protect organisms from adverse effects associated with long-term or continuous exposure to a contaminant, including sub-lethal impacts on growth, reproduction, and survival.

⁵ Acute guidelines are intended to protect aquatic organisms from adverse effects resulting from short-term exposure to a contaminant, typically addressing immediate or lethal toxicity effects.

⁶ SIN is the sum of ammoniacal nitrogen and total oxidised nitrogen, comprising nitrate nitrogen and nitrite nitrogen.

The compliance assessment criteria set out in Section 4.3.3 were developed to reflect the nature of the trigger values and associated exposure pathways. For chronic triggers, which are intended to manage longer-term exposure risks, a limited number of exceedances is permitted over defined assessment periods, consistent with approaches adopted in regional and international guideline frameworks. This allows for natural variability and analytical uncertainty while maintaining protection of ecological health. In contrast, acute trigger values are applied on the basis of a single exceedance, reflecting the potential for short-duration, high-concentration events to cause immediate biological effects. Supporting rationale for the compliance assessment framework is provided in Section 5.4.

5.2.4 Local context

The local relevance of trigger values was evaluated by comparison with historical surface water quality and aquatic biological data collected between 1990 and 2026 at the monitoring sites outlined in Table 1. Although HC02, CJ01, and TC01 are excluded from the MP4 application, data from these sites, along with other non-compliance monitoring locations, have been included for comparison.

Where background concentrations (i.e., pre Macraes Operation or at control sites) exceeded generic guideline values, ecological monitoring (e.g., macroinvertebrate community index (MCI) scores) was used to assess the alignment between water quality and ecological condition, and to evaluate whether the default guideline values were suitable for application at the site, particularly where concentrations are influenced by natural background conditions.

The intent of this framework is to provide a consistent and scientifically robust set of trigger values applicable across all Macraes Operation receiving water sites, superseding the existing suite of historically derived consent limits. It is designed to provide early warning of potential water quality changes, enabling identification of exceedances and timely management responses to avoid adverse effects. The same trigger value is generally proposed for all compliance sites to ensure consistency, with exceptions limited to specific sites and parameters where legacy influences necessitate alternative values.

5.3 Trigger Value Derivation

5.3.1 Physicochemical parameters

pH

Recommended trigger

A pH range of 6.5 to 9.0 is recommended.

Basis for trigger

The recommended pH range is based on the USEPA (1986) Quality Criteria for Water (“Gold Book”), which has been widely applied internationally for the protection of freshwater aquatic life. The range also aligns with New Zealand regional guidance, such as Waikato Regional Council’s (WRC) classifications, where pH values of 7–8 are considered excellent and ranges of 6.5–7 and 8–9 are considered satisfactory for ecological health in rivers (WRC 2026). Similarly, the range is consistent with NIWA’s proposed National Objectives Framework, where pH values outside the range of 6–9 correspond to B and D conditions, which are associated with significant and persistent stress to aquatic organisms (Davies-Colley *et al.* 2013).

The proposed range is comparable to existing Macraes Operation consent limits, which are typically 6.0 to 9.5 across most water quality compliance sites. A narrower range of 7.0 to 8.5 applies at NB03 and Shag River sites to protect drinking water uses.

The adoption of the broader 6.5 to 9.0 range is considered suitable for impact assessment as it is directly linked to ecotoxicological response thresholds and ensures consistency across the monitoring network while maintaining protection of aquatic ecosystem health.

Local context

Historical pH data for Macraes Operation monitoring sites were compared with the proposed trigger range, with time-series plots of this comparison provided in Appendix B (Figures B1 and B2).

A review of long-term pH monitoring data indicates that the proposed pH range of 6.5 to 9.0 is well aligned with prevailing conditions at both impact and control sites, which generally exhibit stable, circumneutral pH values. Departures from this range have been rare and generally limited to a few isolated historical results just outside this range. The main exception is one notably low measurement (3.5) at NBWRRF, with no comparable values observed within the past five years.

Overall, pH does not indicate an elevated risk to receiving water environments, and the proposed trigger range is appropriate for maintaining existing conditions and protecting freshwater aquatic life.

Turbidity (Water clarity)

Recommended trigger

A turbidity trigger of 5 NTU is recommended.

Basis for trigger

The recommended trigger value is based on Schedule 15 of the ORC Regional Plan for Water (ORC 2026), which specifies trigger values for receiving environments with limited flushing and moderate turbidity, consistent with Macraes Operation conditions.

While the ORC Regional Plan applies this trigger under baseflow conditions, this restriction is not considered appropriate for Macraes Operation sites. Sediment discharges are most likely during rainfall events, when sediment control infrastructure is actively operating and the potential for effects on receiving environments is greatest. Applying the trigger across all flow conditions, in conjunction with upstream control sites, allows natural flow-related increases in turbidity to be accounted for while maintaining sensitivity to mine-related inputs.

Turbidity is adopted as the primary compliance parameter due to its responsiveness to short-term changes in suspended sediment and its suitability for operational monitoring. Analysis of Macraes Operation monitoring data⁷ indicates a moderate positive relationship between turbidity and total suspended solids (TSS), supporting the use of turbidity as a surrogate indicator of suspended sediment (refer Figure C1 in Appendix C). While variability reflects differences in particle characteristics and site conditions, the relationship is sufficiently consistent for operational monitoring purposes. TSS will be retained as a supporting parameter to inform interpretation and refine site-specific relationships with turbidity over time.

⁷ Date-matched measurements of turbidity and TSS at key monitoring sites.

Local context

Available monitoring data indicate that turbidity values exceeding 5 NTU are infrequent but occasionally occur at both impact and upstream control sites (refer Appendix B, Figures B3 and B4). The recurrence of exceedances did not, however, meet the framework criteria for non-compliance (i.e., greater than two exceedances in any rolling 12-month period).

The use of upstream control sites enables differentiation between natural variability and site-related effects. The proposed trigger is therefore considered suitable for identifying departures from background conditions while accounting for inherent variability in turbidity.

Sulphate

Recommended trigger

A sulphate trigger value derived from site-specific hardness is recommended, with a value of 500 g/m³ applied where hardness is less than 100 g/m³ as CaCO₃, and 1,000 g/m³ when hardness is greater than or equal to 100 g/m³ as CaCO₃.

Basis for trigger

National sulphate guidance in New Zealand is limited. The ANZECC (2000) stock drinking water guideline value of 1,000 g/m³ has historically been used for livestock watering supplies, with more recent ANZG (2023b) draft guidance proposing a lower value of 500 g/m³.

The earlier ANZECC (2000) value of 1,000 g/m³ remains the basis for the existing sulphate consent limit at most sites across the Macraes Operation. However, a lower limit of 250 g/m³ applies at NB03 and the Shag/Waihemo River sites, reflecting their use as drinking water sources and will continue to apply (refer Section 4.3.4).

The proposed ecological trigger value is informed by the Iowa Department of Natural Resources sulphate criteria (Iowa DNR 2009), which relate sulphate toxicity to water hardness and chloride. For application to Macraes Operation receiving waters, the framework has been simplified to a hardness-based approach, with chloride-dependent adjustments not retained. This reflects a review of site data, which indicated that chloride concentrations had limited influence on the applicable sulphate criterion, and as such, hardness is the primary driver of sulphate toxicity under site conditions.

Locally relevant ecotoxicity data were used to refine a suitable level of protection. Laboratory studies using site-representative seepage water indicate that mortality effects on Taieri flathead galaxias (*Galaxias depressiceps*) - a species known to be present within Macraes Operation receiving waters (Viridis 2026) - did not occur until exposure to sulphate concentrations between 1,640 g/m³ and 1,920 g/m³ (OGNZL 2018). A NIWA study on single-gill mayflies (*Deleatidium* sp.), conducted under comparatively low hardness conditions, reported a no observable effects concentration (NOEC; a chronic endpoint) of 775 g/m³, with 15% and 50% effect concentrations of 963 and 1,597 g/m³, respectively (NIWA 2024).

On this basis, a chronic trigger value of 1,000 g/m³ for waters with hardness greater than or equal to 100 g/m³ as CaCO₃ is considered appropriate. This value lies above the reported NOEC (775 g/m³) for single-gill mayflies and, while close to the 15% effect concentration (963 g/m³), remains below the 50% effect concentration (1,597 g/m³), providing a balance between protection against chronic effects and avoidance of overly conservative limits.

As the NIWA toxicity endpoints were generated under relatively low hardness conditions, they are considered conservative relative to the moderate-to-high hardness typical of the Macraes Operation

receiving environment. The trigger framework has therefore been simplified to two hardness bands, reflecting hardness as the primary driver of sulphate toxicity within the receiving environment.

Local context

Historical data from control sites DC00 and MB00 indicate low background sulphate concentrations (typically less than 25 g/m³) (refer Figures B5 and B6, Appendix B). Assessment of historical data against the proposed sulphate trigger values, adjusted where possible for site-specific hardness⁸ indicates that exceedances meeting the framework criteria for non-compliance occurred at sites CJ01, SPMP1, MC01 and MC02, where exceedances were recurrent (Table B1, Appendix B).

To assess whether the maximum trigger value of 1,000 g/m³ for high-hardness waters is appropriate, long-term trends in *Deleatidium* species abundance were examined (Figures C2 and C3, Appendix C). As demonstrated in the NIWA (2024) study, single-gill mayflies are sensitive to sulphate and are therefore a useful indicator species for assessing potential impact. Declines in abundance were most pronounced at sites that frequently exceed 1,000 g/m³ of sulphate (e.g., at CJ01 and MC01). While reductions in abundance were also observed at lower sulphate concentrations, these patterns were less consistent and are likely influenced by multiple interacting environmental factors. At sites where sulphate concentrations remained low (e.g. DC00), no adverse relationship with *Deleatidium* abundance was evident.

While sulphate is not the sole driver of ecological condition, the co-occurrence of elevated sulphate concentrations and reduced abundance of a sensitive indicator species at key sites supports the application of 1,000 g/m³ as a biologically relevant upper bound for chronic exposure in high-hardness Macraes Operation receiving waters. Above this concentration, adverse ecological effects become more likely.

5.3.2 Nutrients

Ammoniacal nitrogen

Recommended trigger

A pH- and temperature-dependent ammoniacal nitrogen trigger value is recommended, derived using the ANZG (2026) lookup table in Appendix A. Under the standard Macraes Operation index conditions (pH 7.8 and 20°C; see Section 5.2.3), this corresponds to a trigger value of 0.52 g N/m³.

Basis for trigger

The only applicable ammoniacal nitrogen compliance limit for Macraes Operation surface water sites is based on the NPS-FM annual median NBL of 0.24 g N/m³ (MfE 2025), which applies to MB02 and has been implemented as a fixed concentration. However, this approach does not incorporate the pH-dependent adjustment described in Appendix 2 of the NPS-FM and therefore does not fully reflect site-specific toxicity conditions. The previous ANZECC (2000) trigger values for ammoniacal nitrogen (which included a 95% species protection level of 0.9 g N/m³ at a pH 8) similarly required adjustment to account for site-specific pH. These values have, however, been recently superseded by the ANZG (2026) updated guidance for ammoniacal nitrogen.

The ANZG (2026) DGV for ammoniacal nitrogen incorporates recent toxicity data and joint toxicity models developed by USEPA (1999, 2013), to account for the influence of both pH and temperature on

⁸ In absence of a site-specific measurement, a site or global mean was applied for assessment.

ammonia toxicity. This approach recognises that pH and temperature alter the balance between ionised and unionised forms of ammonia, with the unionised fraction being the primary driver of ecotoxicity.

The recommended trigger value is based on the latest ANZG guidance, which provides a site-responsive framework for ecological protection. Tabulated DGVs for a range of pH and temperature conditions are reproduced in Appendix A of this report. This trigger addresses direct toxicity but does not, on its own, manage eutrophication. Nutrient-related effects are addressed separately through a SIN trigger and assessment of ecological response (refer eutrophication section below).

Local context

In the absence of temperature data for the Macraes Operation compliance sites, the standard index condition of 20°C was applied in conjunction with site-specific pH measurements to assess compliance with the trigger. This temperature was adopted as a representative assessment condition for retrospective evaluation of historical monitoring data. Exceedances of the adjusted trigger value were rare, with only single exceedances recorded at CJ01 (1.5 g N/m³ on 16/11/2020), MB01 (0.75 g N/m³ on 17/03/2020) and (MB02 1.3 g N/m³ on 16/03/2020) (refer Figures B7 and B8, Appendix B).

Accordingly, given the isolated nature of historical elevated results, the proposed ammoniacal nitrogen trigger value is considered achievable under site conditions while maintaining a high level of ecological protection.

Nitrate nitrogen

Recommended trigger

A nitrate nitrogen toxicity trigger value (i.e. as NO₃-N, reported in g N/m³) derived from site-specific hardness and, where applicable, chloride conditions is recommended:

- 1.1 g N/m³, when hardness is less than 30 g/m³ as CaCO₃.
- 2.6 g N/m³, when hardness is between 30-150 g/m³ as CaCO₃, or greater than 150 g/m³ as CaCO₃ but chloride concentrations are less than 30 g/m³.
- 29 g N/m³, when hardness is greater than 150 g/m³ as CaCO₃ and chloride concentration is greater than or equal to 30 g/m³ as CaCO₃.

Basis for trigger

National DGVs for nitrate nitrogen toxicity have evolved over time, with earlier ANZECC (2000) values subsequently revised following identification of methodological issues (Hickey 2002, 2013). More recent guidance is provided in ANZG (2025a), which incorporates updated chronic toxicity data and defines nitrate nitrogen DGVs across three hardness categories: soft (<30 g/m³ as CaCO₃), moderately hard (30-150 g/m³ as CaCO₃), and hard (>150 g/m³ as CaCO₃) waters. The recommended trigger values are based on the ANZG DGVs at the 95% species protection level, consistent with application to moderately disturbed freshwater systems, as is the case for the Macraes Operation receiving environment.

The ANZG (2025a) dataset includes chronic growth toxicity data for koura, confirming representation of locally relevant taxa within the species sensitivity distribution underpinning the DGVs.

Supporting information in ANZG (2025a) indicates that nitrate toxicity in hard waters may be moderated by chloride concentrations. Chloride effects are therefore incorporated only for high-hardness waters, where interactions between chloride and nitrate toxicity are most pronounced. In softer waters, hardness remains the dominant modifying factor. Consistent with this approach, the high-hardness trigger value (29 g N/m³) is applied only when chloride concentrations are ≥30 g/m³, with the

intermediate trigger value (2.6 g N/m^3) adopted where hardness exceeds 150 g/m^3 as CaCO_3 but chloride is $<30 \text{ g/m}^3$.

Existing consent limits for Macraes Operation sites are based on the NPS-FM (2020) nitrate NBL, expressed as fixed annual median (2.4 g N/m^3) and an annual 95th percentile (3.5 g N/m^3) concentrations. However, these limits do not account for the influence of hardness on nitrate toxicity, which is now well established.

Nitrate sources within the Macraes Operation catchments may include both anthropogenic inputs (e.g. explosives residues) and natural geological contributions; however, the proposed trigger values are based on toxicity and are independent of source.

The proposed nitrate nitrogen trigger values address direct toxicity but do not, on their own, manage eutrophication. Like ammonia, elevated nitrate concentrations can stimulate algal growth and associated secondary stressors; therefore, nutrient-related effects are addressed separately through a SIN trigger and assessment of ecological response (refer eutrophication section below).

Local context

Nitrate nitrogen concentrations within the Shag/Waihemo catchment compliance sites are generally low (refer Figure B9 of Appendix B). Nitrate concentrations at MB01 and MB02 on Mare Burn in the Taieri River catchment, and at MC01 and MC02 in Murphys Creek in the Waikouaiti River catchment (refer Figure B10 of Appendix B) periodically exceed the proposed hardness-adjusted trigger values, with exceedances persisting at some locations through to 2025 (Table B2 of Appendix B). MB01 and MB02 are located downstream in the Mare Burn system, which receives flows from the Trimble Gully tributary, where nitrate was previously noted as a potential contributor to toxicity effects on kōura alongside ammonia (Ryder 2016).

Sites exhibiting elevated nitrate concentrations generally correspond with lower QMCI and MCI scores, where monitored (refer Appendix C, Figures C4 through C7). While it is not possible to attribute observed ecological condition solely to nitrate, given the potential influence of other constituents and habitat factors, the coincidence of elevated nitrate with reduced macroinvertebrate indices indicates that ecological communities may be constrained or impacted at these locations.

In contrast, sites that do not demonstrate consistent elevation of nitrate concentrations (e.g., DC00) exhibit higher invertebrate indices (refer Appendix C). Given the established chronic toxicity of nitrate at elevated concentrations, the proposed hardness-adjusted trigger values are considered appropriate for identifying exceedances that may adversely affect aquatic communities and for informing management actions to reduce these effects within the Macraes Operation receiving environment.

Eutrophication

Recommended trigger

A SIN trigger value of 0.075 g N/m^3 is recommended as an indicator of nutrient enrichment and eutrophication risk. Assessment of ecological response is also required to determine whether nutrient enrichment is resulting in nuisance plant or algal growth. This is assessed in parallel against a periphyton-based trigger, with non-compliance determined where both the nutrient and ecological response trigger values are exceeded. The ecological response metric is outlined in the site's water quality management plan (WGA 2026), with the optimal method to be determined on an adaptive basis.

Basis for trigger

The ammoniacal nitrogen and nitrate nitrogen trigger values discussed above address direct toxic effects and do not, in isolation, protect against eutrophication effects associated with elevated nutrients.

Eutrophication in streams typically manifests as increased periphyton growth and associated effects such as reduced habitat quality and oxygen availability. These responses are influenced by nutrient supply as well as flow regime, light availability and invertebrate grazing pressure.

The New Zealand Periphyton Guidelines (Biggs 2000) remain a key reference for understanding relationships between nutrient enrichment, periphyton growth and stream ecosystem response. Biggs (2000) identifies that periphyton biomass is influenced by both nutrient supply and the duration of accrual between disturbance events (i.e., higher-flow events, such as flushing flows or floods, that have sufficient energy to remove accumulated periphyton biomass from the stream bed). Corresponding SIN concentrations are provided for different accrual periods and disturbance regimes.

In this context, a SIN trigger value of 0.075 g N/m³ has been adopted as an indicator of nutrient enrichment and eutrophication risk, consistent with the 30-day accrual threshold identified by Biggs (2000). Hydrological analysis indicates that accrual periods of approximately 30 days or greater occur within the Macraes Operation catchments, providing conditions under which nuisance plant and algal growth may occur (refer Figures C8, Appendix C).

Biggs (2000) also provides nationally recognised approaches for assessing ecological responses to nutrient enrichment. Periphyton cover-based methods are currently applied at several Macraes Operation monitoring sites and provide an existing dataset for comparison; however, Biggs (2000) also identifies more quantitative biomass measures, including ash-free dry weight (AFDW) and chlorophyll-*a*, as alternative metrics, and these are increasingly favoured as a basis for ecological response assessment. Chlorophyll-*a* is also the metric adopted for the periphyton attribute under the NPS-FM (2020) (MFE 2025), providing a nationally consistent basis against which any site-specific approach could be benchmarked. The ecological response metric is outlined in the site's water quality management plan (WGA 2026).

Dissolved reactive phosphorus (DRP) thresholds are also identified in Biggs (2000); however, historical monitoring data indicate that DRP concentrations at Macraes Operation are generally low and mine-related contributions are minimal (refer Appendix D).

Local context

Analysis of historical Macraes Operation monitoring data indicates no clear relationship between nutrient concentrations and periphyton cover, with high variability in cover observed even at low nutrient concentrations (refer Figure C9 in Appendix C). This indicates that nutrient availability acts as a pressure on the system rather than a direct predictor of ecological response and suggests that ecological responses at Macraes Operation are strongly influenced by non-nutrient factors such as flow regime, light availability, and grazing pressure.

A SIN concentration of 0.075 g N/m³ is considered appropriate for the Macraes Operation monitoring framework as it reflects historical nutrient conditions observed within the Macraes Operation catchments, while still providing sensitivity to incremental increases in nutrient concentrations.

The observed variability in ecological response supports the use of a combined nutrient and ecological response assessment approach, while highlighting the need for the ecological response methodology to be tailored to site-specific conditions.

Supporting rationale for the proposed eutrophication assessment framework is discussed further in Section 5.4.3, with retrospective application of the SIN trigger value to historical monitoring data presented in Figures B11 and B12 of Appendix B. Comparison of historical nutrient conditions and ecological response data supports the conclusion that nutrient concentrations act as a pressure on the system, while ecological outcomes are influenced by a range of site-specific factors and therefore require separate assessment.

5.3.3 Inorganic toxicants

Arsenic

Recommended trigger

A trigger value of 0.013 g/m³ for dissolved arsenic is recommended for most compliance sites, with a higher trigger value of 0.042 g/m³ applied at DC08 and SPMP1 to reflect natural background and legacy mining influences.

Basis for trigger

Under oxic surface water conditions, arsenic is predominantly present in the pentavalent form, As(V). Accordingly, the recommended arsenic triggers are based on the ANZECC (2000) trigger values for As(V) at the 95% species protection level (0.013 g/m³) and the 90% species protection level (0.042 g/m³).

Arsenic speciation analysis is not routinely undertaken for Macraes Operation samples, as it requires specialised analytical methods that are costly and typically outsourced internationally. Routine monitoring is therefore limited to total or dissolved arsenic concentrations. The As(V) DGVs are considered a conservative proxy for assessing dissolved arsenic.

Existing consent limits for dissolved arsenic across the Macraes Operation range from 0.01 g/m³ to 0.15 g/m³ (the latter reflecting the USEPA (1995) chronic criterion concentration (CCC) for As(III)), depending on the applicable schedule, with the most stringent limits at NB03 and the Shag/Waihemo River sites reflecting drinking water standards. A standardised trigger framework, aligned with national ecotoxicological guidance, is therefore considered suitable for application across Macraes Operation compliance sites.

Local context

Historical monitoring data for dissolved arsenic indicate that elevated concentrations are primarily observed in Deepdell Creek (particularly DC08) and GB02.

Review of pre-mining data shows that dissolved arsenic concentrations increased downstream along Deepdell Creek (from upstream site DC02 to the then most downstream site DC07), with downstream concentrations at or above the 95% species protection trigger value (0.013 g/m³) prior to mining (refer to relevant sections of BHP (1988), reproduced in Appendix C⁹). This pattern is consistent with inputs from mineralised geology and legacy mining features (including the historical Golden Point adit and Battery Creek), rather than site operations.

Post-mining monitoring indicates that dissolved arsenic concentrations at DC07 and DC08 remain within the historical range, with no clear long-term increase (refer Figure C10 of Appendix C). DC08 is located slightly downstream of the historical DC07 site and is therefore considered representative of the same lower catchment conditions. SPMP1 is located on Battery Creek, which discharges to Deepdell Creek just

⁹ BHP (1988) apply different names to the compliance sites referred to in this document. DC02, SPMP1 and DC07 are referred to as C, F and L, respectively, in Figure 4.1.4.

upstream of DC05. Pre-mining data indicate that arsenic concentrations in Battery Creek were already elevated (mean 40.7 g/m³; range 27-51 g/m³; Table 4.1.8 of BHP (1988), reproduced in Appendix C). This is consistent with the mineralised setting of the lower catchment.

In contrast, other parameters (e.g. sulphate) show clearer patterns associated with current mine operations, which are not evident for arsenic at DC08 or SPMP1, where concentrations reflect natural and legacy sources.

Elevated arsenic concentrations were also observed at GB02, with the highest values recorded during active mining prior to 2007 (refer Figure B14 of Appendix B). Concentrations reduced following cessation of mining and subsequent filling of the pit with water, but a later period of elevated concentrations is evident from around 2017, consistent with discharge from the pit to Golden Bar Creek. Exceedances of the 95% species protection trigger at this site, in accordance with the non-compliance criteria, are summarised in Table B3 (Appendix B). Additional episodic non-compliances were also observed at MC01, NBWRRF and SPMP1 (refer Figures B13 and B14 of Appendix B).

Macroinvertebrate metrics (MCI and QMCI) show an early decline at sites downstream of DC00; however, no ongoing decline is evident over time (refer Figures C4 and C6 of Appendix C). This, together with the absence of a clear relationship with arsenic concentrations, suggests that ecological condition is influenced by multiple factors rather than arsenic alone.

On this basis, the 95% species protection trigger value (0.013 g/m³) is below natural background concentrations within the lower Deepdell Creek and Battery Creek catchments. Adoption of a site-specific trigger value based on 90% species protection (0.042 g/m³) at DC08 and SPMP1 is therefore considered appropriate and consistent with pre-mining conditions.

Boron

Recommended trigger

A dissolved boron trigger value of 0.94 g/m³ is recommended.

Basis for trigger

There are currently no consent limits in place for boron at the Macraes Operation. However, boron is emerging as a constituent of potential concern following recent column leachate testing, which identified elevated boron concentrations in leachate from two waste rock domains (MWM 2026)¹⁰.

National guidance is provided by ANZG (2021) for dissolved boron, which specifies a DGV of 0.94 g/m³ at the 95% species protection level. The DGV is formally applicable only within a defined hardness range of 9.2 g/m³ to 250 g/m³ as CaCO₃ and pH range of 6.8–10. These bounds reflect the conditions under which the underlying toxicity datasets were generated. As several Macraes Operation compliance sites exhibit hardness values higher than the defined range, applying the DGV as a trigger requires extending its use beyond the water chemistry range on which it was originally derived.

The ANZG (2021) boron technical brief indicates that water hardness only begins to materially reduce acute boron toxicity at levels greater than 500 g/m³ as CaCO₃, based on studies of several crustacean species (*Daphnia magna*, *Ceriodaphnia dubia* and *Hyalella azteca*). Therefore, application of the ANZG DGV to harder waters is expected to be conservative, rather than under-protective. In addition, any shift

¹⁰ Leachate concentrations were elevated above the ANZG (2021) DGV of 0.94 g/m³.

towards lower pH conditions would be addressed through the site's proposed pH trigger (refer Section 5.3), which would initiate a management response at pH values below 6.5.

In the absence of site-specific toxicity data or updated national guidance extending the validated chemistry range, adoption of the ANZG (2021) DGV as a trigger value provides a precautionary, nationally consistent, and technically defensible basis for assessment.

Local context

Boron has not historically formed part of the Macraes Operation routine surface water monitoring programme and has only recently been incorporated into the suite of analytes. Results from a targeted one-off sampling round undertaken in January 2026 indicate that concentrations were below the laboratory detection limits (0.05 g/m³) at all monitored sites, with the exception of CJ01, where two low-level detections (0.06 and 0.08 g/m³) were recorded (refer Appendix D). These values are well below the proposed trigger value. While the dataset is limited, the results do not indicate any current elevation of boron in receiving waters.

Copper

Recommended trigger

A DOC dependent dissolved copper trigger value is recommended for chronic exposure, defined by the following equation:

$$\text{Chronic TV} = 0.00047 \times \left(\frac{\text{DOC}}{0.5} \right)^{0.977}$$

At a representative DOC concentration of 4.5 g/m³, this corresponds to a trigger value of 0.004 g/m³.

An acute trigger value is also recommended, defined as a function of DOC, hardness and pH using the following equation:

$$\text{Acute TV} = \frac{\exp(-6.6 + 0.78 \text{ pH} + 0.58 \times \ln(\text{hard.}) + 0.70 \times \ln(\text{DOC}))}{1,000}$$

At representative Macraes Operation conditions, (pH of 7.8, hardness of 220 g/m³ as CaCO₃ and DOC of 4.5 g/m³), this corresponds to a trigger value of 0.039 g/m³.

Basis for trigger

National chronic guidelines for copper in freshwater include trigger values published in ANZECC (2000), for which hardness-based algorithms were originally provided for site-specific adjustments. However, subsequent research demonstrated that water hardness exerts limited influence on copper toxicity relative to other water chemistry parameters. Accordingly, the copper guidance was revised in 2018 (Warne *et al.* 2018) to no longer recommend hardness adjustment.

Existing consent limits across the Macraes Operation network reflect earlier regulatory approaches. These include the now superseded USEPA chronic criterion concentration (CCC), expressed as a hardness dependent value (e.g., 0.018 g/m³ at a hardness of 220 g/m³ as CaCO₃) and the hardness modified ANZECC (2000) DGV at the 95% protection level (e.g., 0.0076 g/m³ at a hardness of 220 g/m³ as CaCO₃), which is applied at HC02. These limits are applied inconsistently and are based on hardness-modification frameworks that do not reflect current understanding of copper bioavailability.

The draft ANZG (2023a) DGV for copper, which is expected to replace the ANZECC (2000) trigger value, represents further advancement by incorporating updated toxicity datasets and explicitly accounting for DOC as a primary toxicity-modifying factor. The guideline includes a DOC-based adjustment algorithm,

recognising the strong influence of DOC on copper complexation¹¹ and reduced bioavailability in freshwater systems at higher concentrations. Recent national acute guidance released by MfE similarly adopts a bioavailability-based methodology but also incorporates pH and hardness in an adjustment expression (Gadd *et al.* 2024).

Adoption of the draft ANZG (2023a) and recent MfE (Gadd *et al.* 2024) guidelines, as chronic and acute trigger values at the 95% species protection level, is recommended. Inclusion of both chronic and acute triggers ensures protection against long-term exposure effects as well as short-duration, higher-concentration events that may cause immediate toxicity. While the ANZG guideline remains in draft form, it represents the most current and scientifically robust national guidance available. Viridis has previously reviewed and provided commentary on the guideline for OGNZL (Viridis 2023), including consideration of its scientific basis, derivation methodology, and applicability to New Zealand conditions. This prior assessment provides confidence in the application of the draft values.

The proposed trigger values may be subject to minor refinement following finalisation of the ANZG guideline. The final guideline can be incorporated through updates to this framework and, where necessary, via consent conditions requiring its review and update. As discussed below, dissolved copper concentrations in MGP-impacted water have generally been low, so minor refinements to the draft ANZG guideline are unlikely to have material implications for compliance.

Local context

Historically, dissolved copper concentrations within the key receiving environments of the Macraes Operation have been consistently low, frequently at or below laboratory detection limits (refer Figures B15 and B16, Appendix B). Assessment of the monitoring data against the proposed chronic trigger value¹² indicates that exceedances were limited to a few occasions at compliance sites (i.e. DC08, MC01 and MC02). Non-compliance criteria were only met at SPMP1, for a short window in 2002-2003 (refer Table B4 of Appendix B).

Exceedance of the proposed acute trigger was limited to a single elevated result at GB02 in February of 2009 (Table B4, Appendix B), which likely reflects a short-term operational influence during the period when Golden Bar Pit remained active. No ongoing or recurrent acute exceedances are evident in the dataset¹³.

Overall, the monitoring data demonstrate that copper concentrations have remained generally low, with exceedances limited to isolated events, and that the proposed chronic and acute trigger framework is appropriate to maintain current water quality conditions, while providing a robust, effects-based trigger should conditions change.

Iron

Recommended trigger

A trigger value of 0.28 g/m³ for total iron is recommended.

¹¹ Copper complexation refers to the binding of dissolved copper to other constituents in water, which reduces the proportion present as free copper ions and therefore lowers its bioavailability and toxicity to aquatic organisms.

¹² In the absence of a DOC measurement for an individual sample, the site-specific historical mean DOC concentration was applied. Where no site-specific DOC data were available, the overall mean DOC derived from all Macraes sites was used.

¹³ Similar to the adjustment method for the chronic trigger value, adjustment of the acute trigger was based on sample DOC, pH and hardness measurements, or in their absence, specific-site or Macraes Operation global means.

Basis for trigger

Existing consent limits for iron across the Macraes Operation surface water sites are based on either the USEPA (1986) CCC of 1 g/m³ or the ANZECC (2000) long-term trigger value in irrigation water of 0.2 g/m³.

The proposed trigger is based on the recently published ANZG (2025b) DGV for iron of 0.28 g/m³ at the 95% species protection level. This DGV supersedes the interim indicative working level of 0.3 g/m³ presented in ANZECC (2000) in the absence of sufficient data to derive a reliable trigger value. This was consistent with the Canadian water quality guideline for iron in freshwater (CCREM 1987).

The ANZG (2025b) DGV is expressed for total iron, with weak-acid extractable iron identified as the preferred analytical fraction where available. As weak-acid extractable iron testing is not routinely available through commercial laboratories (Hills Laboratories, pers. comm., February 2026), total iron is retained as the applicable trigger parameter. While dissolved iron can provide additional insight into bioavailable fractions, total iron is retained to align with the ANZG (2025b) guideline derivation and to avoid underestimation of exposure associated with colloidal and particulate forms. This is conservative, as total iron may include mineralised sediment-bound forms that are unlikely to be bioavailable.

Local context

Total iron data are limited across the monitoring network, with several sites represented by a single sampling event in April 2024. The concentrations at these sites are generally below the proposed trigger (refer Appendix D), with a single exceedance at MB02 (0.31 g/m³).

More comprehensive total iron datasets are available for NB03, MC02 and NBWRRF (refer Figure B17, Appendix B). At MC02, concentrations were generally below the proposed trigger, with only occasional exceedances (up to a maximum of 0.37 g/m³). At NB03, concentrations are generally below the proposed ecological trigger value, although the more stringent drinking water value of 0.2 g/m³ applies separately for protection of drinking water uses. Isolated elevated results of 1 g/m³ and 4 g/m³ were recorded in July 2022, but these were not sustained in subsequent monitoring. At NBWRRF, concentrations were more variable and frequently exceed the proposed trigger, with values up to 0.65 g/m³. Some of these exceedances meet the defined recurrence criteria for non-compliance (Table B5, Appendix B).

Available dissolved iron data, reviewed as a proxy for total, indicate that exceedances likely occurred at several sites across the monitoring network, including at control sites such as DC00 and MB00 (refer Figures B18 and B19, Appendix B).

The available data indicate that elevated iron concentrations are spatially variable and influenced by broader catchment and geological conditions rather than a consistent mine-related signal. Elevated concentrations at control sites support the interpretation that naturally elevated iron concentrations occur within the Macraes catchment.

To account for this, exceedances should be interpreted in the context of available control site data collected during the same monitoring event, broader catchment conditions, temporal trends, and comparison with adjacent or downstream monitoring sites, consistent with the compliance assessment framework described in Section 4.3.3. This assessment approach considers whether observed concentrations are consistent with background variability or indicate an additional contribution from site-related sources.

Overall, elevated iron concentrations are variable across the monitoring network, with no consistent downstream increase evident. Elevated concentrations, including within the dissolved fraction, also occur at control sites and support the interpretation that broader catchment and geological conditions contribute to observed exceedances. The proposed ecological trigger therefore remains appropriate as a conservative benchmark for identifying and assessing potential site-related effects.

Lead

Recommended trigger

A dissolved lead trigger value is recommended, defined as a function of hardness by the following equation:

$$TV = 0.0034 \times \left(\frac{\text{Hardness}}{30} \right)^{1.27}$$

At the standard Macraes Operation hardness of 220 g/m³ as CaCO₃, this corresponds to a trigger value of 0.043 g/m³.

Basis for trigger

Most sites across the Macraes Operation apply a hardness dependent limit derived from the USEPA CCC for lead (e.g., 0.0059 g/m³ at a hardness of 220 g/m³ as CaCO₃). A higher hardness adjusted limit (e.g., 0.043 g/m³ at a hardness of 220 g/m³ as CaCO₃) applies at HC02 under the Deepdell East Waste Rock Stack schedule, reflecting use of the ANZECC (2000) hardness modified trigger value (HMTV) for lead rather than the USEPA CCC.

The ANZECC (2000) HMTV provides a nationally recognised, effects-based approach that incorporates hardness as a toxicity-modifying factor. Although the current ANZECC HMTV for lead carries a moderate reliability rating, adoption of the 95% species protection level, with site-specific hardness adjustment, provides a consistent and technically defensible trigger for application across all compliance sites.

Local context

Historical monitoring indicates that dissolved lead concentrations are consistently low across the Macraes Operation monitoring network, with most results at or near analytical detection limits (refer Figures B20 and B21 of Appendix B). All recorded detections are below the proposed hardness-adjusted trigger value. No spatial or temporal pattern of elevated concentrations is evident.

On this basis, dissolved lead does not indicate any elevation relative to the proposed trigger across the monitoring network. The trigger value is therefore considered appropriate for identifying potential site related ecological effects.

The proposed trigger value is intended for ecological protection. The more stringent drinking water value for lead (0.01 g/m³) applies separately at sites where protection of potable water supply is required, and observed concentrations are also below this value.

Nickel

Recommended trigger

A dissolved nickel trigger value is recommended, defined as a function of DOC, hardness and pH using the ANZG (2024a) lookup table in Appendix A.

At representative Macraes Operation conditions (DOC 4.5 g/m³, hardness 220 g/m³ as CaCO₃ and pH 7.8), this corresponds to a trigger value of 0.008 g/m³.

Basis for trigger

Nickel is a trace metal that may be present in a range of geological materials and can be mobilised through weathering or mine-related disturbance, making it a relevant parameter within the Macraes Operation even where historical concentrations have been low. There are no existing consent limits for nickel across the Macraes Operation network. Development of a trigger therefore addresses a gap in the existing consent framework.

The ANZECC (2000) HMTV for nickel at the 95% species protection level (e.g., 0.002 g/m³ at a hardness of 220 g/m³ as CaCO₃) has a low reliability rating, reflecting limitations in the underlying toxicity dataset (Warne *et al.* 2018). The draft ANZG (2024a) update represents a significant improvement, incorporating expanded chronic toxicity data and a bioavailability-based framework that adjusts for DOC, hardness and pH. This approach aligns with recent revisions for other metals and better reflects site-specific exposure conditions. Adoption of the draft ANZG (2024a) DGV at a 95% species protection level is recommended as the most technically robust and nationally consistent framework currently available. Viridis has previously reviewed and provided commentary on the guideline for OGNZL (Viridis 2024a), including consideration of its scientific basis, derivation methodology, and applicability to New Zealand conditions. This prior assessment provides confidence in the application of the draft values.

The draft DGV is formally applicable only within defined water chemistry ranges of 0.5-20 g/m³ DOC, hardness between 12-397 g/m³ as CaCO₃, and pH 6-8.5, based on the ecotoxicity studies that informed the guideline development. However, as some compliance sites record hardness values outside this range, a pragmatic adaptation is required. In these instances, the nearest boundary value within the validated range is applied. Consistent with the approach adopted for boron, this results in a precautionary (i.e., potentially over-protective) trigger, rather than one that risks under-protection.

Local context

Nickel has not historically been included in routine Macraes Operation surface water monitoring, with available data limited to a superseded compliance site (DC07) from the 1990s. Historical concentrations at DC07 were consistently low (≤ 0.0026 g/m³), indicating no evidence of elevated nickel under baseline conditions.

More recent data are limited to retrospective laboratory analyses for samples collected between July and December 2025, supplemented by results from the January 2026 sampling round (Appendix D). Across the wider Macraes Operation monitoring network, nickel concentrations are generally low and below site-specific trigger values, with exceedances confined to the Mare Burn catchment (MB01 and, to a lesser extent, MB02).

Within the Mare Burn catchment, concentrations at the upstream control site (MB00) are consistently low (≤ 0.0009 g/m³) and well below site-specific trigger values, confirming that background nickel concentrations within the Mare Burn catchment are minimal. In contrast, elevated nickel concentrations are observed at MB01, with multiple exceedances of site-specific trigger values. At MB02, nickel concentrations are generally lower than those observed at MB01 and are typically at or below site-specific trigger values.

Several exceedances occur where hardness exceeds the validated range of the draft ANZG (2024a) guideline (>397 g/m³ as CaCO₃). In these instances, application of the upper hardness boundary is conservative, resulting in trigger values that are likely over-protective and may overstate exceedance frequency.

The absence of exceedances at the upstream control site (MB00), combined with elevated concentrations at MB01, indicates that nickel is being introduced within the catchment downstream of the control site. Lower concentrations at MB02 are consistent with downstream dilution. This pattern indicates a localised source within the Mare Burn catchment. The proposed trigger framework, applied with control site comparison, is considered appropriate for identifying site-related effects.

Zinc

Recommended trigger

A dissolved zinc trigger value is recommended for chronic exposure, defined as a function of DOC, hardness and pH using the ANZG (2024b) lookup table in Appendix A.

At representative Macraes Operation conditions (DOC 4.5 g/m³, hardness 220 g/m³ as CaCO₃ and pH 7.8), this corresponds to a chronic trigger value of 0.016 g/m³.

An acute trigger value is also recommended, defined as a function of DOC, hardness and pH by the following equation:

$$Acute\ TV = \frac{\exp(2.5 - 0.12\ pH + 0.6 \times \ln(hard.) + 0.13 \times \ln(DOC))}{1,000}$$

At representative Macraes Operation conditions, this corresponds to an acute trigger value of 0.148 g/m³.

Basis for trigger

National chronic guidance for zinc in freshwater is provided in ANZECC (2000). The trigger values for zinc incorporate hardness-based adjustment to account for reduced bioavailability under higher calcium carbonate concentrations. Unlike copper, the 2018 review (Warne *et al.* 2018) retained hardness as an appropriate toxicity-modifying factor for zinc.

Existing consent limits across Macraes Operation reflect earlier regulatory approaches, including hardness-adjusted values derived from the USEPA CCC (e.g., 0.23 g/m³ at hardness of 220 g/m³ as CaCO₃) and the ANZECC (2000) HMTV (e.g., 0.044 g/m³ at a hardness of 220 g/m³ as CaCO₃ at HC02). These approaches do not account for DOC or pH, which are now recognised as key controls on zinc bioavailability.

The draft ANZG (2024b) update represents a substantive refinement, incorporating expanded chronic toxicity datasets and a bioavailability-based framework that accounts for DOC, hardness and pH. This reflects contemporary understanding of zinc speciation in freshwater systems, where abiotic factors substantially influence the bioavailable fraction (Zn²⁺). Recent national acute guidance released by MfE (Gadd *et al.* 2024) similarly applies a bioavailability-based methodology.

Adoption of the draft ANZG (2024b) chronic framework, alongside the MfE (Gadd *et al.* 2024) acute guidance, is therefore recommended. Inclusion of chronic and acute triggers provides protection against long-term exposure effects as well as short-duration peak concentrations. While the ANZG guideline remains in draft form, it represents the most current and scientifically robust national guidance available. Viridis has previously reviewed and provided commentary on the guideline for OGNZL (Viridis 2024b), including consideration of its scientific basis, derivation methodology, and applicability to New Zealand conditions. This prior assessment provides confidence in the application of the draft values.

The proposed trigger values may be subject to minor refinement following finalisation of the ANZG guideline. The final guideline can be incorporated through updates to this framework and, where necessary, via consent conditions requiring its review and update.

Local context

Dissolved zinc concentrations within the Macraes Operation receiving environment are generally low, with many results at or near laboratory detection limits (refer Figures B22 and B23 of Appendix B). Concentrations occasionally exceeded the chronic trigger at several sites, including control site DC00. Within the Mare Burn catchment, concentrations at the upstream control site (MB00) remained consistently low, while repeated exceedances were observed downstream at MB01, particularly over the past year, meeting the framework criteria for non-compliance (Table B6, Appendix B).

This pattern indicates a localised increase in zinc concentrations between MB00 and MB01. At MB01, concentrations frequently exceed the chronic trigger, although this has not resulted in a consistent decline in macroinvertebrate community metrics (MCI/QMCI), which have fluctuated without a clear long-term trend (refer Appendix C).

A single exceedance of the proposed acute trigger was recorded at DC00 in June 2024 (Table B6, Appendix B), corresponding to the highest recorded dissolved zinc concentration at this site (0.13 g/m^3). This likely reflects an isolated upstream event or anomalous result, rather than a persistent condition.

On this basis, while elevated zinc concentrations are observed at some locations, these are not uniformly associated with mine-related activities across the monitoring network. However, the persistent exceedances observed at MB01 represent a localised issue downstream of the Mare Burn control site. The proposed trigger framework, applied with control site comparison as defined in this framework, is considered appropriate for identifying site-related effects.

Cyanide

Recommended trigger

A free cyanide ($\text{HCN} + \text{CN}^-$) trigger value is recommended, defined as a function of pH and temperature by the following equation:

$$TV = 0.007 \times (1 + 10^{(pH - (9.721 - 0.0194 \times Temp))})$$

Note: For conditions outside 10-30°C and 6-9 pH, the nearest boundary condition within the validated range should be applied.

At representative Macraes Operation conditions (pH 7.8 and temperature 20°C), this corresponds to a value of 0.0072 g/m^3 .

Basis for trigger

The ANZECC (2000) trigger value for cyanide is 0.007 g/m^3 , expressed as unionised hydrogen cyanide (HCN) at the 95% species protection level. HCN is the toxicologically active fraction, and its proportion within free cyanide is strongly influenced by pH and temperature.

To enable practical application, the ANZECC (2000) HCN-based guideline is used to derive a pH and temperature dependent trigger value for free cyanide. This approach defines the concentration of free cyanide ($\text{HCN} + \text{CN}^-$) that would correspond to the ANZECC HCN limit under site-specific conditions. In this way, the toxicity-based HCN guideline is retained, while expressing the trigger in a form that can be readily applied in monitoring and compliance assessment.

Routine monitoring at Macraes Operation has historically focused on weak acid dissociable (WAD) cyanide, which includes free cyanide and weak metal-cyanide complexes, but excludes strongly bound

iron-cyanide complexes. As unionised HCN represents only a fraction of free cyanide, and free cyanide is itself a subset of WAD cyanide, direct comparison of WAD cyanide results to an HCN-based trigger is inherently conservative and may overestimate ecological risk. This is particularly relevant under the circumneutral to mildly alkaline conditions typical of Macraes Operation receiving waters, where the proportion of unionised HCN is expected to be comparatively low.

Measurement of free cyanide is recommended to allow direct comparison with the proposed trigger value. However, given current analytical limitations in New Zealand (Hills Laboratories, pers. comm., February 2026), WAD cyanide may be used as a conservative interim surrogate.

Local context

Historical WAD cyanide results for key Macraes Operation compliance sites were reviewed as a surrogate for free cyanide and compared against a pH adjusted free cyanide trigger value. In the absence of measured temperature data, a standard assessment temperature of 20°C was adopted for retrospective evaluation of historical monitoring data.

Use of WAD cyanide as a surrogate for free cyanide is likely to overestimate ecological risk, particularly under the mildly alkaline conditions typical of Macraes Operation waters, where the proportion of unionised HCN is expected to be low. As a result, most detected cyanide concentrations were interpreted as exceedances, including isolated detections at control sites MB00 and DC00 (refer Figures B24 and B25 of Appendix B). Compliance sites most frequently exceeding the trigger value under this assumption, and thus qualifying as non-compliant, were CJ01 and TC01 (Table B7, Appendix B).

On this basis, the apparent frequency of exceedances reflects limitations in the use of WAD cyanide as a surrogate rather than a clear indication of ecological risk. The proposed trigger framework, supported by measurement of free cyanide where practicable, is considered appropriate for identifying site-related ecological effects.

5.3.4 Excluded constituents

Overview

A broad suite of constituents was reviewed as part of the screening assessment; however, only those considered relevant to the MP4 receiving environment have been selected for development of trigger values. The parameters discussed below were identified as potentially relevant but have not been progressed further, based on their risk profile and site-specific context.

Aluminium

Aluminium is a naturally abundant element that commonly enters aquatic systems via weathering processes. Its toxicity is strongly pH-dependent, with the most bioavailable and toxic forms occurring under acidic conditions. At the circumneutral to mildly alkaline pH typical of Macraes Operation receiving waters, aluminium is expected to predominate as hydroxide complexes, which are substantially less bioavailable.

The ANZECC (2000) 95% species protection level trigger value for aluminium of 0.055 g/m³ (applicable at pH >6.5) is assigned low reliability and is recommended only as an interim value under updated ANZG guidance (Warne *et al.* 2018). At the Macraes Operation, aluminium has not historically formed part of routine surface water monitoring. However, a six-month retrospective dataset (July to December 2025) obtained for some Macraes Operation sites indicates concentrations within key catchments are consistently below the interim DGV, ranging from below the laboratory detection limit (0.003 g/m³) to a

maximum of 0.043 g/m³ (Appendix D). No clear differences between control and compliance sites were observed. Additionally, mine seepage monitoring undertaken in 2023 and 2024 indicates relatively low dissolved aluminium concentrations (all below 0.03 g/m³) are being generated from the site's waste rock stacks (Appendix D).

Given the pH conditions of the receiving waters and the absence of elevated aluminium concentrations in available monitoring data, aluminium does not indicate an elevated risk to receiving water environments at Macraes Operation, and development of a trigger value is not warranted at this stage.

Antimony

Antimony has been excluded as a constituent of concern. Column leach testing undertaken by MWM (2026) identified low-level antimony release from two waste rock domains; however, concentrations remained well below the adopted water quality reference value of 0.074 g/m³ (i.e., Canadian chronic value; BC 2023). Available surface water monitoring data similarly indicate that antimony concentrations across the Macraes Operation remain consistently low and do not indicate a material risk to surface water quality.

Across the Macraes Operation monitoring network (Appendix D), total antimony concentrations are typically below laboratory detection limits (0.00021 g/m³), including at sites with longer-term records (NB03, MC02 and NBWRRF). Where detected, concentrations are very low; the maximum recorded value (0.006 g/m³ at DC08) is well below the adopted water quality reference value. Dissolved antimony data show a consistent pattern of non-detects or negligible concentrations, at upstream and control sites, further confirming that antimony has not been elevated in the receiving environment as a result of mining operations.

Cadmium

Cadmium has been monitored intermittently at Macraes Operation surface water sites, including limited historical data from the 1990s, recent monitoring in 2024, and retrospective data for 2025. Available results were at or below the detection limit (0.00005 g/m³) (Appendix D).

Guidance for cadmium includes the ANZECC (2000) HMTV of 0.012 g/m³ (at the 95% species protection level, adjusted for a representative Macraes Operation hardness of 220 g/m³ as CaCO₃). On this basis, cadmium concentrations in Macraes Operation receiving waters are well below guideline levels and do not indicate an elevated ecological risk. Development of a trigger value for cadmium is therefore not warranted at this stage.

Chloride

Chloride is relevant to irrigation water quality due to its potential effects on crop productivity and soil salinity. This is of particular relevance to the Shag River and NB03 receiving water sites, which may be subject to downstream irrigation uses.

The ANZECC (2000) irrigation guidelines include chloride criteria for the prevention of foliar injury to crops and for managing the risk of increased cadmium uptake in soils. Based on historical monitoring data for these sites (refer Appendix D), chloride concentrations fall within the most stringent category for protection of sensitive crops (<175 g/m³), and the 'low' risk category for increased cadmium uptake in soils (0-350 g/m³).

Given the low concentrations observed historically and their compliance with the most stringent irrigation guideline category, chloride does not currently indicate an elevated risk to irrigation uses at

the relevant receiving water quality sites. Accordingly, development of a chloride trigger value is not considered necessary for the proposed framework at this stage. This position should be revisited if future project design or treatment approaches indicate the potential for materially increased chloride concentrations in receiving waters.

Chromium

The environmental behaviour and toxicity of chromium are strongly dependent on oxidation state, with hexavalent chromium (Cr(VI)) recognised as the more bioavailable and toxic species in surface waters, compared with trivalent chromium (Cr(III)). In this context, the ANZECC (2000) trigger value for Cr(VI) of 0.001 g/m³ (at a 95% species protection level) provides an appropriate and conservative benchmark for assessing potential ecotoxicological risk.

Chromium has not been routinely monitored in Macraes Operation surface waters; however, recent back-trace data (July to December 2025) for dissolved chromium show that concentrations were consistently at or below the detection limit (0.0005 g/m³) at all sites assessed (Appendix D). These results represent dissolved chromium and do not distinguish between oxidation states; accordingly, comparison with the Cr(VI) trigger value is conservative. Notwithstanding this conservatism, concentrations remained well below the Cr(VI) guideline.

Given that results are at or near detection limits and that the limited detections are not associated with site-derived influences, chromium does not indicate an elevated risk to receiving water environments at Macraes Operation and development of a trigger value for chromium is not warranted at this stage.

Cobalt

Cobalt has not been routinely monitored in surface waters or mine waters at Macraes Operation. Guidance remains limited, with criteria available in the Canadian Federal Water Quality Guidelines (Environment Canada 2017) and ANZECC (2000).

The ANZECC (2000) freshwater trigger value of 0.0014 g/m³ is of uncertain reliability and does not specify a defined species protection level. The Canadian FWQG is hardness-dependent and corresponds to 0.0014 g/m³ at a hardness of 220 g/m³ as CaCO₃.

Retrospective data for July to December 2025 indicate that cobalt concentrations were generally low, with most sites below the detection limit (0.0002 g/m³). Relative to the hardness-adjusted Canadian guideline, exceedances were limited to a single event at MB00 (control site) and MB02. The absence of a consistent downstream signal (refer Appendix D) indicates that these exceedances are unlikely to be associated with mine-related sources.

On this basis, cobalt does not indicate an elevated risk to receiving water environments at Macraes Operation, and development of a trigger value is not warranted at this stage.

Fluoride

Fluoride was included in the January 2026 monitoring round at several compliance sites to inform an initial risk assessment. Concentrations across the relevant surface water sites ranged from 0.08 g/m³ at MB00 to 0.22 g/m³ at CJ01 (Appendix D). These values are well below the ANZG (2024c) DGV at the 95% species protection level of 1.7 g/m³ (expressed as fluoride ion). On this basis, development of a trigger value is not warranted at this stage.

Mercury

Dissolved mercury has been measured intermittently over time, with recent surface water results reported below detection limits (0.00008 g/m^3 - refer Appendix D). This detection limit is well below the ANZECC (2000) trigger value for inorganic mercury at the 95% level of protection of 0.0006 g/m^3 .

The 2018 guideline review (Warne *et al.* 2018) recommends accounting for mercury bioaccumulation by applying a higher level of protection than would ordinarily be selected (i.e., the 99% species protection level, which is 0.00006 g/m^3). As the current laboratory detection limit exceeds this DGV, comparison against the more conservative benchmark is not practicable.

Notwithstanding this limitation, available monitoring data indicate that dissolved mercury concentrations are consistently low and below the 95% level of protection. On this basis, and given the absence of evidence for elevated concentrations in receiving waters, inclusion of a specific trigger value is not warranted at this stage.

Molybdenum

To date, molybdenum has not been included in routine surface water or mine water monitoring at Macraes Operation, and no site-specific data are currently available to inform an assessment of risk. National guidance is limited to the ANZECC (2000) trigger value of 0.034 g/m^3 ; however, this value is assigned an uncertain reliability and does not specify a protection level.

In the absence of monitoring data and any indication of a mobilisation pathway associated with MP4 activities, development of a trigger value for molybdenum is not warranted at this stage.

Sodium

Like chloride, sodium is relevant to irrigation water quality due to its potential effects on crop productivity. This is of particular relevance to the Shag River and NB03 receiving water sites, which may be subject to downstream irrigation uses.

Based on historical monitoring data (refer Appendix D), sodium concentrations at the Shag River and NB03 sites consistently fall within the most stringent ANZECC (2000) category for protection of sensitive crops ($<115 \text{ g/m}^3$). Accordingly, sodium does not indicate an elevated risk to irrigation uses¹⁴.

Given the low sodium concentrations observed historically and their compliance with the most stringent irrigation guideline category, sodium does not currently indicate an elevated risk to irrigation uses at the relevant receiving water sites. Accordingly, development of a sodium trigger value is not considered necessary for the proposed framework at this stage.

Tungsten

Tungsten has not been monitored in Macraes Operation surface waters, and no site-specific data are currently available to inform risk. Although historically considered relatively immobile, more recent investigations have shown that tungsten can dissolve and migrate under certain environmental conditions. The USEPA classifies tungsten as an emerging contaminant, with limited and evolving information regarding its environmental fate and ecological toxicity (USEPA 2017).

¹⁴ The ANZECC (2000) irrigation guidelines also assess sodium-related soil impacts using the sodium adsorption ratio (SAR) in combination with salinity. Given the low sodium concentrations observed and their placement within the most stringent crop sensitivity category, SAR was not evaluated as part of this screening-level assessment.

In the absence of monitoring data and any indication of a mobilisation pathway associated with MP4 activities, development of a trigger value for tungsten is not warranted at this stage.

5.4 Compliance Assessment Rationale

5.4.1 Chronic trigger value assessment

Many of the proposed chronic trigger values are based on ANZG default guideline values (DGVs). ANZG recommends assessment against the 95th percentile of monitoring data to evaluate chronic ecological risk (ANZG 2023c). For monthly monitoring programmes, this percentile is typically evaluated over a five-year period to provide a statistically robust estimate¹⁵.

While this approach provides a high degree of statistical confidence, it is not always well suited to compliance frameworks where timely identification of emerging impacts and management responses is required. Accordingly, the MP4 framework adopts compliance assessment based on exceedance frequency and duration over shorter rolling timeframes, rather than formal percentile calculations. This provides a more practical and responsive method, while still capturing sustained exposure conditions and seasonal influences relevant to chronic ecological risk.

The adopted exceedance frequency (i.e., more than two exceedances in any rolling 12-month period) distinguishes repeated departures from trigger values from isolated exceedances that may arise from natural variability, episodic events or analytical uncertainty. The approach reflects a low tolerance for repeated exceedance of trigger values while providing confidence that non-compliance represents a persistent condition rather than a short-term fluctuation.

5.4.2 Acute trigger value assessment

Acute trigger values are assessed on the basis of any single exceedance, reflecting the potential for short-term exposures to cause immediate ecological effects. This approach aligns with the application of acute guideline values in ANZG and other international frameworks, where a single exceedance represents an elevated likelihood of adverse ecological effects.

5.4.3 Eutrophication trigger assessment

The eutrophication assessment framework adopts a SIN trigger value as an indicator of nutrient enrichment and eutrophication risk and recognises the need for ecological response assessment to determine whether nutrient enrichment is resulting in nuisance plant or algal growth.

The SIN trigger value is derived from the New Zealand Periphyton Guidelines (Biggs 2000), which identify nutrient thresholds associated with periphyton growth under different accrual periods and flow disturbance regimes. Consistent with the underlying intent of the guideline, the MP4 framework assesses the SIN trigger using a rolling annual median concentration to reflect the importance of sustained nutrient conditions in influencing plant and algal growth over time.

Historical monitoring within the Macraes Operation catchments demonstrates substantial variability in plant and algal growth at similar nutrient concentrations, indicating that ecological responses are strongly influenced by site-specific factors, including flow regime, riparian shading, light availability and grazing pressure. Accordingly, ecological response assessment is also required alongside the SIN trigger

¹⁵ At a 95% confidence interval. For example, to estimate a 90th percentile to this degree of accuracy, a minimum sample size of 36 is required. For a monthly sampling programme, five years of monitoring provides a sufficient number of samples to calculate a 95th percentile to this degree of accuracy.

assessment and should be interpreted in the context of broader site conditions and relevant control site data where available.

5.4.4 Return to compliance

For chronic and acute trigger values, return to compliant status requires a sustained period without further exceedance, reflecting the need to demonstrate that elevated concentrations were not persistent and that water quality conditions have stabilised.

For eutrophication, return to compliance will be assessed in accordance with the nutrient and ecological response assessment framework adopted through the consenting process. In general, return to compliance is expected to occur where either nutrient concentrations no longer exceed the applicable trigger value, or monitoring demonstrates that the ecological response assessment criteria are no longer exceeded.

The adopted return-to-compliance periods provide an appropriate balance between demonstrating sustained improvement and avoiding unnecessary delay in recognising recovery. For chronic and acute trigger values, a six-month lag period was selected to provide sufficient time to demonstrate that elevated concentrations are not persistent, while still allowing the framework to remain responsive to changing receiving environment conditions.

6 CONCLUSION

This report presents a recommended framework of surface water quality trigger values to support assessment and management of potential effects associated with the proposed MP4 development under the FTAA. The framework establishes a consistent, site-wide approach to water quality management at the Macraes Operation, replacing historically derived limits with a unified system aligned with contemporary national and international guidance.

The proposed trigger values have been developed using a weight-of-evidence approach that integrates site-specific water chemistry, historical monitoring data, and available ecological information. Where appropriate, bioavailability-based methods have been applied to ensure that trigger values reflect both current scientific understanding and local receiving environment conditions.

Historical monitoring indicates that surface water quality across the Macraes Operation is generally consistent with the trigger values. Exceedances are typically localised and parameter-specific, reflecting a combination of natural background influences, legacy mining effects, and, in some cases, inputs associated with the current Macraes Operation. For several constituents assessed but not included in the proposed trigger framework (Section 5.3.4), available data show concentrations are consistently low relative to guideline values, with no evidence of ecological effects; accordingly, additional trigger values are not proposed at this stage.

The framework distinguishes between early warning trigger exceedances and defined non-compliance conditions, enabling a proportionate and risk-based response to changes in water quality. This approach supports timely investigation and, where required, management intervention, while avoiding over-interpretation of short-term variability.

Overall, the proposed framework provides a scientifically robust, site-specific, and effects-based basis for assessing surface water quality, supporting consistent compliance assessment and adaptive management of the Macraes Operation receiving environment. The framework also provides flexibility to further refine aspects of the assessment methodology, including ecological response assessment for eutrophication, through the consenting process.

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Appendix A

Toxicity Modifier Lookup Tables

Table A1. ANZG (2026) freshwater 95% species-protection guideline values for ammoniacal nitrogen (g N/m³) at different pH and temperature values.

Temp. (°C)	pH																														
	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0
10	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.6	1.6	1.5	1.4	1.3	1.2	1.2	1.0	0.94	0.84	0.74	0.64	0.55	0.47	0.40	0.34	0.29	0.24	0.21	0.17	0.15	0.13
11	1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.6	1.5	1.5	1.4	1.4	1.3	1.2	1.1	1.0	0.90	0.80	0.71	0.61	0.53	0.45	0.38	0.33	0.27	0.23	0.20	0.17	0.14	0.12
12	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.4	1.4	1.3	1.2	1.1	1.0	0.95	0.85	0.76	0.67	0.58	0.50	0.43	0.36	0.31	0.26	0.22	0.19	0.16	0.13	0.12
13	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.3	1.3	1.2	1.1	1.1	0.99	0.90	0.81	0.72	0.63	0.55	0.47	0.41	0.34	0.29	0.25	0.21	0.18	0.15	0.13	0.11
14	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.3	1.3	1.2	1.2	1.1	1.0	0.94	0.85	0.77	0.68	0.60	0.52	0.45	0.39	0.33	0.28	0.23	0.20	0.17	0.14	0.12	0.10
15	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.2	1.2	1.1	1.0	0.98	0.90	0.82	0.74	0.66	0.58	0.50	0.43	0.37	0.31	0.27	0.22	0.19	0.16	0.14	0.12	0.10
16	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.1	1.1	1.0	0.93	0.86	0.78	0.70	0.63	0.55	0.48	0.41	0.35	0.30	0.25	0.21	0.18	0.15	0.13	0.11	0.096
17	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.0	0.95	0.89	0.82	0.75	0.67	0.60	0.52	0.46	0.39	0.34	0.29	0.24	0.20	0.17	0.15	0.12	0.11	0.091
18	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.13	1.10	1.1	1.0	0.97	0.91	0.85	0.78	0.72	0.64	0.57	0.50	0.44	0.38	0.32	0.27	0.23	0.20	0.17	0.14	0.12	0.10	0.087
19	1.2	1.2	1.2	1.2	1.2	1.15	1.13	1.11	1.09	1.06	1.0	0.98	0.93	0.88	0.82	0.75	0.69	0.62	0.55	0.48	0.42	0.36	0.31	0.26	0.22	0.19	0.16	0.13	0.11	0.098	0.084
20	1.1	1.1	1.1	1.1	1.1	1.09	1.08	1.06	1.03	1.00	0.97	0.93	0.88	0.83	0.78	0.72	0.65	0.59	0.52	0.46	0.40	0.34	0.29	0.25	0.21	0.18	0.15	0.13	0.11	0.093	0.080
21	1.1	1.1	1.1	1.0	1.0	1.03	1.01	0.99	0.97	0.94	0.91	0.87	0.83	0.78	0.73	0.67	0.61	0.55	0.49	0.43	0.37	0.32	0.28	0.23	0.20	0.17	0.14	0.12	0.10	0.087	0.075
22	1.0	1.0	1.0	1.0	1.0	0.99	0.98	0.96	0.94	0.91	0.88	0.84	0.80	0.76	0.71	0.65	0.59	0.53	0.47	0.42	0.36	0.31	0.27	0.23	0.19	0.16	0.14	0.12	0.099	0.084	0.072
23	0.98	0.98	0.97	0.96	0.95	0.94	0.93	0.91	0.89	0.87	0.84	0.80	0.76	0.72	0.67	0.62	0.56	0.51	0.45	0.40	0.34	0.30	0.25	0.22	0.18	0.15	0.13	0.11	0.093	0.080	0.069
24	0.93	0.92	0.92	0.91	0.90	0.89	0.88	0.86	0.84	0.82	0.79	0.76	0.72	0.68	0.63	0.58	0.53	0.48	0.42	0.37	0.32	0.28	0.24	0.20	0.17	0.15	0.12	0.10	0.088	0.075	0.065
25	0.88	0.88	0.87	0.87	0.86	0.85	0.83	0.82	0.80	0.78	0.75	0.72	0.68	0.65	0.60	0.55	0.51	0.45	0.40	0.36	0.31	0.27	0.23	0.19	0.16	0.14	0.12	0.099	0.084	0.072	0.062
26	0.84	0.83	0.83	0.82	0.81	0.80	0.79	0.78	0.76	0.74	0.71	0.68	0.65	0.61	0.57	0.53	0.48	0.43	0.38	0.34	0.29	0.25	0.22	0.18	0.16	0.13	0.11	0.094	0.080	0.068	0.058
27	0.79	0.79	0.78	0.78	0.77	0.76	0.75	0.74	0.72	0.70	0.68	0.65	0.62	0.58	0.54	0.50	0.45	0.41	0.36	0.32	0.28	0.24	0.20	0.17	0.15	0.12	0.11	0.089	0.075	0.064	0.056
28	0.75	0.75	0.74	0.74	0.73	0.72	0.71	0.70	0.68	0.66	0.64	0.61	0.58	0.55	0.51	0.47	0.43	0.39	0.34	0.30	0.26	0.23	0.19	0.16	0.14	0.12	0.099	0.084	0.071	0.061	0.052
29	0.71	0.71	0.70	0.70	0.69	0.68	0.67	0.66	0.64	0.62	0.60	0.58	0.55	0.52	0.48	0.45	0.41	0.37	0.32	0.29	0.25	0.21	0.18	0.16	0.13	0.11	0.094	0.079	0.067	0.058	0.050
30	0.66	0.66	0.66	0.65	0.65	0.64	0.63	0.62	0.60	0.58	0.57	0.54	0.52	0.49	0.45	0.42	0.38	0.34	0.30	0.27	0.23	0.20	0.17	0.15	0.12	0.10	0.088	0.074	0.063	0.054	0.046

Notes: For conditions outside the ranges of 10-30°C and 6-9 pH, the trigger value corresponding to the nearest boundary condition within the validated range should be applied.

Table A2. ANZG (2024a) freshwater 95% species-protection guideline values for dissolved nickel (g/m³) at different pH, hardness and DOC values.

Parameter		DGV (g/m ³)							
pH		6.0							
Hardness (g/m ³ CaCO ₃)		12	23	31	39	83	166	223	397
DOC (g/m ³)	0.5	0.0027	0.0041	0.0048	0.0055	0.0079	0.011	0.012	0.016
	1	0.0039	0.0061	0.0073	0.0084	0.012	0.017	0.02	0.025
	3	0.0065	0.01	0.013	0.015	0.023	0.033	0.039	0.051
	5	0.0081	0.013	0.016	0.019	0.03	0.044	0.051	0.068
	10	0.011	0.017	0.02	0.024	0.04	0.061	0.072	0.106
	15	0.013	0.02	0.023	0.028	0.046	0.071	0.086	0.118
	20	0.015	0.022	0.026	0.03	0.05	0.079	0.096	0.134
pH		6.5							
Hardness (g/m ³ CaCO ₃)		12	23	31	39	83	166	223	397
DOC (g/m ³)	0.5	0.0024	0.0034	0.0039	0.0044	0.0061	0.0079	0.0089	0.011
	1	0.0034	0.005	0.0058	0.0066	0.0094	0.012	0.014	0.018
	3	0.0053	0.0082	0.0099	0.012	0.017	0.024	0.028	0.035
	5	0.0065	0.01	0.012	0.014	0.022	0.032	0.037	0.047
	10	0.0084	0.013	0.016	0.019	0.03	0.044	0.052	0.069
	15	0.0099	0.015	0.018	0.022	0.035	0.053	0.062	0.084
	20	0.011	0.017	0.02	0.024	0.038	0.059	0.07	0.096
pH		7.0							
Hardness (g/m ³ CaCO ₃)		12	23	31	39	83	166	223	397
DOC (g/m ³)	0.5	0.0019	0.0026	0.0029	0.0033	0.0043	0.0056	0.0062	0.0077
	1	0.0027	0.0038	0.0043	0.0048	0.0065	0.0085	0.0095	0.012
	3	0.0043	0.0063	0.0074	0.0084	0.012	0.016	0.018	0.023
	5	0.0051	0.0077	0.0091	0.01	0.015	0.021	0.024	0.03
	10	0.0065	0.0098	0.012	0.014	0.021	0.03	0.034	0.044
	15	0.0074	0.011	0.013	0.016	0.024	0.035	0.041	0.055
	20	0.0082	0.012	0.015	0.017	0.027	0.04	0.047	0.062

Parameter		DGV (g/m ³)							
pH		7.5							
Hardness (g/m ³ CaCO ₃)		12	23	31	39	83	166	223	397
DOC (g/m ³)	0.5	0.0014	0.0018	0.002	0.0022	0.0028	0.0034	0.0038	0.0046
	1	0.002	0.0027	0.003	0.0033	0.0042	0.0052	0.0057	0.0068
	3	0.0032	0.0045	0.0052	0.0057	0.0077	0.0098	0.011	0.013
	5	0.0038	0.0055	0.0064	0.0072	0.01	0.013	0.014	0.017
	10	0.0047	0.0069	0.0082	0.0093	0.014	0.019	0.021	0.026
	15	0.0052	0.0078	0.0093	0.011	0.016	0.022	0.025	0.032
	20	0.0057	0.0085	0.01	0.012	0.018	0.025	0.029	0.037
pH		8.0							
Hardness (g/m ³ CaCO ₃)		12	23	31	39	83	166	223	397
DOC (g/m ³)	0.5	0.001	0.0012	0.0013	0.0014	0.0016	0.002	0.0023	0.003
	1	0.0014	0.0018	0.002	0.0021	0.0024	0.0029	0.0031	0.0039
	3	0.0023	0.003	0.0034	0.0037	0.0047	0.0055	0.0059	0.0067
	5	0.0026	0.0037	0.0042	0.0047	0.0062	0.0075	0.008	0.009
	10	0.0031	0.0045	0.0053	0.006	0.0084	0.011	0.012	0.014
	15	0.0033	0.005	0.0059	0.0067	0.0097	0.013	0.015	0.018
	20	0.0035	0.0053	0.0063	0.0072	0.011	0.015	0.017	0.02
pH		8.5							
Hardness (g/m ³ CaCO ₃)		12	23	31	39	83	166	223	397
DOC (g/m ³)	0.5	0.0007	0.0008	0.0008	0.0008	0.0011	0.0015	0.0017	0.0021
	1	0.001	0.0012	0.0012	0.0013	0.0014	0.0019	0.0022	0.0028
	3	0.0015	0.002	0.0022	0.0023	0.0028	0.003	0.0032	0.004
	5	0.0017	0.0023	0.0026	0.0029	0.0037	0.0042	0.0043	0.0049
	10	0.0019	0.0027	0.0032	0.0036	0.0049	0.0062	0.0067	0.0073
	15	0.002	0.0029	0.0034	0.0039	0.0056	0.0074	0.0082	0.0094
	20	0.002	0.003	0.0036	0.0041	0.006	0.0082	0.0092	0.011

Notes: For conditions outside pH 6-8.5, hardness 12-397 g/m³ and DOC 0.5-20 g/m³, the trigger value corresponding to the nearest boundary condition within the validated range should be applied.

Table A3. ANZG (2024b) freshwater 95% species-protection guideline values for dissolved zinc (g/m³) at different pH, hardness and DOC values.

Parameter		DGV (g/m ³)							
pH		6.2							
Hardness (g/m ³ CaCO ₃)		20	30	60	90	120	180	300	440
DOC (g/m ³)	0.5	0.0079	0.0092	0.012	0.013	0.015	0.017	0.019	0.021
	1	0.0087	0.01	0.013	0.015	0.016	0.019	0.021	0.023
	2	0.0096	0.011	0.014	0.016	0.018	0.021	0.024	0.026
	5	0.011	0.013	0.016	0.019	0.021	0.025	0.028	0.03
	10	0.012	0.014	0.018	0.021	0.024	0.028	0.031	0.033
	15	0.013	0.015	0.019	0.023	0.026	0.029	0.032	0.035
pH		6.5							
Hardness (g/m ³ CaCO ₃)		20	30	60	90	120	180	300	440
DOC (g/m ³)	0.5	0.0065	0.0076	0.0097	0.011	0.012	0.014	0.016	0.017
	1	0.0075	0.0087	0.011	0.013	0.014	0.017	0.018	0.02
	2	0.0086	0.01	0.013	0.015	0.017	0.019	0.021	0.023
	5	0.01	0.012	0.015	0.018	0.02	0.023	0.026	0.028
	10	0.012	0.014	0.018	0.021	0.023	0.027	0.03	0.033
	15	0.013	0.015	0.019	0.023	0.025	0.03	0.033	0.035
pH		7.0							
Hardness (g/m ³ CaCO ₃)		20	30	60	90	120	180	300	440
DOC (g/m ³)	0.5	0.0048	0.0056	0.0072	0.0083	0.0092	0.011	0.012	0.013
	1	0.0059	0.0068	0.0087	0.01	0.011	0.013	0.015	0.016
	2	0.0072	0.0083	0.011	0.012	0.014	0.016	0.018	0.019
	5	0.0094	0.011	0.014	0.016	0.018	0.021	0.023	0.025
	10	0.011	0.013	0.017	0.02	0.022	0.026	0.029	0.031
	15	0.013	0.015	0.019	0.022	0.025	0.029	0.032	0.035

Parameter		DGV (g/m ³)							
pH		7.5							
Hardness (g/m ³ CaCO ₃)		20	30	60	90	120	180	300	440
DOC (g/m ³)	0.5	0.0035	0.0041	0.0053	0.0061	0.0068	0.0079	0.0088	0.0096
	1	0.0045	0.0053	0.0068	0.0079	0.0088	0.01	0.011	0.012
	2	0.0059	0.0069	0.0088	0.01	0.011	0.013	0.015	0.016
	5	0.0083	0.0097	0.012	0.014	0.016	0.018	0.02	0.022
	10	0.011	0.013	0.016	0.018	0.02	0.024	0.026	0.028
	15	0.013	0.015	0.019	0.021	0.024	0.027	0.03	0.033
pH		8.0							
Hardness (g/m ³ CaCO ₃)		20	30	60	90	120	180	300	440
DOC (g/m ³)	0.5	0.0025	0.003	0.0039	0.0045	0.0051	0.0059	0.0066	0.0072
	1	0.0035	0.0041	0.0053	0.0062	0.0069	0.008	0.0089	0.0097
	2	0.0048	0.0056	0.0073	0.0084	0.0093	0.011	0.012	0.013
	5	0.0072	0.0085	0.011	0.013	0.014	0.016	0.018	0.019
	10	0.0097	0.011	0.015	0.017	0.019	0.021	0.023	0.025
	15	0.012	0.014	0.018	0.02	0.022	0.025	0.028	0.03
pH		8.3							
Hardness (g/m ³ CaCO ₃)		20	30	60	90	120	180	300	440
DOC (g/m ³)	0.5	0.0021	0.0025	0.0033	0.0038	0.0042	0.005	0.0055	0.006
	1	0.003	0.0035	0.0046	0.0053	0.0059	0.0069	0.0077	0.0084
	2	0.0042	0.005	0.0065	0.0075	0.0083	0.0095	0.011	0.011
	5	0.0065	0.0077	0.01	0.012	0.013	0.015	0.016	0.017
	10	0.0089	0.011	0.014	0.016	0.018	0.02	0.022	0.023
	15	0.011	0.013	0.017	0.019	0.021	0.024	0.026	0.028

Notes: For conditions outside 6 pH-8.3, hardness 20-440 g/m³ and 0.5-15 g/m³ DOC, the trigger value corresponding to the nearest boundary condition within the validated range should be applied.

Appendix B

Evaluation of Trigger Values against Historical Data

pH

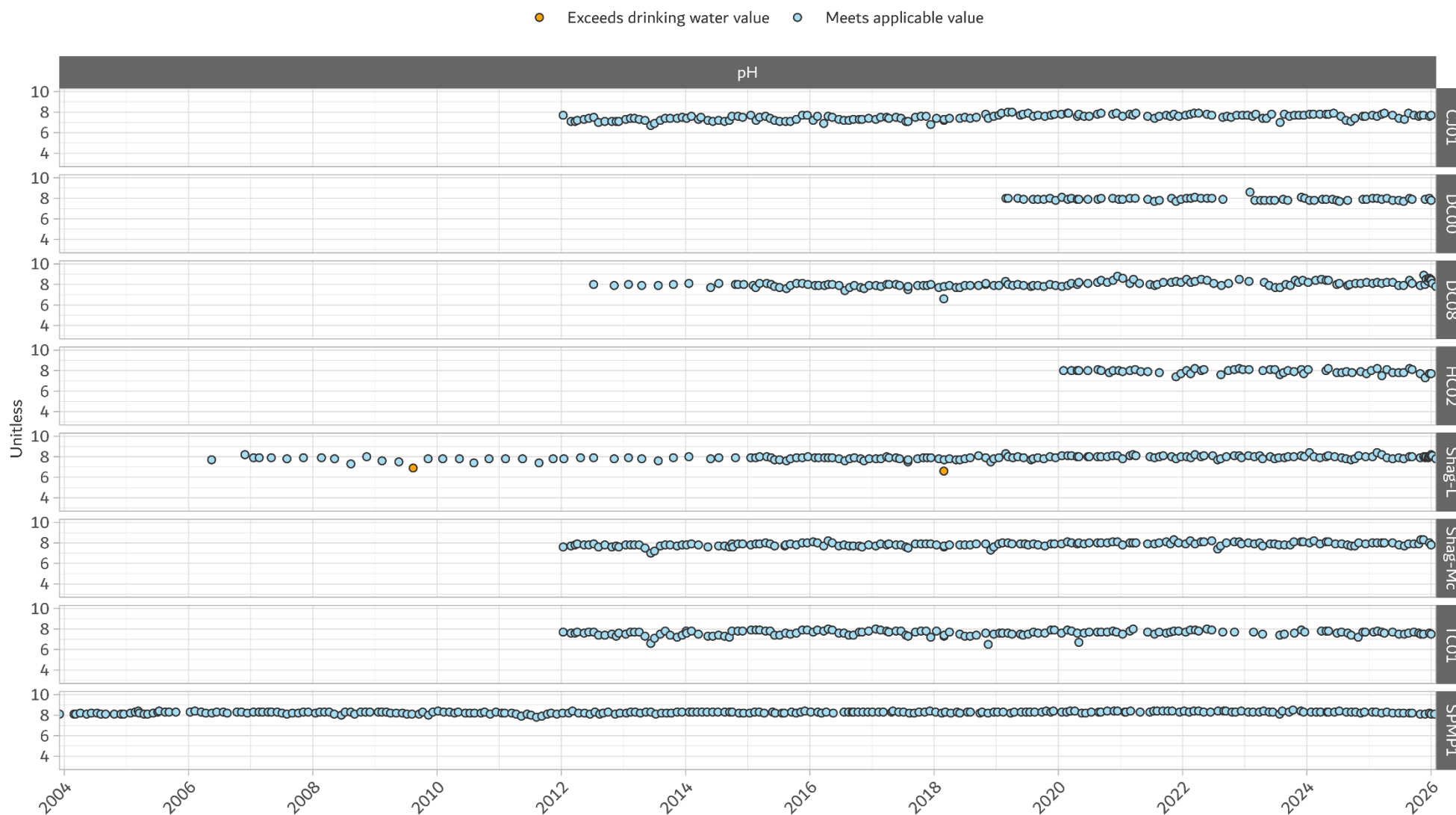


Figure B1. Historical pH measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed pH trigger range.

Note: scale excludes earlier measurements at SPMP1 between 2001 and 2004, all of which were within the proposed trigger range (refer Appendix D).

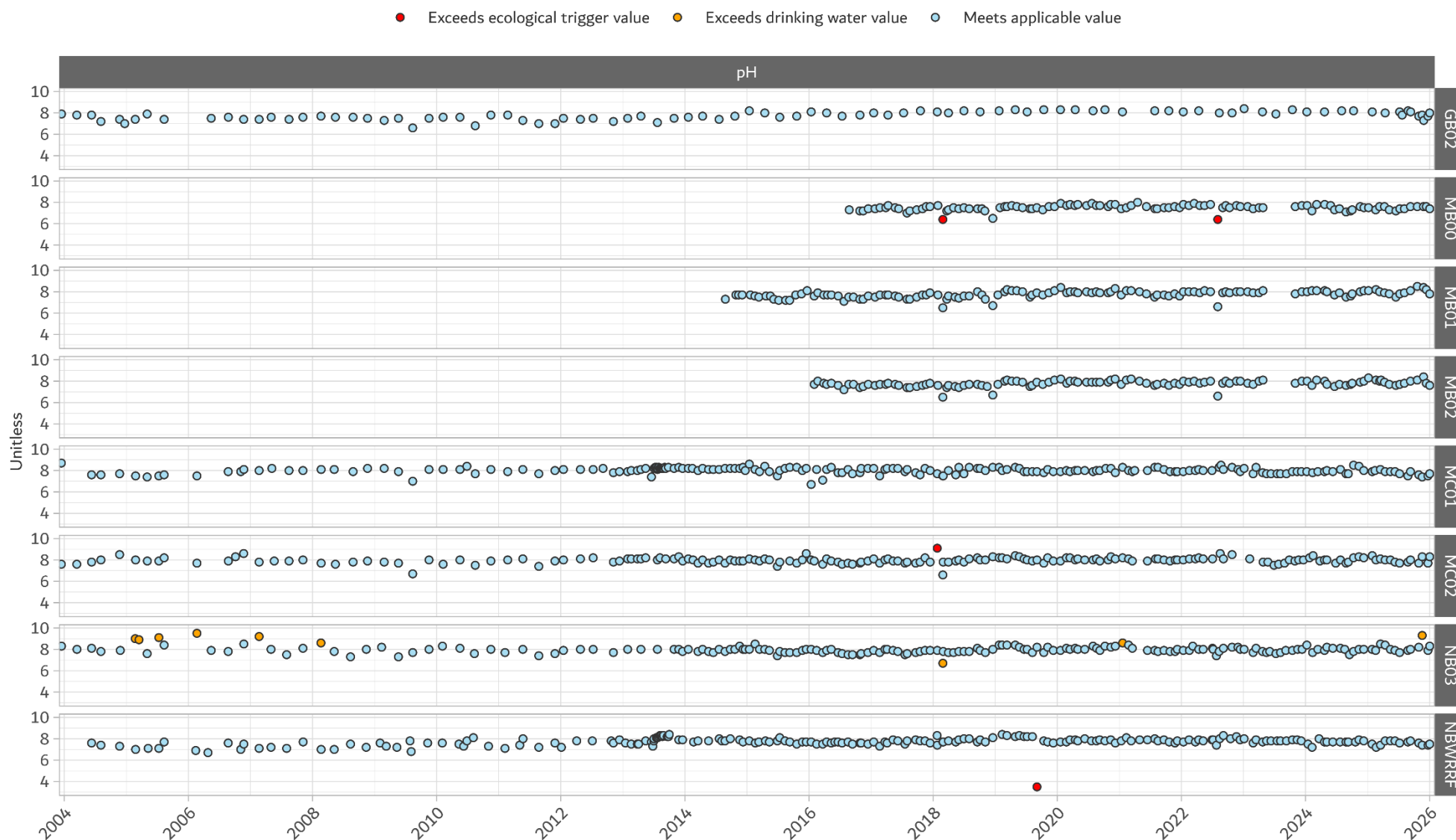


Figure B2. Historical pH measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed pH trigger range.

Turbidity

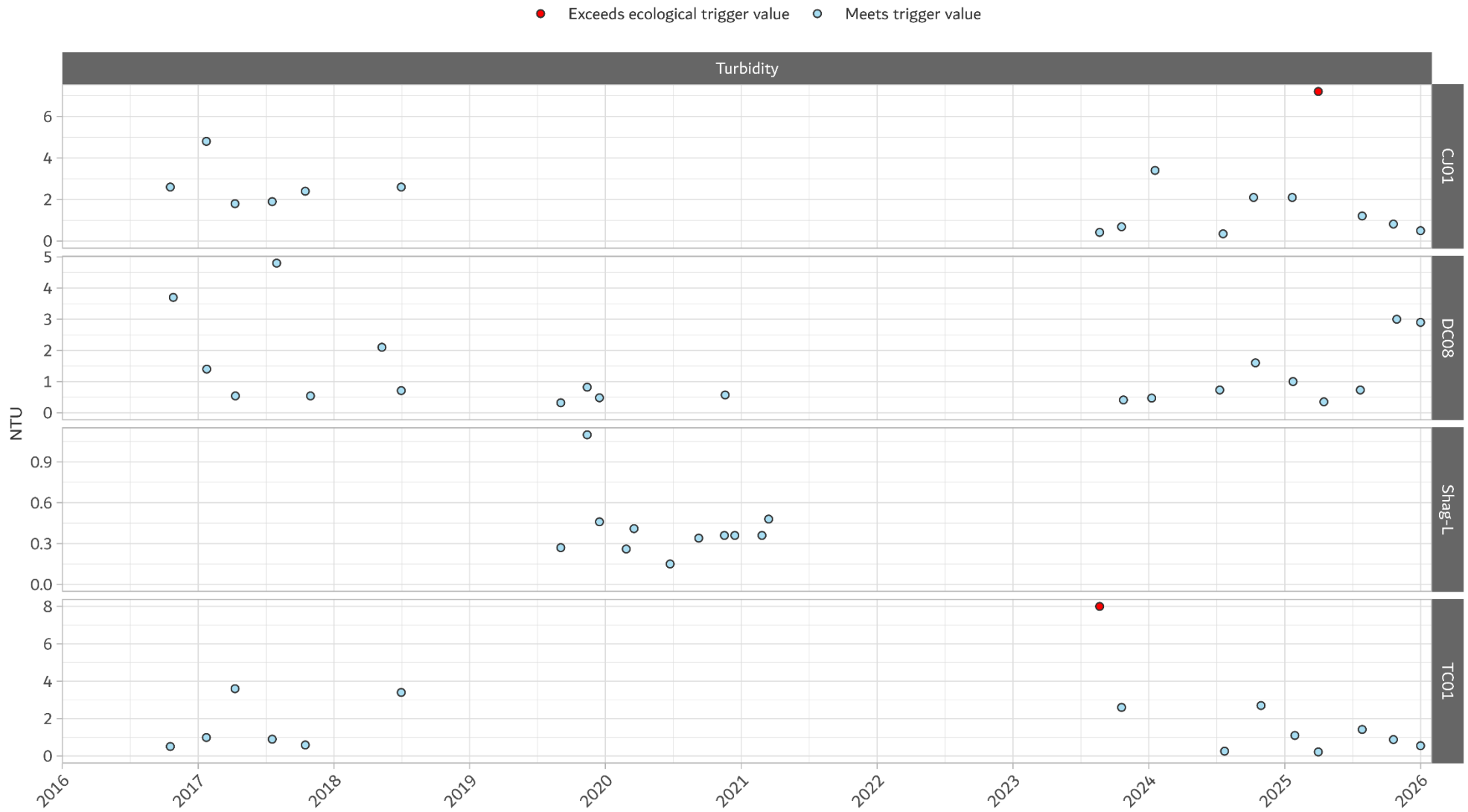


Figure B3. Historical turbidity measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed turbidity trigger.

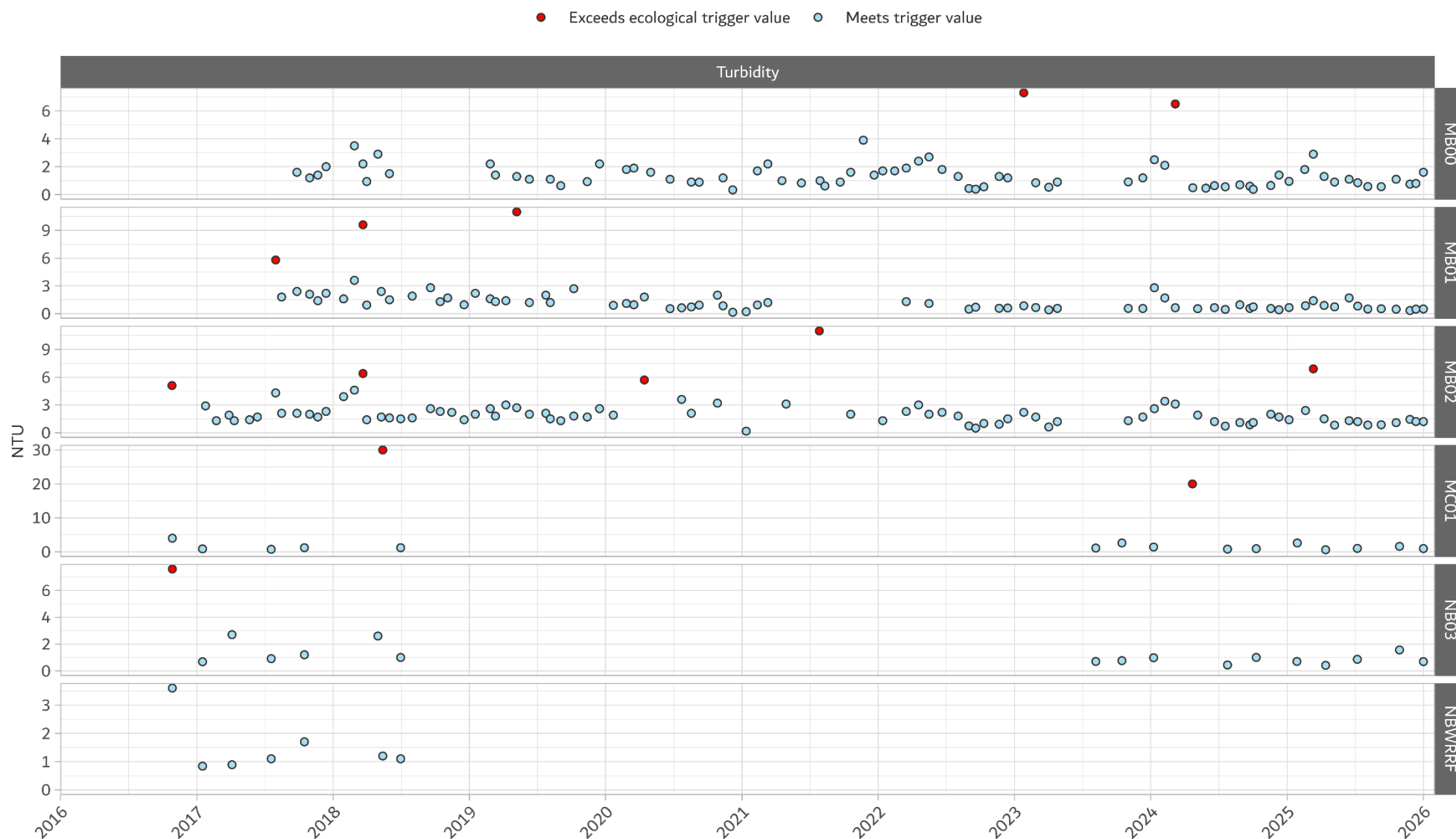


Figure B4. Historical turbidity measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed turbidity trigger. Note: scale excludes isolated exceedance of 40 NTU at NBWRRF on 26 April 2006.

Sulphate

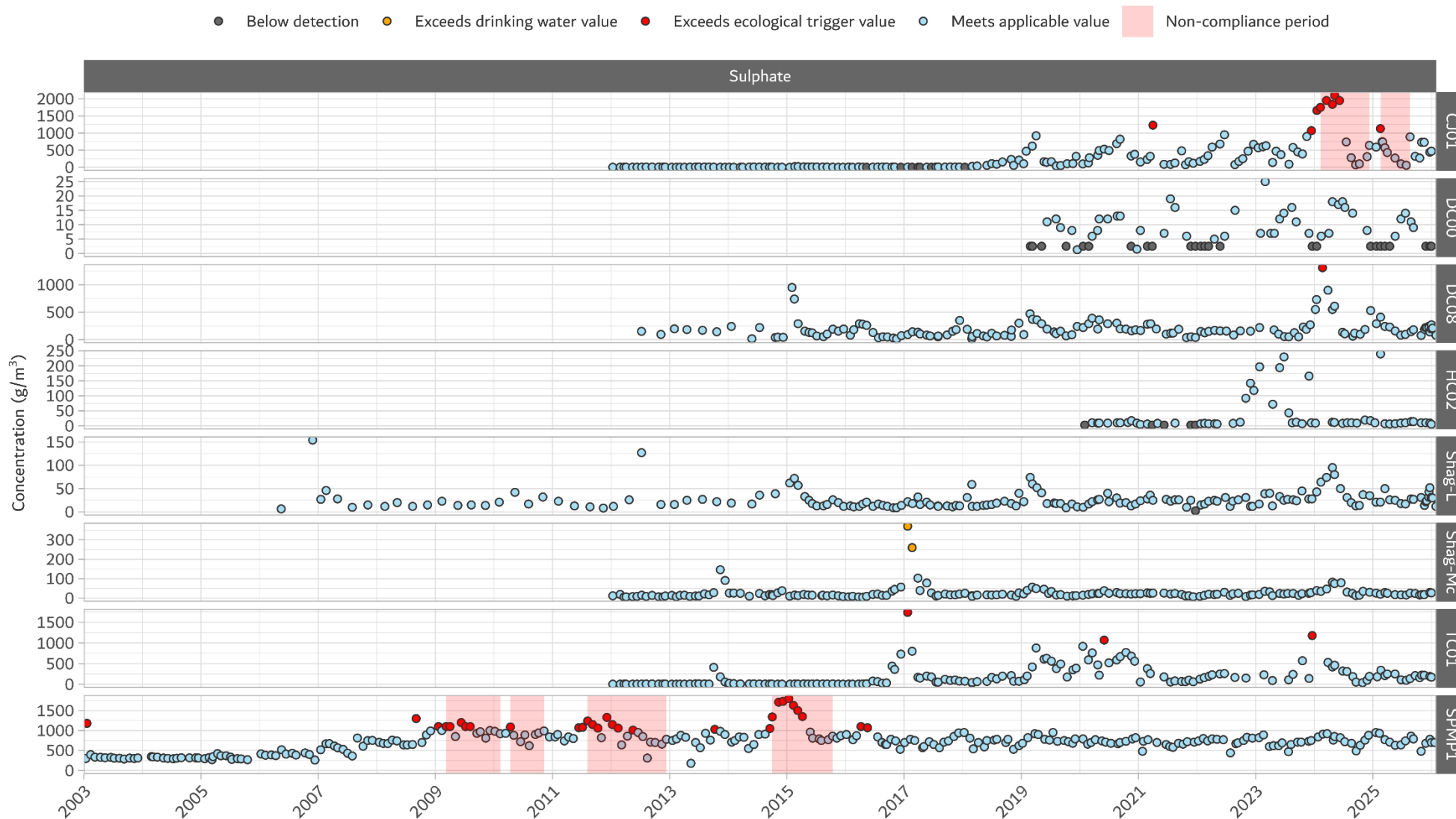


Figure B5. Historical sulphate measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed sulphate trigger.
Note: scale excludes earlier measurements at SPMP1 between 2001 and 2003, all of which were below the applicable trigger value (refer Appendix D).

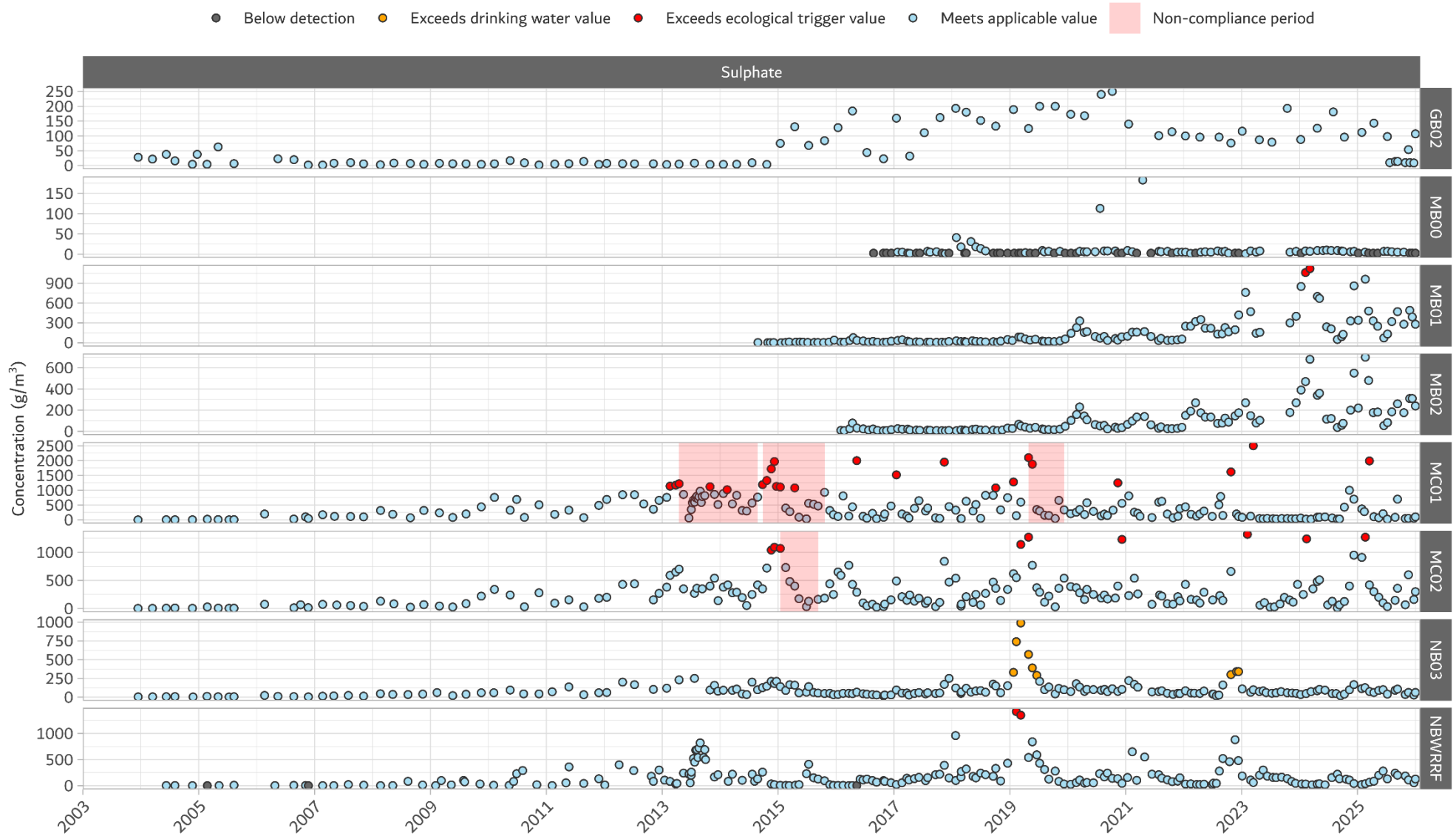


Figure B6. Historical sulphate measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed sulphate trigger.

Table B1. Non-compliance periods for sulphate, defined as >2 exceedances of the ecological trigger value, within any rolling 12-month period.

Site	Non-compliance window		Number of measurements	Number of exceedances*
	Start	End		
CJ01	9/02/2024	10/12/2024	11	5
CJ01	17/02/2025	21/08/2025	9	1
MC01	17/04/2013	25/08/2014	27	3
MC01	25/09/2014	21/10/2015	15	7
MC01	29/04/2019	9/12/2019	9	2
MC02	15/01/2015	10/09/2015	8	1
SPMP1	9/03/2009	9/02/2010	12	5
SPMP1	14/04/2010	9/11/2010	8	1
SPMP1	8/08/2011	11/12/2012	17	7
SPMP1	2/10/2014	13/10/2015	13	7

Notes: *During the non-compliance window; inclusive of the first measurement that triggers non-compliance.

Ammoniacal nitrogen

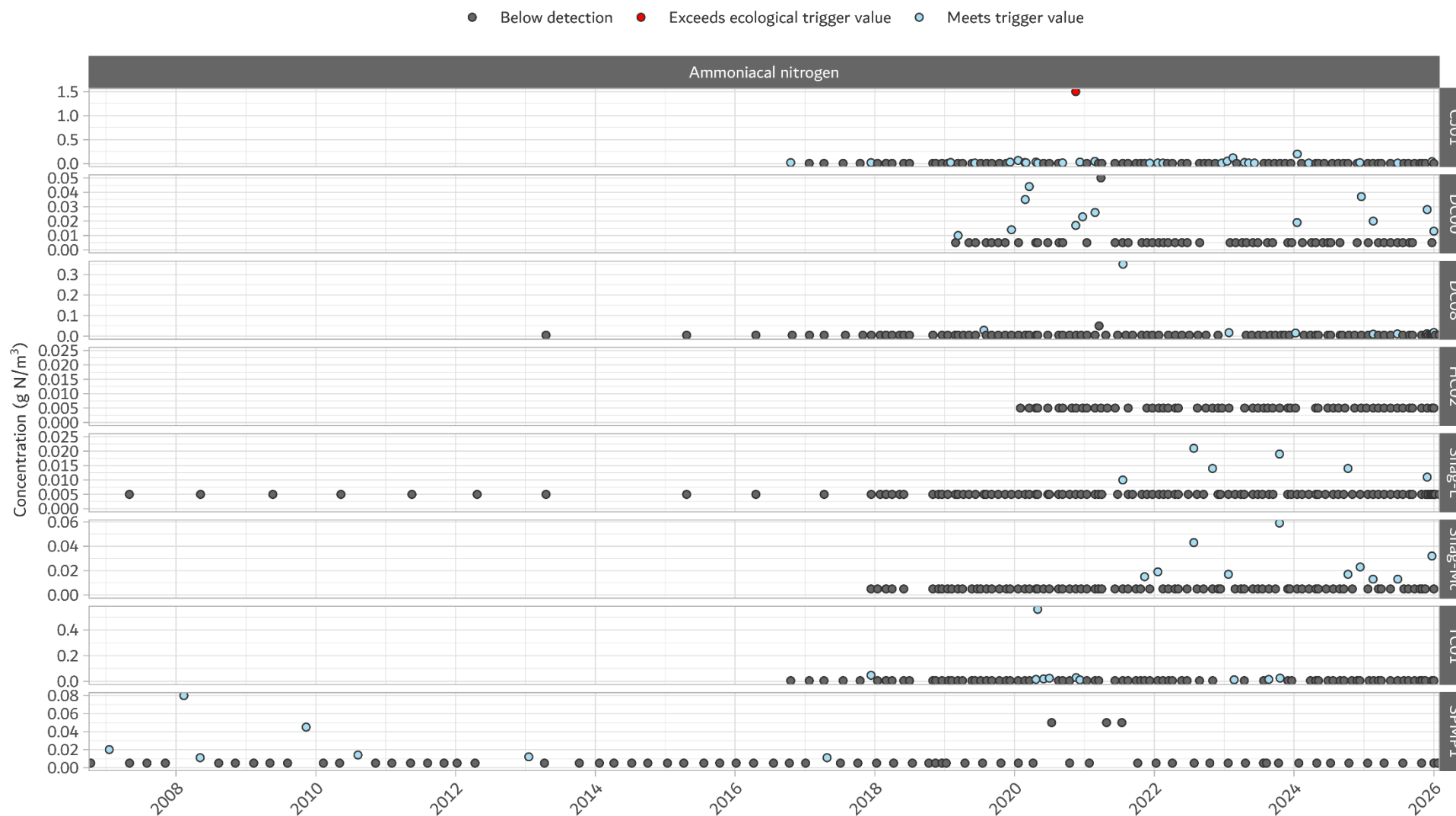


Figure B7. Historical ammoniacal nitrogen measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed trigger. Note: scale excludes earlier measurements at SPMP1 between 2001 and 2007, all of which were below the applicable trigger value (refer Appendix D).



Figure B8. Historical ammoniacal nitrogen measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed trigger.

Nitrate nitrogen

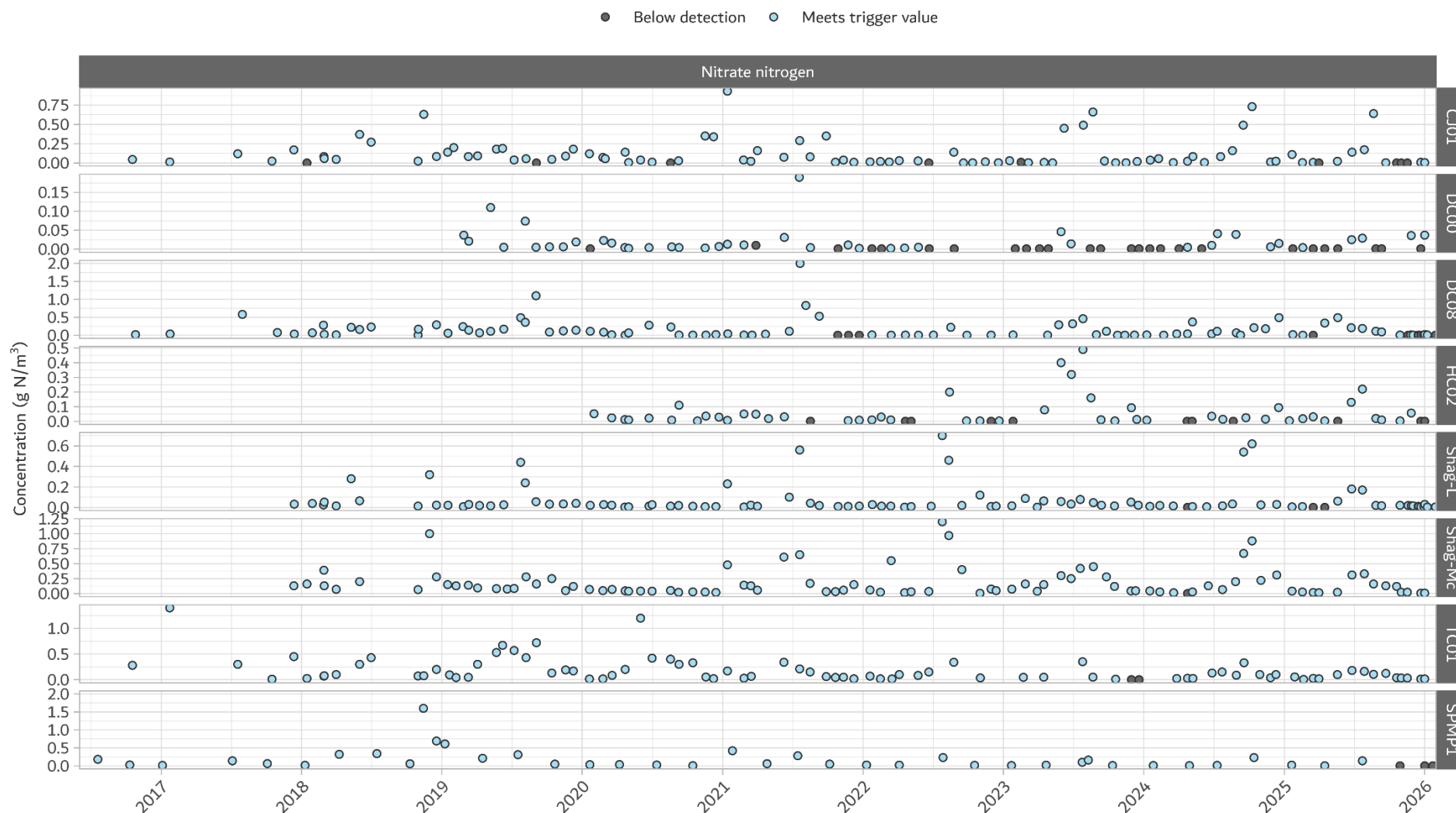


Figure B9. Historical nitrate nitrogen measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed trigger.

Note: scale excludes earlier measurements at some sites between 2001 and 2016, which were below the proposed trigger, except for SPMP1 in January 2003 and TC01 in May 2020 (refer Appendix D).

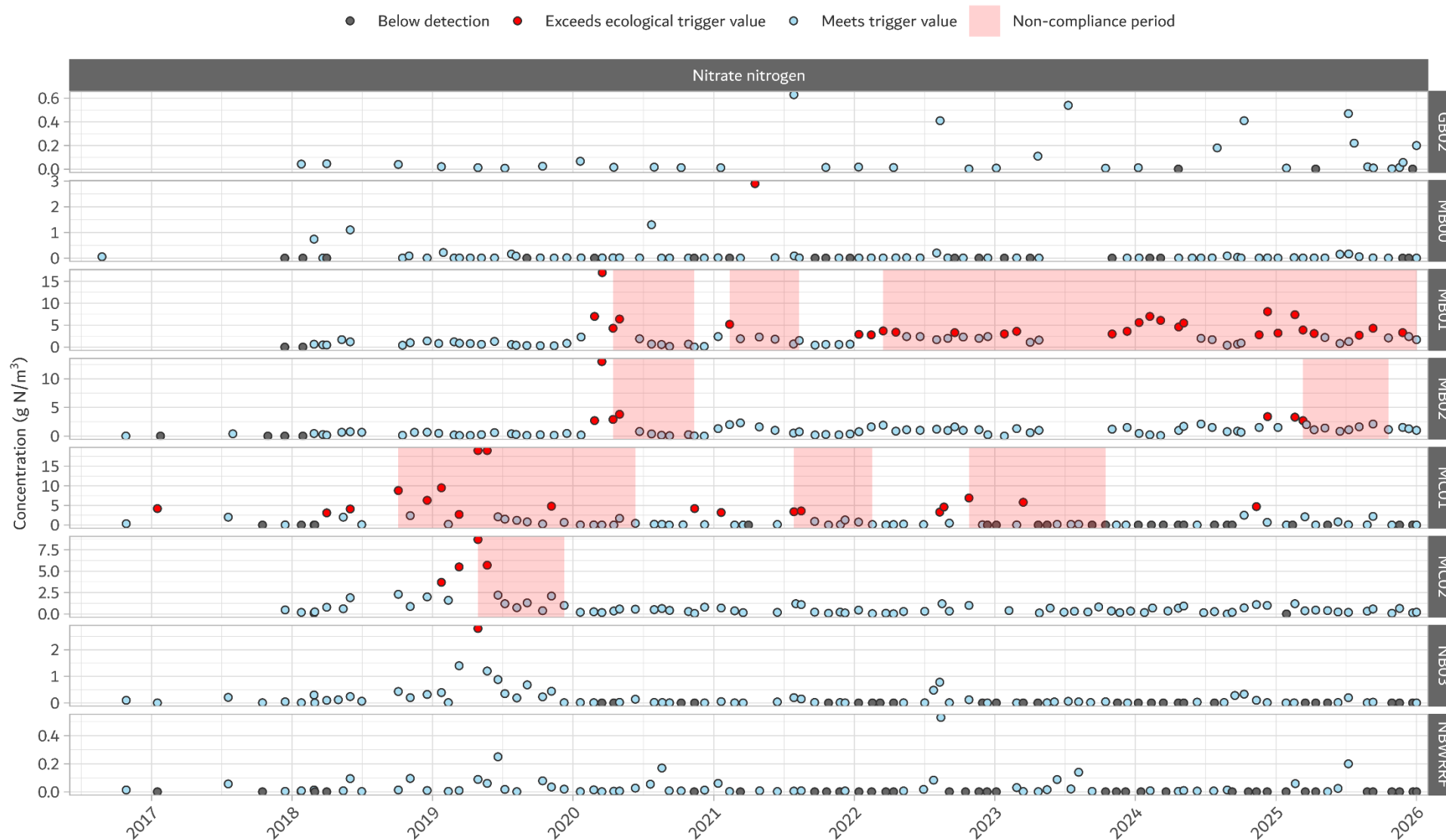


Figure B10. Historical nitrate nitrogen measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed trigger. Note: scale excludes sporadic measurements between 2003 and 2010 at a few sites, all of which were below with the proposed trigger, and single exceedance at NBWRRF in September 2019 (refer Appendix D).

Table B2. Non-compliance periods for nitrate nitrogen, defined as >2 exceedances of the ecological trigger value, within any rolling 12-month period.

Site	Non-compliance window		Number of measurements	Number of exceedances*
	Start	End		
MB01	14/04/2020	11/11/2020	8	2
MB01	11/02/2021	11/08/2021	6	1
MB01	17/03/2022	1/01/2026	41	21
MB02	14/04/2020	11/11/2020	8	2
MB02	12/03/2025	20/10/2025	9	1
MC01	4/10/2018	11/06/2020	21	7
MC01	28/07/2021	17/02/2022	8	2
MC01	26/10/2022	16/10/2023	13	2
MC02	29/04/2019	9/12/2019	9	2

Notes: *During the non-compliance window; inclusive of the first measurement that triggers non-compliance.

Eutrophication (soluble inorganic nitrogen)

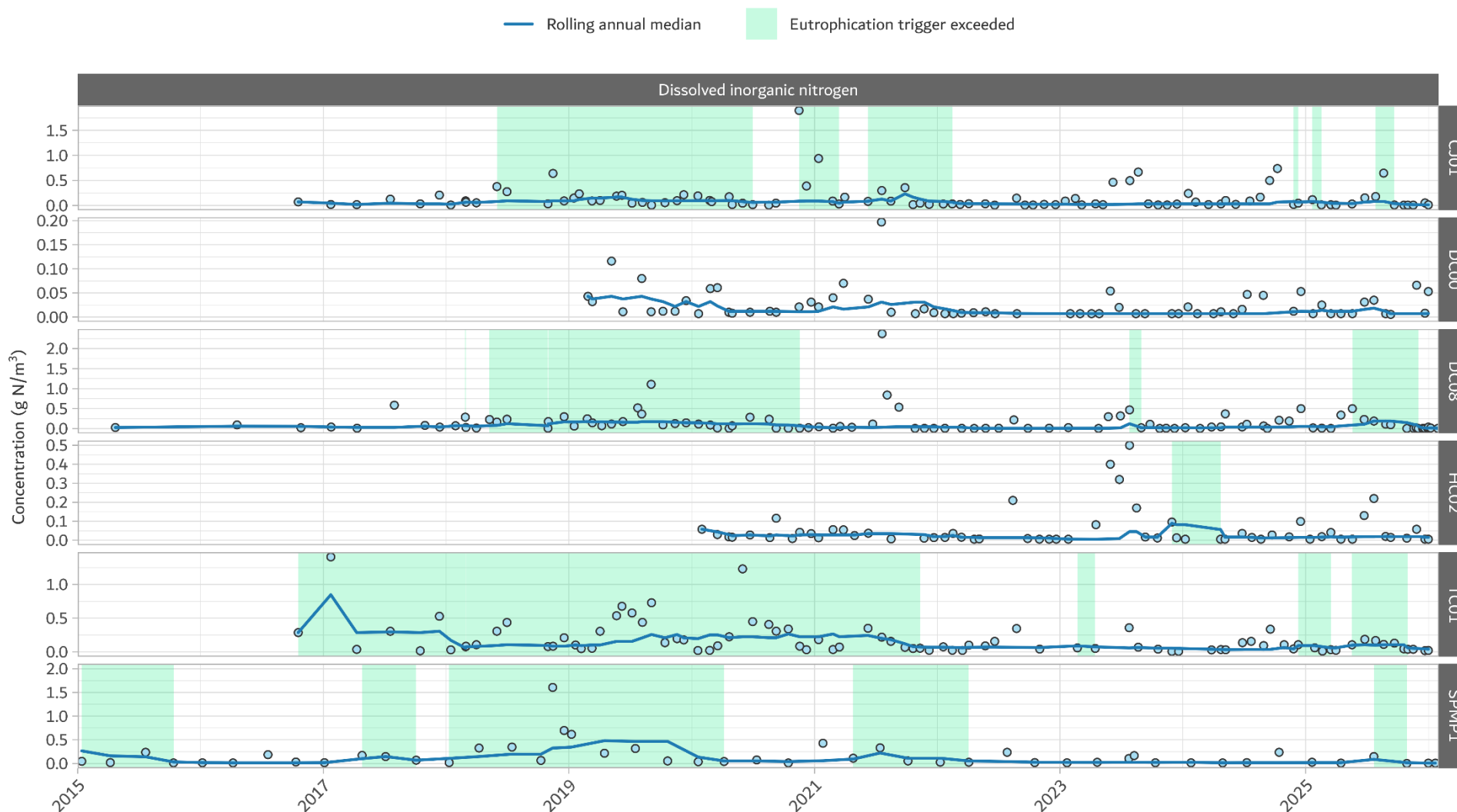


Figure B11. Historical soluble inorganic nitrogen measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed trigger for SIN. Note: exceedances assessed against rolling annual median. Non-compliance criteria still to be determined. Scale excludes earlier (2007-2015) measurements at SPMP1 and a one-off elevated SIN measurement at TC01 in May 2020.

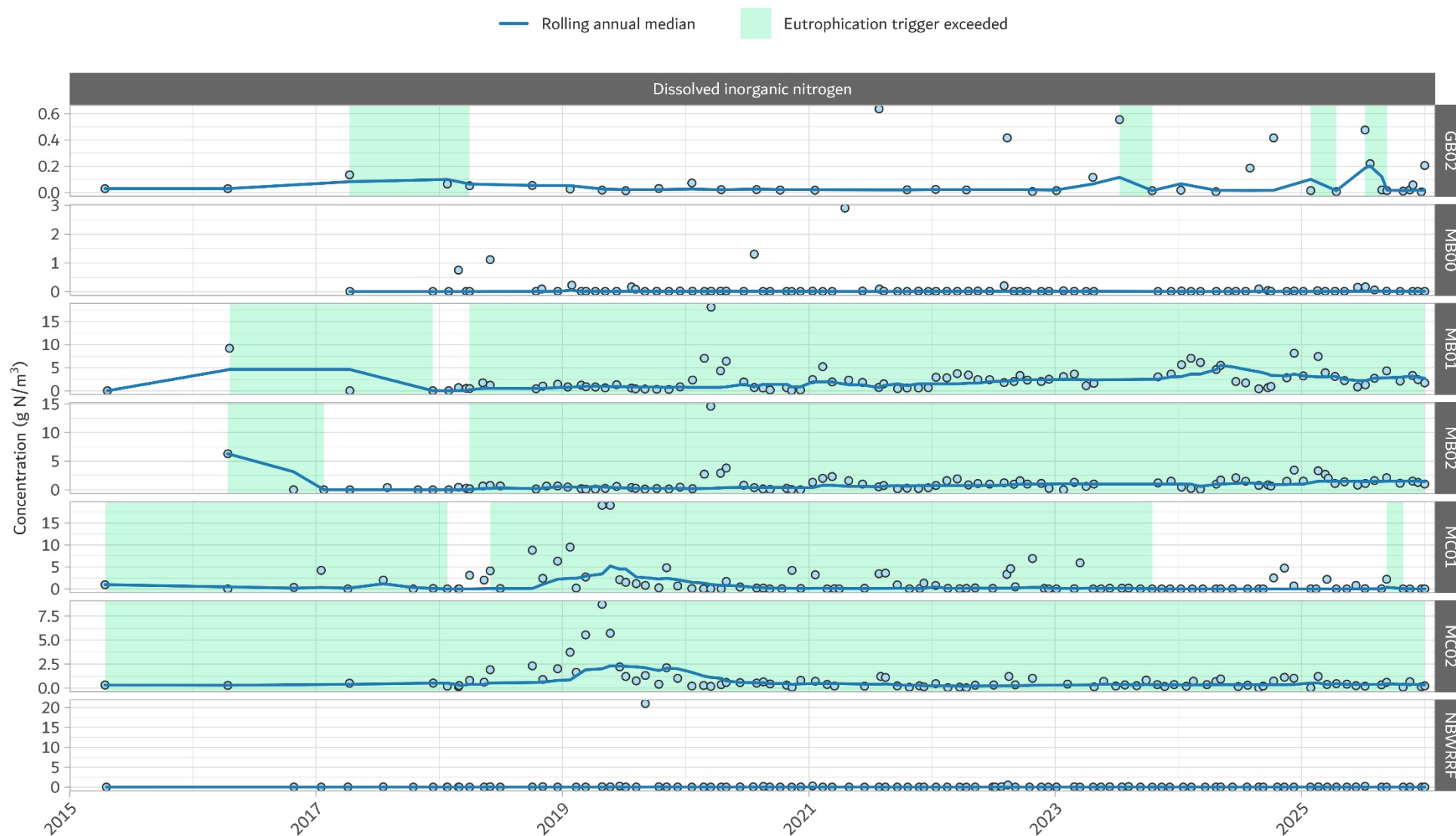


Figure B12. Historical soluble inorganic nitrogen measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed trigger for SIN. Note: exceedances assessed against rolling annual median. Non-compliance criteria still to be determined. Scale excludes earlier measurements at few sites (GB02, MC01, MC02, NBWRRF).

Arsenic

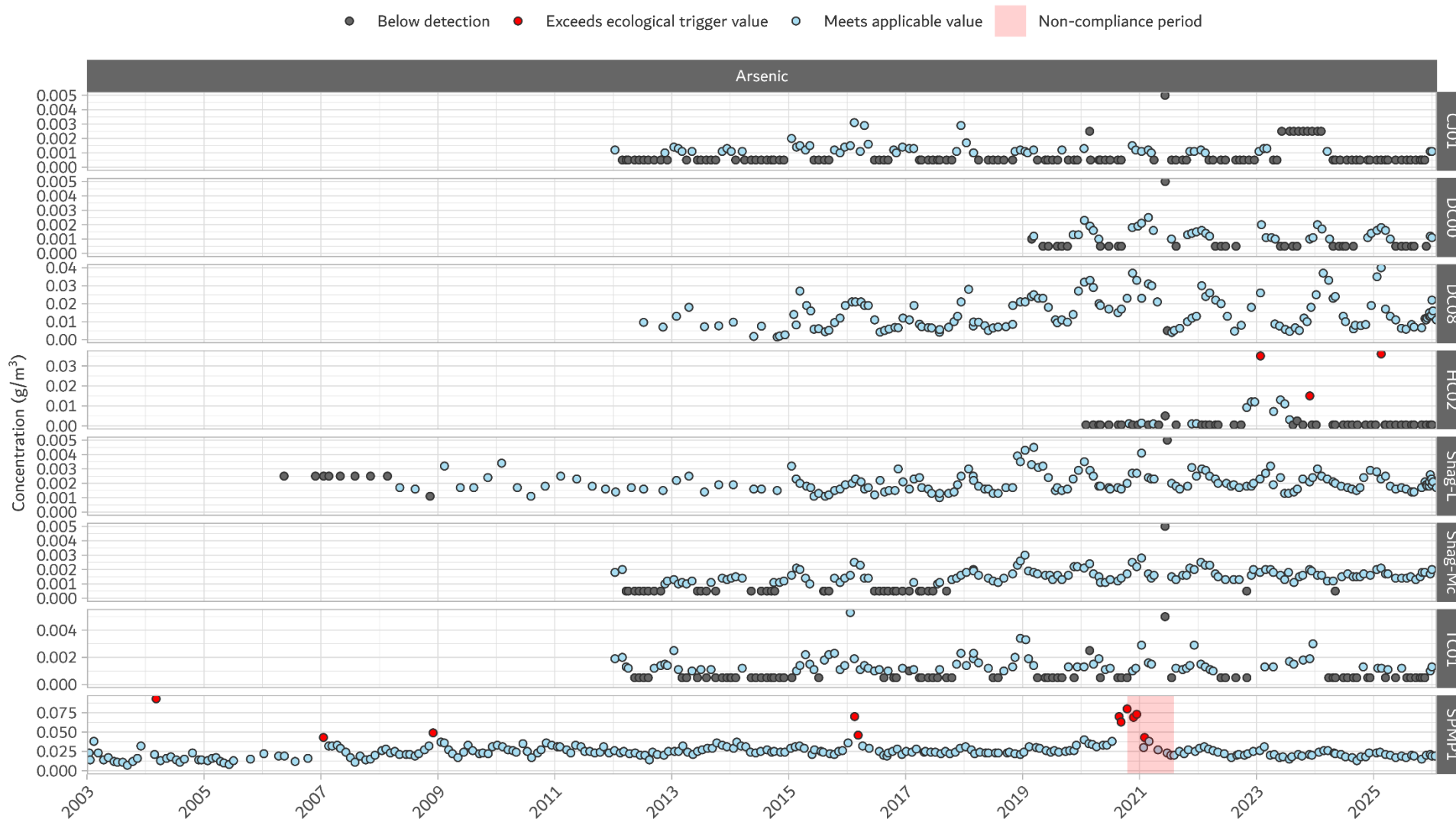


Figure B13. Historical dissolved arsenic measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed trigger.

Note: a less stringent trigger value applies at DC08 and SPMP1 due to elevated background concentrations of arsenic in the catchment, as a result of legacy mine influences. Scale excludes earlier measurements at SPMP1 that follow a similar compliance pattern (see Table B4 below) and likely erroneous elevation at Shag McCormicks in July 2020 (refer Appendix D).

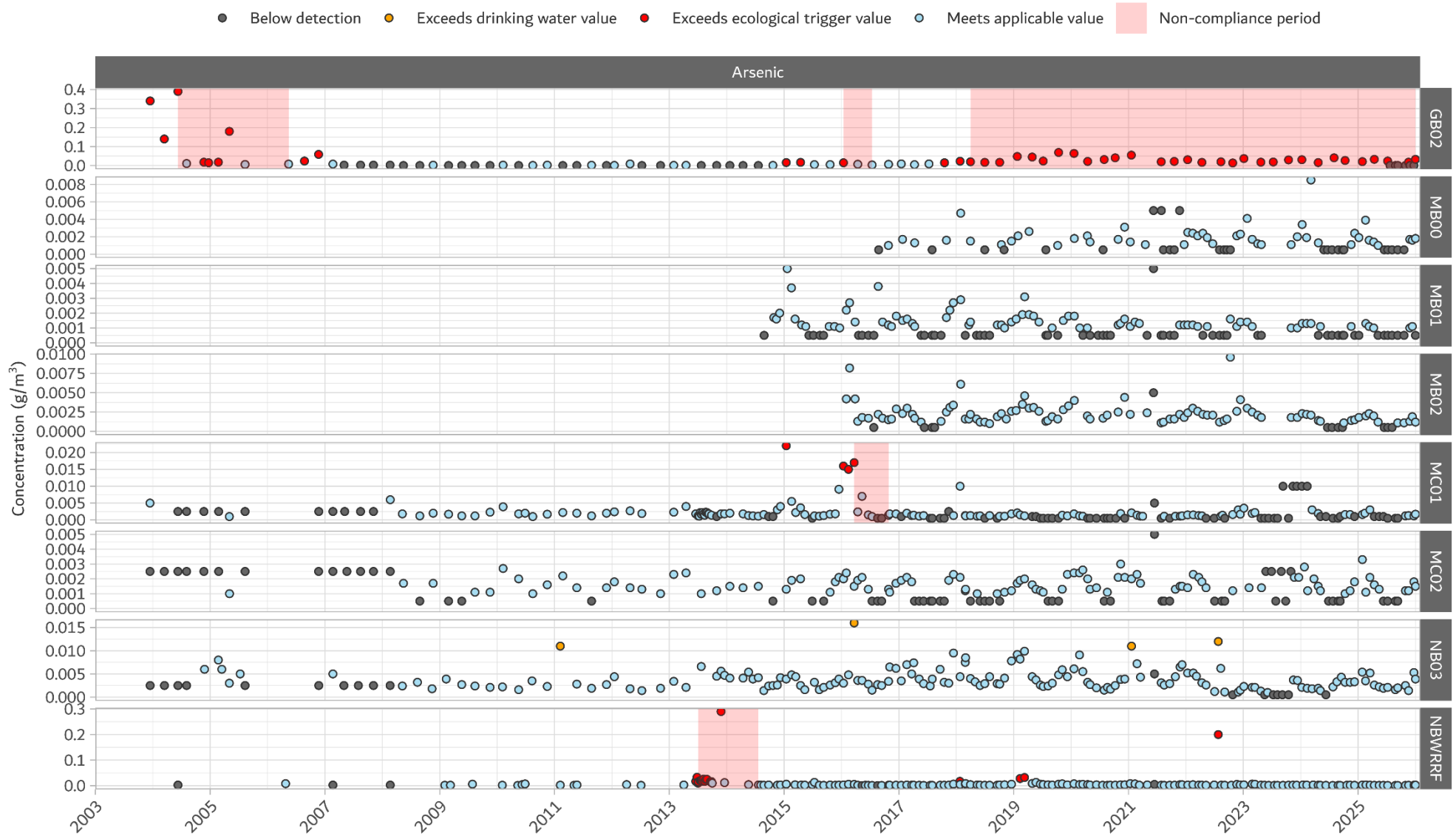


Figure B14. Historical dissolved arsenic measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed trigger.

Table B3. Non-compliance periods for arsenic, defined as >2 exceedances of the ecological trigger value within any rolling 12-month period.

Site	Non-compliance window		Number of measurements	Number of exceedances*
	Start	End		
GB02	10/06/2004	15/05/2006	8	5
GB02	14/01/2016	14/07/2016	3	1
GB02	1/04/2018	1/01/2026	37	31
MC01	22/03/2016	27/10/2016	8	1
NBWRRF	3/07/2013	22/07/2014	15	11
SPMP1	15/10/2020	4/08/2021	10	4

Notes: *During the non-compliance window; inclusive of the first measurement that triggers non-compliance.

Copper

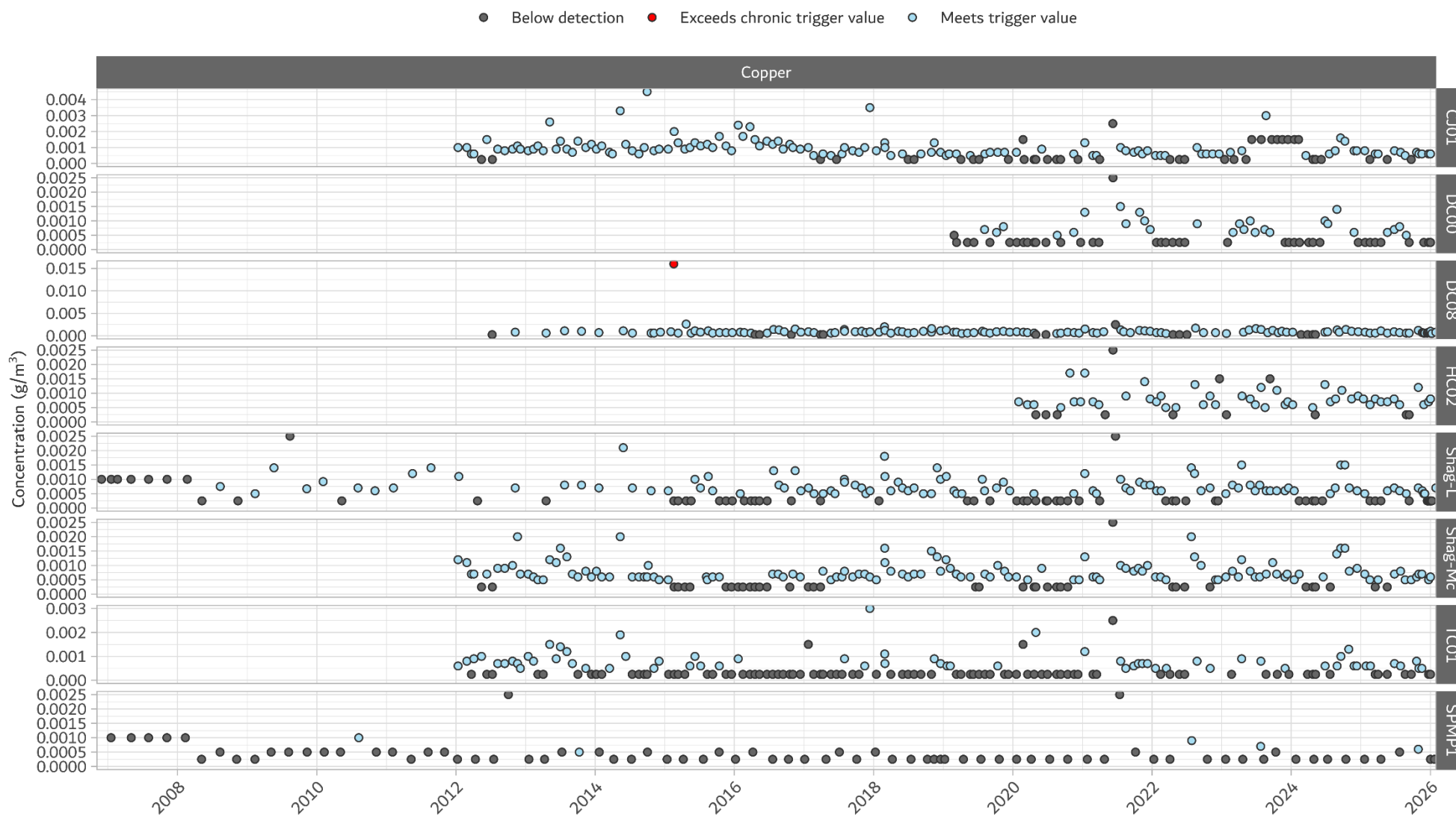


Figure B15. Historical dissolved copper measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed chronic and acute trigger values. Scale excludes earlier measurements at SPMP1 that resulted in non-compliance (see Table B5 below).



Figure B16. Historical dissolved copper measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed chronic and acute triggers. Note: scale excludes isolated below detect measurements in 2003 and 2004 at sites GB02, MC01, MC02, and NB03.

Table B4. Non-compliance periods for copper, defined as a single acute trigger exceedance, or >2 chronic trigger exceedances within any rolling 12-month period.

Site	Non-compliance window		Type	Number of measurements	Number of exceedances*
	Start	End			
SPMP1	15/01/2002	21/01/2003	Chronic	8	1
GB02	26/02/2009	8/02/2010	Acute	2	1

Notes: *The number of exceedances recorded during the non-compliance window; inclusive of the first measurement that triggers non-compliance.

Iron

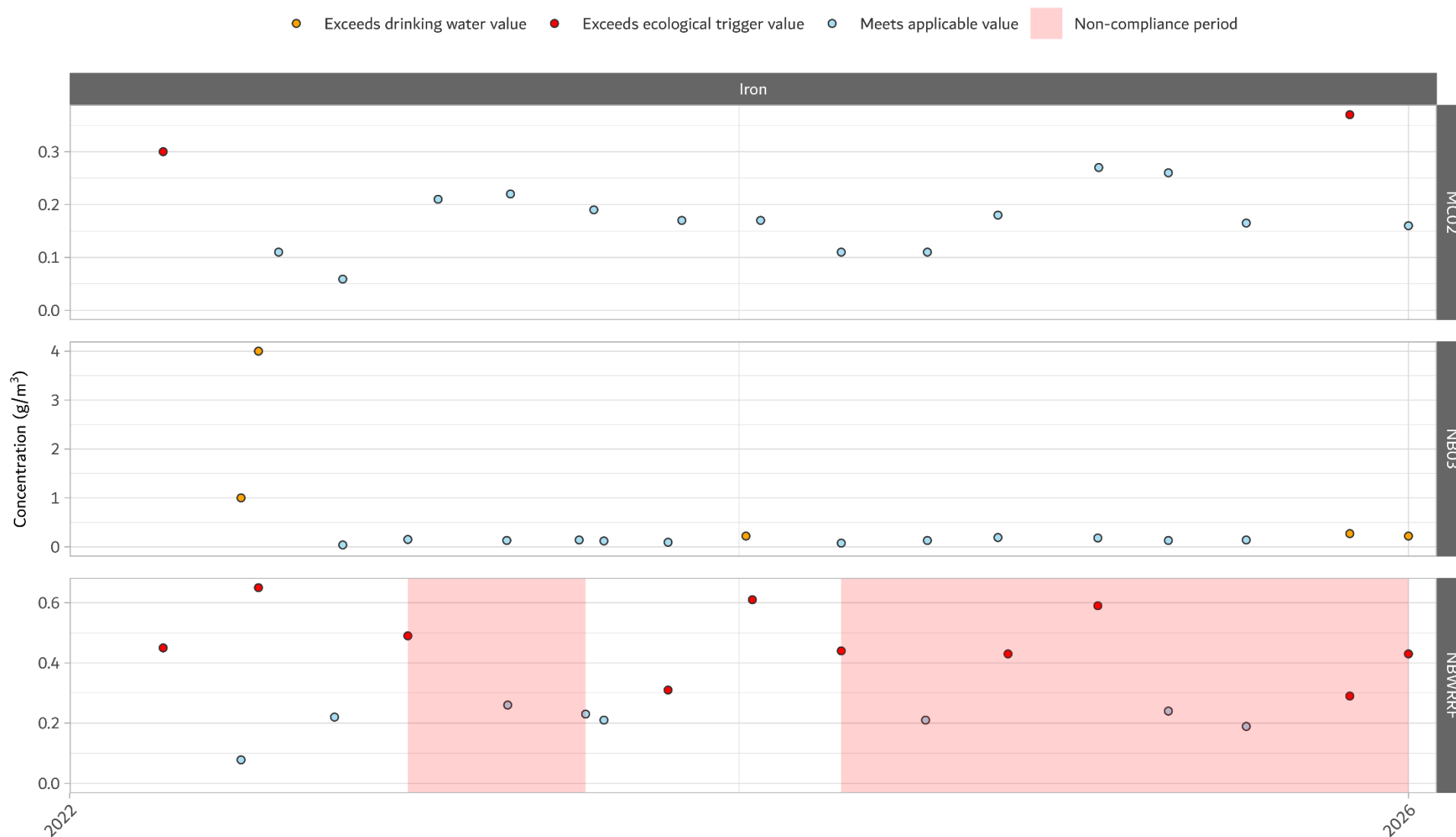


Figure B17. Historical total iron measurements at compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed trigger.

Table B5. Non-compliance periods for total iron, defined as >2 exceedances of the ecological trigger value within any rolling 12-month period.

Site	Non-compliance window		Number of measurements	Number of exceedances*
	Start	End		
NBWRRF	26/07/2022	18/07/2023	5	2
	16/10/2023	1/01/2026	10	7

Notes: *During the non-compliance window; inclusive of the first measurement that triggers non-compliance.

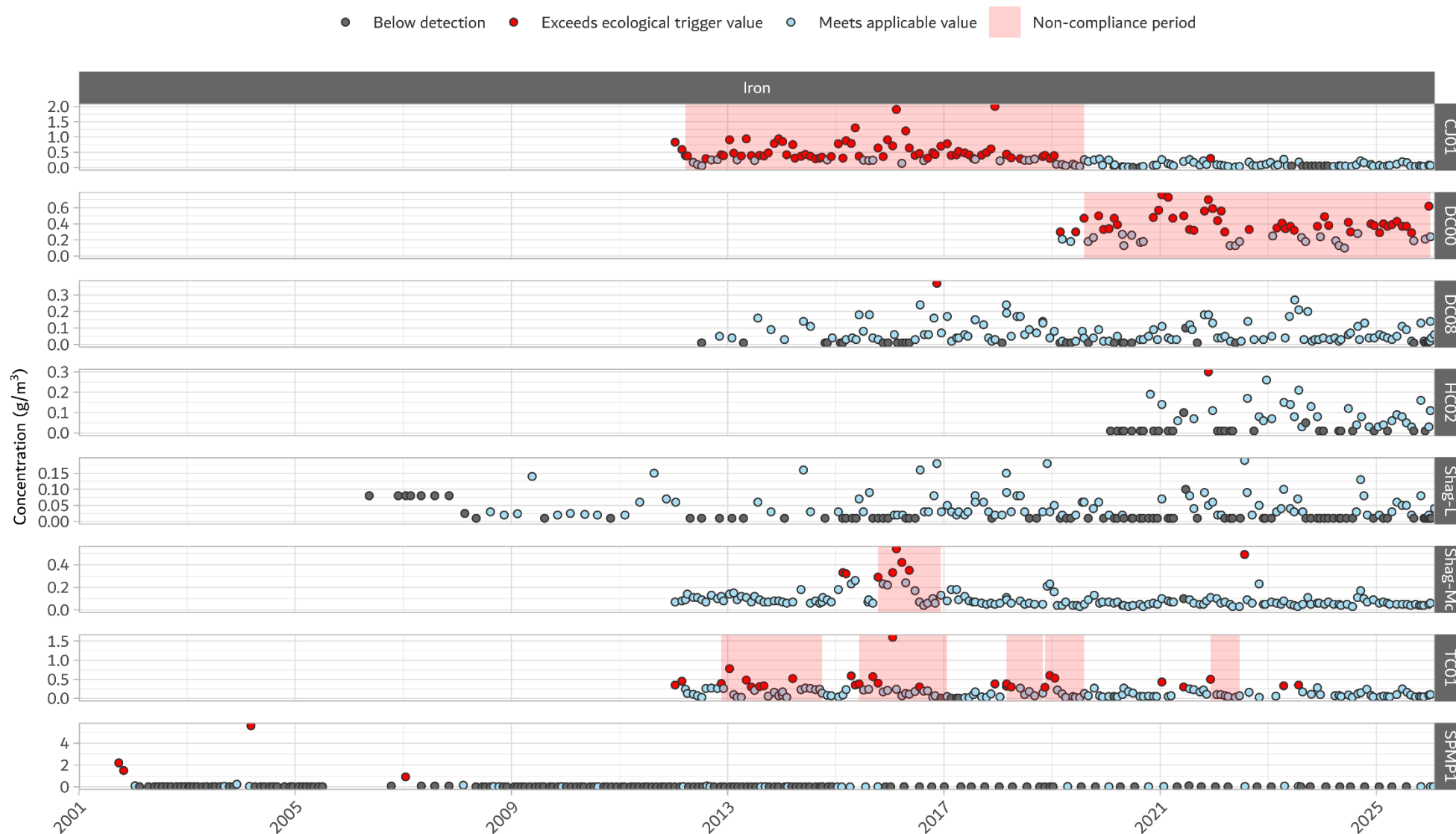


Figure B18. Historical dissolved iron measurements (as a proxy for total iron) at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed trigger.

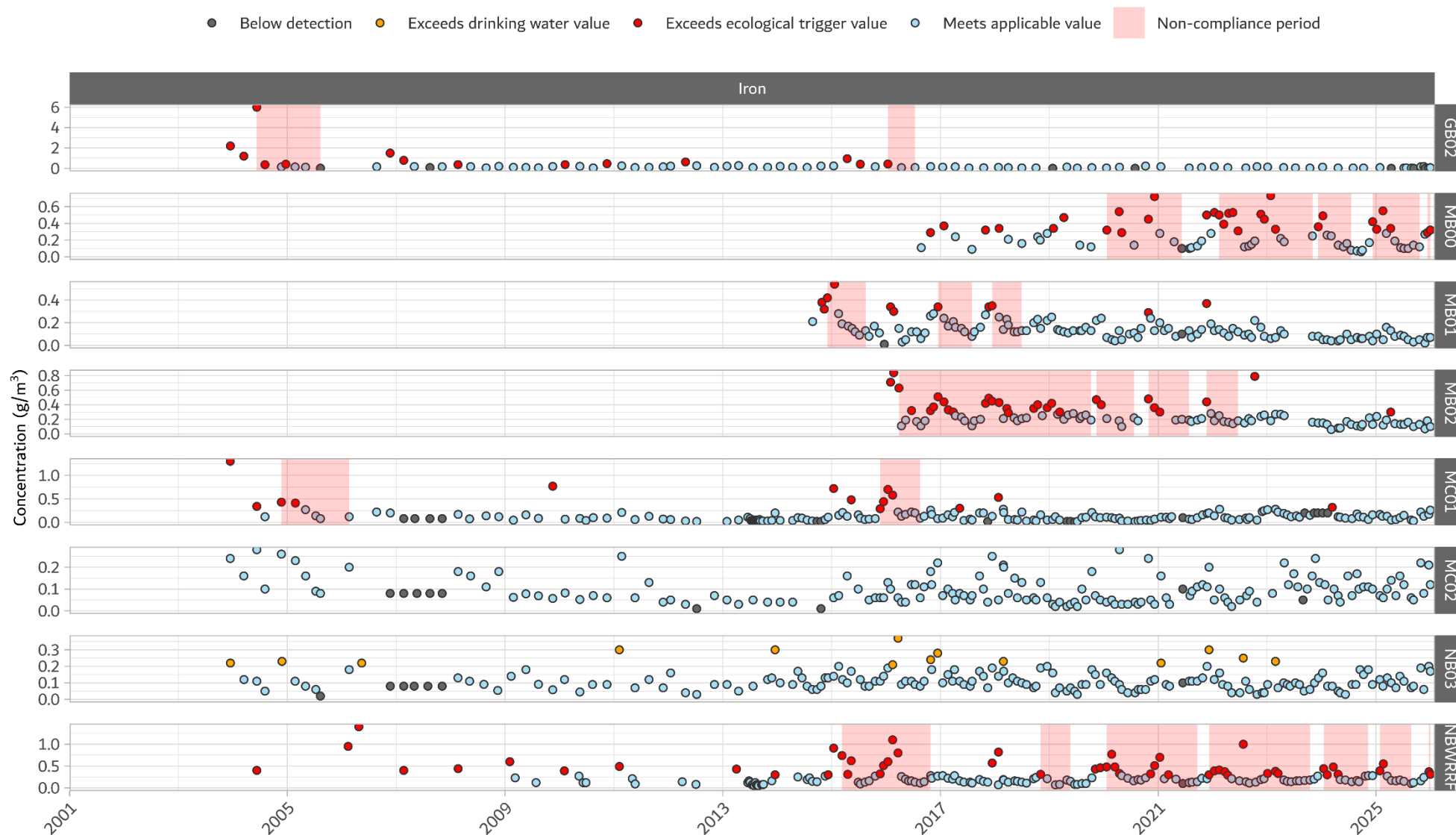


Figure B19. Historical dissolved iron measurements (as a proxy for total iron) at key compliance sites within the Waikouaiti and Taieri River catchment, assessed against the proposed trigger.

Lead

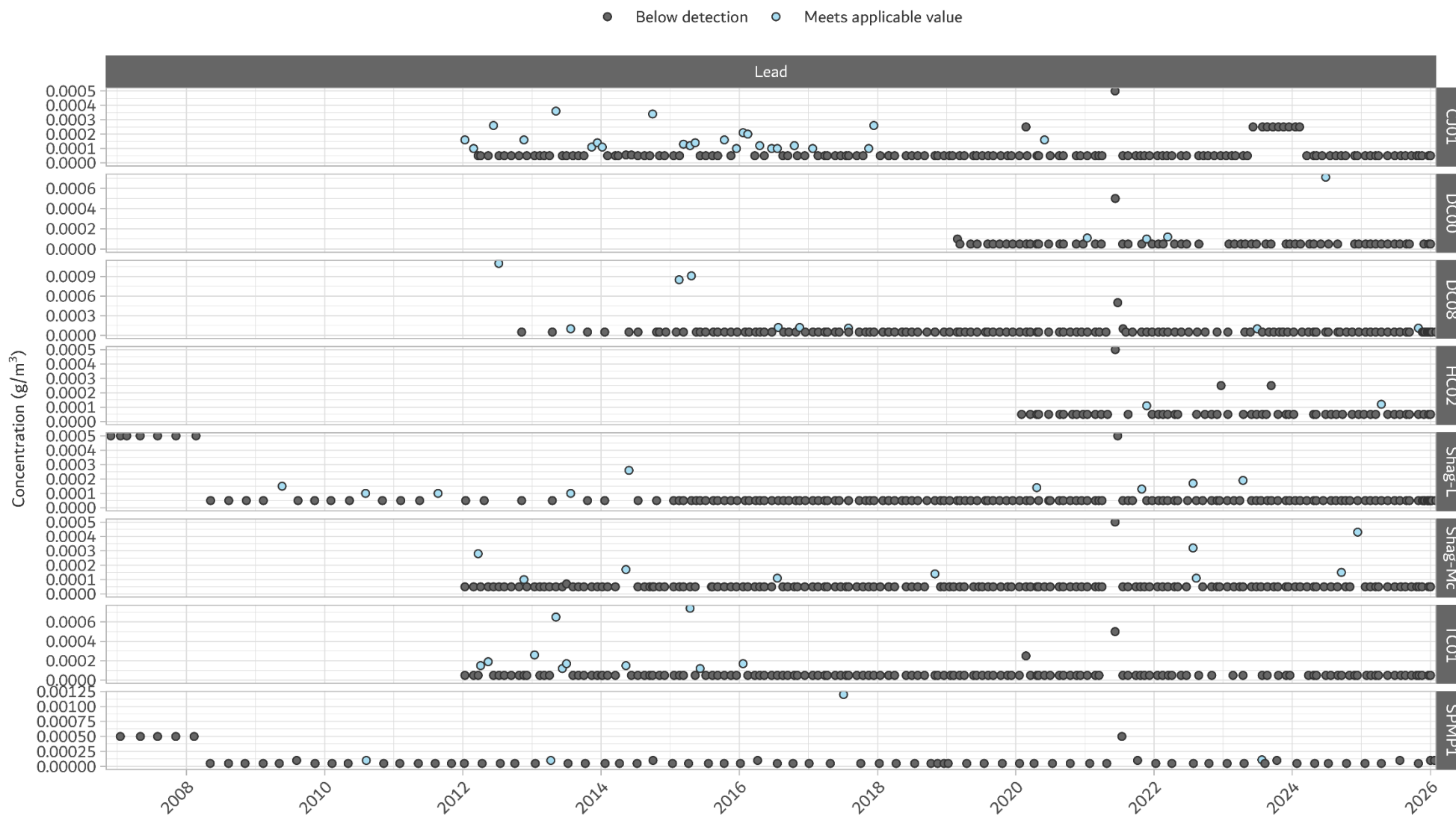


Figure B20. Historical dissolved lead measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed trigger.

Note: scale excludes earlier measurements at SPMP1, all of which were below the proposed trigger (refer Appendix D).

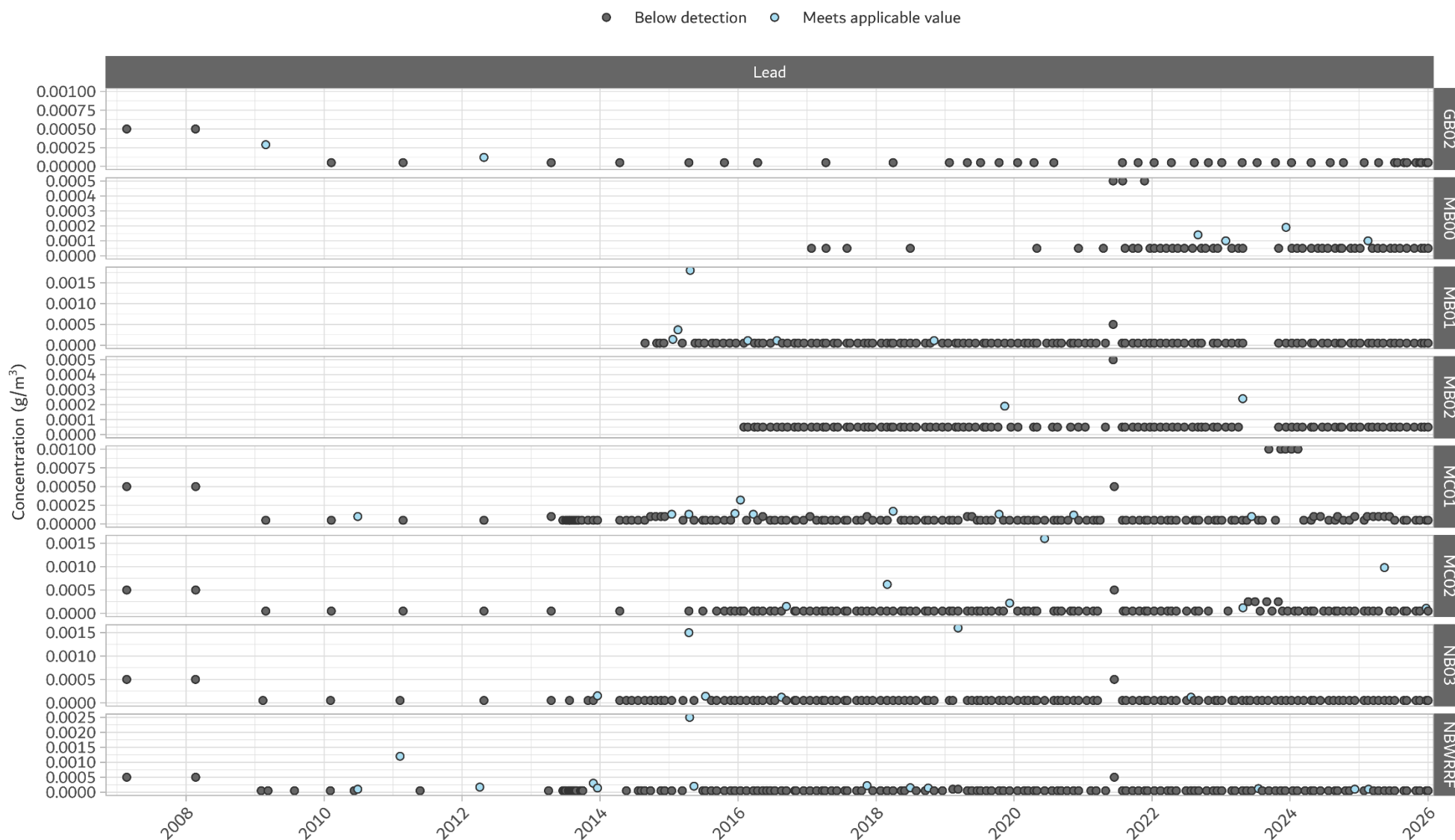


Figure B21. Historical dissolved lead measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed trigger.

Zinc

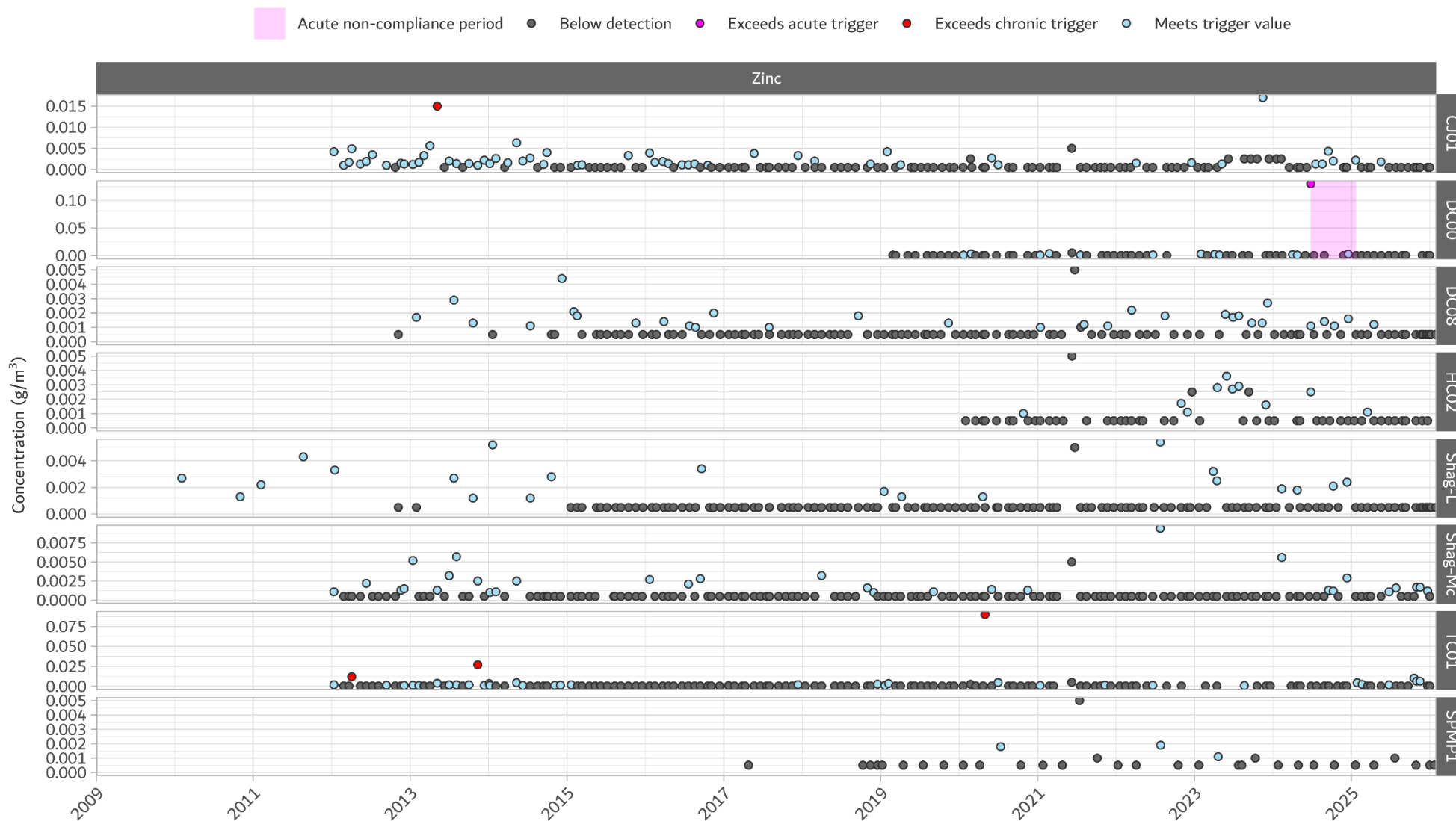


Figure B22. Historical dissolved zinc measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed triggers.



Figure B23. Historical dissolved zinc measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed triggers.

Table B6. Non-compliance periods for zinc, defined as a single acute trigger exceedance, or >2 chronic trigger exceedances within any rolling two-year period.

Site	Non-compliance window		Type	Number of measurements	Number of exceedances*
	Start	End			
DC00	26/06/2024	23/01/2025	Acute	6	1
MB01	23/09/2024	1/01/2026	Chronic	17	5

Notes: *For chronic exceedances, this is the number of exceedances recorded during the non-compliance window; inclusive of the first measurement that triggers non-compliance.

Cyanide

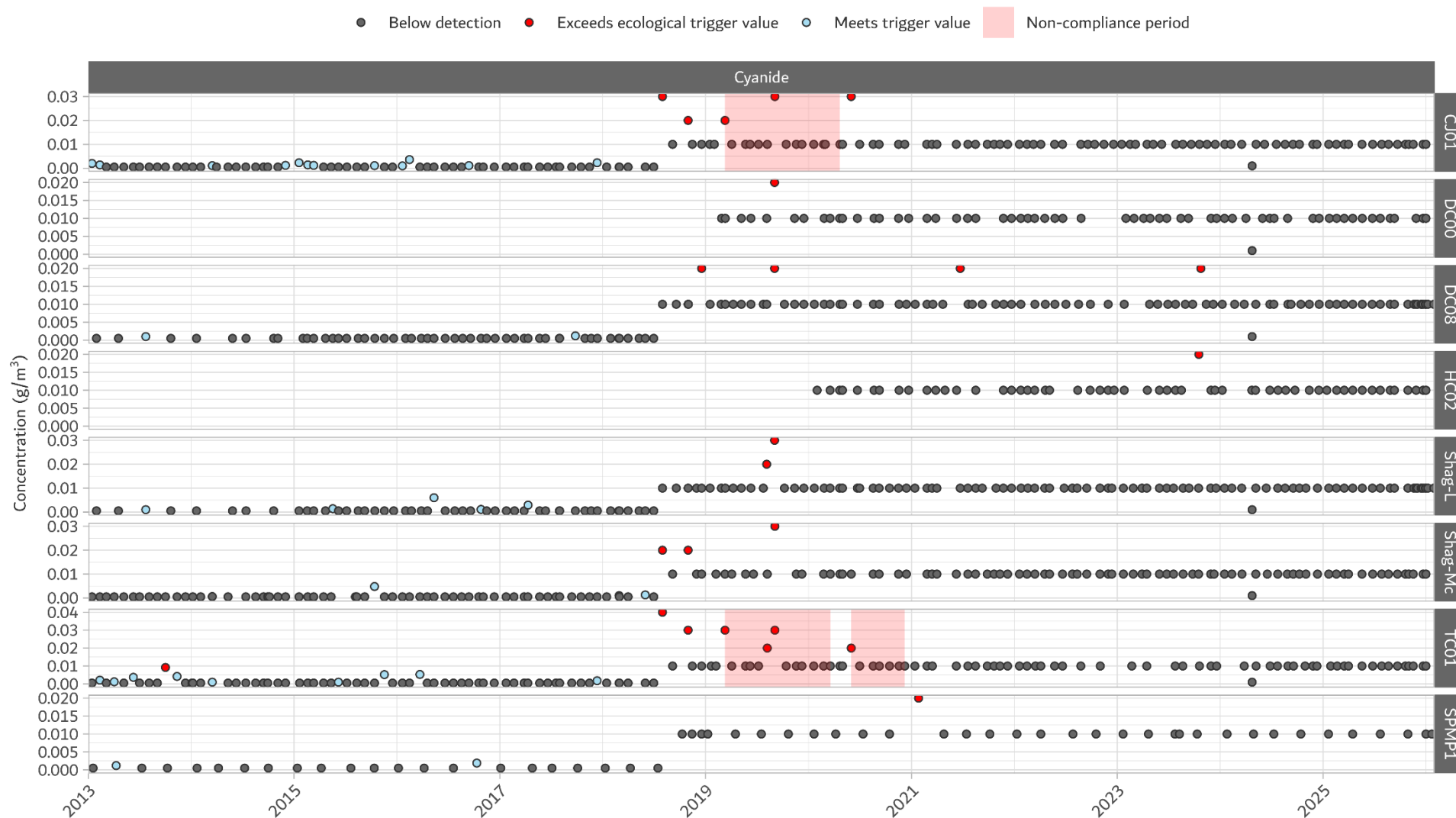


Figure B24. Historical WAD cyanide measurements (as a proxy for free cyanide, adjusted for HCN proportions) at key compliance sites within the Shag/Waiheho River catchment, assessed against the proposed trigger. Note: scale excludes earlier measurements at few sites between 2001 and 20013, all of which were below the applicable trigger value (refer Appendix D).

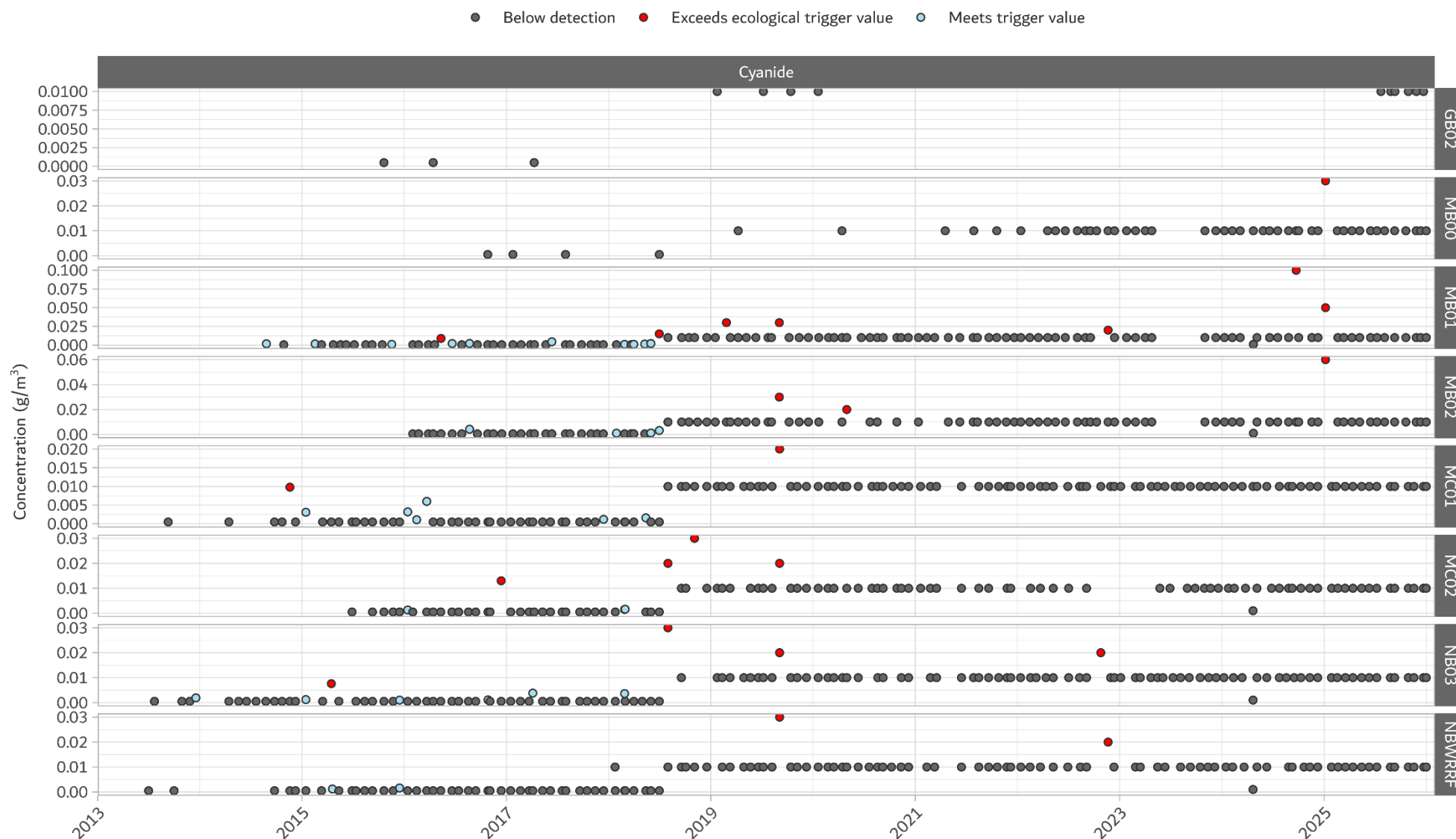


Figure B25. Historical WAD cyanide measurements (as a proxy for free cyanide, adjusted for HCN proportions) at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed trigger. Note: scale excludes isolated below detect measurement at NBWRRF on 10 June 2004.

Table B7. Non-compliance periods for cyanide, defined as >2 exceedances within any rolling 12-month period.

Site	Non-compliance window		Number of measurements	Number of exceedances*
	Start	End		
CJ01	11/03/2019	22/04/2020	14	2
TC01	11/03/2019	19/03/2020	13	3
TC01	1/06/2020	8/12/2020	7	1

Notes: *During the non-compliance window; inclusive of the first measurement that triggers non-compliance.

Appendix C

Supporting Data Analyses

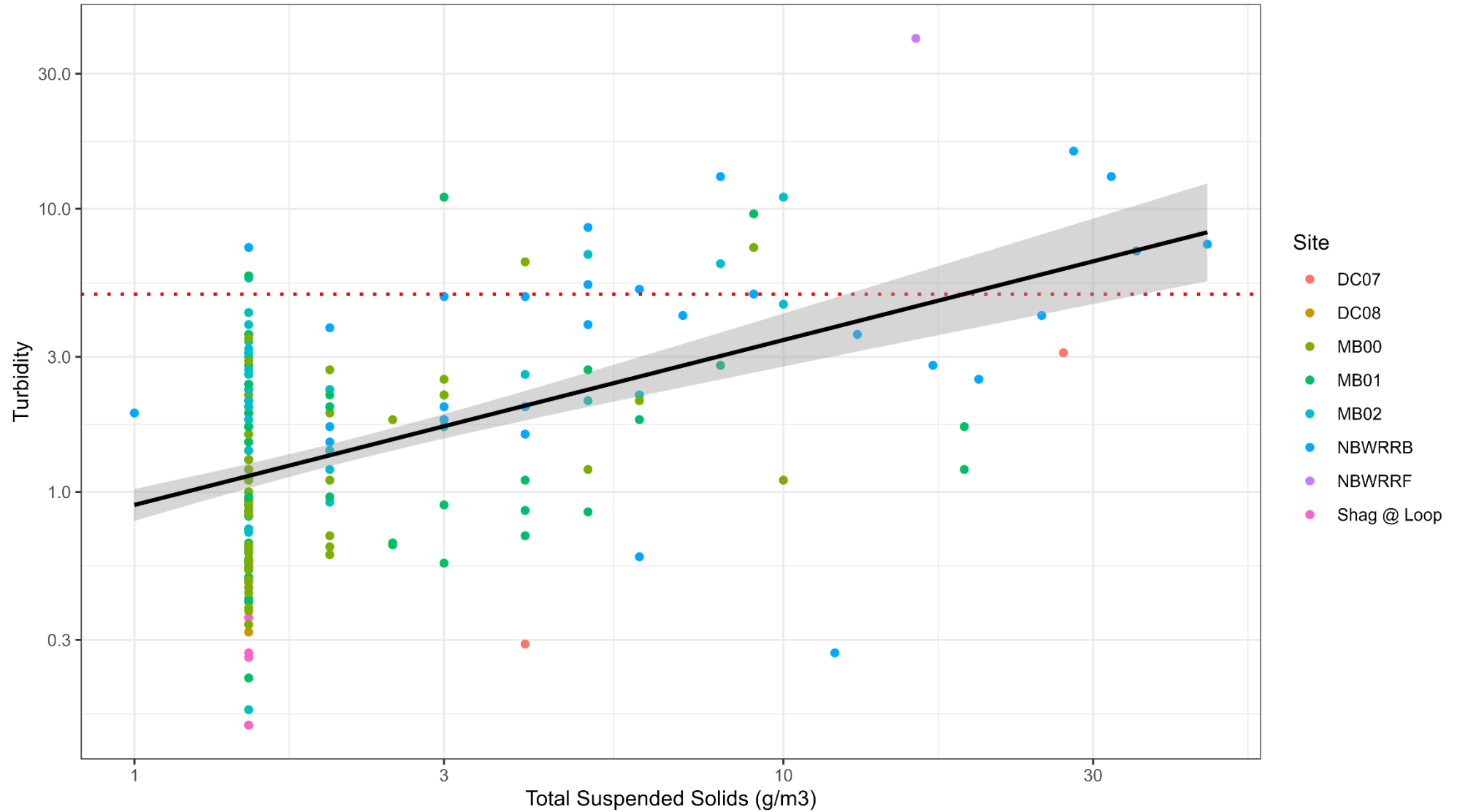


Figure C1. Relationship between turbidity and total suspended solids (TSS) based on date-matched measurements available for MGP monitoring sites, with fitted linear regression and 95% confidence interval.

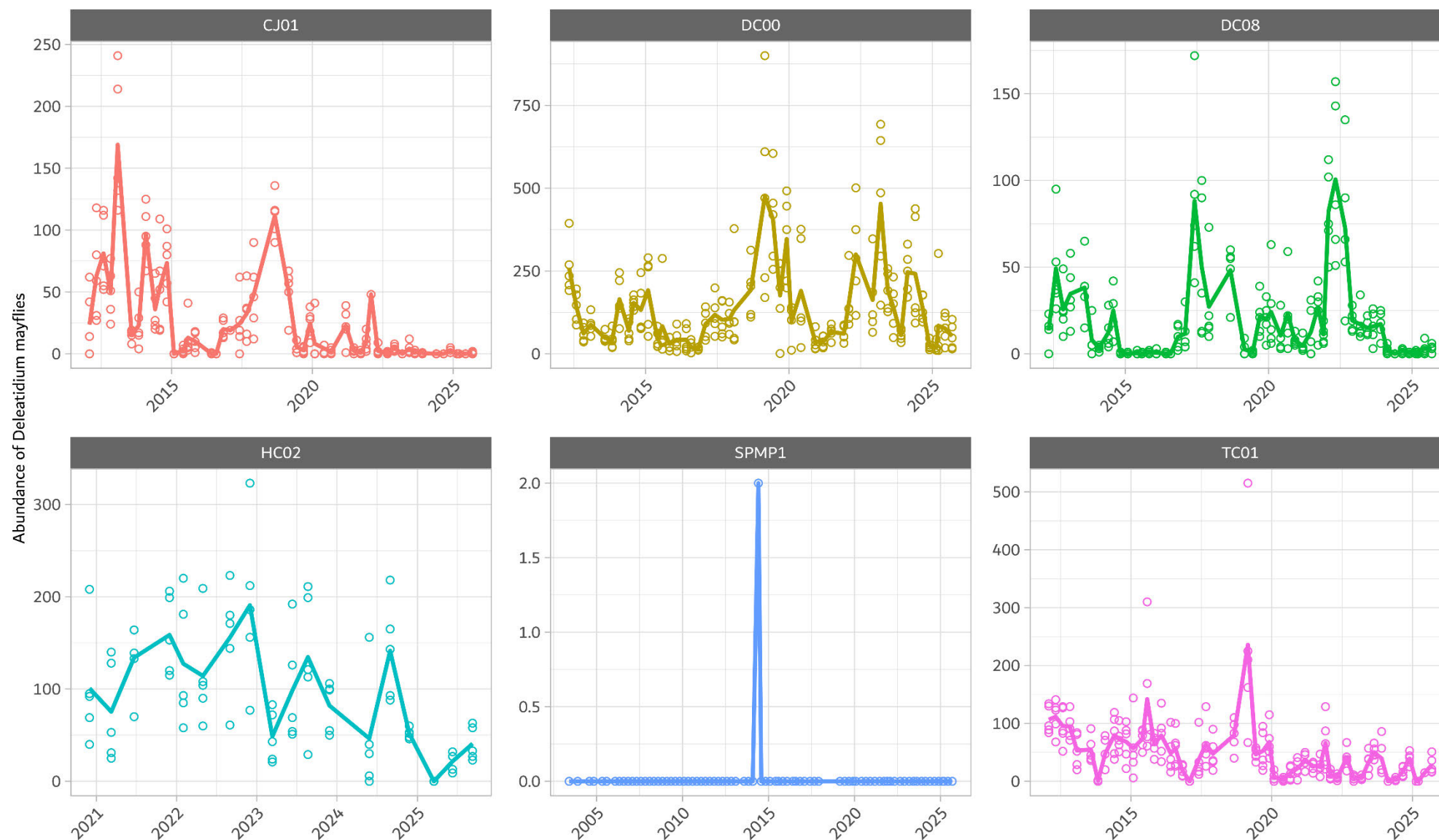


Figure C2. Abundance of *Deleatidium* mayflies in replicate samples collected at key compliance sites within the Shag/Waihemo River catchment, presented over time. Mean abundance is presented as a trend line.

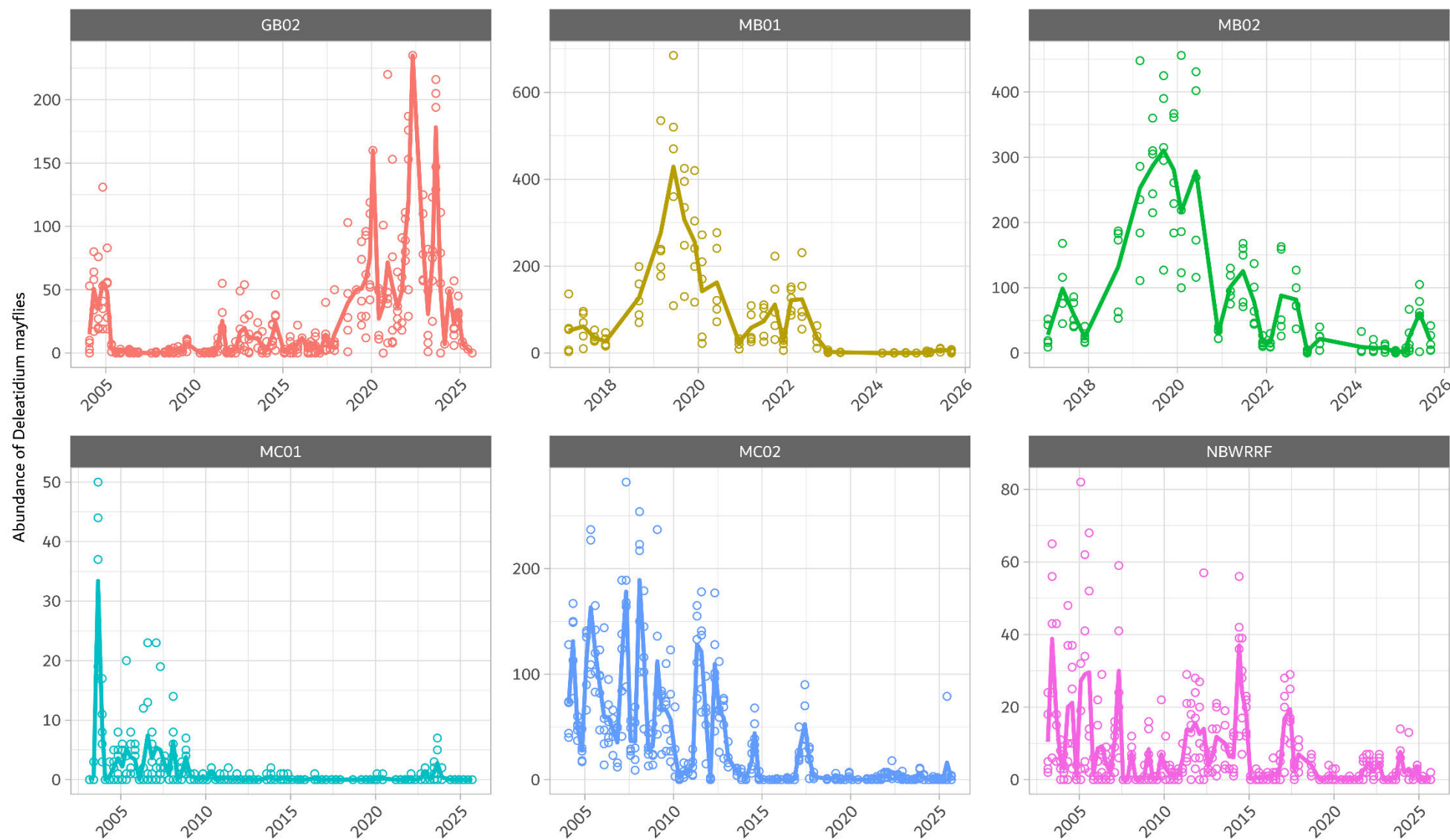


Figure C3. Abundance of *Deleatidium* mayflies in replicate samples collected at key compliance sites within the Waikouaiti and Taieri River catchments, presented over time. Mean abundance is presented as a trend line.

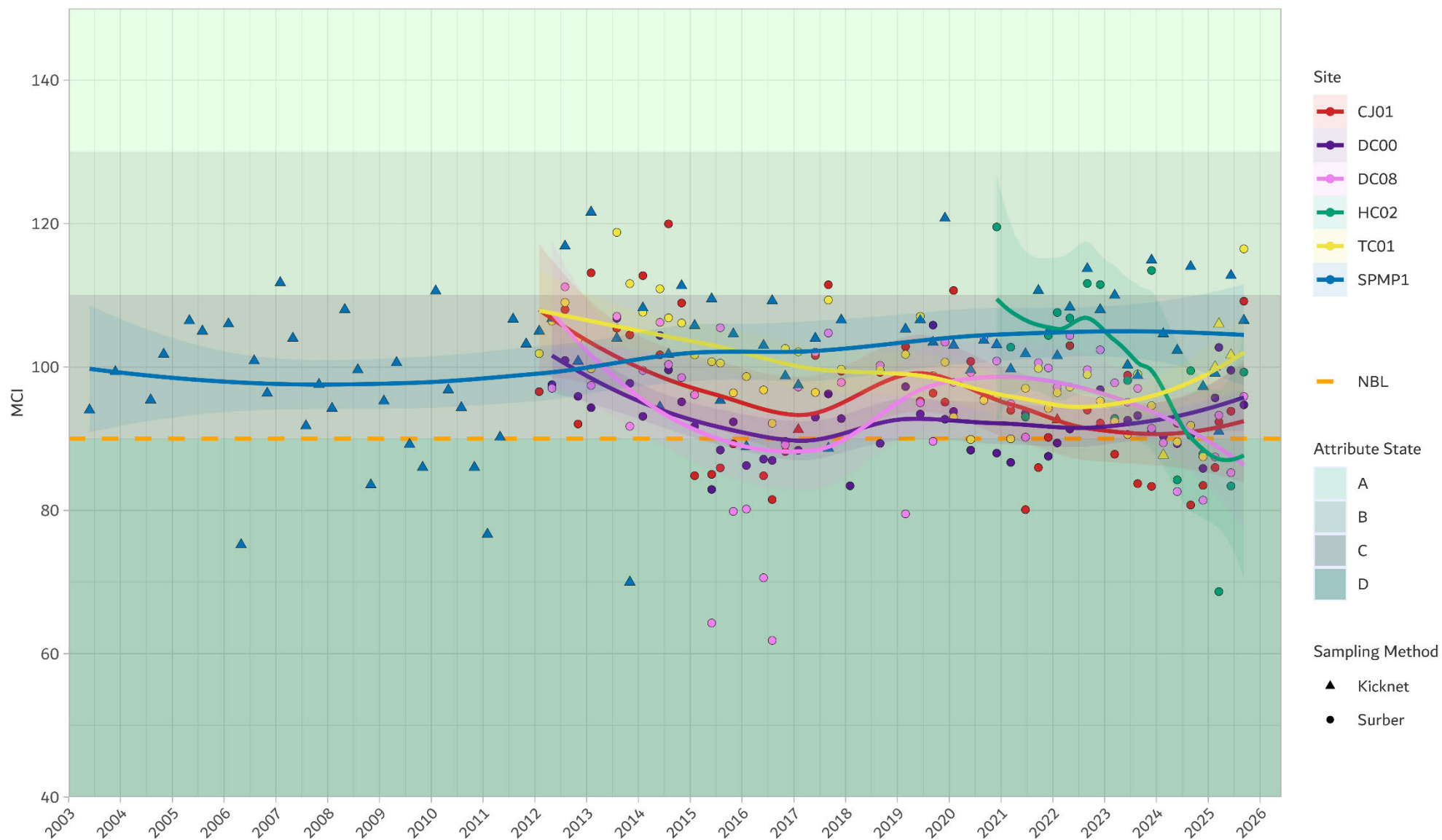


Figure C4. Long-term MCI trends in key Shag/Waihemo catchment sites between 2003 and 2026.

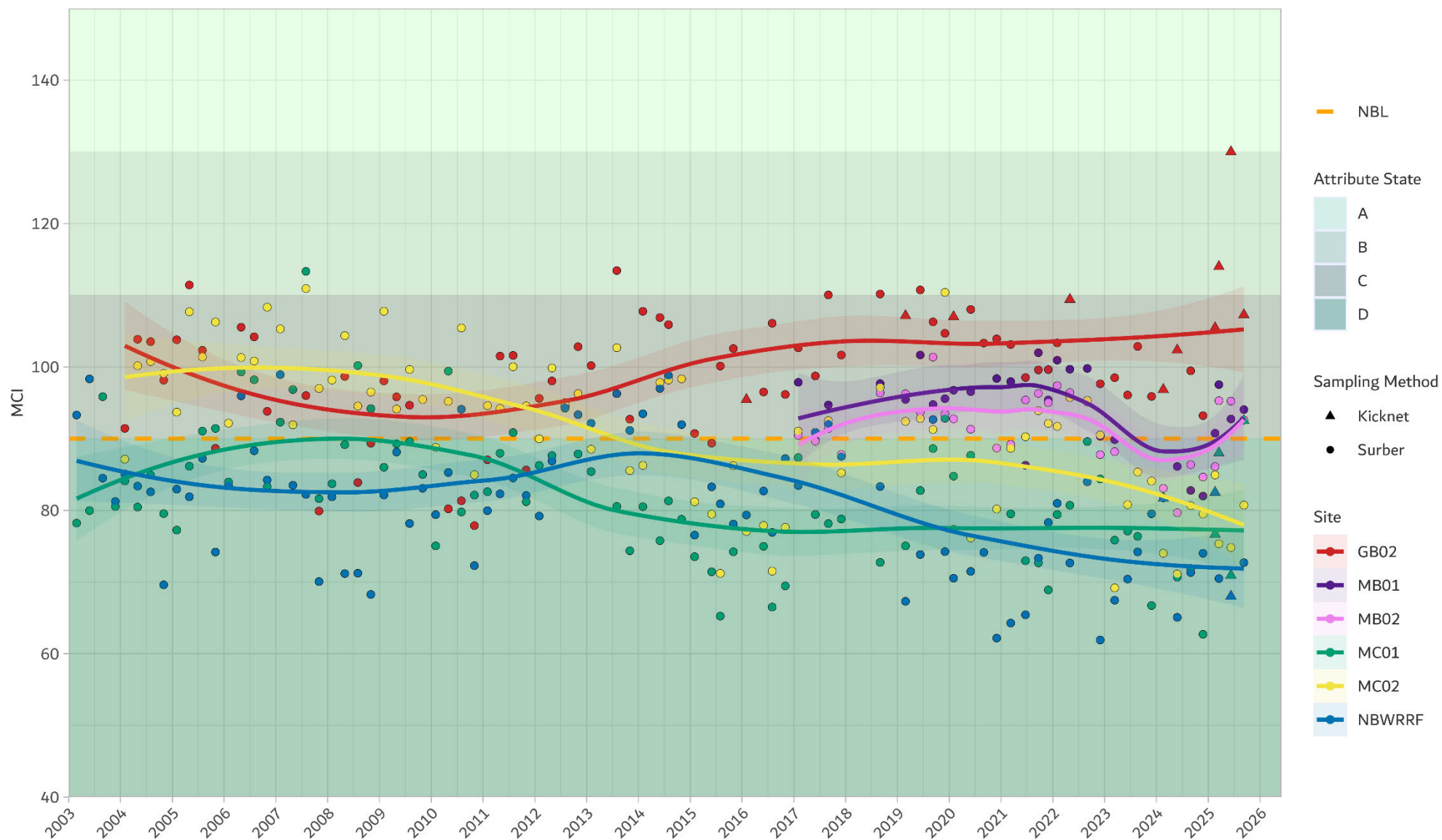


Figure C5. Long-term MCI trends in key Waikouaiti and Taieri River catchment sites between 2003 and 2026.

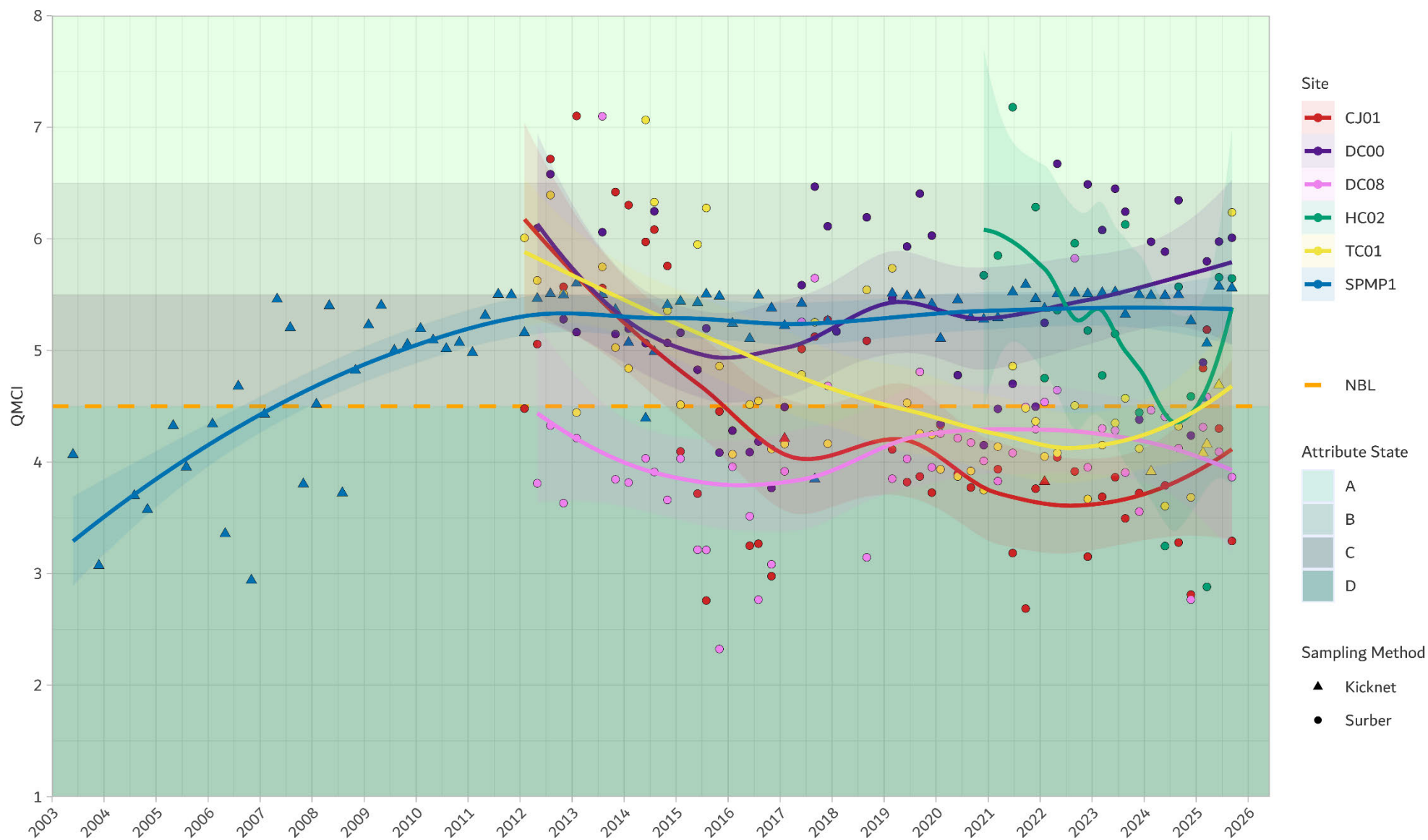


Figure C6. Long-term QMCI trends in key Shag/Waihemo catchment sites between 2003 and 2026.

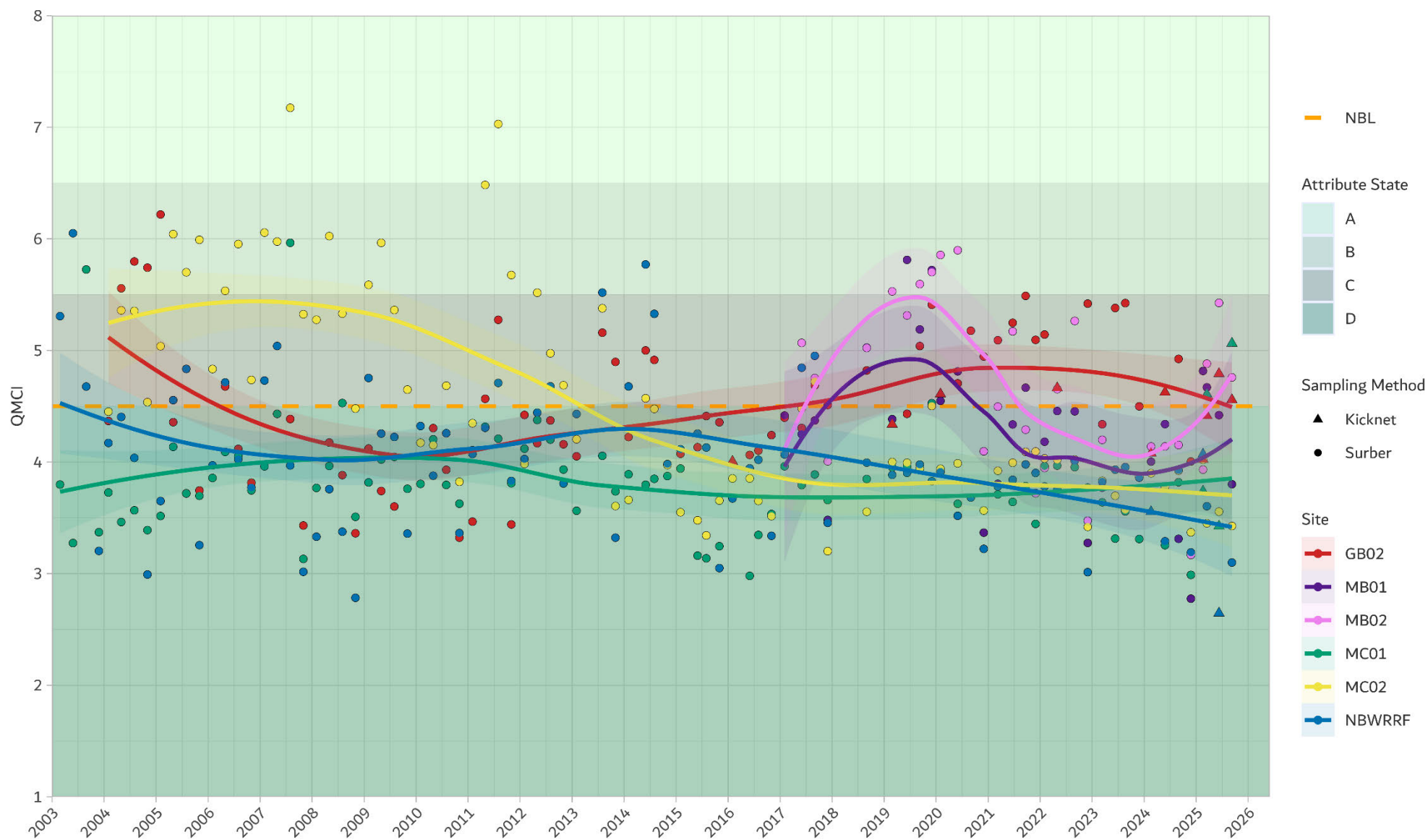


Figure C7. Long-term QMCI trends in key Waikouaiti and Taieri River catchment sites between 2003 and 2026.

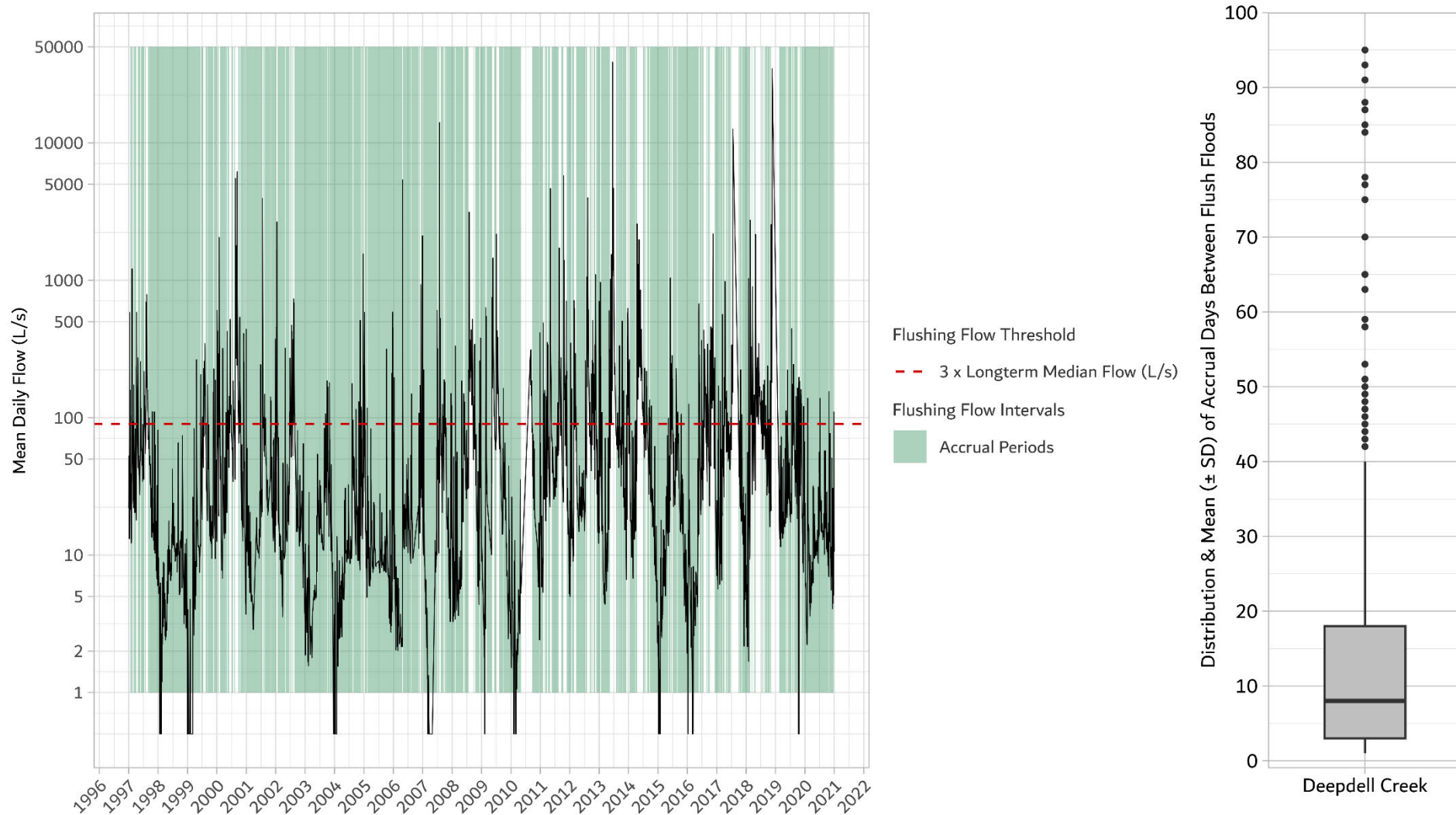


Figure C8. Mean daily flow in Deepdell Creek at Golden Point weir from 1997 to 2022, showing flushing flow threshold and accrual periods. Right: boxplot of accrual duration between flushing events, where box spans the interquartile range, the central line is median, whiskers extend to $1.5 \times$ IQR, and points beyond are outliers.

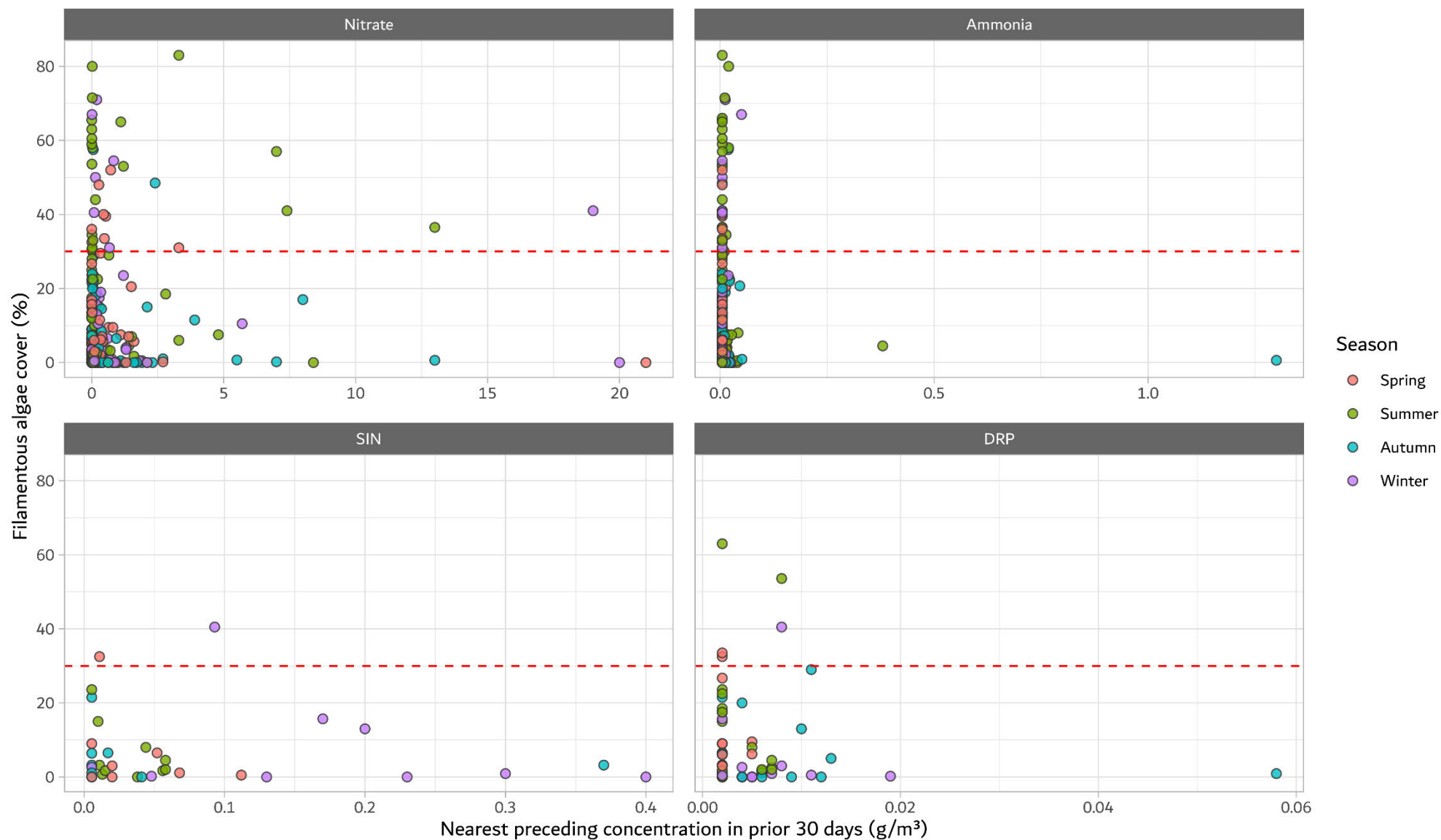


Figure C9. Relationship between filamentous algae cover and nearest preceding 30-day nutrient concentrations (nitrate, ammonia, SIN, and DRP) at MGP sites.

● Below detection ○ Measured value

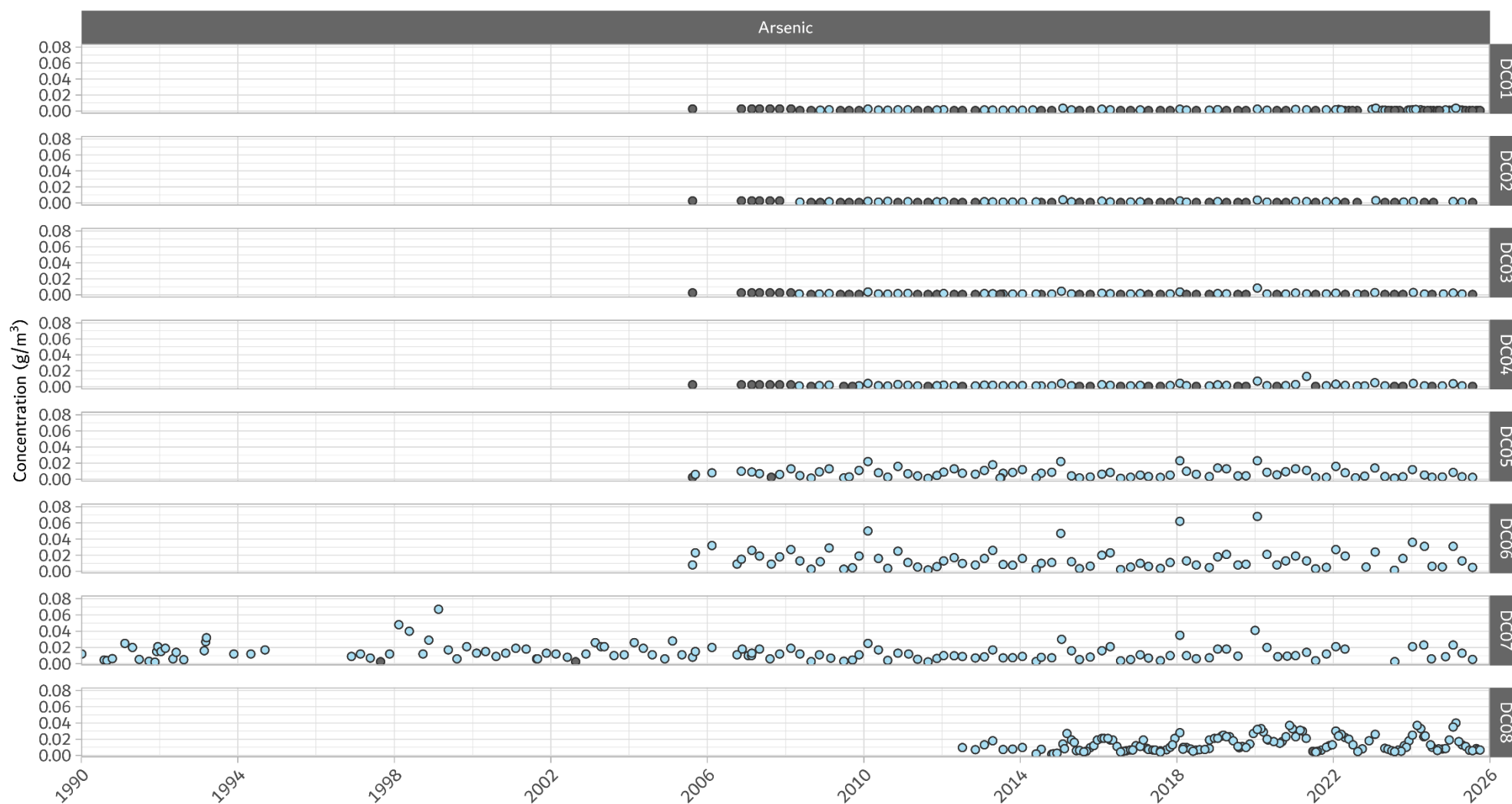
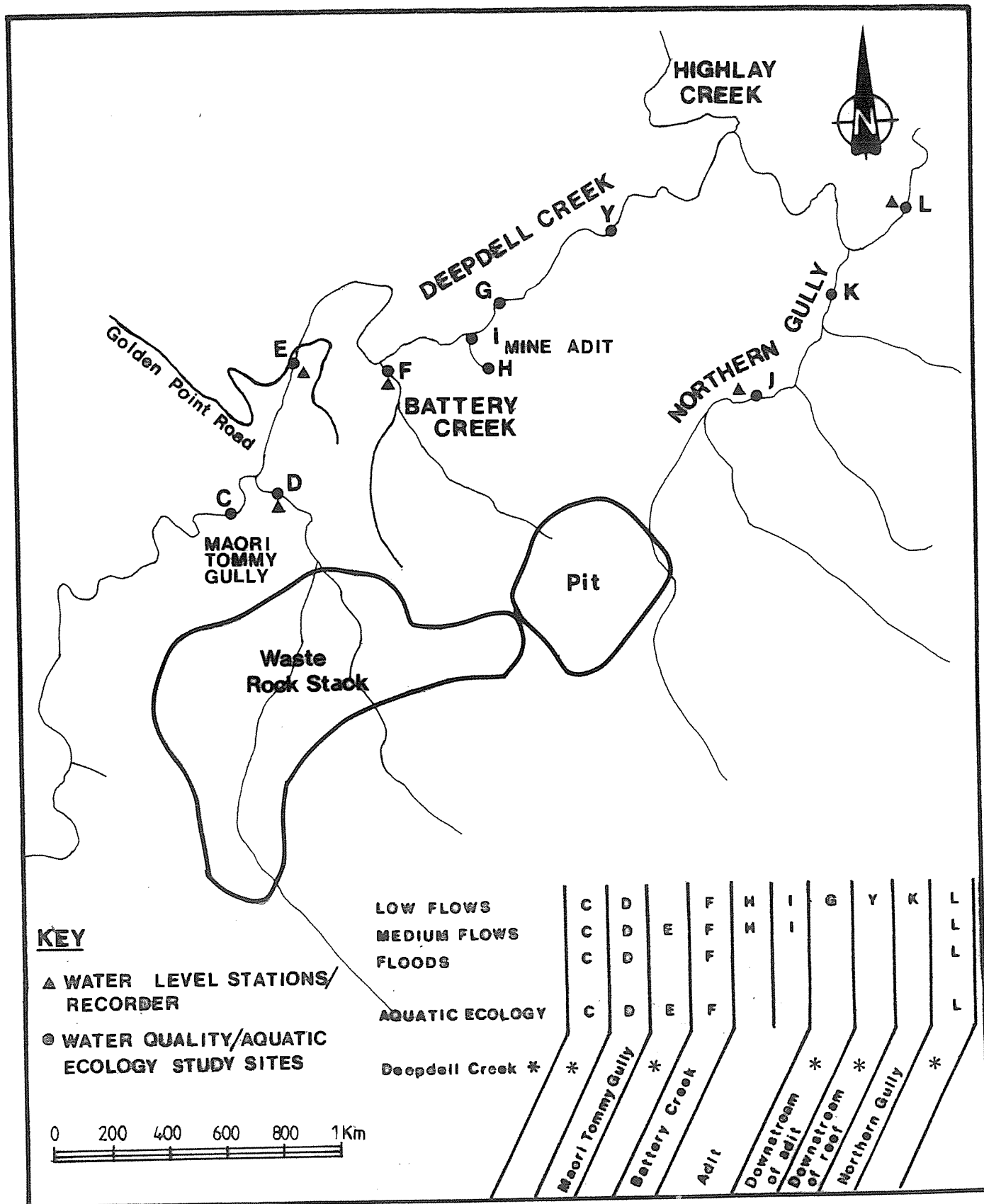


Figure C10. Historical concentrations of dissolved arsenic in Deepdell Creek, dating from the commencement of MGP (mid 1990) to 2026.



HYDROLOGICAL NETWORK WATER QUALITY/AQUATIC ECOLOGY STUDY SITES

Macraes Joint Venture
Gold Mine Project Otago

Figure 4-1-4

TABLE 4.1.7 VARIATION IN WATER QUALITY FOR A RANGE OF FLOW REGIMES

PARAMETER		----- LOW FLOW (8 - 11 l/s) -----			----- MEDIUM FLOW (41 - 161 l/s) -----			----- HIGH FLOW (672 - 6900 l/s) -----		
		Deepdell C.	Maori Tommy	Deepdell C.	Deepdell C.	Maori Tommy	Deepdell C.	Deepdell C.	Maori Tommy	Deepdell C.
		(Upper Site)	Gully	(D/S N.Gully)	(Upper Site)	Gully	(D/S N.Gully)	(Upper Site)	Gully	(D/S N.Gully)
		C	D	L	C	D	L	C	D	L
		(n=3)	(n=3)	(n=3)	(n=3)	(n=1)	(n=3)	(n=1)	(n=1)	(n=2)
pH	Mean	8.1	7.8	7.8	7.5	7.7	7.8	6.0	6.1	6.9
	Range	7.6 - 8.9	7.6 - 7.9	7.5 - 8.2	7.4 - 7.6	-	7.5 - 8.4	-	-	6.2 - 7.5
CONDUCTIVITY at 20 deg C (µS/cm)	Mean	13.7	25.3	18.3	10.6	21.0	12.5	4.7	5.0	8.4
	Range	12 - 15	24 - 27	17 - 20	8.8 - 13.0	-	9.5 - 16.0	-	-	8.0 - 8.7
ALKALINITY - TOTAL (as HCO ₃) (g/m ³)	Mean	60.3	156.7	95.0	45.0	12.0	56.0	15.0	17.0	21.2
	Range	66 - 75	150 - 160	91 - 98	35 - 57	-	41 - 73	-	-	33 - 42
HARDNESS - TOTAL (as CaCO ₃) (g/m ³)	Mean	51.0	117.7	78.0	33.0	81.0	43.0	16.0	19.0	26.5
	Range	44 - 59	106 - 130	68 - 83	26 - 43	-	32 - 54	-	-	24 - 29
SOLIDS - SUSPENDED (g/m ³)	Mean	LT 6	LT 6	LT 6	2.5	-	3.0	280.0	17.0	148.5
	Range	-	-	-	2.0 - 3.0	-	1.0 - 5.0	-	-	17 - 280
TURBIDITY (NTU)	Mean	0.7	2.7	0.2	1.7	2.0	1.2	40.0	20.0	35.0
	Range	0.7 - 0.8	2.5 - 3.0	0.2 - 0.3	1.2 - 2.5	-	0.4 - 2.2	-	-	7 - 63
SULPHATE (g/m ³)	Mean	2.9	4.8	7.4	3.6	3.6	5.3	1.5	0.77	2.4
	Range	2.2 - 3.8	3.4 - 5.8	6.1 - 8.7	3.3 - 4.1	-	4.0 - 6.8	-	-	2.2 - 2.5
CALCIUM (g/m ³)	Mean	13.4	33.0	21.0	8.3	23.0	11.0	3.9	5.4	6.8
	Range	11 - 16	30 - 36	18 - 23	6 - 11	-	8 - 14	-	-	6.1 - 7.5
MAGNESIUM (g/m ³)	Mean	4.4	8.6	6.1	3.1	5.8	3.7	1.5	1.3	2.4
	Range	3.9 - 4.9	7.6 - 9.7	5.5 - 6.6	2.6 - 3.9	-	2.9 - 4.5	-	-	2.1 - 2.6
POTASSIUM (g/m ³)	Mean	1.3	0.6	1.3	1.0	0.7	1.1	2.1	2.3	1.5
	Range	1.0 - 1.5	0.4 - 0.8	1.1 - 1.5	0.9 - 1.2	-	0.9 - 1.3	-	-	0.9 - 2.0
SODIUM (g/m ³)	Mean	11.6	14.3	12.7	9.8	13.0	10.1	3.8	4.6	7.0
	Range	11 - 12	14 - 15	12 - 13	9 - 11	-	9 - 12	-	-	5.8 - 8.2
ALUMINIUM (µg/m ³)	Mean	68.0	59.0	15.0	27.3	10.0	32.3	2300	670	1440
	Range	-	-	-	10 - 47	-	34 - 58	-	-	280 - 2600
ARSENIC (µg/m ³)	Mean	1.6	8.9	18.7	1.8	14.1	15.6	9.2	13.0	30.5
	Range	1.3 - 2.1	4.6 - 11.0	17.0 - 21.0	1.3 - 2.1	-	7.1 - 29.3	-	-	8.9 - 52.0
CADMIUM (µg/m ³)	Mean	LT 0.010	0.020	LT 0.010	0.010	0.006	0.009	-	-	LT 0.010
	Range	-	LT 0.01-0.02	-	0.009-LT 0.01	-	0.007-LT 0.01	-	-	-
COBALT (µg/m ³)	Mean	0.56	0.28	0.07	0.13	LT 0.05	0.09	2.60	0.66	1.40
	Range	-	-	-	0.06 - 0.19	-	LT 0.05-0.11	-	-	0.39 - 2.40
COPPER (µg/m ³)	Mean	0.62	0.19	0.66	0.64	0.27	0.65	5.1	1.5	3.8
	Range	0.47 - 0.75	0.14 - 0.24	0.56 - 0.76	0.53 - 0.75	-	0.60 - 1.00	-	-	2.2 - 6.3
IRON (µg/m ³)	Mean	200	483	33	320	600	153	6600	2000	3680
	Range	180 - 240	350 - 580	28 - 36	250 - 370	-	50 - 230	-	-	960 - 6400
LEAD (µg/m ³)	Mean	LT 0.10	LT 0.10	LT 0.10	0.09	0.14	0.10	6.20	0.90	2.85
	Range	-	-	-	0.08 - LT 0.1	-	LT 0.1-0.1	-	-	0.39 - 5.30
MANGANESE (µg/m ³)	Mean	20.0	46.0	4.6	15.2	40.0	5.9	580	150	352
	Range	-	-	-	7.4 - 30.0	-	3.5 - 10.0	-	-	64 - 640
MERCURY (µg/m ³)	Mean	LT 0.01	0.03	0.01	0.03	0.01	0.04	0.017	0.010	0.095
	Range	-	LT 0.01-0.056	LT 0.01-0.01	LT 0.01-0.04	-	LT 0.01-0.07	-	-	0.03 - 0.16
NICKEL (µg/m ³)	Mean	0.42	0.39	0.52	0.53	0.40	0.47	5.50	0.84	2.76
	Range	-	-	-	0.52 - 0.54	-	0.56 - 0.58	-	-	0.52 - 5.00
ZINC (µg/m ³)	Mean	0.31	0.22	0.16	0.41	1.29	0.38	34.0	2.9	13.60
	Range	0.16 - 0.54	0.08 - 0.41	0.11 - 0.20	0.24 - 0.63	-	0.32 - 0.57	-	-	2.1 - 25.0

- Where values are less than (LT) the lower detection limits, the mean is calculated using lower detection limit value.

- * indicates n = 1 for all sites at Low Flow.

- ** indicates n = 2 for all sites at Low Flow.

- Metals indicate total recoverable concentrations (see Volume 3, Appendix 8 for acid soluble concentrations).

TABLE 4.1.8 DOWNSTREAM VARIATION IN WATER QUALITY IN DEEPELL CREEK (Low Flows : 8 - 11 l/s)

		Deepdell C. Maori Tommy (Upper Site)	Battery C. Gully	Mine Adit (U/S Wetland)	Mine Adit (D/S Wetland)	Deepdell C. (D/S Adit)	Deepdell C. (D/S Reef)	Northern Gully	Deepdell C. (D/S N.Gully)	
PARAMETER		C (n=3)	D (n=3)	F (n=3)	H (n=1)	I (n=3)	G (n=2)	Y (n=2)	K (n=3)	L (n=3)
pH	Mean	8.07	7.77	7.83	6.90	7.63	7.60	8.10	6.77	7.80
	Range	7.6 - 8.9	7.6 - 7.9	7.8 - 7.9	-	7.5 - 7.7	7.5 - 7.7	7.8 - 8.4	6.7 - 6.8	7.5 - 8.2
CONDUCTIVITY at 20 deg C (µS/cm)	Mean	13.67	25.33	41.00	88.00	79.67	18.00	18.00	16.00	18.33
	Range	12 - 15	24 - 27	40 - 42	-	78 - 81	17 - 19	17 - 19	13 - 18	17 - 20
ALKALINITY - TOTAL (as HCO3) (g/m³)	Mean	70.3	156.7	253.3	410.0	330.0	95.5	96.5	86.3	95.0
	Range	66 - 75	150 - 160	240 - 270	-	320 - 340	93 - 98	94 - 99	71 - 97	91 - 98
HARDNESS - TOTAL (as CaCO3) (g/m³)	Mean	51.00	117.67	206.67	510.00	466.67	73.50	76.50	60.67	78.00
	Range	44 - 59	106 - 130	200 - 210	-	440 - 480	68 - 79	72 - 81	46 - 68	68 - 83
SOLIDS - SUSPENDED (g/m³)	Mean	LT 6	LT 6	15	13	LT 6	LT 6	LT 6	LT 6	LT 6
	Range	-	-	12 - 16	-	-	-	-	-	-
TURBIDITY (NTU)	Mean	0.72	2.67	2.53	27.0	0.35	0.45	0.42	0.77	0.24
	Range	0.65 - 0.80	2.5 - 3.0	2.2 - 2.8	-	0.20 - 0.52	0.35 - 0.55	0.40 - 0.44	0.45 - 1.10	0.16 - 0.32
SULPHATE (g/m³)	Mean	2.93	4.80	17.67	200.00	203.33	6.75	7.05	4.63	7.40
	Range	2.2 - 3.8	3.4 - 5.8	11.0 - 23.0	-	200 - 210	6.2 - 7.3	6.5 - 7.6	2.6 - 5.7	6.1 - 8.7
CALCIUM (g/m³)	Mean	13.43	33.00	61.67	150.00	125.67	20.00	21.00	15.00	21.00
	Range	11.3 - 16.0	30.0 - 36.0	60.0 - 64.0	-	117 - 130	18.0 - 22.0	20.0 - 22.0	11.0 - 17.0	18.0 - 23.0
MAGNESIUM (g/m³)	Mean	4.43	8.60	12.67	35.00	36.00	5.75	5.85	5.63	6.07
	Range	3.9 - 4.9	7.6 - 9.7	12.0 - 13.0	-	35 - 37	5.4 - 6.1	5.5 - 6.2	4.5 - 6.3	5.5 - 6.6
POTASSIUM (g/m³)	Mean	1.27	0.63	0.33	2.2	2.13	1.20	1.20	1.07	1.30
	Range	1.0 - 1.5	0.4 - 0.8	0.1 - 0.7	-	2.0 - 2.3	1.0 - 1.4	1.0 - 1.4	1.0 - 1.1	1.1 - 1.5
SODIUM (g/m³)	Mean	11.60	14.33	16.67	18.00	16.67	13.50	13.50	13.67	12.67
	Range	11 - 12	14 - 15	16 - 18	-	16 - 18	13 - 14	13 - 14	13 - 14	12 - 13
ALUMINIUM (µg/m³)	Mean	68	59	120	11	36	29	14	67	15
	Range	-	-	-	-	-	-	-	-	-
ARSENIC (µg/m³)	Mean	1.63	8.87	40.67	4000.00	836.67	23.50	33.00	0.55	18.67
	Range	1.3 - 2.1	4.6 - 11.0	27 - 51	-	780 - 890	21 - 26	27 - 39	0.33 - 0.72	17 - 21
CADMIUM (µg/m³)	Mean	LT 0.01	0.02	LT 0.01	-	0.01	LT 0.01	LT 0.01	0.01	LT 0.01
	Range	-	LT 0.01-0.02	-	-	LT 0.01-0.01	-	-	LT 0.01-0.01	-
COBALT (µg/m³)	Mean	0.56	0.28	0.75	7.7	0.76	0.36	0.26	0.30	0.07
	Range	-	-	-	-	-	-	-	-	-
COPPER (µg/m³)	Mean	0.62	0.19	0.53	LT 0.10	0.19	0.69	0.66	0.73	0.66
	Range	0.47 - 0.75	0.14 - 0.24	0.45 - 0.59	-	0.15 - 0.21	0.65 - 0.72	0.64 - 0.68	0.61 - 0.84	0.56 - 0.76
IRON (µg/m³)	Mean	200	483	457	7300	74	160	195	65	33
	Range	180 - 240	350 - 580	420 - 490	-	12 - 140	140 - 180	150 - 240	26 - 99	28 - 36
LEAD (µg/m³)	Mean	LT 0.10	LT 0.10	0.49	LT 0.10	LT 0.10	LT 0.10	LT 0.10	LT 0.10	LT 0.10
	Range	-	-	0.44 - 0.56	-	-	-	-	-	-
MANGANESE (µg/m³)	Mean	20	46	60	1500	32	14	15	3.3	4.6
	Range	-	-	-	-	-	-	-	-	-
MERCURY (µg/m³)	Mean	LT 0.01	0.03	0.03	0.03	0.02	0.01	0.03	0.01	0.01
	Range	-	LT 0.01-0.06	0.02 - 0.05	-	LT 0.01-0.03	LT 0.01-0.01	LT 0.01-0.05	LT 0.01-0.01	LT 0.01-0.01
NICKEL (µg/m³)	Mean	0.42	0.39	0.25	2.20	0.58	0.47	0.57	1.00	0.52
	Range	-	-	-	-	-	-	-	-	-
ZINC (µg/m³)	Mean	0.31	0.22	2.53	1.20	0.56	0.48	0.38	0.45	0.16
	Range	0.16 - 0.54	0.08 - 0.41	1.70 - 3.70	-	0.35 - 0.80	0.30 - 0.65	0.26 - 0.50	0.22 - 0.79	0.11 - 0.20

- Where values are less than (LT) the lower detection limits, the mean is calculated using lower detection limit value.
- * indicates Run 1 only : Flow = 8 l/s (All flows measured in Deepdell Creek at Ford Gauging Site).
- *** indicates Run 2 and 3 : Flows = 9 l/s and 11 l/s respectively.
- Metals indicate total recoverable concentrations (see Volume 3, Appendix 8 for acid soluble concentrations).

Appendix D

Raw Data

The following supporting data files are provided separately in electronic format. These files contain detailed datasets and analyses referenced in this report and its appendices.

Files provided:

- OGNZL_Macraes_MP4_Data_Surface_Water_Quality.xlsx

Raw grab sample data for surface water quality monitoring sites collected between 1990 and 2026, including back-trace analyses referenced in this report. Values below the laboratory detection limit and have been presented as '<' but were halved for data analyses, consistent with standard practice.

- OGNZL_Macraes_MP4_Data_Invertebrates.xlsx

Macroinvertebrate sampling results for key ecological monitoring sites between 2003 and 2026, presented as abundance counts from replicate samples. Zeros indicate absence of a given taxon; null values are shaded in grey and indicate no measurement.

- OGNZL_Macraes_MP4_Data_Flora.xlsx

Periphyton and macrophyte coverage data for key ecological monitoring sites between 2002 and 2026, including percent cover estimates for long filamentous algae. Data are derived from field assessments using standard quantitative methods. Transect-level resolution of coverage is not available for all surveys, as data have been transcribed and compiled from previous reports. Zeros indicate absence of observable coverage; null values are shaded in grey and indicate no measurement.

- OGNZL_Macraes_MP4_Data_Mine_Seepage.xlsx

A small subset of mine seepage water quality data for dissolved aluminium between 2023 and 2024.

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Appendix B

Waterways Classification

Table B1. Summary of field-based stream classification (ephemeral, intermittent, permanent) for streams subject to works.

Waterway	Continuous flow	Evidence of natural pools	Well defined channel. Banks and bed can be distinguished	Surface water present (more than 48hrs after a rain event)	Rooted terrestrial vegetation not present across the entire cross-sectional width of channel	Organic debris present in floodplain	Evidence of substrate sorting processes, including scour and deposition	Comments	Classification
1	X	X	✓	X	X	NA	X		Ephemeral
2	X	X	✓	X	X	NA	X		Ephemeral
3	X	X	✓	X	X	NA	X		Ephemeral
4	X	X	✓	X	X	NA	X	Wetland present in lower reaches	Ephemeral
5	✓							Permanent from downstream of sediment pond	Permanent
6	X	✓	✓	✓	✓	NA	✓	Some areas of no flow, wetland at upper extent of reach	Intermittent
7	X	X	✓	X	X	NA	X	Lower portion transitions to intermittent	Ephemeral
8	X	X	✓	X	X	NA	X	Wetland at downstream extent	Ephemeral
9	X	X	✓	X	X	NA	X	Wetland at downstream extent	Ephemeral
10	X	X	✓	X	X	NA	X		Ephemeral
11	X	X	✓	X	X	NA	X	Transitions to wetland area at downstream extent	Ephemeral
12	X	X	✓	X	X	NA	X		Ephemeral
13	X	X	✓	X	X	NA	X	Transitions to intermittent beyond site boundaries	Ephemeral
14	X	X	✓	X	✓	NA	✓	Some damp areas, channel well defined with areas of scour	Intermittent
15	X	X	X	X	X	NA	X	Very shallow depression	Ephemeral

Waterway	Continuous flow	Evidence of natural pools	Well defined channel. Banks and bed can be distinguished	Surface water present (more than 48hrs after a rain event)	Rooted terrestrial vegetation not present across the entire cross-sectional width of channel	Organic debris present in floodplain	Evidence of substrate sorting processes, including scour and deposition	Comments	Classification
16	X	X	X	X	X	NA	X	Very shallow depression	Ephemeral
17	X	X	✓	X	X	NA	X		Ephemeral
18	X	X	✓	X	X	NA	X		Ephemeral
19	X	X	✓	X	X	NA	X		Ephemeral
20	X	X	✓	✓	X	NA	X	Some areas of shallow surface water and damp soil. No erosion or scour and vegetation present on whole cross section	Ephemeral
21	X	X	✓	X	X	NA	X		Ephemeral
22	X	X	✓	X	X	NA	X	Diverse riparian vegetation, but no water, scour or erosion. Very steep channel gradient	Ephemeral
23	X	X	✓	X	X	NA	X	Constructed pond at downstream of reach	Ephemeral
24	X	X	✓	X	X	NA	X	Constructed pond at downstream of reach	Ephemeral
25	X	X	✓	X	✓	NA	X	Short reach between pond and road bund. No vegetation, highly modified channel	Ephemeral
26	X	X	✓	X	X	NA	X		Ephemeral
27	X	X	✓	X	X	NA	X	Constructed pond at downstream of reach	Ephemeral

Waterway	Continuous flow	Evidence of natural pools	Well defined channel. Banks and bed can be distinguished	Surface water present (more than 48hrs after a rain event)	Rooted terrestrial vegetation not present across the entire cross-sectional width of channel	Organic debris present in floodplain	Evidence of substrate sorting processes, including scour and deposition	Comments	Classification
28	X	X	✓	X	X	NA	X	Constructed pond at downstream of reach	Ephemeral
29	X	X	✓	X	X	NA	X	Constructed pond at downstream of reach	Ephemeral
30	X	X	✓	X	X	NA	X		Ephemeral
31	✓							Water sourced from seep from WRS collecting in sediment pond. Permanent both sides of sediment pond. Wetland conditions in upper reach.	Permanent
32	X	X	✓	X	X	NA	X	Shallow depression, evidence of pugging	Ephemeral
33	X	X	✓	X	X	NA	X	Lower reaches of channel cut off by existing GB pit	Ephemeral
34	X	X	✓	✓	X	NA	X	More in line with wetland classification in this reach	Ephemeral
35	X	X	✓	X	X	NA	X	Some pugging with damp soil, not enough scour or erosion or suggest more regular flow	Ephemeral
36	X	X	✓	✓	X		✓	Some flow, then areas of no flow.	Intermittent
37	X	X	✓	X	X		X	Upstream of vehicle track. No water present.	Ephemeral
38	X	X	✓	✓	X		✓	Some flow, then areas of no flow.	Intermittent

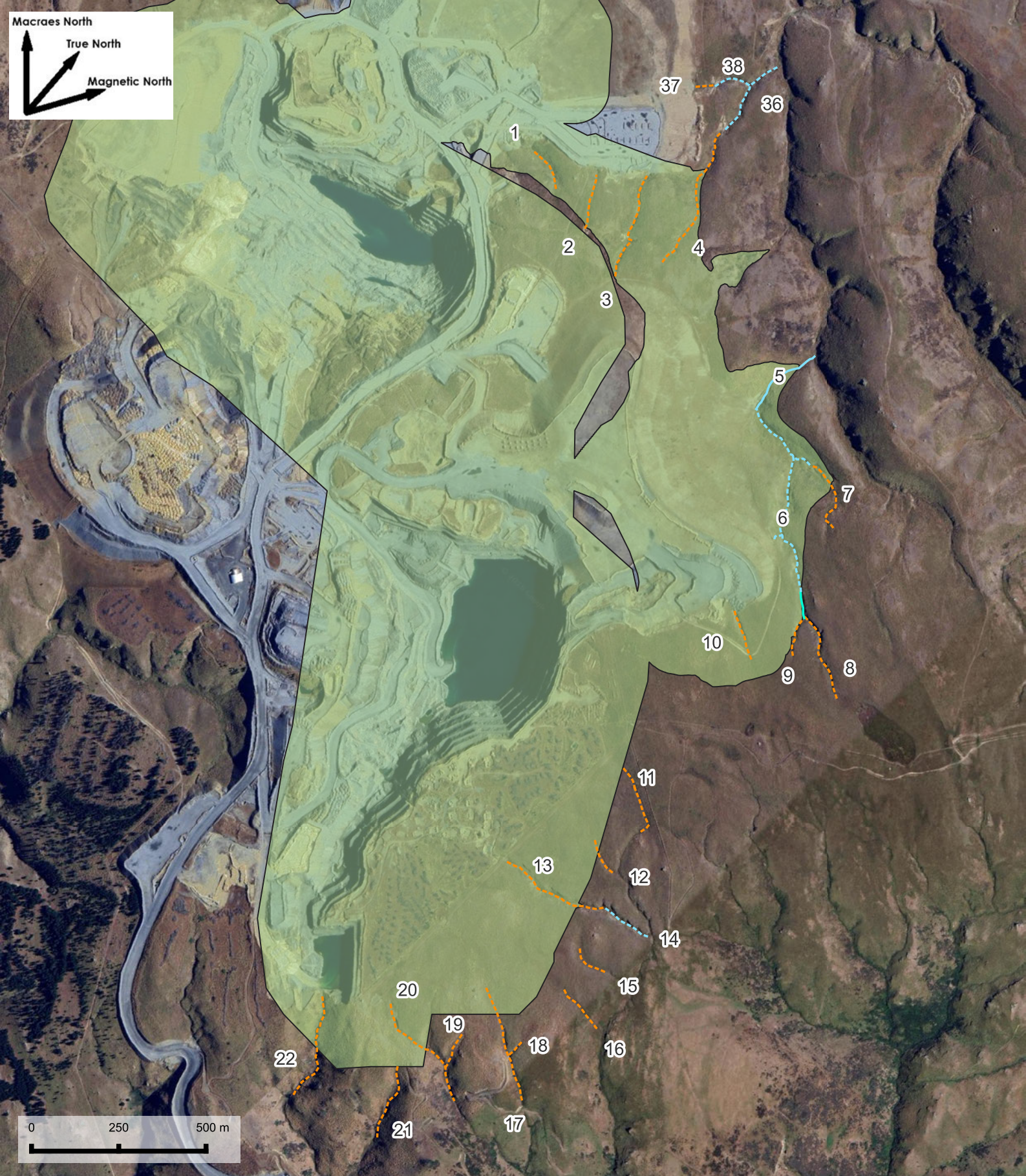


Figure B1. Waterway classification - Coronation

PROJECT NO. 10023
 DRAWN BY: AJC
 DATE: 13/08/2026
 SCALE **1:14,000** @ A4

Proposed footprint

Waterways

- Permanent
- - - Intermittent
- - - Ephemeral
- Wetland*

* Classified as a wetland rather than a stream and addressed by Bioresearches. Illustrated here for completeness.



SOURCES
 Google Satellite 2023

DISCLAIMER: This map/plan is not an engineering draft. This map/plan is illustrative only and all information should be independently verified on site before taking any action.

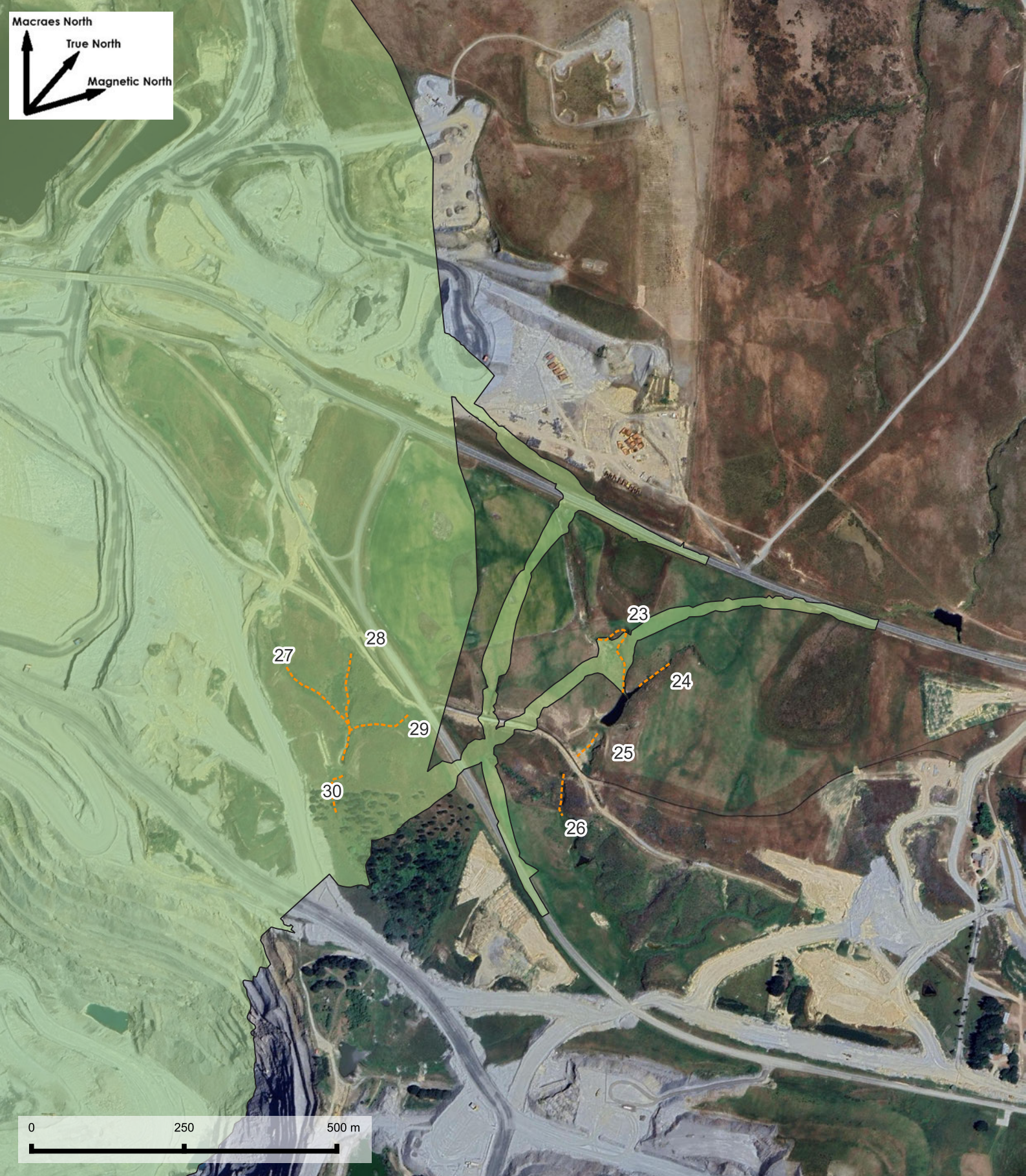


Figure B2. Waterway classification - Frasers & Innes Mills

PROJECT NO. 10023
DRAWN BY: AJC
DATE: 13/08/2026
SCALE **1:8,000** @ A4

 Proposed footprint
Waterways
 Ephemeral

 **VIRIDIS**
Environmental Consultants

SOURCES
Google Satellite 2023

DISCLAIMER: This map/plan is not an engineering draft. This map/plan is illustrative only and all information should be independently verified on site before taking any action.

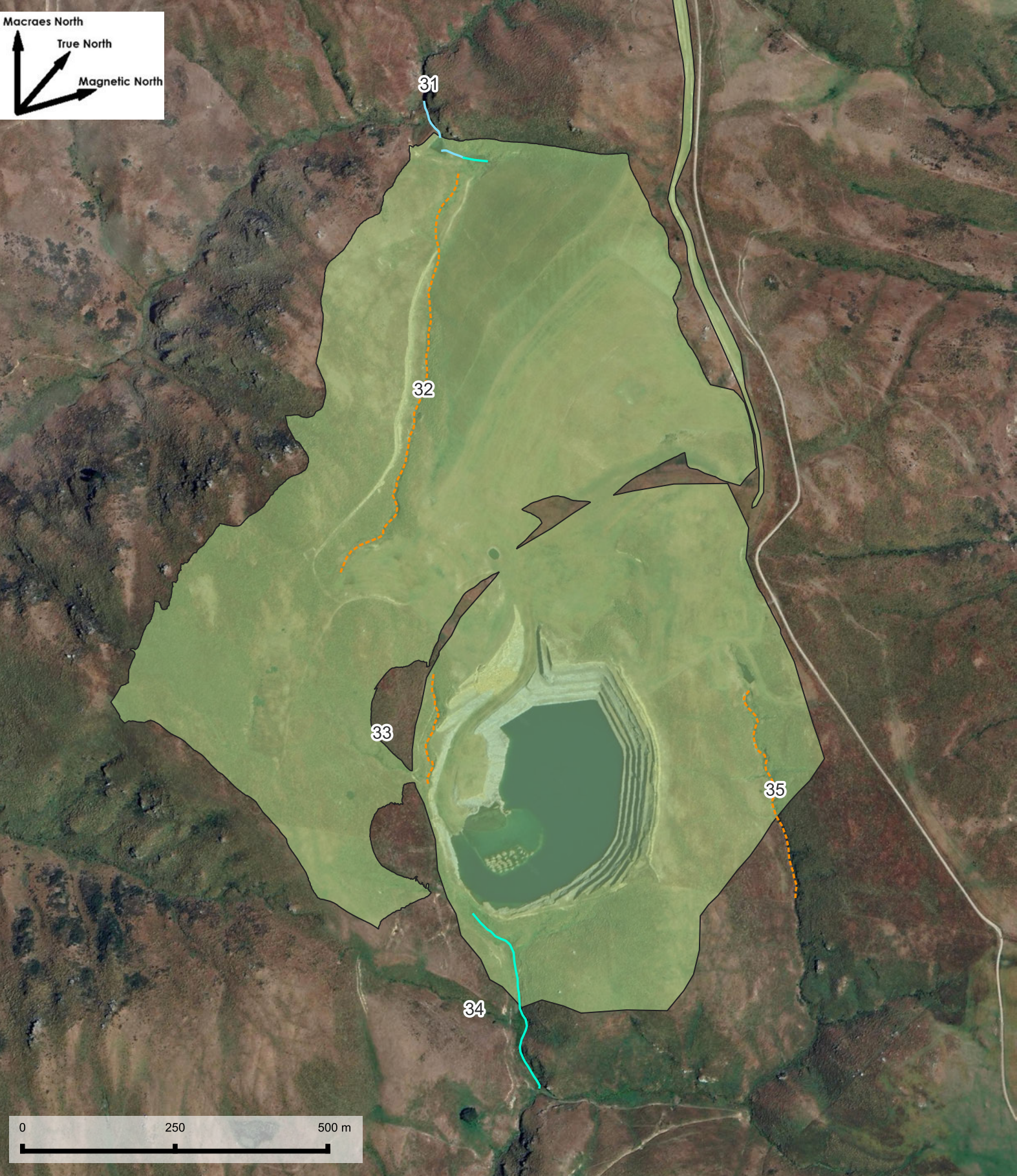
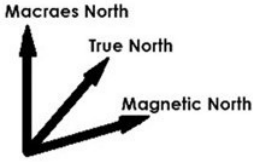


Figure B3. Waterway classification - Golden Bar

PROJECT NO. 10023
DRAWN BY: AJC
DATE: 13/08/2026
SCALE **1:8,000** @ A4

Proposed footprint

Waterways

- Permanent
- Ephemeral
- Wetland*

* Classified as a wetland rather than a stream and addressed by Bioresearches. Illustrated here for completeness.



SOURCES
Google Satellite 2023

DISCLAIMER: This map/plan is not an engineering draft. This map/plan is illustrative only and all information should be independently verified on site before taking any action.

Appendix C

Stream Ecological Valuation Data

Table C1. SEV assumptions – Trimbells Gully

Function Category	Variable	TG Permanent potential	TG Intermittent potential
Hydraulic	Vchann	Minor reduction in sediment, increase in gravel due to improved sediment pond function	No change expected
	Vlining	Minor reduction in sediment load due to improved sediment pond function	No change expected
	Vpipe	No change expected	No change expected
	Vbank	No change expected, connectivity to floodplain naturally present along majority of reach	No change expected, connectivity to floodplain naturally present along majority of reach
	Vrough	No change expected	No change expected
	Vbarr	No change expected	No change expected, sediment pond barrier would remain
	Vchanshape	No data entry required – populated from other variables	No data entry required – populated from other variables
Biogeochemical	Vshade	No change expected	No change expected
	Vdod	No change expected. Land use will not change and stock are already excluded	No change expected. Land use will not change and stock are already excluded
	Vveloc	No change expected	No change expected
	Vdepth	No change expected	No change expected
	Vripar	No change expected. Moderate to tall tussocks already present	No change expected. Moderate to tall tussocks already present
	Vdecid	No change expected	No change expected
	Vmacro	No change expected. Some macrophyte growth present, riparian vegetation provides shading already	No change expected. Some macrophyte growth present, riparian vegetation provides shading already
	Vretain	No data entry required – populated from other variables	No data entry required – populated from other variables
	Vsurf	Minor reduction in sediment, increase in gravel due to improved sediment pond function. No change to macrophytes expected	No change expected
	Vripfilt	No change expected. Riparian vegetation already present	No change expected. Riparian vegetation already present
Habitat provision	Vgalspawn	No change expected	No change expected
	Vgalqual	No change expected	No change expected
	Vgobspawn	No data entry required – populated from other variables	No data entry required – populated from other variables
	Vphyshab	No change expected	No change expected

Function Category	Variable	TG Permanent potential	TG Intermittent potential
	Vwatqual	No change expected. Land use will not change	No change expected. Land use will not change
	Vimperv	No change, no impervious surfaces	No change, no impervious surfaces
Biodiversity	Vfish	No change presumed. Difficult to predict but no fish detected and assumed no fish present	No change. Fish barrier downstream of reach will remain
	Vmci	No change presumed due to no major changes in habitat	No change presumed due to no major changes in habitat
	Vept	No data entry required – populated from other variables	No data entry required – populated from other variables
	Vinvert	No data entry required – populated from other variables	No data entry required – populated from other variables
	Vripcond	No data entry required – populated from other variables	No data entry required – populated from other variables
	Vripconn	No change expected	No change expected

Table C2. SEV assumptions – North Branch Waikouaiti

Function category	Variable	NB Waikouaiti potential	NB Waikouaiti improved
Hydraulic	Vchann	No change expected without physical reshaping	Channel not reshaped but addition of logs and boulders creates some variation of channel shape, reduction of macrophyte growth
	Vlining	No change expected	Reduction in sediment load, though high levels of sediment still expected in some reaches
	Vpipe	No change expected	No change expected
	Vbank	No change expected, connectivity to floodplain present along majority of reach	No change expected, connectivity to floodplain maintained along majority of reach
	Vrough	Transition to establishing native riparian vegetation	Transition to establishing native riparian vegetation
	Vbarr	No change expected	No change expected, expected channel will still dry downstream
	Vchanshape	No change expected. Existing culvert would remain	No change expected. Existing culvert would remain
Biogeochemical	Vshade	Increase in shade through riparian planting	Increase in shade through riparian planting
	Vdod	No change expected without removal of anoxic material	Minor improvement in habitat through removal of sediment, increased flow velocity and construction of drain to intercept poor quality water flowing from RS
	Vveloc	Minor increase in velocity due to decreased macrophyte growth. Channel lacks gradient for large increases	Minor increase expected through reduction of macrophyte growth
	Vdepth	No change expected	Difficult to predict therefore conservatively no change expected
	Vripar	Increase in riparian planting to include 10 m on either bank	Increase in riparian planting to include 10 m on either bank
	Vdecid	No change expected	No change expected
	Vmacro	Reduction in excessive macrophyte growth through development of riparian shading	Reduction in excessive macrophyte growth through development of riparian shading
	Vretain	No data entry required – populated from other variables	No data entry required – populated from other variables
	Vsurf	No change expected without physical works and/or increased flow	Minor changes through addition of boulders and logs. Reduction of macrophyte growth through establishment of riparian shade

Function category	Variable	NB Waikouaiti potential	NB Waikouaiti improved
	Vripfilt	Increase in filtration through establishment of riparian vegetation. Some patchiness expected	Increase in filtration through establishment of riparian vegetation. Some patchiness expected at least in medium term
Habitat provision	Vgalspawn	No change expected	No change expected
	Vgalqual	Difficult to predict with wider catchment uses. Potential minor improvement through stock exclusion and riparian planting	Difficult to predict with wider catchment uses. Likely improvement through stock exclusion and riparian planting
	Vgobspawn	No data entry required – populated from other variables	No data entry required – populated from other variables
	Vphyshab	Limited changes to channel itself through riparian planting will increase shade	Minor increase in instream habitat through addition of boulders and logs creating some heterogeneity, riparian vegetation significantly increase shade
	Vwatqual	Increase in shading from establishment of riparian vegetation	Increase in shading from establishment of riparian vegetation
	Vimperv	No change, impervious surfaces relating to Red Bank Road will not change	No change, impervious surfaces relating to Red Bank Road will not change
Biodiversity	Vfish	No change presumed. Difficult to predict as fish passage depends on permanent water presence downstream of the site as well	No change presumed. Difficult to predict as fish passage depends on permanent water presence downstream of the site as well
	Vmci	No change presumed but difficult to predict, may increase due to increase in shade	No change presumed but difficult to predict, may increase due to increase in shade and habitat quality through stream works
	Vept	No data entry required – populated from other variables	No data entry required – populated from other variables
	Vinvert	No data entry required – populated from other variables	No data entry required – populated from other variables
	Vripcond	No data entry required – populated from other variables	No data entry required – populated from other variables
	Vripconn	No change expected	No change expected

Table C3. SEV assumptions – Murphys Creek

Function category	Variable	Murphys Creek 20 m planting
Hydraulic	Vchann	Reduction in macrophyte growth through increase in shading.
	Vlining	No change expected. Likely still small areas of fine sediment even with stock exclusion and planting.
	Vpipe	No change expected
	Vbank	No change expected, connectivity to floodplain maintained along majority of reach
	Vrough	Sedge planting 0-2m, mixed natives 2-20 m.
	Vbarr	No change expected
	Vchanshape	No data entry required – populated from other variables
Biogeochemical	Vshade	Increase in shade through riparian planting
	Vdod	Improvement through increased shading, removal of stock, and increased filtration
	Vveloc	Difficult to predict but no major changes expected. Current macrophyte growth likely reduced/removed but natural variation in flow as a result of substrates and future riparian vegetation
	Vdepth	No change expected
	Vripar	Riparian planting on both banks to 20 m. Likely still some patchiness in vegetation coverage. Sedges planted on stream edge, not trees and bushes.
	Vdecid	No change expected
	Vmacro	Reduction in excessive macrophyte growth through development of riparian shading
	Vretain	No data entry required – populated from other variables
	Vsurf	No major changes in substrate expected, minor increase in woody debris. Decrease in macrophytes and increase in leaf litter expected
	Vripfilt	Increase in filtration through establishment of riparian vegetation to 20 m
Habitat provision	Vgalspawn	No change expected.
	Vgalqual	Difficult to predict with wider catchment uses. Likely improvement through stock exclusion and riparian planting
	Vgobspawn	No data entry required – populated from other variables
	Vphyshab	Likely small increase in habitat diversity and abundance. Large increases in shading and riparian integrity from riparian planting
	Vwatqual	Assumed most of upper reaches are planted
	Vimperv	No change, no impervious surfaces
Biodiversity	Vfish	No change presumed. Moderate diversity community containing fish expected to be present.

Function category	Variable	Murphys Creek 20 m planting
	Vmci	No change presumed but difficult to predict, may increase due to increase in shade and habitat quality
	Vept	No data entry required – populated from other variables
	Vinvert	No data entry required – populated from other variables
	Vripcond	No data entry required – populated from other variables
	Vripconn	No change expected

Date		6-Jul-26			Test sites										Reference sites						
					Site name/number										Site name/number						
Function category	Report section*	Function	Worksheet #	Variable (code)	Trimbells Gully Permanent current	Trimbells Gully Intermittent current	Trimbells Gully Permanent potential	Trimbells Gully Intermittent potential	NB Waikouaiti	NB Waikouaiti potential	NB Waikouaiti improved	Murphys current	Murphys improved		Highlay Creek	Cranky Jims					
Hydraulic	4.1	NFR		Vchann	1.00	1.00	1.00	1.00	0.10	0.10	0.24	0.88	1.00	0.00	1.00	1.00	0.00				
				Vlining	0.90	1.00	0.94	1.00	0.80	0.80	0.90	0.98	0.98	0.00	1.00	1.00	0.00				
				Vpipe	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	enter data	1.00	1.00	enter data				
				=	0.97	1.00	0.98	1.00	0.33	0.33	0.46	0.91	0.99	#VALUE!	1.00	1.00	#VALUE!				
Hydraulic	4.2	FLE		Vbank	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00				
				Vrough	1.00	1.00	1.00	1.00	0.20	0.80	0.80	0.64	0.84	0.00	0.80	0.90	0.00				
				=	1.00	1.00	1.00	1.00	0.20	0.80	0.80	0.64	0.84	0.00	0.80	0.90	0.00				
				Vbarr	1.00	0.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00				
Hydraulic	4.3	CSM		Vchanshape	1.00	1.00	1.00	1.00	0.20	0.20	0.24	0.98	1.00	0.00	1.00	1.00	0.00				
				Vlining	0.90	1.00	0.94	1.00	0.80	0.80	0.90	0.98	0.98	0.00	1.00	1.00	0.00				
				=	0.93	1.00	0.96	1.00	0.60	0.60	0.68	0.98	0.99	0.00	1.00	1.00	0.00				
				Hydraulic function mean score					0.98	0.75	0.99	0.75	0.53	0.68	0.74	0.88	0.96	#VALUE!	0.95	0.98	#VALUE!
biogeochemical	4.5	WTC		Vshade	0.40	0.58	0.40	0.58	0.00	0.24	0.50	0.20	0.70	#DIV/0!	0.44	0.90	#DIV/0!				
				=	0.40	0.58	0.40	0.58	0.00	0.24	0.50	0.20	0.70	#DIV/0!	0.44	0.90	#DIV/0!				
				Vdod	0.45	0.68	0.45	0.68	0.17	0.25	0.45	0.68	1.00	#DIV/0!	0.60	1.00	#DIV/0!				
				=	0.45	0.68	0.45	0.68	0.17	0.25	0.45	0.68	1.00	#DIV/0!	0.60	1.00	#DIV/0!				
biogeochemical	4.6	DOM		Vripar	0.20	0.20	0.20	0.20	0.00	0.50	0.50	0.20	0.80	0.00	1.00	0.80	0.00				
				Vdecid	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	#DIV/0!	1.00	1.00	#DIV/0!				
				=	0.20	0.20	0.20	0.20	0.00	0.50	0.50	0.20	0.80	#DIV/0!	1.00	0.80	#DIV/0!				
				Vmacro	0.40	0.19	0.40	0.19	0.00	0.55	0.55	0.51	0.93	#DIV/0!	0.54	0.79	#DIV/0!				
biogeochemical	4.8	IPR		Vretain	1.00	1.00	1.00	1.00	0.20	0.20	0.28	0.84	1.00	0.00	1.00	1.00	0.00				
				=	0.40	0.19	0.40	0.19	0.00	0.20	0.28	0.51	0.93	#DIV/0!	0.54	0.79	#DIV/0!				
				Vsurf	0.63	0.39	0.65	0.39	0.79	0.72	0.76	0.61	0.57	#DIV/0!	0.86	0.50	#DIV/0!				
				Vripfilt	0.80	0.80	0.80	0.80	0.20	0.70	0.76	0.30	0.80	0.00	0.80	1.00	0.00				
biogeochemical	4.9	DOP		=	0.72	0.59	0.73	0.59	0.49	0.71	0.76	0.45	0.68	#DIV/0!	0.83	0.75	#DIV/0!				
				Biogeochemical function mean score					0.43	0.45	0.43	0.45	0.13	0.38	0.50	0.41	0.82	#DIV/0!	0.68	0.85	#DIV/0!
				habitat provision	4.10	FSH		Vgalspwn	0.55	0.40	0.55	0.40	1.00	1.00	1.00	1.00	1.00	#DIV/0!	1.00	0.00	#DIV/0!
								Vgalqual	0.25	0.25	0.25	0.25	0.00	0.25	0.75	0.25	0.75	0.00	0.25	0.00	0.00
Vgobspwn	0.10	0.10	0.10					0.10	0.10	0.10	1.00	0.80	1.00	#DIV/0!	1.00	1.00	#DIV/0!				
=	0.12	0.10	0.12					0.10	0.05	0.18	0.88	0.53	0.88	#DIV/0!	0.63	0.50	#DIV/0!				
habitat provision	4.11	HAF		Vphyshab	0.77	0.64	0.77	0.64	0.21	0.49	0.63	0.62	1.00	0.00	0.91	1.00	0.00				
				Vwatqual	0.14	0.26	0.14	0.26	0.01	0.09	0.23	0.14	0.85	#DIV/0!	0.19	0.95	#DIV/0!				
				Vimperv	1.00	1.00	1.00	1.00	0.95	0.95	0.95	1.00	1.00	0.00	1.00	1.00	0.00				
				=	0.67	0.64	0.67	0.64	0.34	0.51	0.61	0.59	0.96	#DIV/0!	0.75	0.99	#DIV/0!				
Habitat provision function mean score					0.39	0.37	0.39	0.37	0.20	0.34	0.74	0.56	0.92	#DIV/0!	0.69	0.74	#DIV/0!				
Biodiversity	4.12	FFI		Vfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.57	0.00	0.57	0.33	0.00				
				=	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.57	0.00	0.57	0.33	0.00				
				Vmci	0.59	0.59	0.59	0.59	0.50	0.50	0.50	0.56	0.56	#DIV/0!	0.63	0.72	#DIV/0!				
				Vept	0.28	0.28	0.28	0.28	0.00	0.00	0.00	0.50	0.50	#VALUE!	0.72	0.67	#VALUE!				
Biodiversity	4.13	IFI		Vinvert	0.22	0.22	0.22	0.22	0.12	0.12	0.12	0.33	0.33	1.00	0.49	0.33	1.00				
				=	0.36	0.36	0.36	0.36	0.20	0.20	0.20	0.46	0.46	#DIV/0!	0.62	0.57	#DIV/0!				
				Vripcond	0.40	0.40	0.40	0.40	0.10	0.60	0.60	0.32	0.56	0.00	0.60	0.70	0.00				
				Vripconn	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	#VALUE!	1.00	1.00	#VALUE!				
Biodiversity	4.14	RVI		=	0.40	0.40	0.40	0.40	0.10	0.60	0.60	0.32	0.56	#VALUE!	0.60	0.70	#VALUE!				
				Biodiversity function mean score					0.25	0.25	0.25	0.25	0.10	0.27	0.27	0.45	0.53	#DIV/0!	0.59	0.54	#DIV/0!
				Overall mean SEV score (maximum value 1)					0.544	0.482	0.547	0.482	0.250	0.437	0.551	0.574	0.811	#VALUE!	0.740	0.802	#VALUE!

Appendix D

Recommended Aquatic Monitoring Programme

TO: OGNZL MP4 Water Team
 OceanaGold (New Zealand) Limited

Date: 3 September 2026

COPY TO:

Document No: 10023-019-4

FROM: Grant Allen

RECOMMENDED MP4 SURFACE WATER QUALITY & AQUATIC ECOLOGY MONITORING

Introduction

This schedule accompanies the Assessment of Aquatic Environmental Effects (Viridis 2026)¹ for OceanaGold (New Zealand) Limited's (OGNZL) Macraes Phase 4 (MP4) Project ('the Project'). It sets out the proposed water quality and aquatic ecology compliance monitoring requirements across the Project's three key receiving catchments: the Shag/Waihemo, Waikouaiti and Taieri River catchments.

The compliance monitoring network has been designed to provide robust detection of potential project-related effects across all three catchments, while rationalising the existing monitoring network to reflect the spatial footprint of MP4. The monitoring network includes sites where continued monitoring is warranted by historical water-quality or ecological issues, together with sites located downstream of areas where GHD (2026)² predicts future changes associated with MP4.

Monitoring

Surface Waters

The consent holder shall collect monthly representative water samples from the sites identified in Table 1, with sites located in the same catchment sampled on the same day, where practicable. Samples shall be analysed at the trace level for the parameters listed in Table 2.

Table 1. Surface water quality compliance monitoring sites.

Site	Watercourse	Catchment	NZTM Coordinates	
			Northing	Easting
MB01	Mare Burn	Taieri	4980411	1393904
MB02	Mare Burn	Taieri	4980505	1392962
DC08	Deepdell Creek	Shag/Waihemo	4976095	1401819
MC01	Murphys Creek	Waikouaiti	4969612	1403034
MC02	Murphys Creek	Waikouaiti	4966875	1405420
GB02*	Golden Bar Creek	Waikouaiti	4967819	1407110
NBWRRF	North Branch Waikouaiti River	Waikouaiti	4967163	1401042
NB03	North Branch Waikouaiti River	Waikouaiti	4964562	1405803
Shag at Loop Road	Shag River	Shag/Waihemo	4978310	1409432
Shag at McCormicks	Shag River	Shag/Waihemo	4970733	1415078

Note: GB02 is currently located close to the Golden Bar pit and is proposed to be relocated downstream to a more representative site, in consultation with ORC, while maintaining comparability with the existing dataset.

¹ Viridis 2026. Macraes Phase 4 Project: Recommended Surface Water Quality Compliance Framework. A report prepared for OceanaGold (New Zealand) Limited by Viridis Limited. 3 September 2026. Document No. 10023-010-5.

² GHD 2026. Macraes Phase 4 FTA | Surface and Groundwater Assessment. A report prepared for OceanaGold (New Zealand) Limited by GHD Limited. 2 September 2026.

Table 2. Proposed surface water quality monitoring parameters.

Category	Parameter
General chemistry	pH
	Electrical conductivity
	Temperature
	Hardness
Water clarity	Turbidity
Major ions	Calcium
	Magnesium
	Potassium
	Sodium
	Bicarbonate
	Carbonate
	Chloride
	Sulphate
Nutrients	Ammoniacal nitrogen
	Nitrate nitrogen
	Soluble inorganic nitrogen (calculated)
Organic carbon	Dissolved non-purgeable organic carbon (DNPOC)
Metals and metalloids	Arsenic
	Boron
	Copper
	Iron
	Lead
	Nickel
	Zinc
Cyanide	Weak acid dissociable (WAD) cyanide

Note: Except for iron, all metals and metalloids are analysed in the dissolved fraction. Iron is analysed as total iron.

Aquatic Biological Monitoring

The consent holder shall engage a suitably qualified and experienced freshwater biologist to undertake the aquatic biological monitoring at the sites identified in Table 3, in accordance with Table 4, unless the site is dry or surface flows are otherwise insufficient to undertake the required sampling.

Aquatic biological monitoring will provide an ongoing record of ecological response to improving water quality and habitat conditions as the proposed mitigation measures are implemented.

Compliance Criteria

Overview

The compliance framework underpinning this schedule is set out in Viridis (2026), which establishes a consistent, site-wide approach to surface water quality compliance, replacing historically derived consent limits with a unified framework aligned with contemporary national and international guidance.

Full compliance with the proposed water quality trigger values is not expected immediately following issue of consent, reflecting the time required to implement the proposed mitigation measures (e.g., construction of the Camp Creek and Coal Creek dams and implementation of the wastewater treatment plant). During this transition period, compliance will be assessed against the existing consent limits. Based on water quality modelling, the new compliance framework is anticipated to become operative from Year 7 (measured from consent commencement).

Eutrophication non-compliance is determined where both the SIN trigger value (rolling annual median) and the ecological response trigger value are exceeded, in accordance with Viridis (2026). The ecological response metric is outlined in the site's water quality management plan (WGA 2026)³, with the optimal method to be determined on an adaptive basis.

Numerical Compliance Criteria for Receiving Waters

Surface water quality at the compliance sites listed in the Monitoring section of this schedule shall be assessed against the trigger values and compliance criteria set out in Viridis (2026).

Except for iron, the trigger values for metals and metalloids apply to the dissolved fraction. The trigger value for iron applies to total iron. Where trigger values are expressed as functions of site-specific water chemistry parameters (including hardness, pH, dissolved organic carbon, chloride and temperature), compliance assessment shall use site-specific values measured at the time of sampling, applied in accordance with the equations and toxicity modifier lookup tables provided in Viridis (2026).

In addition to the water quality trigger values, drinking water guideline values apply at the Shag River at Loop Road, Shag River at McCormicks, and NB03 sites, as set out in Viridis (2026).

A site is considered non-compliant where trigger values are exceeded at the frequency or duration outlined in Viridis (2026). For chronic trigger values, exceedance on a single occasion does not constitute non-compliance but will prompt further assessment and, where appropriate, a management response. Drinking water guideline value exceedances are assessed on the basis of a single sampling occasion, in accordance with Viridis (2026).

Table 3. Aquatic ecology compliance monitoring sites.

Site	Watercourse	Catchment	NZTM Coordinates	
			Northing	Easting
MB01	Mare Burn	Taieri	4980411	1393904
MB02	Mare Burn	Taieri	4980505	1392962
DC08	Deepdell Creek	Shag/Waihemo	4976095	1401819
MC01	Murphys Creek	Waikouaiti	4969612	1403034
MC02	Murphys Creek	Waikouaiti	4966875	1405420
GB02	Golden Bar Creek	Waikouaiti	4967819	1407110
NBWRRF	North Branch Waikouaiti River	Waikouaiti	4967163	1401042
NB03	North Branch Waikouaiti River	Waikouaiti	4964562	1405803

³ WGA 2026. Macraes Phase 4 Water Quality Management Plan. Prepared for OceanaGold (New Zealand) Limited by WGA Limited. September 2026.

Table 4. Aquatic biological monitoring components and frequency.

Sample type	Frequency	Sites	Methods
Aquatic flora*	Summer (Dec-Feb) Autumn (Mar-May) Spring (Sep-Nov)	MB01, MB02, DC08, MC01, MC02, GB02, NBWRRF, NB03	Visual assessment of percentage cover of filamentous algae, mat-forming algae, macrophytes and moss.
Benthic macroinvertebrates	Summer (Dec-Feb) Autumn (Mar-May) Winter (Jun-Aug) Spring (Sep-Nov)	MB01, MB02, DC08, MC01, MC02, GB02, NBWRRF, NB03	Taxonomic composition and abundance. Sampling shall include calculation of the macroinvertebrate community index (MCI) and the quantitative MCI (QMCI)
Fish**	Late summer (Feb-Mar)	MB01, MB02, DC08, MC01, MC02, NBWRRF, NB03	Taxonomic composition and abundance, by electric fishing survey.

Notes: * Aquatic flora monitoring supports the ecological response trigger assessment described in Viridis (2026). The visual cover-based method is consistent with monitoring undertaken under the existing Macraes Operation consents and is proposed as the starting method for MP4. The optimal method will be confirmed through the water quality management plan (WGA 2026), applying an adaptive management approach; and ** fish monitoring is not proposed at GB02, as no fish have been recorded at this site during monitoring undertaken since 2004.

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Appendix E

Stream Compensation Plan



Macraes MP4 Project

Stream Compensation Plan

Prepared for: Oceana Gold New Zealand Limited

August 2026



DOCUMENT CONTROL AND REVISION HISTORY

Document title	Macraes MP4 Project
	Stream Compensation Plan
Prepared for	Oceana Gold New Zealand Limited
Version	Final 1
Date	20 August 2026
Document number	10023-015-1

Version	Issue date	Document number
Draft A	23 June 2026	10023-015-A
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Reference: Viridis 2026. Macraes MP4 Project Stream Compensation Plan. A report prepared for Oceana Gold New Zealand Limited by Viridis Limited. August 2026.

Cover photo: Permanent reach of Trimbells Gully to be impacted by proposed works, photo December 2025.

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1 INTRODUCTION

1.1 Background

OceanaGold (New Zealand) Limited ('OGNZL') currently undertakes open pit and underground gold mining operations at the Macraes Operation located at Golden Point Road, Macraes Flat, East Otago ('the site'). As part of their ongoing operations, OGNZL continually reviews the remaining life of the Macraes Operation in light of updated knowledge of the gold resource and the economics of mining.

Reflecting recent exploration success and optimisation work, together with higher gold prices, the Macraes Phase Four Project ('MP4' or 'the Project') seeks to extend the life of mining at the Macraes Operation until at least 2039. The Project, which will enable ongoing gold production at a rate of approximately 130,000 ounces per annum, is identified as a Listed Project in Schedule 2 of the Fast-track Approvals Act 2024 ('FTAA') as a project providing significant national or regional benefits.

Parts of the works associated with MP4 require the reclamation of portions of two waterways.

The contents of this plan set out the requirements for enhancement of the nominated compensation waterways – Murphys Creek and North Branch Waikouaiti River. It includes planting plans, schedules, and recommended maintenance to establish vegetation within the compensation reaches.

1.2 Compensation Requirements

The Assessment of Aquatic Environmental Effects report (AAEE)¹ prepared for the MP4 Project identifies residual stream habitat loss associated with the proposed works in Trimbells Gully and the Clydesdale Creek tributary. The realignment of Trimbells Gully will result in the loss of 180 m of permanent stream. This is partly offset by an additional 75 m of intermittent stream habitat created in the new channel, giving a net loss of 105 lineal metres of stream. Separately, reclamation will result in the loss of 22 m of permanent stream in the Clydesdale Creek tributary, and construction of a sediment retention pond will result in the loss of 80 m of intermittent stream in the Trimbells Gully tributary. The AAEE identifies that these residual losses are to be compensated through enhancement of Murphys Creek and the North Branch Waikouaiti River.

The AAEE applies widely used and accepted ecological compensation ratios to determine the minimum compensation required. Permanent stream losses in Trimbells Gully and the Clydesdale Creek tributary are to be compensated through enhancement of the permanent Murphys Creek, while intermittent stream loss in Trimbells Gully tributary is to be compensated through enhancement of the intermittent North Branch Waikouaiti River. While there will be no overall loss of intermittent stream habitat in Trimbells Gully as the realignment will result in additional intermittent habitat, there will be a lag between constructing the realignment and the channel functioning as a natural stream. Proposed enhancement of North Branch Waikouaiti River is also intended to compensate for this lag. The final compensation reach lengths exceed the minimum compensation lengths required by the calculated compensation ratios.

The required compensation outcomes identified in the AAEE, and the corresponding compensation works provided for in this plan, are summarised in Table 1.

¹ Viridis 2026. Macraes MP4 Project - Assessment of Aquatic Environmental Effects. A report prepared for Oceana Gold (New Zealand) Limited by Viridis Limited. August 2026. 10023-011-1.

Table 1. Summary of required compensation outcomes and proposed delivery through this plan.

Impacted reach	Stream habitat loss	Compensation reach	Required compensation outcome from AAEE	Proposed delivery in this plan	Relevant plan section
Trimbells Gully — permanent reach	180 m / 126 m ² permanent stream	Murphys Creek	Compensation ratio of 3.5:1, requiring 539 m of Murphys Creek enhancement	Included within 640 m of Murphys Creek enhancement, with 20 m riparian planting from the stream edge where practicable	Sections 2.2, 2.4–2.7 and 3
Clydesdale Creek tributary — permanent reach	22 m / 15 m ² permanent stream	Murphys Creek	Compensation ratio of 3.5:1, requiring 66 m of Murphys Creek enhancement	Included within 640 m of Murphys Creek enhancement, with 20 m riparian planting from the stream edge where practicable	Sections 2.2, 2.4–2.7 and 3
Trimbells Gully — intermittent reach*	0*	North Branch Waikouaiti River	0*	Included within 950 m of North Branch Waikouaiti River enhancement, with 10 m riparian planting from the stream edge and instream boulder placement to improve habitat heterogeneity	Sections 2.2, 2.3, 2.4–2.7 and 3
Trimbells Gully tributary — intermittent reach	80 m / 38 m ² intermittent stream	North Branch Waikouaiti River	Compensation ratio of 2.4:1, requiring 31 m of North Branch Waikouaiti River enhancement, rounded up to 80 m because the compensation reach should not be shorter than the impact reach	Included within 950 m of North Branch Waikouaiti River enhancement, with 10 m riparian planting from the stream edge and instream boulder placement to improve habitat heterogeneity	Sections 2.2, 2.3, 2.4–2.7 and 3

Notes: * While no compensation is strictly necessary for the intermittent reach of the Trimbells Gully, there will be a lag time between establishing the realignment and the realignment functioning as a natural stream. Therefore, the enhancement of North Branch Waikouaiti River is also considered to compensate for this impact.

1.3 Local Environment

The reclaimed streams, as well as the compensation reaches, are situated in the Macraes Ecological District (ED) of the Lammerlaw Ecological Region. The district is characterised by a series of faulted, gently sloping ridges around 600 m above sea level (asl), extending to 800 m asl. The climate is generally cool and dry, and snow can remain in place for weeks during winter. Historically (pre-human), vegetation in the area would have included podocarp, broadleaf, hardwood forest, however post-human arrival areas of forest have significantly decreased and tussock land with areas of coprosma-flax scrubland have proliferated. Review of historic aerial images shows the site has been devoid of significant areas of vegetation for the duration of the available record.

The wider Macraes Operation area has been subject to various scales of gold mining activity for more than a century. The Macraes Operation in its current form was first established in 1990, and it has expanded over time to occupy its current footprint. Prior to establishment of the current mining operation, the area was characterised as extensive agricultural land (sheep and beef), and this activity continues on site where mining operations do not occur.

1.4 Impacted Reaches²

1.4.1 Trimbells Gully

The ecological value of Trimbells Gully tributary is considered to be low.

Trimbells Gully originates to the east of the current Trimbells Gully waste rock stack (WRS), draining from the north-western face of Highlay Hill. It flows in a generally north-western direction, around the base of the WRS before joining with Maori Hen Creek and discharging to Mare Burn. It ultimately sits within the Taieri River catchment.

The permanent reach downstream of the sediment pond was contained within a moderately incised channel with banks formed by both natural soil substrates, and large tussocks. The stream substrates were heavily dominated by fine sediment, however beneath the sediment the channel was relatively firm. Periphyton and macrophyte growth formed a moderate component of the channel. Macrophytes were generally limited to areas where tussocks were thinner and included emergent exotic grasses including *Glyceria* sp. and creeping bent (*Agrostis stolonifera*). The relatively small catchment upstream of the site suggests flow will be flashy, rapidly increasing and then decreasing following rainfall.

Upstream of the sediment pond the reach was considered to be intermittent. The wetted channel was generally narrower and shallower than the permanent reach, and there were portions where water appeared to flow just below ground level. Substrates were more variable in this reach with gravels and small cobbles present as well as fine sediment. Flow was also variable, generally depending on water depth. As with the permanent reach, macrophytes were present and included both *Glyceria* sp. and creeping bent. Small amounts of exotic monkey musk (*Erythranthe guttata*) were also present where tussock growth was lower and less dense.

No fish were present in either reach. eDNA sampling undertaken downstream of the sediment pond detected no fish. The pond presents a significant barrier to fish movement, although it is possible eels may be able to negotiate it if they are ever present in the channel. Given the lack of fish detected, and the high location in the catchment, fish are not expected to be present.

² Impacted and compensation reaches are shown on Figure 1 with full descriptions provided in the AAEE.

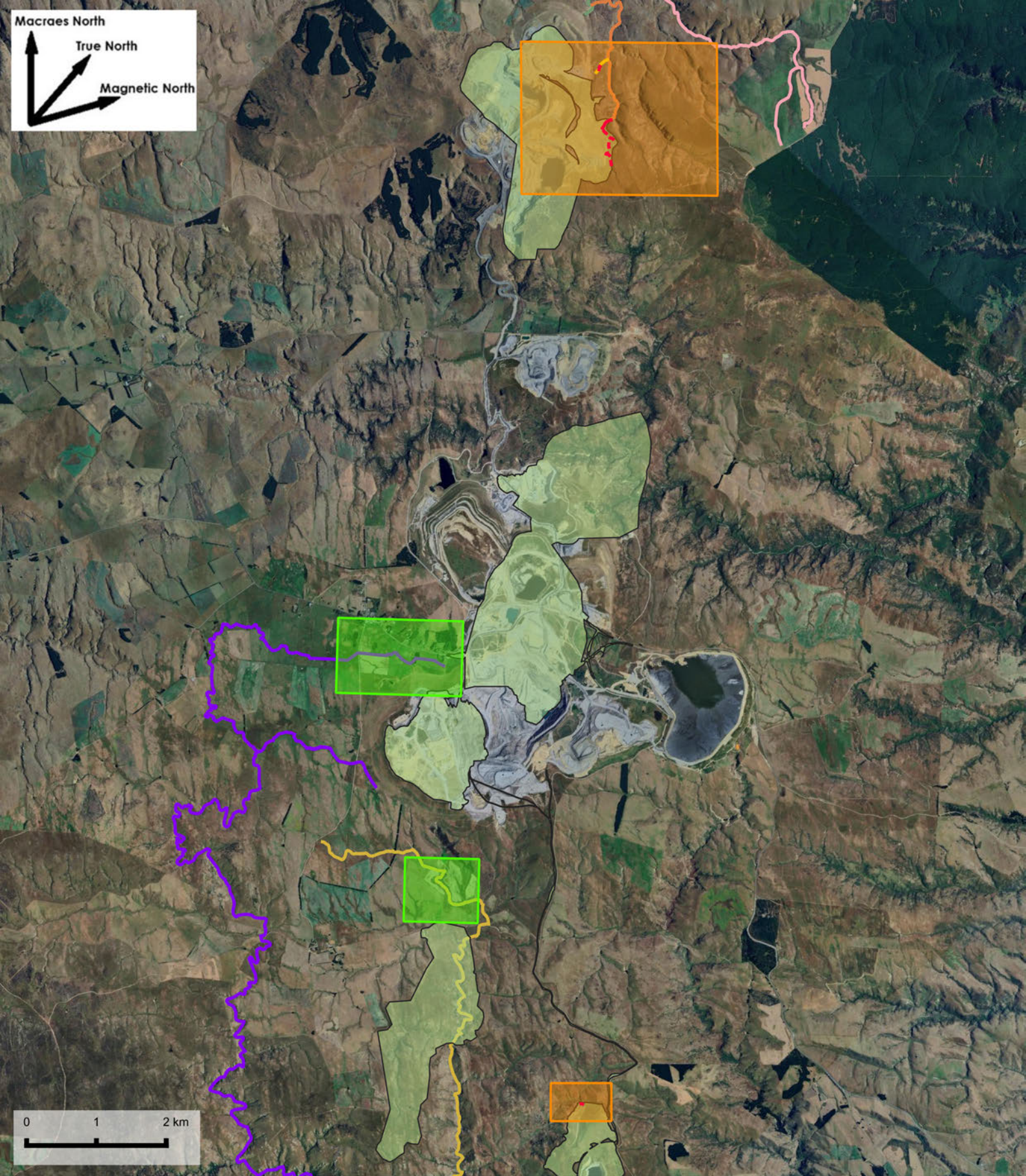


Figure 1. MP4 stream impact and compensation reaches

PROJECT NO. 10023
 DRAWN BY: AJC
 DATE: 30/07/2026
 SCALE 1:70,000 @ A4

 MP4 Footprint	 Murphys Creek
 Compensation	 Mare Burn
 Impact	 Maori Hen Creek
Impacted waterways	
 Intermittent	 North Branch Waikouaiti River
 Permanent	 Trimbells Gully tributary
Watercourses	
 Trimbells Gully Creek	

VIRIDIS
 Environmental Consultants

SOURCES
 Google Satellite 2023

DISCLAIMER: This map/plan is not an engineering draft. This map/plan is illustrative only and all information should be independently verified on site before taking any action.

1.4.2 Clydesdale Creek Tributary

The ecological value of the Clydesdale Creek tributary is considered to be low.

A short reach (22 m) of stream was present on the north-western side of the Golden Bar WRS, fed by seepage from the WRS and an area of wetland in the upper reaches of the channel. The channel discharges to the Clydesdale Creek sediment pond which, in turn, discharges to Clydesdale Creek.

Stock have unrestricted access to the channel and the stream and riparian margins are generally heavily pugged. The upper reaches of the channel were difficult to define due to the pugging, though the lower reaches were more defined and appeared to contain a permanent flow of water. Substrates were entirely soft sediment. Riparian vegetation was limited to grazed pasture grass and some tussocks in the upper reaches, which provided minimal shading.

No fish are expected to be present in the channel. The sediment pond is contained by a significant bund, and discharges via a perched culvert. The bund and culvert present a total barrier to fish passage.

1.4.3 Trimbells Gully Tributary

The ecological value of the Trimbells Gully tributary is considered to be low.

The Trimbells Gully tributary originates as an ephemeral channel on the northern side of the existing Coronation North WRS, flowing northwards for a short distance before discharging to Trimbells Gully. The channel transitions from ephemeral to intermittent at a constructed vehicle access track which acts as a bund across the channel. A small culvert/pipe is present here too that conveys overland flow from the upper catchment into the intermittent channel.

The channel is characterised by areas of obvious channel with gravel substrates interspersed by reaches where flow appeared to go subsurface and no clear channel was present. It is essentially identical in character to the intermittent reaches of Trimbells Gully itself.

The intermittent nature, location high in the catchment, and lack of detection of fish in the adjacent Trimbells Gully means it is unlikely fish are present within the stream.

1.5 Compensation Reaches³

1.5.1 Murphys Creek

The ecological value of Murphys Creek is considered to be moderate.

Murphys Creek originates south of the current active mining area, near the southern end of Red Bank Road. It flows through a steep gully system, in a generally south-easterly direction, before discharging to the North Branch Waikouaiti River.

The upper reaches flow through a relatively flat area. The flatness, coupled with pugging from stock has allowed the stream to widen significantly and become more diffuse. A lack of shading in this area has resulted in significant growth of *Glyceria sp.* Within and below the heritage covenant area (administered by the Department of Conservation), present at the downstream extent of the compensation reach, the creek is much more defined. Flow is variable, with deep still pools, and shallow riffles. Substrates are variable and range from areas of exposed bedrock to areas dominated by silt. Macrophyte coverage is

³ The current state of the compensation reaches in Murphys Creek and North Branch Waikouaiti River is shown on Figure 2.

seasonally influenced. Significant growths of exotic water buttercup (*Ranunculus trichophyllus*) are present given appropriate conditions.

Stock have direct access to the majority of the creek. Riparian vegetation is typical of the extensive agricultural landscape and includes mixed tussocks and exotic pasture grasses, with some scrubby vegetation. The vegetation provides very limited shading.

Taieri flathead galaxiid, shortfin eel (*Anguilla australis*; Not Threatened) and longfin eel (At Risk – Declining) are present within the stream, though galaxiids are limited to areas of clear flowing water. Where *Glyceria* clogs the channel only eels are expected to be present, and likely in low numbers.

1.5.2 North Branch Waikouaiti River

The ecological value of the North Branch Waikouaiti River, within land owned by OGNZL, is considered to be low.

The river originates just to the east of the Macraes township. The upper reaches of the North Branch Waikouaiti River are contained within OGNZL land where it flows through a highly modified, straightened channel, before leaving OGNZL land via a culvert under Red Bank Road, and continuing its flow downstream.

The identified compensation reaches are intermittent and generally only contain flow during wetter winter months. The channel is subject to excessive macrophyte growth year-round. Substrates are dominated by soft, fine sediment, beneath the macrophyte growth. Native riparian vegetation is absent, with pasture the only vegetation type along its length. Stock, when present in the adjacent paddocks, have direct access to the channel.

No fish have been recorded within the channel. Annual monitoring immediately upstream of Red Bank Road has not detected any fish since it commenced in 2018. Fish are highly unlikely to be present given the intermittent nature and low-quality habitat. It is possible a small number of tolerant shortfin eels may occasionally be present providing there is surface flow connecting the site to permanent downstream reaches.

a)



b)



Figure 2. Current state of compensation reaches: a) Murphys Creek, b) North Branch Waikouaiti River.

2 STREAM COMPENSATION PLANTING PLAN

2.1 Objectives

Planting a total of 17,450 m² at North Branch Waikouaiti River and 26,765 m² at Murphys Creek, including riparian planting within the compensation reaches, will have a number of beneficial effects on both terrestrial and freshwater ecological values for the reaches and wider environment. The details below describe the approach to successfully revegetate the identified areas in order to enhance ecological values within the reaches and provide the following beneficial outcomes:

- To reinstate and enhance riparian function
- To restore the forest ecosystem potential (CLF4.2⁴), and increase biodiversity of the sites
- To provide shade to the waterways
- To prevent waterway bank erosion
- To provide filtration of runoff, including nutrients, sediment and other stormwater contaminants
- To increase natural habitat and food resources for native fauna
- To improve landscape and amenity values
- To promote the successful establishment and persistence of planted species

2.2 Timing

Compensation works will be implemented in accordance with the approved project staging and consent conditions. At a minimum, stock exclusion fencing and initial weed control will occur before planting, and pioneer planting will occur during the first suitable planting season following reclamation works associated with Trimbells Gully.

2.3 Fencing

A stock exclusion fence will be installed around the perimeter of all enhancement reaches (Figure 3 and Figure 4). At a minimum the fence will be sufficient to exclude all domestic stock animals, as well as feral pigs. Gates providing access to the plantings for maintenance will be installed at appropriate locations. The fence will be located a minimum of 10 m from the edge of the North Branch Waikouaiti River, and 20 m from the edge of Murphys Creek. Where topographic constraints (e.g. steep gully walls, rock outcrops) prevent the fence along Murphys Creek being installed at 20 m from the stream edge, the fence may be located further away, but not within 20 m of the stream edge. If moved further from the stream, the area between the fence and the edge of the planting (20 m from the stream edge) will be managed in one of two ways. Either the additional area will be planted using the same plant list and methodologies as 'upper bank' planting areas, or it will be subject to ongoing periodic maintenance to ensure weeds and exotic pasture grasses do not become a nuisance. Once the upper bank planting has developed a canopy and is generating shade, control of pasture in these areas can be reduced.

⁴ Wildlands 2022. Planting lists for selected forest, wetland, and coastal ecosystems in Otago. Contract Report No. 6408, prepared for Otago Regional Council.



Figure 3. Compensation planting plan - North Branch Waikouaiti River

PROJECT NO. 10023

DRAWN BY: AJC

DATE: 11/06/2023

SCALE **1:7,000** @ A4

--- Stock proof fence

Compensation planting

Stream side

Mid bank

Upper bank

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SOURCES

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Figure 4.
Compensation planting
plan - Murphys Creek

PROJECT NO. 10023
DRAWN BY: AJC
DATE: 11/06/2023
SCALE **1:2,000** @ A4

-  Murphys Creek Heritage Reserve
-  Stock proof fence
- Compensation planting**
 -  Stream side
 -  Mid bank
 -  Upper bank



SOURCES
Google Satellite 2023

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2.4 Instream Enhancement

No physical works within the streams are proposed as part of the enhancement works. Murphys Creek currently follows a natural alignment and therefore no realignment or instream habitat additions are considered necessary as part of the enhancement.

North Branch Waikouaiti River is highly modified, and the compensation reaches are artificially straight. While wider works constraints prevent full realignment of this channel, instream habitat variability will be created through the addition of boulders to the channel. The boulders, placed on the stream edges, extending into the channel, will create small meanders and introduce flow variability and habitat heterogeneity. No earthworks are required to install the boulders. They will be placed in North Branch Waikouaiti River compensation reaches using the following procedure:

- Boulders will be placed before planting commences and ideally before fencing to allow for easy access to the channel by machinery.
- All boulders will be at least 500 mm x 500 mm.
- Boulders will be placed approximately every 10 m to 15 m.
- Boulders will be placed on the channel edges, in contact with water when present.
- Boulders will be placed on alternating sides of the channel, i.e. the left bank, then the right bank, then the left bank.
- No boulder should extend further into the channel than one quarter of the channel's width, unless an engineer is consulted to determine if the boulders will impact conveyance of flood flows. If this occurs, boulders should be placed at the recommendation of the engineers.
- Boulders can be placed in groups, i.e. more than one boulder can be placed at each location.
- All boulders will be placed in the channel during periods of no flow/dry conditions where practicable in order to minimise sediment disturbance.
- Machinery tracking within the riverbed should be avoided as far as practicable.

2.5 Plant Sourcing

The sites are located within the Macraes Ecological District. The plants to be established will as far as practicable be eco-sourced from the Macraes Ecological District to maintain the local genetic lineage of plants and improve the likelihood that plants are adapted to environmental conditions. Where this is not possible, i.e. there are no populations of this species within the district to act as a source, plants will be sourced from adjacent districts.

2.6 Plant Schedule

2.6.1 Overview

Approximate planting areas are shown in Figure 3 and Figure 4. The topography of the planting area on North Branch Waikouaiti is largely flat, while on Murphys Creek it is variable and includes areas of rocky outcrop. Planting has been split into three zones. Stream side planting extends from the stream edge to approximately 2 m. Some variation is provided for Murphys Creek where the wider, shallow gully bottom means the wetted channel is wide. Mid bank planting extends from 2 m (with the exception of the variation on Murphys Creek) out to 5 m for North Branch Waikouaiti River and 10 m for Murphys

Creek. Upper bank planting extends beyond this. Planting schedules for each zone within the North Branch Waikouaiti River and Murphys Creek enhancement reaches are provided in Sections 2.6.2 and 2.6.3, respectively.

Plants have been selected based on the relevant potential ecosystem types for each area and based on guidance within Otago Regional Council's riparian planting guide for east Otago⁵ and the planting lists for CLF4.2 vegetation type as per Wildlands 2022⁴. Where exact number of plants of species of plants are not able to be sourced, they may be substituted for an appropriate similar species. Any substitutions will be undertaken following consultation with the planting contractor and/or project aquatic ecologist.

To account for normal die off and/or failure to thrive of plants prior to and following planting, 10% more plants of each species have been added to the total number of plants required. The 10% extra provides a buffer and limits the impact of needing to reorder seedlings which could take more than one growing season to be available for replanting.

2.6.2 North Branch Waikouaiti River enhancement reaches

Planting schedules for streamside zones are provided for North Branch Waikouaiti River compensation reaches A and B in Table 2 and Table 3, mid bank zones in Table 4 and Table 5, and upper bank zones in Table 6 and Table 7.

Table 2. North Branch Waikouaiti River compensation reach A streamside planting (0-2 m, 1,802 m²).

Species name	Common name	Spacing (m)	Abundance (%)	Number of plants
<i>Carex virgata</i>	Sedge	1	25	496
<i>Carex secta</i>	Pūrei	1	25	496
<i>Carex sinclairii</i>	Sinclair's sedge	1	30	595
<i>Chionochloa rubra</i>	Red tussock	1	20	396
Total + 10% to account for die off				1,982

Table 3. North Branch Waikouaiti River compensation reach B streamside planting (0-2 m, 1,684 m²).

Species name	Common name	Spacing (m)	Abundance (%)	Number of plants
<i>Carex virgata</i>	Sedge	1	25	463
<i>Carex secta</i>	Pūrei	1	25	463
<i>Carex sinclairii</i>	Sinclair's sedge	1	30	556
<i>Chionochloa rubra</i>	Red tussock	1	20	370
Total + 10% to account for die off				1,852

⁵ Otago Regional Council, Riparian planting guide, www.orc-riparian-plant-guide_east_digital.pdf

Table 4. North Branch Waikouaiti River compensation reach A mid bank planting (2-5 m, 2,719 m²).

Species name	Common name	Spacing (m)	Abundance (%)	Number of plants
Pioneer planting				
<i>Leptospermum scoparium</i>	Mānuka	1.4	8	122
<i>Coprosma propinqua</i>	Mingimingi	1.4	4	61
<i>Cordyline australis</i>	Cabbage tree	1.4	6	92
<i>Phormium tenax</i>	Harakeke	1.4	5	76
<i>Veronica salicifolia</i>	Koromiko	1.4	6	92
<i>Coprosma crassifolia</i>	Mingimingi	1.4	4	61
<i>Coprosma linariifolia</i>	Mingimingi	1.4	4	61
<i>Pseudopanax crassifolius</i>	Lancewood	1.4	4	61
<i>Myrsine divaricata</i>	Weeping matipo	1.4	5	76
<i>Discaria toumatou</i>	Matagouri	1.4	6	92
<i>Hoheria angustifolia</i>	Houhere	1.4	6	92
<i>Carpodetus serratus</i>	Marble leaf	1.4	5	76
Enrichment planting				
<i>Olearia hectorii</i>	Hector's Tree Daisy	5	8	10
<i>Olearia odorata</i>	Scented Tree Daisy	5	8	10
<i>Corokia cotoneaster</i>	Korokio	5	6	7
<i>Podocarpus laetus</i>	Thin barked tōtara	5	7	8
<i>Sophora microphylla</i>	Kowhai	5	8	10
Total + 10% to account for die off				1,006

Table 5. North Branch Waikouaiti River compensation reach B mid bank planting (2-5 m, 2,597 m²)

Species name	Common name	Spacing (m)	Abundance (%)	Number of plants
Pioneer planting				
<i>Leptospermum scoparium</i>	Mānuka	1.4	8	117
<i>Coprosma propinqua</i>	Mingimingi	1.4	4	58
<i>Cordyline australis</i>	Cabbage tree	1.4	6	87
<i>Phormium tenax</i>	Harakeke	1.4	5	73
<i>Veronica salicifolia</i>	Koromiko	1.4	6	87
<i>Coprosma crassifolia</i>	Mingimingi	1.4	4	58
<i>Coprosma linariifolia</i>	Mingimingi	1.4	4	58
<i>Pseudopanax crassifolius</i>	Lancewood	1.4	4	58
<i>Myrsine divaricata</i>	Weeping matipo	1.4	5	73
<i>Discaria toumatou</i>	Matagouri	1.4	6	87

Species name	Common name	Spacing (m)	Abundance (%)	Number of plants
Pioneer planting				
<i>Hoheria angustifolia</i>	Houhere	1.4	6	87
<i>Carpodetus serratus</i>	Marble leaf	1.4	5	73
Enrichment planting				
<i>Olearia hectorii</i>	Hector's Tree Daisy	5	8	9
<i>Olearia odorata</i>	Scented Tree Daisy	5	8	9
<i>Corokia cotoneaster</i>	Korokio	5	6	7
<i>Podocarpus laetus</i>	Thin barked tōtara	5	7	8
<i>Sophora microphylla</i>	Kowhai	5	8	9
Total + 10% to account for die off				961

Table 6. North Branch Waikouaiti River compensation reach A upper bank planting (5-10 m, 4,465 m²)

Species name	Common name	Spacing (m)	Abundance (%)	Number of plants
Pioneer planting				
<i>Kunzea ericoides</i>	Kānuka	2	6	74
<i>Coprosma propinqua</i>	Mingimingi	1.4	6	150
<i>Cordyline australis</i>	Cabbage tree	1.4	5	125
<i>Coprosma crassifolia</i>	Mingimingi	1.4	5	125
<i>Coprosma linariifolia</i>	Mingimingi	1.4	5	125
<i>Pseudopanax crassifolius</i>	Lancewood	1.4	5	125
<i>Myrsine divaricata</i>	Weeping matipo	1.4	6	150
<i>Pittosporum eugenioides</i>	Lemonwood	1.4	6	150
<i>Hoheria angustifolia</i>	Houhere	1.4	6	150
<i>Carpodetus serratus</i>	Marble leaf	1.4	6	150
<i>Plagianthus regius</i>	Ribbonwood	2	6	74
Enrichment planting				
<i>Olearia hectorii</i>	Hector's Tree Daisy	5	7	14
<i>Olearia odorata</i>	Scented Tree Daisy	5	7	14
<i>Corokia cotoneaster</i>	Korokio	5	8	16
<i>Podocarpus laetus</i>	Thin barked tōtara	5	8	16
<i>Sophora microphylla</i>	Kowhai	5	8	16
Total + 10% to account for die off				1,475

Table 7. North Branch Waikouaiti River compensation reach B upper bank planting (5-10 m, 4,183 m²)

Species name	Common name	Spacing (m)	Abundance (%)	Number of plants
Pioneer planting				
<i>Kunzea ericoides</i>	Kānuka	2	6	69
<i>Coprosma propinqua</i>	Mingimingi	1.4	6	141
<i>Cordyline australis</i>	Cabbage tree	1.4	5	117
<i>Coprosma crassifolia</i>	Mingimingi	1.4	5	117
<i>Coprosma linariifolia</i>	Mingimingi	1.4	5	117
<i>Pseudopanax crassifolius</i>	Lancewood	1.4	5	117
<i>Myrsine divaricata</i>	Weeping matipo	1.4	6	141
<i>Pittosporum eugenioides</i>	Lemonwood	1.4	6	141
<i>Hoheria angustifolia</i>	Houhere	1.4	6	141
<i>Carpodetus serratus</i>	Marble leaf	1.4	6	141
<i>Plagianthus regius</i>	Ribbonwood	2	6	69
Enrichment planting				
<i>Olearia hectorii</i>	Hector's Tree Daisy	5	7	13
<i>Olearia odorata</i>	Scented Tree Daisy	5	7	13
<i>Corokia cotoneaster</i>	Korokio	5	8	15
<i>Podocarpus laetus</i>	Thin barked tōtara	5	8	15
<i>Sophora microphylla</i>	Kowhai	5	8	15
Total + 10% to account for die off				1,382

2.6.3 Murphys Creek enhancement reach

Planting schedules for streamside, mid bank and upper bank zones at the Murphys Creek compensation reach are provided in Table 8, Table 9 and Table 10.

Table 8. Murphys Creek compensation reach streamside planting (0-2 m, 4,210 m²).

Species name	Common name	Spacing (m)	Abundance (%)	Number of plants
<i>Carex virgata</i>	Sedge	1	25	1,158
<i>Carex secta</i>	Pūrei	1	25	1,158
<i>Carex sinclairii</i>	Sinclair's sedge	1	30	1,389
<i>Chionochloa rubra</i>	Red tussock	1	20	926
Total + 10% to account for die off				4,631

Table 9. Murphys Creek compensation reach mid bank planting (2-10 m, 8,930 m²)

Species name	Common name	Spacing (m)	Abundance (%)	Number of plants
Pioneer planting				
<i>Leptospermum scoparium</i>	Mānuka	1.4	6	301
<i>Coprosma propinqua</i>	Mingimingi	1.4	4	200
<i>Cordyline australis</i>	Cabbage tree	1.4	6	301
<i>Phormium tenax</i>	Harakeke	1.4	5	251
<i>Chionochloa rubra</i>	Red tussock	1.4	8	401
<i>Veronica salicifolia</i>	Koromiko	1.4	6	301
<i>Coprosma crassifolia</i>	Mingimingi	1.4	4	200
<i>Coprosma linariifolia</i>	Mingimingi	1.4	4	200
<i>Pseudopanax crassifolius</i>	Lancewood	1.4	4	200
<i>Myrsine divaricata</i>	Weeping matipo	1.4	5	251
<i>Discaria toumatou</i>	Matagouri	1.4	6	301
<i>Hoheria angustifolia</i>	Houhere	1.4	6	301
<i>Carpodetus serratus</i>	Marble leaf	1.4	5	251
Enrichment planting				
<i>Olearia hectorii</i>	Hector's Tree Daisy	5	5	20
<i>Olearia odorata</i>	Scented Tree Daisy	5	8	31
<i>Corokia cotoneaster</i>	Korokio	5	5	20
<i>Podocarpus laetus</i>	Thin barked tōtara	5	5	20
<i>Sophora microphylla</i>	Kowhai	5	8	31
Total + 10% to account for die off				3,580

Table 10. Murphys Creek compensation reach upper bank planting (10-20 m, 13,625 m²)

Species name	Common name	Spacing (m)	Abundance (%)	Number of plants
Pioneer planting				
<i>Kunzea ericoides</i>	Kānuka	2	6	225
<i>Coprosma propinqua</i>	Mingimingi	1.4	6	459
<i>Cordyline australis</i>	Cabbage tree	1.4	5	382
<i>Coprosma crassifolia</i>	Mingimingi	1.4	5	382
<i>Coprosma linariifolia</i>	Mingimingi	1.4	5	382
<i>Pseudopanax crassifolius</i>	Lancewood	1.4	5	382
<i>Myrsine divaricata</i>	Weeping matipo	1.4	6	459
<i>Pittosporum eugenoides</i>	Lemonwood	1.4	6	459
<i>Hoheria angustifolia</i>	Houhere	1.4	6	459

Species name	Common name	Spacing (m)	Abundance (%)	Number of plants
Pioneer planting				
<i>Carpodetus serratus</i>	Marble leaf	1.4	6	459
<i>Plagianthus regius</i>	Ribbonwood	2	6	225
Enrichment planting				
<i>Olearia hectorii</i>	Hector's Tree Daisy	5	7	42
<i>Olearia odorata</i>	Scented Tree Daisy	5	7	42
<i>Corokia cotoneaster</i>	Korokio	5	8	48
<i>Podocarpus laetus</i>	Thin barked tōtara	5	8	48
<i>Sophora microphylla</i>	Kowhai	5	8	48
Total + 10% to account for die off				4,501

2.7 Planting Guide

The planting will be undertaken in general accordance with the following guidelines:

- Exclusion fencing will be erected around the perimeter of the enhancement reaches. The fencing will, at a minimum, exclude all stock as well as feral pigs.
- Weed and grass removal will occur in the summer immediately prior to planting, employing the methods set out in Section 3. Spraying will not occur in any locations where spray may enter water.
- Planting is to be undertaken during the planting season (September-November and late March-April) to establish root systems during the seasons which typically have higher rainfall and lower plant moisture stress.
- Any grasses/annual weeds that have established after initial weed removal has occurred will be skimmed off the surface using a spade to reduce the risk of smothering the new plant.
- Prior to planting, plants will be thoroughly watered and allowed to drain, out of direct sunlight. They will then be laid out according to the spacing recommended, in a natural pattern (i.e., not in straight rows).
- A hole twice the size of the root ball or plant container will be dug for each plant. A slow-release fertiliser may be added to the dug hole and be mixed well into the soil to avoid root burn.
- Plants will be carefully removed from the pot/bag, retaining as much of the soil as possible. The roots may need to be loosened/untangled at the base of the root mass prior to planting to stimulate growth and in-soil establishment.
- Soil will then be gradually filled around the plant, firming the soil well. The base of the main stem will be located slightly below the soil.
- To protect new plantings from pest browse (e.g. from rabbits), it is recommended that biodegradable plant guards (e.g., EmGuard™; Fibre Guard) are installed until plants become well established. Where plants are planted immediately adjacent to flowing water the person/s undertaking the planting will make a judgement call as to whether plant guards are appropriate. If the plant is likely to be inundated during high flows, a plant guard may not be appropriate.

- Pioneer plants as per Table 2 to Table 10 will be planted in the first planting season. Enrichment planting will be undertaken following the same steps as above one or two planting seasons following completion of pioneer planting. Depending on the season, two or more years may be required to allow sufficient establishment of pioneer plants. The decision regarding whether enrichment planting will occur one or two seasons following pioneer planting will be made by the person responsible for managing planting and plant maintenance after considering how much establishment of the pioneer plants has occurred. Enrichment planting may also be delayed if seedlings require additional time to reach a size suitable for planting out. It is preferable to delay enrichment planting than to plant too small plants, or plants in areas where sufficient shelter has not yet established as these factors will influence survival of the enrichment species.

2.8 Ongoing Maintenance

2.8.1 Inspections and activities

Ongoing maintenance is required until five years have passed following enrichment planting. Maintenance will ensure successful establishment of the native plantings. Plant maintenance may include the following:

- Plant releasing – by hand or via herbicide spraying to prevent grasses/annual weeds from smothering young plantings.
- Plant replacement – infill planting (during planting season only) of the same species assemblage where more than 10% of plant loss has occurred, or if concentrated plant loss has occurred, leaving a gap of more than 10 m wide.
- Pest plant control where these may be invading the planting area.
- Fertilisation if plants are not performing well.
- Watering if any areas are particularly dry.
- Assessing for signs of pest damage (e.g. rabbits, insects) and implementing control as required.

Table 11 recommends the frequency of plant maintenance checks during the months specified. Maintenance checks will be required more frequently during the first 2-3 years when young plants are most susceptible to competition and abiotic influences. Maintenance frequency can then be reduced as 90% canopy cover is achieved within the relevant planting area or zone. Maintenance should continue until five full years of maintenance have occurred following completion of enrichment planting, or until 90% canopy cover is achieved, whichever is longest.

Table 11. Recommended maintenance schedule for native plantings

Year	Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Fence installation	Before any planting occurs											
	Initial weed control		✓	✓					✓	✓			
	Pioneer planting			✓	✓					✓	✓	✓	
	Pioneer plant maintenance							✓		✓		✓	
2	Enrichment planting weed control*		✓	✓					✓	✓			
	Enrichment planting*			✓	✓					✓	✓	✓	
	Pioneer plant maintenance	✓		✓		✓		✓			✓		
3	Plant maintenance	✓			✓			✓			✓		
4	Plant maintenance			✓						✓			
5	Plant maintenance			✓						✓			
6	Plant maintenance #			✓						✓			

Notes: * Enrichment planting to occur in year two only if pioneer planting has established sufficiently. If not, enrichment planting will be delayed; # If enrichment planting is delayed, additional years of plant maintenance will be required until five years have been completed post completion of enrichment planting.

2.8.2 Maintenance and weed control records

Records will be kept of each maintenance period, including but not limited to:

- Number or proportion of plants that have died and/or are not thriving including the species and location of these plants.
- Number of plants that are replaced, including the general location of these and what species the replacement plants are.
- Whether plant browse or damage as a result of pest animals is present, including location of damaged plants.
- Condition of plant guards including if any are missing or have been replaced.
- Condition of the stock proof fence.
- Any additions of water or fertiliser.
- Application of herbicides including location, type and quantity.
- General comments regarding condition and establishment of planting.

3 PEST MANAGEMENT

3.1 Overview

The management of weeds and pest animals is recommended within the compensation sites to prevent pest plants and other exotic weeds from outcompeting native plantings. Weeds and pest animals are present in areas around and adjacent to the compensation reaches.

Weed control will occur over the entire area of all enhancement reaches, for a period of five years following the completion of planting in the compensation reaches.

3.2 Pest Control

Pest control methods are outlined in the Pest Control and Elimination Plan⁶. All pest control within the enhancement reaches will occur in accordance with the recommendations in this plan.

3.3 Weed Control Methods

3.3.1 Weed species

Table 12 outlines all pest plants/weeds likely to be present within the site or may invade the site over time. It provides best practice methodologies for removal of each species listed. Any plants identified in the site at a later date but not listed in Table 12 will be managed according to best practice methods outlined by Otago Regional Council or other relevant guidance.

3.3.2 General weed control guidance

Manual (by hand) or mechanical removal of pest plants is recommended where possible. If chemical control is required, control methods such as 'cut and paste' or 'drill and fill' using gels are preferred over foliar spraying to minimise chemical usage, particularly around waterways.

3.3.3 Herbicide use

Chemical controls will be applied to terrestrial areas only, in accordance with the Agrichemical Users' Code of Practice, NZS 8409 2004: "The Management of Agrichemicals" (or any update or replacement of that Code) and will be undertaken in a way that avoids damage to new plantings or established native vegetation. The manufacturer's instructions will be followed carefully, along with any recommended safety precautions to protect the user and environment. General guidance notes for using herbicides:

- Care will be taken when using herbicide around/under valuable native trees.
- Avoid spraying on windy days to minimise potential non-target damage.
- A marker dye (e.g., Envirodye) will be mixed in when using herbicide spraying or gels to avoid spray drift and to show where control has been undertaken.
- No single herbicide will be effective for all species, active ingredients will be considered and chosen carefully.
- Chemical control will only be undertaken by those holding the relevant certificates, where required.
- If chemical controls are used within areas prior to planting, planting efforts may need to be delayed, ensuring the new plantings are not adversely affected by residual chemicals in the soil.

⁶ Alliance Ecology 2026. Pest Control and Elimination Plan. Macraes Phase 4 Project (MP4). Prepared for OceanaGold (New Zealand) Limited by Alliance Ecology Limited. August 2026.

Table 12. Recommended weed removal methodologies for weeds observed in the area.

Common name	Species name	Weed removal method
Blackberry	<i>Rubus fruticosus</i> agg.	• Dig out plant manually including root system and dispose at refuse/green waste station or burn in an appropriate location on site, or • Cut stump and paste freshly cut base of stems with metsulfuron gel.
Pampas	<i>Cortaderia jubata</i> and <i>C. selloana</i>	• Dig or pull out plant manually including root system and dispose at refuse/green waste station or burn in an appropriate location on site, or • Foliar spray with 200 mL glyphosate green per 10 L of water.
Broom	<i>Cytisus scoparius</i> and <i>Teline monspessulana</i>	• Cut plant and treat stump using herbicide gel containing either metsulfuron, triclopyr or glyphosate, or • Foliar spray when the plant is actively growing using suitable herbicides such as Tordon or Grazon
Gorse	<i>Ulex europaeus</i>	• Cut plant and treat stump using herbicide gel containing either metsulfuron, triclopyr or glyphosate, or • Foliar spray when the plant is actively growing using suitable herbicides such as Tordon or Grazon
Nodding thistle	<i>Carduus nutans</i>	• Foliar spray with MCPB or similar, or • Grubbing to remove at least 5 cm of the root to prevent regrowth
Old man's beard	<i>Clematis vitalba</i>	• Cut the stem/trunk and apply metsulfuron gel (10 g/L strength) or picloram gel (43 g/L strength) to cover the entire stump, or • Foliar spray with glyphosate at a rate of 20 mL/L or to cover entire plant, or other suitable herbicides
Wilding conifers	<i>Pinus spp.</i>	• Pull or dig out small plants, or • Fell at ground level ensuring no branches or green needles below cut, or • Stump swab with metsulfuron-methyl 1 g/L or a product containing 100 g picloram+300 g triclopyr/L (50 mL/L) or triclopyr 600 EC (50 mL/L) or picloram gel, or • Foliar spray with glyphosate (100 mL/10 L)

3.3.4 Timing and follow-up control

Initial weed control efforts will be completed in the summer immediately prior to native revegetation planting being undertaken.

Follow-up weed control is generally recommended every **three** months until successful eradication of each species has occurred, and then less frequently as required to maintain little-to-no weed presence. Preferably, weed control will be undertaken prior to, or during, active growth periods, or prior to each species producing seeds.

3.3.5 Documentation of control efforts

It is recommended that regular documentation of physical and chemical weed control efforts is kept. Maintaining up to date records of agrichemical usage is a legal requirement for the management of agrichemicals under the Hazardous Substances and New Organisms (HSNO) Act and specified in the Code of Practice (NZS 8409:2004). Records should be included in an annual report.

Weed control records will include the following details:

- Date and location of weed control/herbicide application
- Weed species targeted, and any new species that have established in the area
- Herbicide type and quantity used, and control method (e.g., cut and paste, foliar spraying)
- Details of any follow up work anticipated

3.3.6 Ecotoxic herbicides to avoid

The following chemical controls will be avoided as far as practicable due to their potential effects when entering surface water such as the adjacent streams and downstream receiving environments. Toxins in the following chemicals could bioaccumulate and cause significant damage to the environment:

- | | |
|---------------------------------------|--------------------------------------|
| • 2, 4-D ester (e.g., broadleaf kill) | • Fluroxypyr |
| • Clopyralid | • Saflufenacil |
| • Asulam | • Haloxyfop-p-methyl (e.g., Gallant) |

Chemicals such as Tordon brush killer and metsulfuron should be avoided if practicable. If their use is required, extra care should be taken to ensure no chemicals, including spray drift, enter surface waters.

3.3.7 Safe weed disposal

To prevent pest plants from spreading, reinvading, or dispersing to nearby sites, it is essential that seeds, seed pods, seed heads and roots are disposed of safely. Once pest plant material has been controlled/removed, green waste will be removed off-site and disposed of at an approved disposal site, such as a community weed waste bin, an approved refuse transfer site or burned on site at an appropriate burning facility/location. If burning is utilised, care should be taken to ensure all green waste is burned and no green vegetation is blown from the area by the wind, hung up on infrastructure or vehicles, or left unburned for any period of time.

For on-site disposal of soft (non-woody), seed-free weed materials, a composting weed bin or bag may be used which aims to break down waste within 6 to 12 months.

4 REPORTING

An annual report will be prepared providing information on the activities and maintenance that have occurred during the preceding 12 months. The report will be incorporated into the Annual Ecological Report (AER) and provided to DC/DCC on 31 July each year. In addition to reporting on the points listed in section 2.8.2 and 3.3.5, the report should include records of planting that has been completed, as per the pioneer and enrichment planting schedules.

If more than 10% of the same species is lost for two or more consecutive monitoring years, or if concentrated plant loss leaving a gap of more than 10 m occurs in the same location for two or more consecutive monitoring years, the monitoring report will provide recommendations for addressing the losses. Options may include, but not be limited to, planting of a different species, addition of water, and/or addition of fertiliser.

The inspections and annual report will be prepared by OGNZL or a suitably qualified contractor engaged by OGNZL.

Reporting will continue on an annual basis until the completion of the plant maintenance period (five years following completion of enrichment planting, or when 90% canopy coverage is achieved, whichever is longer). If enhancement planting does not occur in year two, five years of maintenance is still required following completion of enrichment planting. At a minimum, the AER will contain six annual reports on planting progress. Maintenance, including reporting will continue until 90% canopy cover is achieved.

This plan is considered to be a 'live' document and may be updated at any time to improve ecological outcomes.

5 SUMMARY OF ACTIVITIES

Table 13 provides a summary of the activities associated with achieving stream compensation associated with MP4 works. It provides an indicative timeline, noting maintenance will continue until 90% canopy cover has been achieved.

Table 13. Summary of stream compensation activities, including indicative timeline.

Year	Activity	Comments
0	Trimbells Gully reclamation works commence	
0	Installation of rocks in North Branch Waikouaiti River	
0	Installation of stock proof fencing around compensation reaches	To be completed prior to commencement of pioneer planting
1	Pioneer planting and maintenance	To occur during the first planting season following reclamation works in Trimbells Gully
2	Pioneer planting maintenance; Enrichment planting if appropriate	Enrichment planting to only occur if pioneer planting sufficiently established, and enrichment plants are large enough to be planted out
3	Plant maintenance; Enrichment planting if delayed from year 2	
4	Plant maintenance; Enrichment planting if delayed from year 2	
5	Plant maintenance	
6	Plant maintenance	If 90 % canopy closure has been achieved, maintenance can cease following completion of year 6. If not achieved, maintenance will continue until 90% canopy cover achieved

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Appendix F

Principles of Biodiversity Compensation

Table F1 provides a summary of compensation ratios and the corresponding lengths and areas necessary to compensate for stream losses.

Table F1. Summary of stream impact and proposed compensation quantities.

Metric	Trimbell's Gully permanent	Clydesdale Creek tributary permanent	Trimbell's Gully intermittent	Trimbell's Gully tributary intermittent
Stream length lost (m)	180	22	0*	80
Stream area lost (m ²)	126	15	0*	38
Compensation stream	Murphys Creek (20 m riparian planting)		North Branch Waikouaiti River (10 m riparian planting)	
Compensation ratio	3.5 : 1		2.4 : 1	
Compensation reach area (m ²)	436	54	0	92
Compensation reach length (m)	539	66	0	31 (increased to 80) +
Final compensation reach length (m)	640		950	

Notes: * North Branch Waikouaiti River is wider than the impact reach of Trimbell's Gully. + Compensation reaches cannot be smaller than the impact reach, therefore minimum length is rounded to the same length as the impact reach.

The proposed compensation planting will result in a net gain of ecological value. The planted compensation reaches are larger than what is required by compensation ratios and will increase ecological values and functions of the compensation reaches.

Table F2 provides commentary on the proposed stream compensation in relation to the principles for biodiversity compensation contained within Appendix 4 of the National Policy Statement for Indigenous Biodiversity.

Table F2. Offsetting principles

	Principle	Commentary
1	Adherence to effects management hierarchy	The effects management hierarchy has been applied. Works to reclaim the streams cannot be avoided and due to topographical constraints, the full length of the streams cannot be reinstated. Effects will be minimised through reinstatement of as much stream length as possible around the toe of the Trimbell's Gully WRS, erosion and sediment controls, and fish salvage. Residual effects are addressed through stream compensation by enhancing nearby streams.
2	When biodiversity compensation is not appropriate	Compensating low value streams, within an area already impacted by historical mining and agricultural practices is not uncommon. The impacted streams are not irreplaceable due to their degraded nature, very small size and location at or near the top of the catchment. The stream reaches to be reclaimed do not contain fish, exhibit low macroinvertebrate indices, are directly grazed by stock, influenced by current and historic mining, lack any complex and diverse riparian vegetation, and contain limited structure and

	Principle	Commentary
		hydrological function. Riparian enhancement is a widely practiced and commonly accepted means for increasing the ecological value and function of stream.
3	Scale of biodiversity compensation	Greater than three times the length of stream lost will be enhanced through compensation plantings. There will be a clear net gain in riparian values and stream function, particularly on North Branch Waikouaiti River which currently exists in a highly degraded state. Riparian vegetation on the reaches to be lost is mostly common tussock and exotic pasture species. Vegetation in the compensation reaches will contain a diverse mix of native species suitable for the landscape. The riparian vegetation will provide shade, habitat, filtration and organic matter inputs. Stock exclusion and pest control will benefit both the riparian planting and streams themselves.
4	Additionality	The compensation reaches are not required by another mechanism. They are in proximity to the MEEA and other areas of terrestrial enhancements providing linkages for terrestrial fauna. The North Branch Waikouaiti River compensation reach ties into wider plans to reinstate the headwaters of river, directly upstream from the compensation reach.
5	Leakage	The compensation sites are currently grazed pasture. No biodiversity values will be lost by undertaking stream enhancement at these locations.
6	Long-term outcomes	Once established, the riparian enhancement areas will be protected through covenants or similar. OGLNZ currently manage various covenants throughout their land associated with ecological protections and enhancement.
7	Landscape context	The compensation reaches are located in proximity to terrestrial enhancement areas, the MEEA, historic reserves (which exclude stock grazing), and the North Branch Waikouaiti River compensation reach ties into wider plans to reinstate the headwaters of river, directly upstream from the compensation reach. Murphys Creek compensation reach, when considered with the proposed MEEA and current historic reserve, will result in over 4.3 km of Murphys Creek having stock excluded or restricted.
8	Time lags	No significant time lags are expected. At a minimum, stock exclusion fencing and initial weed control will occur before planting, and pioneer planting will occur during the first suitable planting season following reclamation works associated with Trimbells Gully. Minor time lags associated with plant establishment will occur, however, given the current nature of the compensation reaches, no losses of ecological values will occur during this period.
9	Trading up	Over three times the length of stream compensation required by the compensation ratios will be enhanced through the project. This is a significant gain, particularly for North Branch Waikouaiti River. No habitat for At Risk of Threatened fish will be lost as fish are not present in the impact reaches. Conversely, enhancement of Murphys Creek will result in gains for habitat for At Risk Taieri flathead galaxiid which are known to be present in the stream.

	Principle	Commentary
10	Financial contributions	Financial contributions are not included in the stream compensation package.
11	Science and mātauranga Māori	The compensation reach will be greater than three times the area compensation ratios require. Demonstrated gains in ecological values are evidenced the use of riparian planting and stock exclusion to enhance ecological values throughout New Zealand. Enhancing North Branch Waikouaiti River ties in to wider catchment management as preferred by local iwi.
12	Tangata whenua and stakeholder participation	Iwi have been engaged with throughout the process. OGLNZ regularly consult with iwi as part of their normal management practices.
13	Transparency	It is anticipated consent conditions will require reporting on vegetation establishment and function. The application material will be publicly available via the Fast Track process. The EclA has expressed the loss and proposed compensation in a transparent manner. Compensation on North Branch Waikouaiti River will be visible from Red Bank Road. Murphys Creek is located on private land.

Appendix G

Fish Management Plan

Macraes MP4 Project

Draft Fish Management Plan

Prepared for: OceanaGold (New Zealand) Limited

August 2026



DOCUMENT CONTROL AND REVISION HISTORY

Document title	Macraes MP4 Project
	Draft Fish Management Plan
Prepared for	OceanaGold (New Zealand) Limited
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Date	20 August 2026
Document number	10023-018-1

Version	Issue date	Document number
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Draft B	16 July 2026	10023-018-B
Draft C	30 July 2026	10023-018-C
Final 1	20 August 2026	10023-018-1

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Reference: Viridis 2026. Macraes MP4 Project Draft Fish Management Plan. A report prepared for OceanaGold (New Zealand) Limited by Viridis Limited. August 2026.

Cover photo: Taieri flathead galaxias captured in Mare Burn, March 2026.

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1 INTRODUCTION

1.1 Purpose of this Fish Management Plan

This Fish Management Plan (FMP) has been prepared to manage the actual and potential adverse effects of the proposed works on freshwater fish and fish habitat associated with the Macraes Phase Four Project (MP4), part of the Macraes Operation located at Golden Point Road, Macraes Flat, East Otago ('the site').

The FMP outlines procedures for:

- The installation and maintenance of fish exclusion devices.
- Fish salvage and relocation.
- Fish handling and transportation.
- Relocation site selection.
- Biosecurity measures.
- Monitoring and reporting requirements.
- Adaptive management during works.

The purpose of these measures is to minimise adverse effects on freshwater fish during instream works and stream reclamation in Trimbells Gully associated with:

- The expansion of the Trimbells Gully waste rock stack (WRS)
- Works within Clydesdale Creek tributary associated with the expansion of the Golden Bar waste rock stack (WRS)
- Culvert installation for the predator-proof fence around the Murphys Ecological Enhancement Area (MEEA).

This FMP gives effect to the following consent conditions [to be completed once consents are granted. Cross-reference the conditions and the sections of the FMP which give effect to them].

This draft FMP accompanies the Fast-track Approvals Act 2024 (FTAA) application and will be finalised following confirmation of the detailed construction methodology and any relevant consent conditions.

1.2 Project Background

OceanaGold (New Zealand) Limited (OGNZL) has applied for resource consent through FTAA to develop MP4 of the Macraes Operation. The Macraes Operation was commissioned in 1990 and is the largest gold mine in New Zealand. MP4 seeks to extend the life of the mine until at least 2039.

Works associated with MP4 that may affect instream habitat and fish habitat include:

- Reclamation of 180 m of permanent stream in Trimbells Gully to accommodate expanded WRS footprint.
- Realignment of 670 m of intermittent stream in Trimbells Gully to accommodate expanded WRS footprint into a new channel 745 m in length, resulting in the loss of 105 m lineal stream length when combined with the reclaimed permanent reach above.
- Reclamation of 22 m of the Clydesdale Creek tributary to accommodate expanded WRS footprint.

- Reclamation of 80 m of Trimbells Gully tributary to accommodate a sediment retention pond.
- Installation of culverts on Murphys Creek associated with the predator proof fence of the MEEA.

As these works will occur within or adjacent to freshwater habitats, there is potential for adverse effects on freshwater fish and aquatic habitat.

This FMP should be read in conjunction with the Assessment of Aquatic Environmental Effects ('AAEE')¹, which assesses the ecological values of the site and the potential effects of the proposed works.

1.3 Site Description

1.3.1 Overview

The site contains various freshwater habitats. For the purposes of this FMP, only the waterways directly impacted by physical works are considered here. These waterways are:

- Trimbells Gully.
- Clydesdale Creek tributary.
- Trimbells Gully tributary.
- Murphys Creek.

The location of the waterways is shown in Figure 1, including how they relate to other waterways in the wider catchments. Note that the size of the waterways in the figure is not to scale; they have been increased in size for visibility.

Full descriptions of the impacted waterways are provided in the AAEE, however, for completeness, waterway descriptions are summarised below.

1.3.2 Trimbells Gully

Trimbells Gully originates to the east of the current Trimbells Gully WRS, draining from the north-western face of Highlay Hill. It flows in a generally north-western direction, around the base of the WRS before joining with Maori Hen Creek and discharging to Mare Burn. It ultimately sits within the Taieri River catchment.

A sediment pond at the base of Trimbells WRS (Figure 2a) presents a complete barrier to fish passage. The discharge point from the pond is a perched culvert. Downstream of the sediment pond, the stream was classified as permanent. Upstream of the pond it was classified as intermittent.

The permanent reach downstream of the sediment pond runs through a moderately incised channel stable channel with no areas of scour or erosion (Figure 2b). Stream substrates were heavily dominated by fine sediment overlying harder material. Base flow is generally low-moderate, though flows can increase rapidly given sufficient rainfall. The small, relatively steep catchment means flows can be flashy. Riparian tussocks and exotic grasses provided moderate levels of shade.

The intermittent channel was narrower and shallower than the permanent reach, with portions where water flowed just below ground level. Substrates were more variable, including gravels and small cobbles alongside fine sediment. Riparian tussocks and exotic grasses provided moderate shade.

¹ Viridis 2026. Macraes MP4 Project. Assessment of Aquatic Environmental Effects. A report prepared for OceanaGold (New Zealand) Limited by Viridis Limited. August 2026. 10023-011-1.

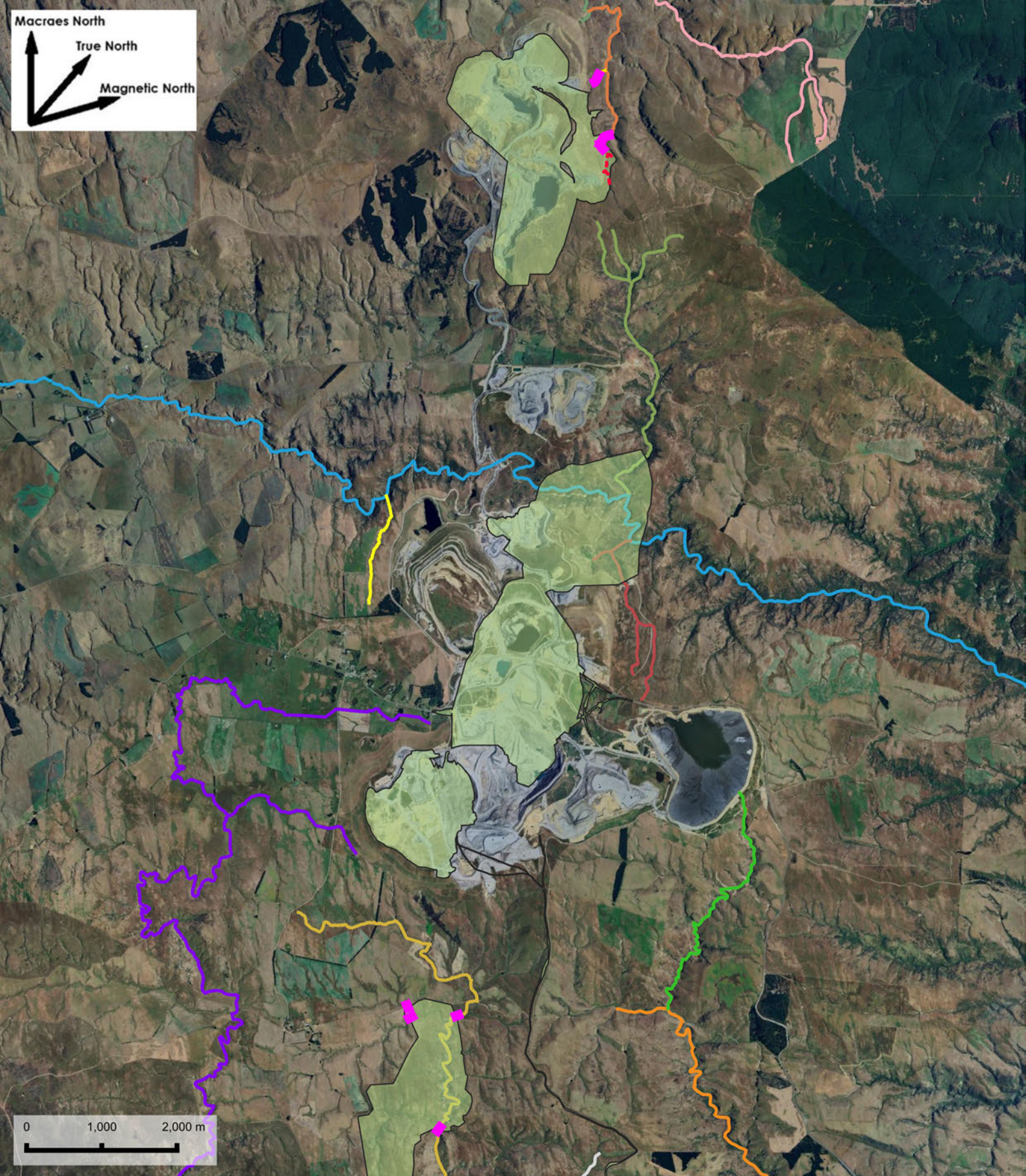


Figure 1. MP4 waterways including impacted reaches

PROJECT NO. 10023
 DRAWN BY: AJC
 DATE: 30/07/2026
 SCALE 1:65,000@ A4

 MP4 footprint	 McCormicks Creek
 Impacted waterways subject to FMP	 Mare Burn
Watercourses	
 Unnamed Tributary	 Maori Hen Creek
 Clydesdale Creek	 Highlay Creek
 Trimbells Gully Creek	 Deepdell Creek
 Tipperary Creek	 North Branch Waikouaiti River
 North Gully Creek	 Trimbells Gully tributary
 Murphys Creek	



SOURCES
 Google Satellite 2023

DISCLAIMER: This map/plan is not an engineering draft. This map/plan is illustrative only and all information should be independently verified on site before taking any action.

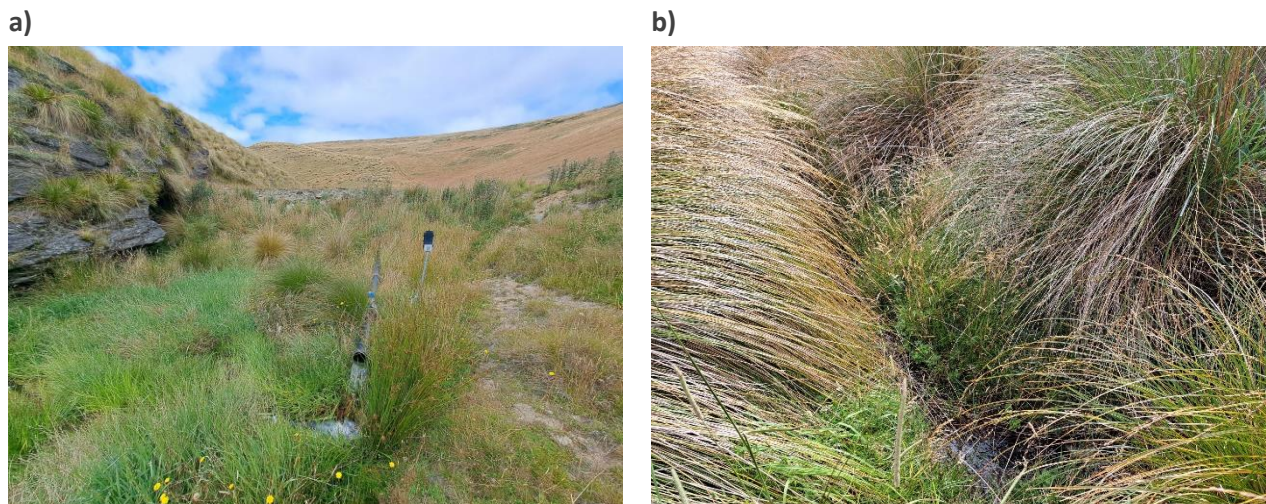


Figure 2. a) The sediment pond presenting a complete barrier to fish passage and b) habitat in the permanent reach of Trimbells Gully.

1.3.3 Clydesdale Creek Tributary

The Clydesdale Creek tributary is on the north-western side of the Golden Bar WRS, fed by seepage from the WRS and an area of wetland in the upper reaches of the channel (Figure 3a). The channel discharges to the Clydesdale Creek sediment pond which, in turn, discharges to Clydesdale Creek (Figure 3b). The sediment pond presents a complete barrier to fish passage due to the elevated bund holding the pond and perched discharge culvert. The channel was heavily pugged by stock and lacked any significant riparian vegetation. It presented low-quality instream habitat for aquatic fauna.



Figure 3. Clydesdale Creek tributary a) looking upstream to the WRS and wetland area and b) the bund holding the sediment pond.

The ecological value of the Trimbells Gully tributary was considered to be low.

The Trimbells Gully tributary originates as an ephemeral channel on the northern side of the existing Coronation North WRS, flowing northwards for a short distance before discharging to Trimbells Gully. The channel transitions from ephemeral to intermittent at a constructed vehicle access track which acts as a bund across the channel. A small culvert/pipe is present here too that conveys overland flow from the upper catchment into the intermittent channel.

The channel is characterised by areas of obvious channel with gravel substrates interspersed by reaches where flow appeared to go subsurface and no clear channel was present. It is essentially identical in character to the intermittent reaches of Trimbells Gully itself.

The intermittent nature, location high in the catchment, and lack of detection of fish in the adjacent Trimbells Gully means it is unlikely fish are present within the stream.

1.3.4 Murphys Creek

Murphys Creek originates south of the current active mining area, near the southern end of Red Bank Road. It flows through a steep gully system, in a generally south-easterly direction, before discharging to the North Branch Waikouaiti River.

The length of the creek is variable, ranging from wide, flat sections where a channel is not obvious, to narrow, moderately swift flows through small areas of gorge. Within the MEEA the creek is generally channelised with substrates consisting of a combination of soft sediment, gravels and small cobbles, and bedrock (Figure 4). Macrophyte coverage is variable and influenced by seasonal patterns. During warmer months, excessive growths of macrophytes can be present. Riparian vegetation includes a mixture of exotic and native scrub as well as common pasture species and agricultural weeds. Stock currently have access to the stream.



Figure 4. Murphys Creek as it flows through the MEEA.

1.4 Fish Values and Species Potentially Present

An instream eDNA survey completed in Trimbells Gully in March 2026 did not detect any fish species. Surveys of Mare Burn, the receiving waterway, undertaken as part of the Macraes Operation annual monitoring programme, have detected the presence of Taieri flathead galaxias (*Galaxias depressiceps*; At Risk – Declining) and freshwater crayfish / kōura (*Paraneophrops zealandicus*; At Risk – Declining).

The presence of the complete fish barriers in the form of the sediment ponds at the downstream extent of the Clydesdale Creek tributary and the intermittent reach of Trimbells Gully means no fish are expected to be present upstream of these barriers. This is further supported by the lack of detection of fish in Trimbells Gully through eDNA sampling.

However, it is possible that eels may be intermittently present in the permanent reach of Trimbells Gully and the intermittent reach of the Trimbells Gully tributary (when water is present) despite not being detected in eDNA or in the receiving environment during annual monitoring. They are known to be present in the wider area. While eels do have climbing ability, the habitat upstream of the sediment ponds in the Clydesdale Creek tributary and the intermittent reach of Trimbells Gully is shallow, narrow and intermittent, and ultimately of very low quality for eels. Therefore, it is considered highly unlikely eels will be present upstream of either sediment pond.

An eDNA sample suite collected from Murphys Creek in March 2026 detected Taieri flathead galaxias, shortfin eel (*Anguilla australis*; Not Threatened) and longfin eel (At Risk – Declining). Eels are expected to be present in relatively low numbers. Despite three sites on Murphys Creek undergoing annual fish surveys, no eels have ever been caught.

Species known to be or potentially present within the permanent reach of Trimbells Gully and Murphys Creek are summarised in Table 1. No fish are expected to be present in the intermittent reach of Trimbells Gully or the Clydesdale Creek tributary due to the presence of existing fish barriers.

Table 1. Summary of fish present in the effected waterways.

Fish	Trimbells Gully permanent	Trimbells Gully intermittent	Clydesdale Creek	Trimbells Gully tributary intermittent	Murphys Creek
Taieri flathead galaxias	Potentially	Not expected	Not expected	Potentially	Present
Shortfin eel	Not expected	Not expected	Not expected	Not expected	Present
Longfin eel	Not expected	Not expected	Not expected	Not expected	Present
Freshwater crayfish / koura	Potentially	Not expected	Not expected	Potentially	Present

1.5 Objectives of Fish Salvage and Relocation

The objectives of fish salvage and relocation are to:

- Minimise injury and mortality to freshwater fish during works.
- Prevent fish entering active work areas.
- Safely capture and relocate fish from affected habitats.
- Relocate fish to suitable habitat within the same catchment.
- Minimise stress during capture, handling, transport, and release.
- Ensure works are undertaken in accordance with relevant permits and industry best practice.
- Maintain appropriate biosecurity controls.

1.6 Roles and Responsibilities

The roles and responsibilities associated with implementation of this FMP are outlined in Table 2.

Table 2. Roles and responsibilities

Role	Responsibility
Supervising freshwater ecologist	Oversee implementation of the FMP; undertake fish salvage and relocation; determine salvage effort requirements; supervise fish handling and release; implement adaptive management measures where necessary; record fish capture data; and prepare post-salvage reporting.
Contractor / consent holder	Install and maintain fish exclusion devices as directed by the freshwater ecologist; provide safe access to work areas; comply with directions provided by the freshwater ecologist; and ensure works are undertaken in accordance with this FMP.
Project manager / consent holder	Ensure relevant permits and approvals are in place prior to works commencing; coordinate timing of salvage works; ensure resource consent conditions are complied with; and provide required reporting to Otago Regional Council where applicable.

2 METHODOLOGY

2.1 Overview

The methodology outlined below describes the procedures that will be implemented to minimise adverse effects on freshwater fish during works within the permanent reach of Trimbells Gully and within Murphys Creek. Fish salvage is only required on the permanent reach of Trimbells Gully, the intermittent Trimbells Gully tributary, only if water is present, and where culverts will be located on Murphys Creek. Fish salvage is not necessary in the intermittent reach of Trimbells Gully and the Clydesdale Creek tributary due to the presence of existing fish barriers.

2.2 Timing

Fish salvage and relocation will be undertaken immediately prior (within two to three days) to the commencement of any stream reclamation in the permanent reach of Trimbells Gully, or installation of culverts on Murphys Creek. Ongoing maintenance of any temporary fish barriers by the contractors will be undertaken until all stream works are complete within the area. Fish salvage should preferentially occur during the drier summer months when weather is generally more settled. No salvage should occur if moderate or higher rainfall is forecast for the salvage period.

2.3 Exclusion Devices

Prior to commencing works in the permanent reach of Trimbells Gully and Murphys Creek, barrier(s) will be installed to prevent fish moving up and downstream through the area of works. Only a downstream exclusion device is required for Trimbells Gully as the sediment pond already acts as an upstream barrier. Barriers are required for all culverts on Murphys Creek and should be located just beyond the up and downstream extents of works associated with each culvert.

Exclusion devices will be constructed from steel waratahs and shade cloth, or similar as shown in Figure 5. Shade cloth, or a similar material, allows water to continue to flow downstream while preventing fish passage. The exclusion screen will extend at least one metre past the wetted width of the aquatic habitat and will be embedded into the dry ground or the banks (Figure 5).

Waratahs will be securely hammered into the ground and evenly spaced across the stream to support the shade cloth. Where extra support is necessary, i.e. if the flow is very swift, wire will be threaded horizontally through the waratahs. Shade cloth will be fastened to the waratahs, and wire supports (where applicable) using zip ties or a similar mechanism. The shade cloth will extend approximately 0.5 m above the water level. Along the stream bed the shade cloth will either be embedded and pinned or securely weighted down, or an apron of the shade cloth will be formed and pinned. This creates a pocket, preventing fish from passing under the barrier.

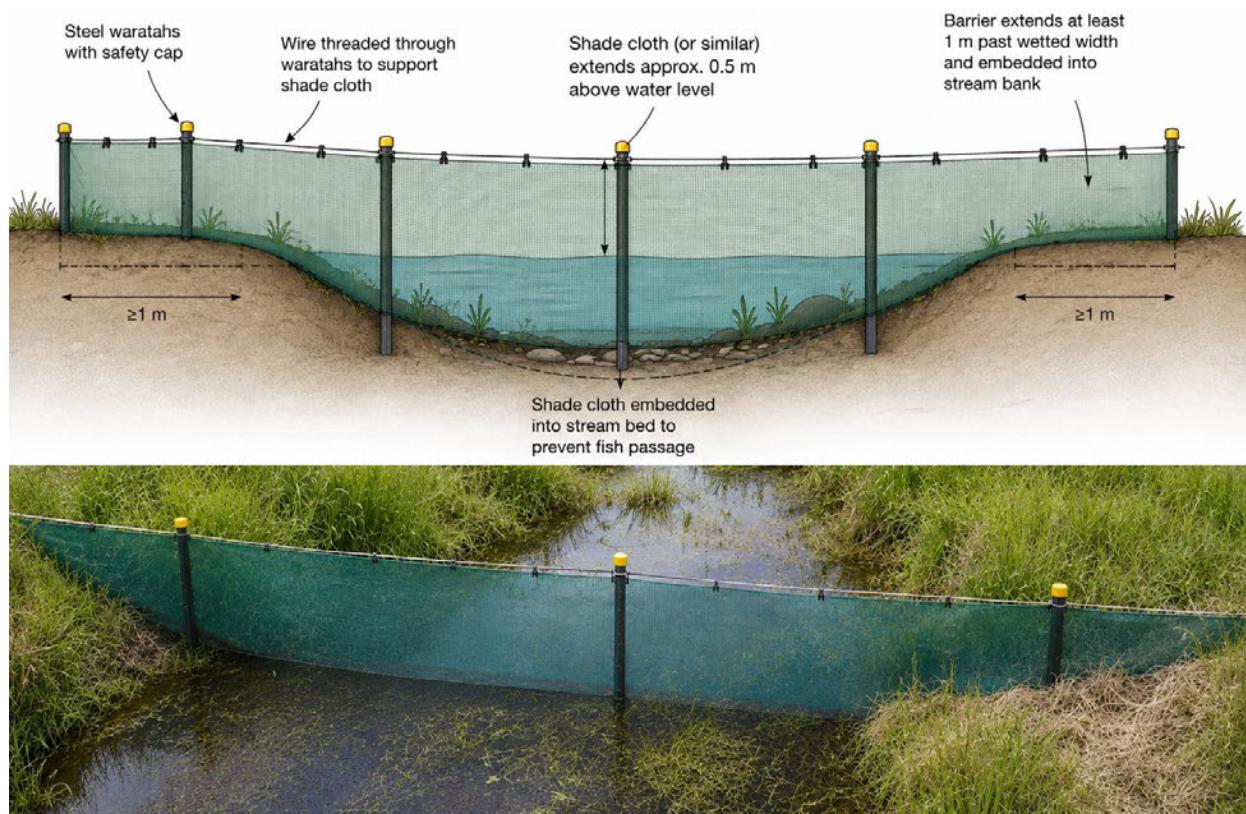


Figure 5. Example of a fish barrier installed in a stream to prevent passage into or out of an area.

2.4 Fish Capture

A combination of electric fishing and netting/trapping is proposed for both waterways where water is present. Where water is absent but saturated mud/sediment remains, this should be searched for eels.

The New Zealand Freshwater Fish Sampling Protocols (Joy *et al.* 2013) will be followed unless specified within this plan.

Electric fishing will be undertaken in the works reach (i.e. between the exclusion devices) prior to setting any nets. Several passes may be undertaken depending on fish capture rate. Fishing should occur from upstream to downstream which helps to shepherd any fish not captured by electric fishing downstream. Following electric fishing and providing water levels allow, baited Gee's minnow traps and fyke nets will be placed at intervals over the stream works areas and left in place overnight. Fine meshed fykes with a separator grill will be used if depth allows. All nets and traps will be set with an airspace to provide trapped fish access to atmospheric oxygen and will be set in general accordance with Joy *et al.* (2013). Floats will be placed in the fyke nets if required to ensure an airspace is available. The traps will be checked the following morning, prior to 9 am, with any captured fish recovered.

Trapping densities will be set, at minimum, at least one fyke net and two Gee's minnow traps over 25 m, in accordance with Joy *et al.* (2013). However, the densities of Gee's minnow traps may be increased if deemed appropriate by the supervising freshwater ecologist. Where water depth prevents fykes being set, the densities of Gee's minnow traps will be increased and hand-netting of any aquatic habitat (e.g. pools, overhanging vegetation, woody debris) will be undertaken. Hand netting will occur moving up the impact reach to sweep for any fish present within the channel which may not be able to move into the traps due to the shallow water depth. If water depths are not suitable for Gee's minnow traps, hand netting will still occur.

If more than 100 native fish are caught during a single fishing effort within the target area, fishing will continue until numbers are depleted to the satisfaction of the supervising freshwater ecologist (using an 80% removal rate as a target, based on the Hayne's (1949) regression method or other suitable method). A single fishing effort is considered to be one night of trapping or one pass of electric fishing. Electric fishing will be undertaken again following clearance of the nets.

Final teamwork's methodologies are not yet available. The final stream works methodology for Murphys Creek will be confirmed prior to works commencing. The FMP will be updated, if required, to align with the confirmed isolation, diversion, dewatering and culvert installation methodology. It is expected works to install the culverts in Murphys Creek will be required to occur 'in the dry'. At this point, bunding or sheet piling or similar will be installed to isolate the works area. Complete dewatering of the works area will commence provided capture rates have declined to the appropriate thresholds. All pumps used for dewatering will be appropriately screened to prevent fish being entrained in the pump. Screens will have gaps no larger than 3 mm. Native fish, such as eels (*Anguilla* spp.), will burrow into silt substrates when they are disturbed or as water levels decrease. As a result of this, during the dewatering stage, the supervising freshwater ecologist will be present to search through drained habitat, rocks/debris, remaining pools or thick sediment for any remaining fish. Once dewatering is completed, an excavator will be used to carefully scrape out any thick layers of soft sediment ('muck out'), if necessary. A toothed bucket will not be used on the excavator. In our experience it is more effective to use a non-toothed bucket. Provided that a minimum depth of approximately 200 mm of sediment is scraped, any eels buried within the mud will be scooped up unharmed. Toothed buckets are inefficient for muck out' as the teeth mean a shallower depth is scraped.

Dewatering is not expected to occur on Trimbells Gully. Given the lack of fish detected within the waterway, once the fish salvage methodology has been completed, the stream will be considered to be 'fished out'.

2.5 Fish Handling

Fish handling will be in accordance with Section 3.9 of the New Zealand Freshwater Fish Sampling Protocols (Joy *et al.* 2013) and the Viridis Ministry for Primary Industries (MPI) Special Permit (875) and Native Fish Transfer Authorisation 420 (NFT 420).

All fish captured in traps/nets or via electric fishing will be immediately transferred to water-filled, lidded containers of an appropriate volume for the number of fish captured. Multiple containers will be used if necessary. Containers will be stored in the shade. Fish will be stored in the containers for no more than one hour. If storage for longer is required, water will be changed at least once per hour and/or a battery powered air pump will be placed in each container to ensure oxygen levels are sufficient. A water conditioner, such as API Stress Coat, may be added to the water to reduce fish stress. Water conditioner will be added as per manufacturer instructions.

If any individual captured fish shows signs of stress (loss of righting response, exuding excessive mucus, gulping air, and/or mouth gaping) the water will be changed to provide more oxygen, or the fish will be moved to the relocation site immediately.

Fish will be visually examined for general health (visual skin lesions or heavy fungal burdens) and if considered unhealthy by the supervising freshwater ecologist, they will be humanely euthanised in accordance with condition 14 of the NFT 420.

Large eels (> 500 mm), if present, will be contained individually to avoid injury to other smaller captured fish. Kōura (*Paranephrops sp.*), if present, will also be separated into their own containers.

Captured fish will be securely transported to the relocation site and gently transferred into the stream as soon as practicable after being captured, but within four hours. If large numbers of fish are captured, they will be distributed across multiple release points in the general area to avoid short term overstocking and predation risks.

2.6 Relocation Site

2.6.1 Trimbells Gully and tributary

Fish captured within Trimbells Gully and the Trimbells Gully tributary will be released to one of two locations (Figure 6). The ultimate decision regarding which release site will be used will be at the discretion of the ecologist completing the fish salvage and will depend on sediment levels in Trimbells Gully downstream of the works sites.

As shown in Figure 6, relocation area 1 is located on Trimbells Gully, downstream of the works areas. It could be anywhere from approximately 100 m downstream of the works area, down to its confluence with Māori Hen Creek. The use of this site will depend on sediment levels in the stream. If visible sedimentation, elevated turbidity, poor flow conditions or other conditions likely to compromise fish welfare is present, as determined by the supervising freshwater ecologist, relocation area 2 will be used.

Relocation area 2 is located on Mare Burn. Mare Burn is the receiving waterway for Trimbells Gully and any fish present in Trimbells Gully would be able to access Mare Burn. The relocation site is located near where Trimbells Gully discharges to Mare Burn. Habitat here is generally similar to the impacted Trimbells Gully, though the wetted stream is larger and deeper and therefore capable of supporting any released fish as well as resident fish.

2.6.2 Murphys Creek

All fish captured in Murphys Creek will be returned to Murphys Creek. Two release sites are proposed (Figure 7). The first is located immediately upstream of the upstream most culvert. The second is located in the MEEA footprint, however use of this area will depend on access being available at the time.

2.7 Biosecurity

All equipment will be thoroughly cleaned and dried prior to use. Equipment includes, but is not limited to electric fishing machine, waders, fyke nets, Gee's minnow traps, stop nets, dip nets and transfer buckets.

Any pest fish caught will be humanely euthanised and all euthanised pest fish will be disposed of in a biosecure manner to land, in accordance with condition 20 of MPI Special Permit 875 and 16(d) of NFT 420.

2.8 Adaptive Management

Due to the high level of intrinsic variability in any fish recovery and relocation, this plan may be slightly modified by the supervising freshwater ecologist to ensure fish are recovered in a safe and professional manner, as well as in accordance with the New Zealand Freshwater Fish Sampling Protocols (Joy et al. 2013).

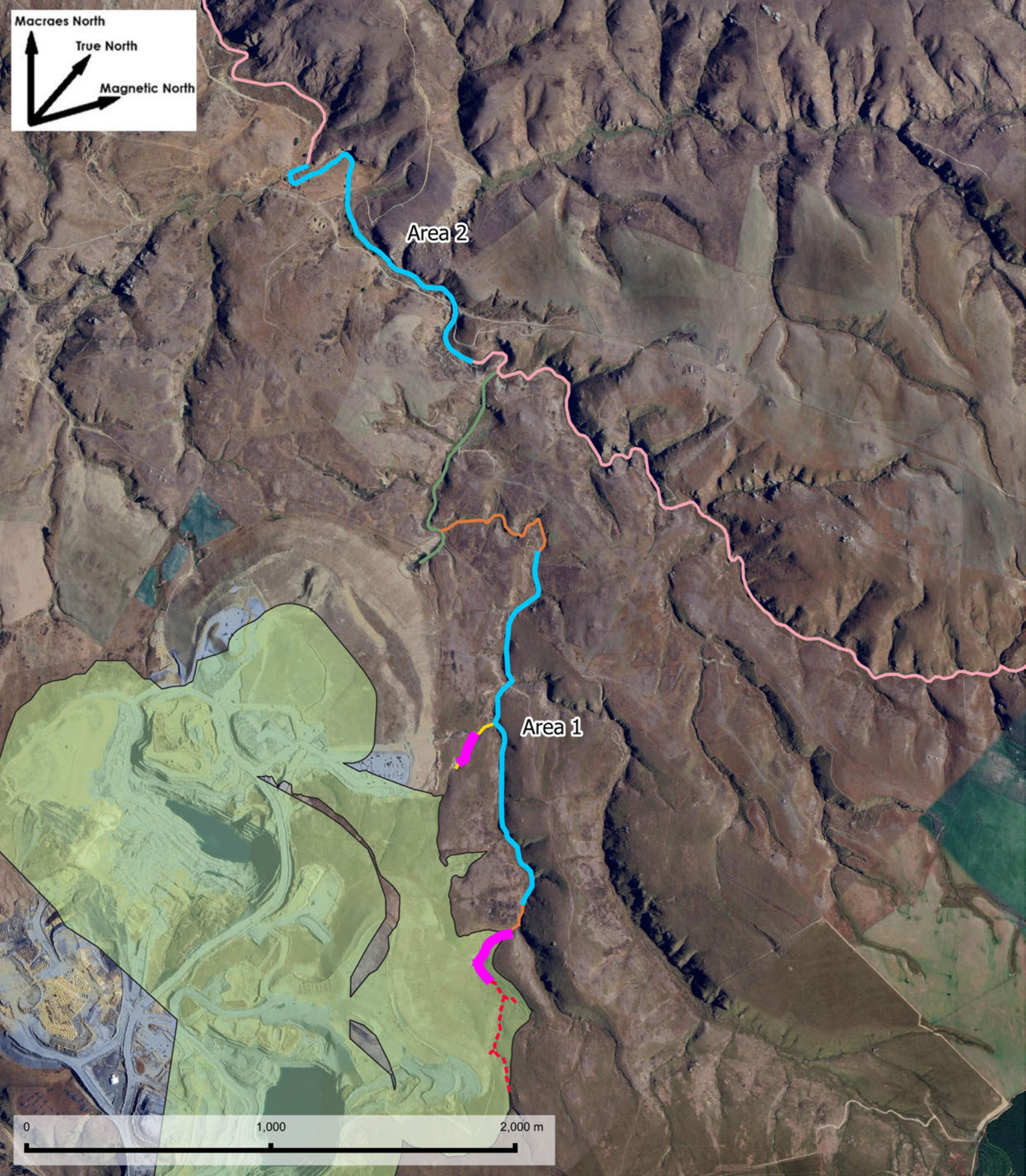


Figure 6. MP4 fish relocation sites - Trimbells Gully works

PROJECT NO. 10023
 DRAWN BY: AJC
 DATE: 30/07/2026
 SCALE 1:20,000@ A4

- | | |
|---|---|
| MP4 footprint | Mare Burn |
| Impacted waterways subject to FMP | Maori Hen Creek |
| Fish release locations | Trimbells Gully tributary |
| Watercourses | |
| Trimbells Gully Creek | |



SOURCES
 Google Satellite 2023

DISCLAIMER: This map/plan is not an engineering draft. This map/plan is illustrative only and all information should be independently verified on site before taking any action.

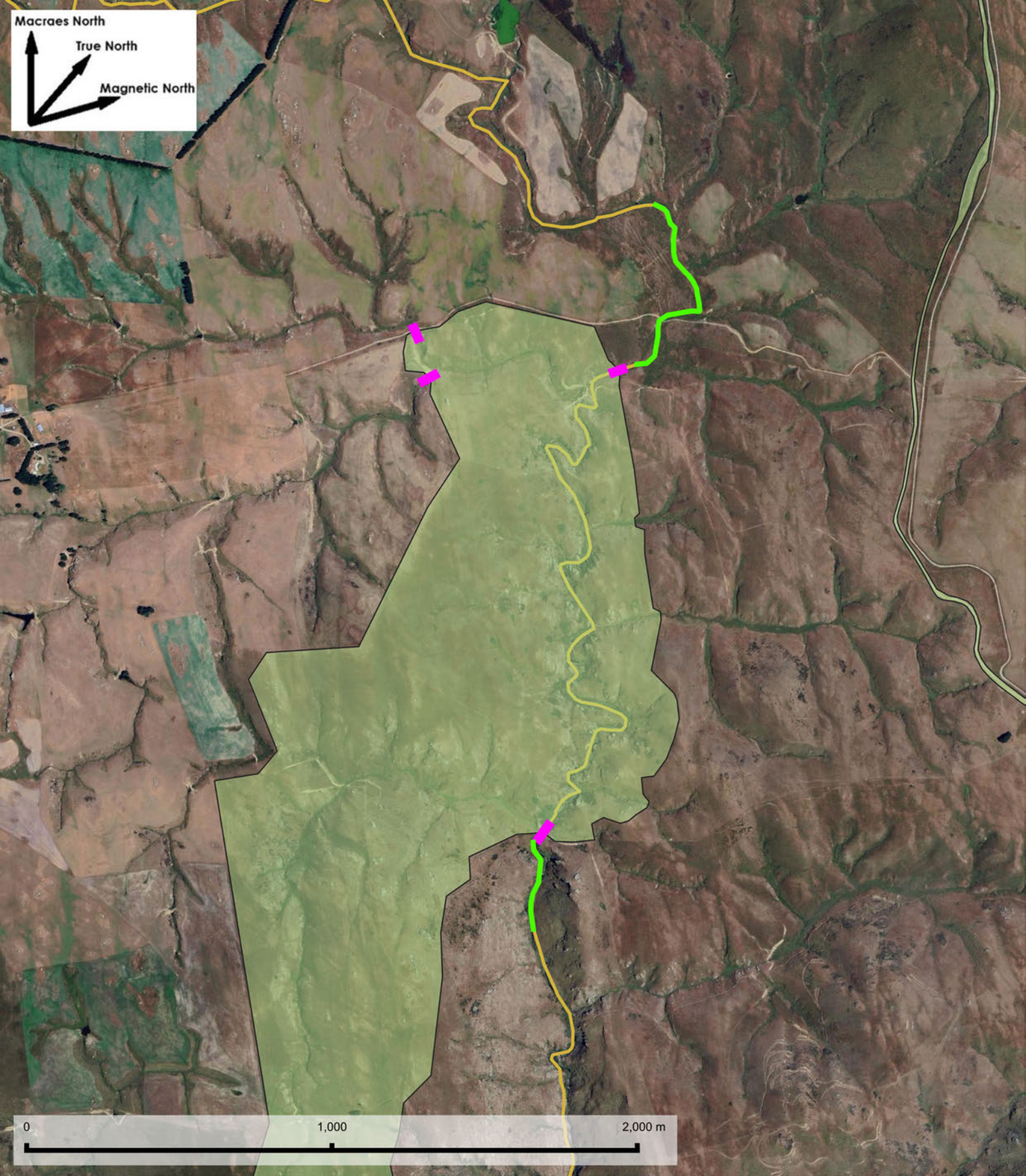


Figure 7. MP4 Fish release locations - MEEA works

PROJECT NO. 10023
 DRAWN BY: AJC
 DATE: 15/07/2023
 SCALE 1:16,000 @ A4

MP4 footprint
 Impacted waterways subject to FMP
 Fish release locations
 Watercourses
 Murphys Creek



SOURCES
 Google Satellite 2023

DISCLAIMER: This map/plan is not an engineering draft. This map/plan is illustrative only and all information should be independently verified on site before taking any action.

2.9 Contingency Measures

Unexpected conditions may arise during fish salvage, relocation, dewatering, or excavation works. The following contingency measures will be implemented where necessary to minimise adverse effects on freshwater fish and aquatic habitat.

2.9.1 Rainfall events

Fish salvage and relocation will not be undertaken during periods of moderate or heavy rainfall, or where such conditions are forecast during the proposed salvage period. Elevated flows and reduced water clarity can reduce salvage effectiveness and increase risks to both fish and personnel.

If significant rainfall occurs during salvage or instream works, activities will cease until flows and water quality have stabilised to a level considered suitable by the supervising freshwater ecologist. Following any significant rainfall event, fish exclusion devices and isolated work areas will be inspected to confirm they remain functional and secure.

2.9.2 Fish mortality

If unexpected fish mortality occurs during salvage, handling, dewatering, or excavation works, the supervising freshwater ecologist will investigate the likely cause and determine whether modifications to salvage methods, handling procedures, work practices, or fish holding arrangements are required.

Any significant fish mortality event, including mortality of Threatened or At Risk species, will be recorded and reported to the relevant regulatory authority where required by resource consent conditions or permit requirements.

Higher-than-expected Capture of At Risk Species or Unexpected Native Species if Threatened or At Risk fish species are captured in greater numbers than anticipated, or an unexpected native fish species is captured, the supervising ecologist will review salvage effort, handling procedures and release arrangements before works continue in the affected area.

Where necessary, additional salvage effort, increased trap densities, or revised handling and relocation procedures may be implemented. Works within the affected area may be temporarily delayed if considered necessary by the supervising freshwater ecologist to ensure appropriate management of the species.

2.9.3 Equipment failure

In the event of equipment failure during salvage or dewatering activities, works will cease until the equipment is repaired or replaced, where failure may compromise fish salvage effectiveness, fish safety, or environmental protection measures.

Backup equipment, including spare nets, buckets, aeration devices, and dewatering pumps (where practicable), will be available during salvage operations to minimise delays and risks to fish.

3 REPORTING

Following completion of fish salvage and relocation works, a short report will be prepared detailing the fish captured (species and number of fish) during the salvage, as well as details on the relocation site. Otago Regional Council shall be provided with a copy of the report, subject to timeframes provided in the consent conditions, on completion of all fish relocation works. Fish capture data can be made available following the completion of stages if works are to be staged to avoid long periods of time between fish salvage and the delivery of the report.

Fish records will also be sent to NIWA to be included in the New Zealand Freshwater Fish Database.

Reporting will be in accordance with any resource consent conditions.

4 PERMITS

Viridis holds an MPI Special Permit (875) and NFT 420 that allows Viridis Limited, and their agents, representatives, and employees to take and relocate aquatic life to a suitable habitat where this is necessary or required to mitigate adverse effects of habitat modification on the aquatic life.

As the capture and relocation sites are not within a conservation area and because any fish captured will be relocated within the same catchment, no other permits are considered necessary.

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