Rastus Burn Wastewater Freshwater Ecological Impact Assessment

NZSki Limited

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Prepared by e3Scientific for NZSki Limited

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Executive Summary

NZSki Ltd is planning upgrades to the wastewater treatment system at the Remarkables Ski Area to accommodate increased visitor numbers and the associated rise in domestic wastewater volumes to 204 m^3/day. The proposal involves directing additional wastewater into a wastewater treatment plant located near the Remarkables Base and existing dispersal field, which discharges to land within the Rastus Burn catchment.

e3Scientific Ltd was engaged by NZSki to assess the freshwater ecological values of the nearby Rastus Burn and evaluate the potential effects of increased wastewater volumes being discharged to land within the catchment. The Rastus Burn is a small, steep alpine stream draining from Lake Alta through a high-elevation tussock and shrubland catchment before flowing to the Kawarau River. The stream is characterised by cold, clear, well-oxygenated water, stable rocky substrates, and naturally low nutrient concentrations.

Ecological surveys and previous monitoring show that the stream supports an algal community typical of alpine environments, with low biomass and dominance by diatoms and filamentous red algae. Macroinvertebrate communities are of "good to excellent" quality and dominated by pollution-sensitive taxa adapted to cool, oligotrophic conditions. The reach near the ski field is naturally fishless due to downstream waterfalls that prevent fish passage.

The wastewater treatment plant will be upgraded to accommodate the increased wastewater volumes, although nutrient loads are expected to remain stable due to improved treatment performance.

The Rastus Burn is assessed as having **Moderate** overall ecological value, reflecting high representativeness, moderate ecological context and rarity values, and naturally low diversity. The key potential effect of increased wastewater discharge is nutrient enrichment, which could alter algal and macroinvertebrate communities if nutrient levels rise. However, the proposals treatment system is to be designed to maintain the existing freshwater ecological communities in their current state by meeting proposed performance criteria. Therefore, the increase in wastewater discharge volume with a lower nutrient

concentration (stable nutrient load) results in a Low magnitude of effect, resulting in a **Low** level of ecological effect.

Monitoring is proposed for dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP) from 1 November to 31 May, the period when temperature and light conditions allow periphyton growth. A trigger-and-response system is used so that any exceedance of ecological nutrient thresholds can prompt further sampling and, if needed, management action. The assessment identifies DIN >150 mg/m³ or DRP >6 mg/m³ (Matheson et al. 2012) as appropriate triggers for this site. If these are exceeded, additional sampling helps determine whether concentrations reflect ambient conditions or a short-term spike or laboratory anomaly. A restrictive periphyton limit of 50 mg/m^2 of Chl *a* is proposed to maintain benthic biodiversity and provide rapid confirmation of whether any exceedance is likely to be ecologically meaningful, enabling fast management responses.

Macroinvertebrates respond more slowly to nutrient enrichment because community changes occur only after sustained increases in periphyton biomass. If macroinvertebrate shifts are detected, a full review of the wastewater treatment system and onsite practices is required. Remedial actions to address nutrient sources and periphyton growth must then be provided to the Otago Regional Council within 20 working days of receiving the macroinvertebrate results.

The management approach provides strong ecological safeguards by ensuring a commitment to achieve the proposed wastewater performance criteria, controlled discharge volumes, and timing the discharge of the majority of the nutrient load during winter and spring to avoid the more sensitive autumn low-flow periods. Land-based infiltration and robust operational, maintenance and risk-management planning further protect Rastus Burn water quality. A comprehensive monitoring programme across periphyton, macroinvertebrates, and downstream wetlands supports early detection of change helping to avoid and mitigate adverse effects and protect overall stream health.

Monitoring is proposed to confirm the potential effects on the freshwater ecological values present. The recommended monitoring actions are summarised below:

- Monthly water quality monitoring of dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP).
- If measured dissolved inorganic nitrogen (DIN) exceeds 150 mg/m^3 and/or dissolved reactive phosphorus (DRP) exceeds 6 mg/m^3 this will trigger further actions such as further nutrient sampling, periphyton sampling a review of treatment system and proposed actions to reduce nutrient levels.
- Every second year, monitoring of periphyton composition and biomass within the Rastus Burn upstream and downstream of the infiltration dispersal fields is recommended during Spring (November/December) and autumn (March/April). The periphyton biomass should be maintained below 50 mg/m^2 of Chl *a*.
- If measured Chl *a* exceeds 50 mg/m^2 at any downstream monitoring site this will trigger an assessment of whether the discharge of treated wastewater is responsible for the exceedance and propose mitigation measures to reduce algal biomass if required.
- Every second year, monitoring of macroinvertebrate taxa densities, community composition and EPT, MCI, SQMCI metrics within the Rastus Burn upstream and downstream of the infiltration dispersal field is recommended and is to be compared to previous surveys.
- If measured EPT, MCI or SQMCI metrics exceed the upstream control score at any of the downstream monitoring sites for two of the three metrics this will trigger an assessment of whether the discharge of treated wastewater is responsible for the change and propose mitigation measures to reduce impacts on benthic ecology.
- Wetland delineation of area downgradient and within 100 m of the land dispersal field.
- Monitoring of any delineated wetlands downgradient (within 100 m) of the land dispersal field for wetland hydrological regime and vegetation community to ensure wetlands remain healthy every two years.

1 Introduction

1.1 Overview

NZSki are anticipating an increase in customers and therefore an increase in the volume of wastewater requiring treatment and discharge to land at the Remarkables Ski field area. NZSki intend to pump the wastewater into the existing Remarkables wastewater management system for treatment and discharge to the existing dispersal field in the Rastus Burn catchment (Figure 1).

The project proposes wastewater treatment upgrades to achieve performance criteria. e3Scientific Limited (e3s) was commissioned by NZSki to complete a Freshwater Ecological Assessment (FEcIA) of the increased wastewater discharge on the Rastus Burn stream habitat and freshwater ecology. This report provides the methodology, results, ecological value and impact assessment of the FEcIA where ecological assessments have been undertaken. Fieldwork associated with this FEcIA was completed on 27th February, 2026.

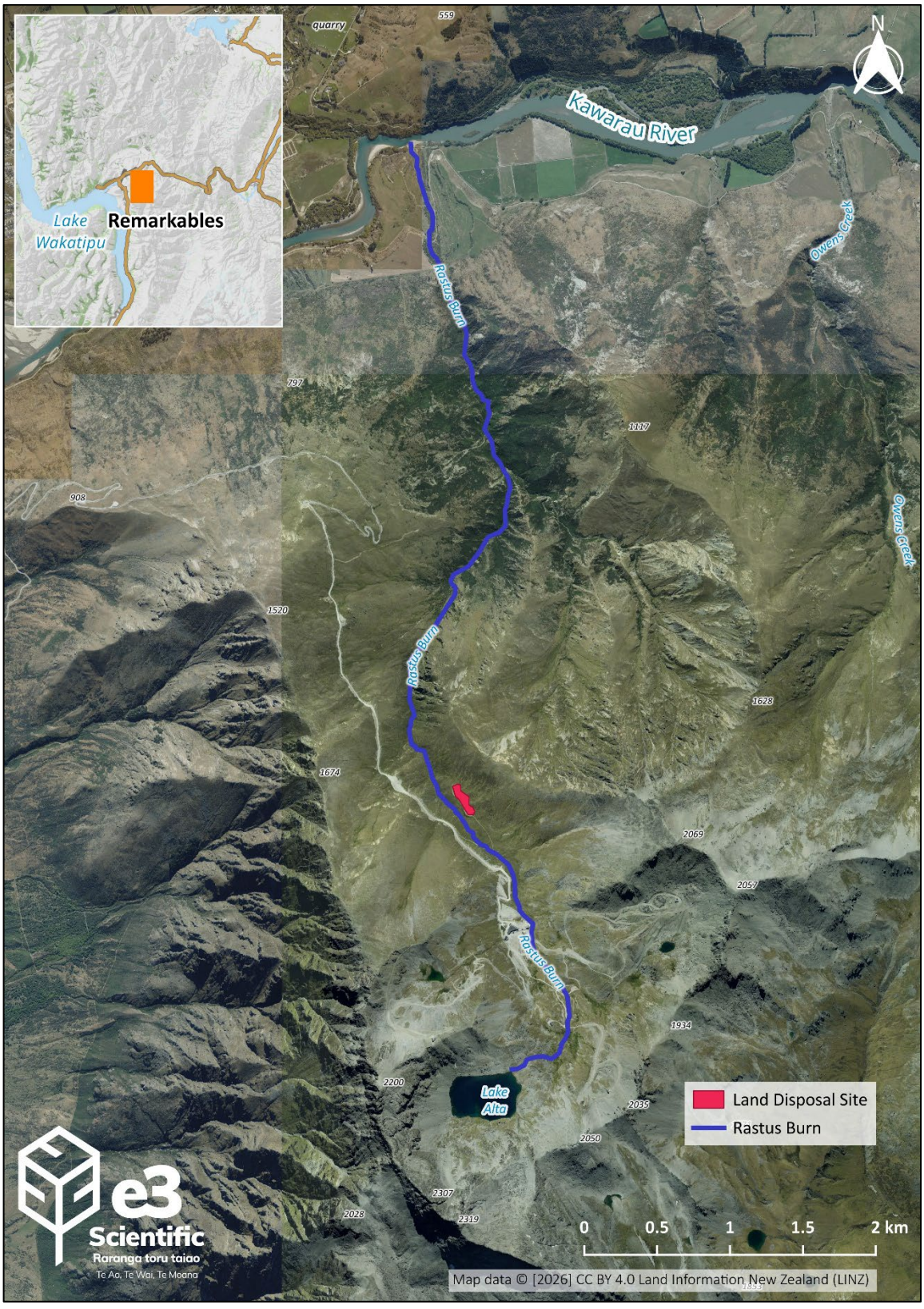

Figure 1: Site overview showing the Rastus Burn and existing wastewater treatment land dispersal site.

1.2 Ecological Report Structure

The FEcIA is structured as follows:

- Section 2: Site location and description of the proposed activity.
- Section 3: Methodology employed during the ecological assessment.
- Section 4: Results
- Section 5: Ecological values
- Section 6: Ecological impact assessment.
- Section 7: Conclusions and recommendations.

1.3 Scope of Work

The scope of work to complete this FEcIA report included a desktop review of available information including monitoring reports associated with the existing wastewater discharge consent. A field site visit was also undertaken to assess and characterise the ecological values of further downstream on the Rastus Burn near the confluence with the Kawarau River to determine if fish were present in the lower reaches of the waterway.

1.4 Limitations

The findings of this report are based on the Scope of Work outlined above. e3Scientific Limited (e3s) performed the services in a manner consistent with the normal level of care and expertise exercised by members of the environmental science profession. No warranties, express or implied, are made. Subject to the Scope of Work, e3s's assessment is limited to a desktop review of the existing information, eDNA and macroinvertebrate sample collection and a freshwater ecological impact assessment following EIANZ guidelines. The confidence in the findings is limited by the Scope of Work.

The results of this assessment are based upon site inspections conducted by e3s personnel, information from interviews with people who have knowledge of site conditions and information provided in previous reports. All conclusions and recommendations regarding the properties are the professional opinions of e3s personnel involved with the project, subject to the qualifications made above. While normal assessments of data reliability have been made, e3s assumes no responsibility or liability for errors in any data obtained from regulatory agencies,

statements from sources outside e3s, or developments resulting from situations outside the scope of this project.
The confidence in the findings is limited by the Scope of Work, and limited data due to the singular site visit at one time of year. A full range of biota that are present at this site may not have been seen or recorded; however, desktop research was utilised to aid the assessment.

1.5 Code of Conduct

The authors of this report are Mark Hamer and reviewer Bryony Miller. Bryony Miller is the Technical Director of Marine and Freshwater Ecology at e3Scientific and is a professional ecologist with over 15 years' experience. She regularly completes freshwater and marine ecological impact assessments on behalf of regional and district councils, private companies, national governmental organisations, not-for-profit and research groups. She has been an expert witness at Environment Court and hearings and has been involved in mediation and expert caucusing. She currently is a member of the NZ Freshwater Science Society, NZ Marine Science Society, NZ Science Diving Committee and is an executive committee board member of the NZ Coastal Society.

Mark Hamer is a professional freshwater ecologist with over 17 years' experience working in the freshwater ecology and monitoring industry. Freshwater biomonitoring proficiency and experience includes wetland delineation, water and sediment quality assessments, eDNA, river periphyton, aquatic plant identification, riparian habitat assessment, macroinvertebrate collection and analysis. Freshwater fish monitoring using electric fishing, netting or spotlighting methods along with associated fish handling, analysis and fish passage assessments. At e3scientific for the past 3 years Mark's focus has been on ecological value assessments and reviewing and producing ecological impact assessments in the consenting process. He has been an expert witness at consent hearings and is a current member of the New Zealand Freshwater Sciences Society.

We confirm that we both have read the Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2023. This report has been prepared in compliance with that Code, as if it was expert evidence presented in proceedings before the Environment Court. Unless we state otherwise, this report is within our area of expertise, and we have not omitted to consider

material facts known to either of us that might alter or detract from the opinions expressed in this report.

2 Activity Description and Environmental Context

2.1 Description of Activity

2.1.1 Wastewater Treatment

The proposed Remarkables ski field expansion will increase operational capacity and visitor numbers, resulting in higher wastewater loads. Upgrades to the existing wastewater infrastructure are therefore required to accommodate increased volumes and loads associated with this growth (Mitchell-Daysh, 2026). The current wastewater treatment plant is located near the base building at 1600 m above sea level (a.s.l.) with the dispersal fields at a lower elevation of 1440 m a.s.l. The wastewater dispersal field comprises of a series of three bunded depressions that extend for 300 m along a colluvial deposit elevated 50 m above the true right bank of the Rastus Burn. The dispersal fields are oblong and are located approximately 50 – 100 m north-east of the Rastus Burn. The dispersal fields cover approximately 0.61 ha and are 2 – 3 m deep which provides enough storage for the estimated annual flows (MWH, 2014), including precipitation.

The proposed volume of wastewater is estimated to be 204 m^3/day during the ski season. The current wastewater treatment process includes primary screening and settlement treatment. The wastewater management system includes a 35 m^3 pre-settlement tank in Car Park 1 that receives toilet and greywater from the staff and base buildings and the public toilets. Flows are then directed to twin 75 m^3 septic tanks with outlet filters before the partially treated effluent is conveyed via a buried 100 mm PVC pipeline—crossing the Rastus Burn on insulated steel bridges—to a 31 m^3 belowground sedimentation tank. From there, flow is measured and split three ways to the infiltration basins, which operate in parallel and discharge wastewater to land through infiltration.

Sludge from the pre-settlement and septic tanks is removed twice yearly. The basins were refurbished in 2014 by excavating and replacing the base material to restore infiltration, and the three dispersal fields provide a combined dispersal area of 6,100 m^2 with a conservative maximum application rate of 20 mm/day for primary treated effluent (Figure 2). The daily wastewater volume is expected to increase by 77 m^3/day, from 127 m^3/day to 204 m^3/day (e3Scientific, 2026a).

An options report and water quality assessment for this proposal has been undertaken and recommended an upgrade to the wastewater treatment system is needed to achieve the performance criteria (e3Scientific, 2026a; Stantec, 2026).

The secondary treatment components typically include primary sedimentation tanks with effluent filter, nitrification chambers, aeration chamber, clarifier, sludge return system from base of clarifier into primary tank, anoxic tanks, treated effluent pump station and effluent disc filters (Stantec, 2026).

The tertiary treatment typically includes primary sedimentation tanks with effluent filter, the secondary treatment stages with additional carbon and alkalinity dosing systems (Stantec, 2026).

The treatment and nutrient load management are to be designed to meet the performance criteria. So, while the wastewater volume is to increase, the additional treatment provided is expected to ensure there is no increase in annual nutrient loads.

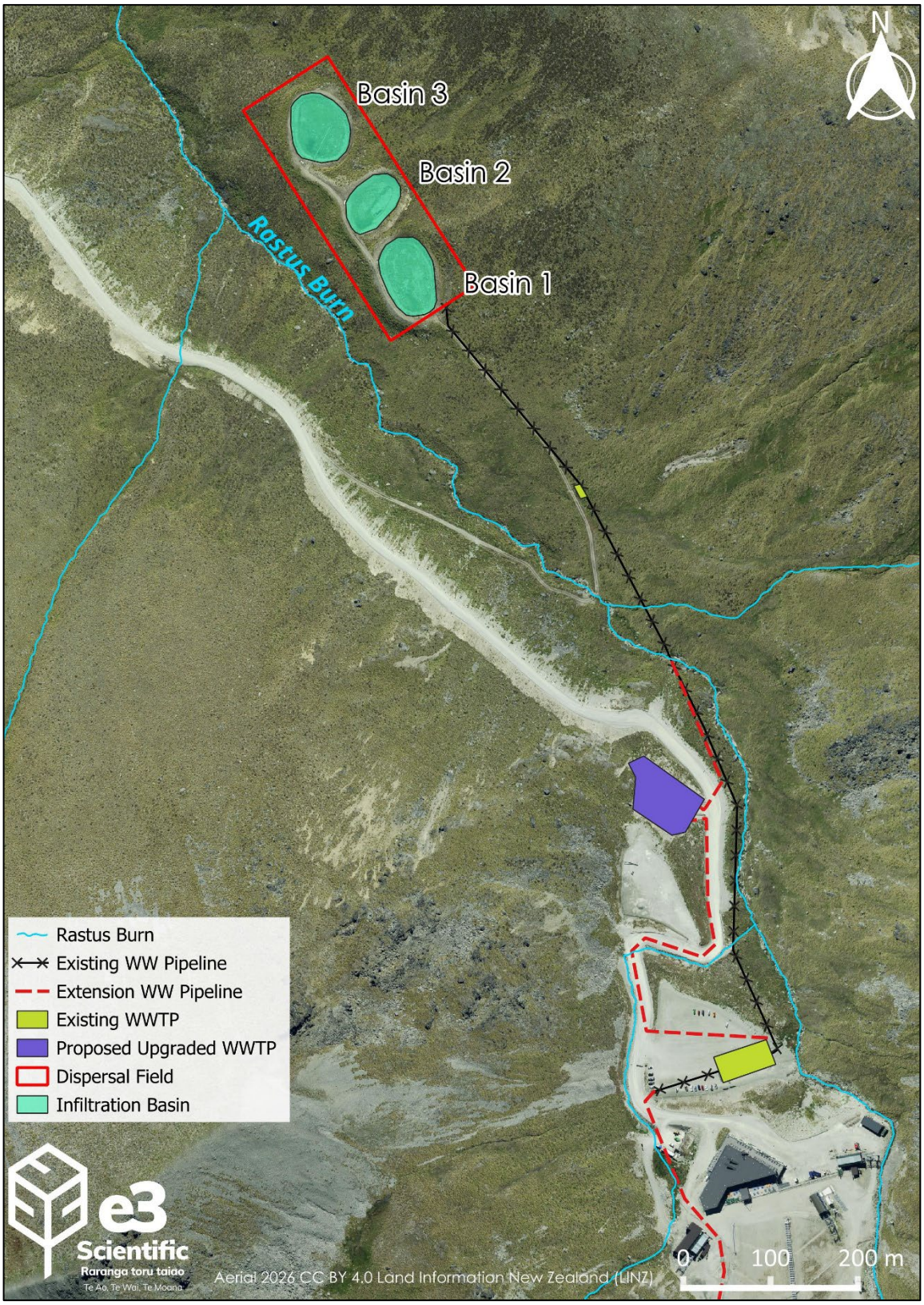

Figure 2: Wastewater treatment system locations (Source: e3Scientific 2026a).

2.2 Environmental Context

2.2.1 Rastus Burn

The catchment has been developed to support the Remarkables ski field with ski lifts, roading, car parks, and associated ski field buildings however there are still areas of undisturbed wetlands, lakes, and alpine terrain. The Remarkables ski field is located in the upper basin of the Rastus Burn which has its headwaters in three small cirque basins. The catchment elevation ranges from 2,300 m a.s.l. at the highest peaks down to 315 m a.s.l. at the confluence with the Kawarau River (e3Scientific, 2025).

The Rastus Burn is a small (~2 m wide), steep mountain stream with a low flow of 25 L/s and a median flow predicted to be approximately 70 L/s. The catchment upstream of the wastewater treatment plant site is 581 ha and drains the northern end of the Remarkables Range. The upper catchment is alpine, so much of the winter precipitation falls as snow. The landcover comprises predominately of tussocks and bare rock although the upper catchment has small wetlands present in summer once the snow has melted. The stream gradient changes from reasonably low gradient in the headwater cirques and past the Remarkables Base to then a much steeper gorge section from 1400 m a.s.l down to 400 m a.s.l. before levelling out 1 km upstream from the confluence with the Kawarau River.

The stream has a distinct seasonal flow pattern of very low flows in winter due to freezing in the upper catchment, a late-spring peak from snowmelt and westerly storms, and a lower summer minimum in February–March. Mean annual low flow at the ski area pumphouse is estimated at 26 L/s (7-day average).

The surrounding terrain is steep and dominated by large snow tussock, spear grass, and an understorey of native herbs and sedges. Low shrubs, mainly *Dracophyllum* species, occur in drier areas, while boggy zones support extensive turf and mound communities (Ludgate, *et al.*, 2014).

2.2.2 Lake Alta Headwaters

Lake Alta sits on Department of Conservation (DOC) land within an area managed as the Remarkables Ski Field by NZSki. The 13 hectare (ha) lake is approximately 34.45 m deep (Figure 1) (Clarke Fortune McDonald & Associates.,

2011). The lake drains from an outlet to the Rastus Burn that flows to the Kawarau River which then converges to the Clutha River 55 km downstream.

Lake Alta was assessed as part of the Lakes 380 project between 2018 and 2021. This study suggests that Lake Alta has "Very poor" water quality with a "Supertrophic", status (Lakes 380, Accessed 2025). However, the lakes 380 assessment was estimated based on bacteria present in lakebed sediment rather than actually based on regular water quality, clarity and Chlorophyll *a* samples (Pearman, *et al.*, 2022).

Previous surveys have demonstrated that fish are absent from the lake, most likely due to the high altitude and harsh (cold) conditions (Ryder Consulting, 2012) but also likely due to being naturally excluded by multiple chutes and waterfalls downstream. The Rastus Burn has been monitored as part of the previous NZSki resource consent. This has outlined a benthic macroinvertebrate community dominated by *Deleatidium* and *Nesameletus* mayfly larvae, Elmidae beetles and Chironomid (non-biting midge) larvae, along with a relatively high proportion of stonefly larvae (Ryder Consulting, 2012). Alpine lake benthic communities are primarily influenced by the limited availability of food, the high radiation intensities during the ice-free summer period promoting algal growth and by the winter cover of ice, with lakeside tussock contributing allochthonous plant material to littoral habitat (Fureder, *et al*., 2006). The macroinvertebrate community is likely to have low diversity due to the high elevation, and relatively short season for macroinvertebrate colonisation and growth between winter freeze over events. Internationally alpine lakes are dominated by chironomid larvae with low numbers of EPT taxa present (Fureder, *et al.,* 2006).

There are no known macrophyte records for Lake Alta. The boulder substrate appears to be not ideal for macrophyte colonisation along with the harsh seasonal conditions with the lake freezing over in winter. Small amounts of filamentous green algae are present within the surface 1 m around the littoral edge and at the outlet to the Rastus Burn (Ryder Consulting, 2012). Benthic algae is a food source for higher tropic levels such as grazing macroinvertebrates. Didymo (*Didymosphenia geminata*) has been confirmed as present by eDNA analysis in the lake outlet channel (D. Jack, *pers. comm*., 2025).

The Lake Alta zooplankton community was sampled in 2002 (Shallenberg, 2002) and 2011 (Ryder Consulting, 2012) where a limited zooplankton fauna typical of

alpine lakes was present with *Boeckella dilatata, Ceriodaphnia dubia, Alona sp.* and *Chydorus sp.* present.

2.2.3 Regional Plan

Regional Plan: Water for Otago

Schedule 1A of the Regional Plan: Water for Otago (2020) identifies the natural and human use values of Otago's surface water bodies. The Rastus Burn is listed in Schedule 1A. The listed ecosystem values of the Rastus Burn include:

- Free from aquatic pest plants.
- Presence of riparian vegetation of significance to aquatic habitats.
- Presence of a boulder bed composition of importance for resident biota.
- Presence of indigenous invertebrates threatened with extinction upstream of NZMS 260 F41:8066 4100.
- Presence of significant fish spawning areas.
- A high degree of naturalness above 900 metres asl.

The Rastus Burn includes most of these ecosystem values, however, is unlikely to have significant fish spawning areas particularly in the upper reaches as it is fishless above the gorge. The location identified as the area of threatened invertebrates is upgradient of the NZSki base and includes a small headwater area upstream of the reach and is largely due to rare moths, beetles, a cave weta and land snail (Patrick, *et al.*, 1992). Although the Rastus Burn is fishless and weed free, we note didymo has been identified recently in the upper Rastus Burn (Figure 5).

The ORC Regional Plan: Water for Otago (2025) does not explicitly provide water quality limits for the Rastus Burn but it does outline in Schedule 15 that the Kawarau River downstream of the Shotover River confluence is in receiving water group 2. The waterway should therefore meet 0.075 mg/l for Nitrate-nitrite nitrogen, 0.1 mg/for ammoniacal nitrogen, 0.01 for dissolved reactive phosphorus, 260 cfu/100ml and 5 NTU to achieve good water quality (Otago Regional Council, 2025).

3 Methods

3.1 Desktop Review

A desktop review of relevant databases including monitoring reports associated with the existing wastewater discharge consent was undertaken.

The desktop study included a review of existing ecological and water quality information to determine habitats and species likely present on the site.

The desktop assessment included:

- A review of the Land and Water Aotearoa (LAWA) website to access water quality and macroinvertebrate records;
- A review of the New Zealand Freshwater Fish Database (NZFFDB) and Wilderlab eDNA database for historic fish records; and
- Determination of the threat status of the species records by using the New Zealand Fish Threat Classifications as outlined in (Dunn, *et al*., 2025) and (Grainger, *et al.*, 2018).
- A review of relevant literature including previous consent monitoring reports related to the discharge of wastewater to the Rastus Burn (Ludgate, *et al*., 2014; Ludgate, 2017; SLR, 2023; SLR, 2026).
- A review of the Otago Regional Plan for known Rastus Burn natural values and expected water quality.

These aspects are then considered against the Otago Regional Council (ORC) Regional Plan: Water for Otago, Schedules 1A and 15. Then the ecological values and impact of the activity are assessed following the methods outlined in the EIANZ Guidelines (Roper-Lindsay, *et al*., 2018).

3.2 Site Visit

On 13 April 2025, e3scientific freshwater ecologists carried out a site visit at Lake Alta outlet to sample the Rastus Burn upstream of the wastewater discharge. A further site visit was undertaken on 27 February 2026 to collect eDNA samples downstream of the Rastus Burn Gorge to determine if fish were present within the lower reaches of the stream near the confluence with the Kawarau River.

Consent monitoring largely used to assess the ecological values present was undertaken in 2014, 2017, 2023 and 2025. The consent monitoring sites comprise of one upstream control site and 3 downstream impact sites. The upstream site is approximately 400 m upstream of the wastewater dispersal fields. The impact sites were monitored 50 m, 200 m and 1500 m downstream of the wastewater dispersal field (SLR, 2026) (Figure 3).

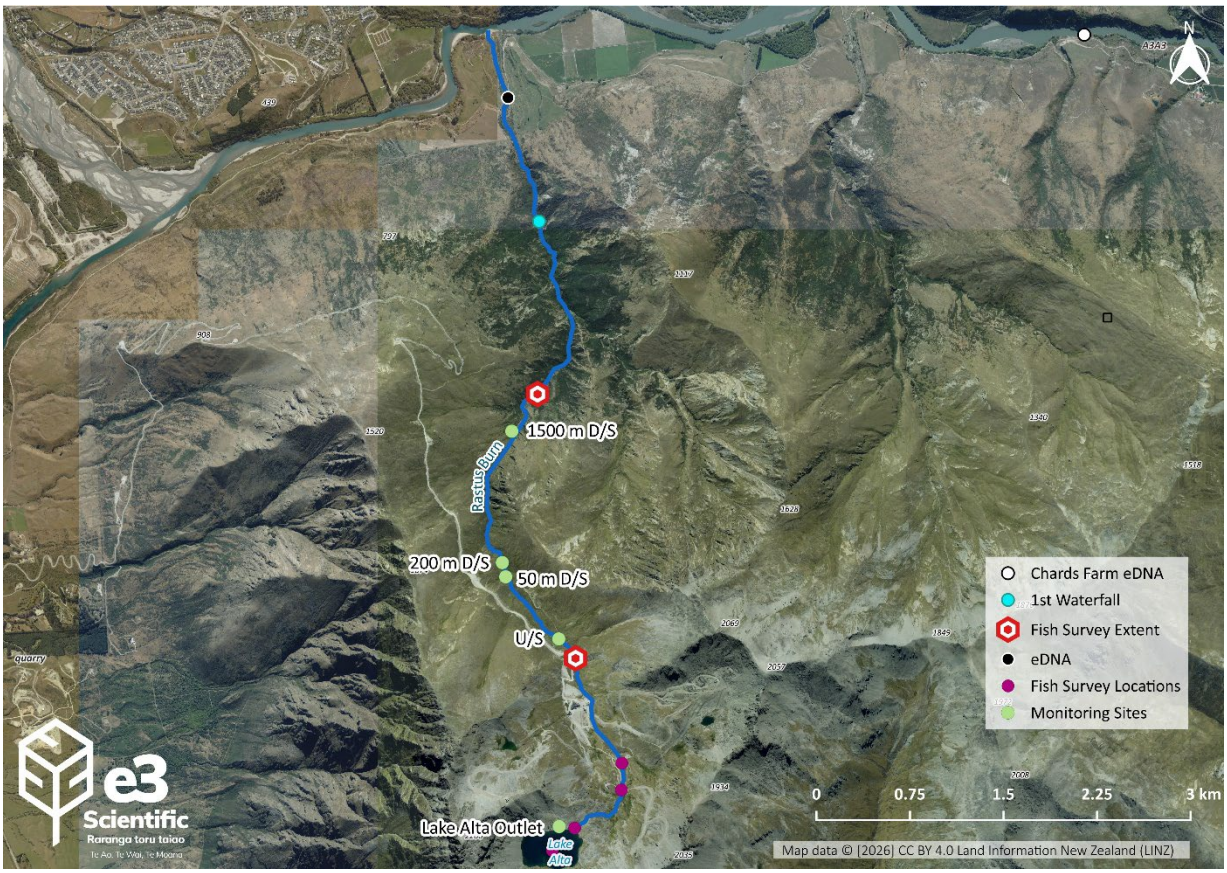

Figure 3: Site Sampling overview.

3.3 Physio-Chemical Parameters

The properties of the water in the Rastus Burn immediately below Lake Alta were assessed on 30 April 2025 using a calibrated YSI ProDSS multiparameter meter that measured water temperature, dissolved oxygen, total dissolved solids, conductivity, pH and turbidity. The meter was deployed mid water and allowed to stabilise for 1 minute before the readings were recorded. The data gathered was then assessed against recognised guideline values for the various relevant parameters. The default guideline values (DGV)(ANZG, 2018) have been developed for different waterway types based on the River Environmental

Classification (REC). This section of the Rastus Burn is considered in the REC to have a cool wet climate and a mountain source of flow (Snelder, *et al.*, 2010), therefore the DGV (See Table 2) for this river type was used to produce guideline values (ANZG, 2018).

3.4 Habitat

Four compliance monitoring sites and the Lake Alta Rastus Burn outlet had habitat observations completed (Figure 4 & 5). The compliance monitoring reports were used to describe the instream and riparian habitat present at the consent compliance monitoring sites. During the April 2025 survey, habitat characteristics of the Rastus Burn at the Lake Alta outlet were assessed and used to describe the instream habitat conditions at this site.

3.5 Periphyton

Periphyton monitoring undertaken as part of the compliance monitoring to assess the existing wastewater discharge was reviewed and periphyton type and abundance over time described. No further periphyton monitoring was completed in April 2025 or February 2026 as part of this assessment.

As per existing compliance monitoring conditions, periphyton was visually assessed at each of the four sites and different substrates available for periphyton growth (e.g., gravels, cobbles) were inspected. Samples of representative algal cover were collected from each site and returned to the laboratory for further identification (SLR, 2026). Samples were inspected under 200-400x magnification to identify algal species present using the keys of Biggs & Kilroy (2000), Entwisle *et al*. (1988) and Moore (2000). Algae were given an abundance score using the reduced ranks scheme, with 1 representing rare, 2 representing common and 3 representing abundant (SLR, 2026).

A periphyton risk assessment was undertaken which reviewed the receiving environment hydrology, baseline conditions, the discharge characteristics, periphyton growth drivers and provided a nutrient guideline recommendation. The findings are summarised in Section 4.3 and the full risk assessment is supplied in Appendix D.

3.6 Macroinvertebrates

Macroinvertebrate sampling within the Rastus Burn Stream was completed on 13 April 2025 by e3scientific freshwater ecologists. The sample was collected upstream of the wastewater outlet and the compliance monitoring sites (Figure 3). As some elevated water parameter levels have been recorded at the upstream compliance monitoring site (e3Scientific, 2026a) it was decided an additional sample recently collected further upstream at the Lake Alta outflow would be useful within this context.

A 0.4 m wide, 500 micron mesh kicknet was used following the C1 hard bottomed protocol (Stark, *et al*., 2001) to obtain a macroinvertebrate sample in order to identify the values present within the Rastus Burn near the outlet of Lake Alta. This involved collecting five subsamples across the assessment reach that are combined into one composite sample. Habitat types were sampled in proportion to their presence with 100% of the sample effort involved sampling cobble riffles. Ethanol was added to a concentration of 70% to preserve the sample. The sample was then transported to e3s laboratory for identification, full count enumeration and metric calculation.

The consent monitoring reports utilised the same kicknet field method and equipment following the C1 protocol (Stark, *et al.,* 2001). The samples were then processed using the full count P3 protocol (Stark, *et al*., 2001; Ludgate, *et al*., 2014; Ludgate, 2017; SLR, 2023; SLR, 2026).

3.6.1 Macroinvertebrate Metrics

Macroinvertebrate metrics (taxa richness, MCI, QMCI, EPT taxa, % EPT Taxa% EPT Abundance and ASPM) were calculated for the Rastus Burn Lake Outlet sample. The compliance monitoring reports also produced MCI, SQMCI and EPT% following the same methods. The MCI, QMCI and SQMCI metrics were compared against quality classes reported in Boothroyd & Stark (2000) and Stark & Maxted (2007) in Table 1. Using these quality classes rather than the more recent NPS-FM (2020) classes is considered appropriate in my opinion as the macroinvertebrate monitoing occurs at the end of the ski season and prior to the end of November wheras the NPS-FM requires sampling to occur December to April (Ministry for the Environment, 2020). Additionally, EPT is used to assess the community diversity and sensitivity.

Table 1: Macroinvertebrate Metric Attribute Bands (Source; Boothroyd & Stark, 2000; Stark & Maxted, 2007).

Quality Class (2000)	Quality Class (2007)	MCI	QMCI
Clean water	Excellent	≥ 120	≥ 6.00
Doubtful quality	Good	100 – 119	5.00 – 5.99
Probable moderate pollution	Fair	80 – 99	4.00 – 4.99
Probable severe pollution	Poor	< 80	< 4.00

3.7 Fish

Electric fishing of the Rastus Burn was undertaken in October 2014 over a 2 km reach from 1500 m downstream of the dispersal field to 400 m upstream (Ludgate, *et al.,* 2014). During this survey Ludgate *et al.,* (2014) noted the presence of waterfalls likely to preclude fish from accessing the upper Rastus Burn.

The ORC Regional Plan suggests that the Rastus Burn provides spawning habitat for trout (Otago Regional Council, 2025). It is assumed this could only possibly occur in the lower reaches near the confluence with the Kawarau River. Therefore, eDNA was collected on 27 February 2026 within the Rastus Burn approximately 4.5 km downstream of the wastewater dispersal filed and approximately 600 m upstream from the confluence with the Kawarau River.

Six replicate eDNA samples were collected following Wilderlab sample collection guidance notes and NIWA replicate recommendations (Melchior & Baker, 2023; Smith, *et al*., 2024). Where 1 litre of stream water was filtered and the filter preserved and labelled and sent to Wilderlab for genetic analysis to identify the species with eDNA within the samples.

The NZFFD and eDNA databases were also reviewed to ascertain if more recent assessments or fish records were present (Figure 3).

3.8 Wetlands

Historical reports were reviewed to ascertain if there were any wetlands near and downgradient of the wastewater dispersal field and discharge. Additionally,

aerial imagery was assessed to identify any potential wetland areas near and down gradient of the wastewater dispersal field.

4 Results

4.1 Surface Water Results

4.1.1 Physico-chemical parameters

Rastus Burn physico-chemical parameters are consistent with those expected for a cool, clear alpine stream in late summer (Table 2). The high dissolved oxygen levels are likely driven by strong re-aeration as water cascades over bouldery habitat, and may also reflect phytoplankton activity in Lake Alta, which could contribute to the slightly lower-than-expected pH. Turbidity and total suspended solids are generally low, although occasional increases occur during snowmelt or when fine material is mobilised from the rocky upper basins or from access-track runoff upstream.

According to Ludgate *et al*., (2014), the Rastus Burn at the compliance monitoring sites contains cool, well-oxygenated, low-nutrient water, with temperatures typically between 1.7°C and 5.1°C and a normal pH range. Faecal contamination is very low and usually below detection limits upstream of the wastewater dispersal field. The turbulence within the stream and well oxygenated water with a high dissolved oxygen content will be resilient to dissolved oxygen reductions or sewage fungus growth that can occur downstream of wastewater discharges in situations where high organic loads, low velocity and low dissolved oxygen zones. These are not the conditions found within the Rastus Burn and therefore sewage fungus is not considered further.

Table 2: Physico-chemical results for the Rastus Burn at the Lake Alta outlet on 13/4/2025 and the DGV (ANZG, 2018) values for sites with a cool wet climate and mountain source of flow.

Site	Rastus Burn	DGV
Temperature (°C)	7.6	N/A
Dissolved Oxygen %	**107**	93 - 103
Conductivity (µS/cm)	16.3	87
pH	**7.31**	7.39 – 7.8
Turbidity (NTU)	0	4.6
Water Clarity (m)	Clear	1

Note: values in bold if outside the recommended DGV range.

Overall, the current discharge of wastewater to land has been assessed to have a slight but measurable increase in nutrient concentrations in the Rastus Burn above baseline levels but remains below the 99% DGV (e3Scientific, 2026a). It is expected that the proposed increase in wastewater volume with improved quality will ensure the existing nutrient load will remain and effects on water quality will be consistent with the current situation.

4.1.2 Nutrients

A brief summary of the findings of the Wastewater Discharge Impact Assessment (e3Scientific, 2026a) is provided below for specific parameters.

Ammonia concentrations in the Rastus Burn spike each ski season from increased nitrogen in groundwater becoming measurable within a month of wastewater addition to the infiltration field and typically peaks about an order of magnitude below the DGV, so impacts are acceptable, although a documented July 2023 leak caused a short-term exceedance that was treated as an anomaly (e3Scientific, 2026a).

Nitrate concentrations as measured as Total Oxidised Nitrogen (TON) in the Rastus Burn are generally about an order of magnitude below the ANZG (2018) DGV and show no evidence of cumulative ecological harm. Although monthly upstream concentrations frequently exceed ORC Schedule 15 in winter (80% of upstream samples over five years). Winter peaks are likely from nitrification as discharge infiltrates the vadose zone and mixes with groundwater. The Rastus Burn contains less nitrate in summer because the total summer nitrate load is lower, even though the wastewater discharged to the infiltration dispersal field has a higher nitrate concentration.

Dissolved reactive phosphorus is consistently detected in the Rastus Burn, generally meeting ORC Schedule 15 (See Figure 14; e3Scientific, 2026a) while also being at levels predicted to constrain didymo growth (See Section 4.3). Winter increases are linked to the higher wastewater inputs, upstream schist weathering and wetlands are additional sources, while groundwater and downstream tributaries provide dilution (e3Scientific, 2026a).

Biochemical oxygen demand is an indicator of organic loading. However, the land dispersal field is distant from the receiving waterway, the cold temperatures,

high dilution and high dissolved oxygen levels present combine to suggest significant oxygen depletion is unlikely (e3Scientific, 2026a).

4.2 Habitat

Streambed habitat in the Rastus Burn consists of bedrock chutes and waterfalls in the steeper reaches, transitioning to cobbles, boulders, and gravel free of fine sediment in the flatter sections. The steep gradient creates cascading reaches with a bed dominated by cobbles and boulders, and pockets of smaller gravels in slower areas (Ludgate, *et al.*, 2014). The Rastus Burn is fed by lake water and the Lake Alta Outlet comprised primarily of cobbles and large gravels smothered in didymo (Table 3; Figure 5).

At the upstream compliance site the riparian zone was dominated by large *Chionochloa* (snow tussock) and *Aciphylla* (spaniard), with scattered low shrubs such as *Dracophyllum* and *Veronica* species, along with small alpine herbs. Moss occurred along the stream margins and on instream rocks. The channel featured tumbling flow over medium boulders, interspersed with small pockets of lower-velocity water where the substrate comprised flat cobbles and medium gravels (SLR, 2026)(Figure 4).

The compliance monitoring site 50 m downstream has riparian vegetation similar to the upstream reach, with snow tussock, spaniard, low shrubs, alpine herbs, and moss on stream edges and boulders. The instream habitat had a noticeably steeper gradient than the upstream and 200 m downstream sites. Large boulders created abrupt drops, and a major cascading waterfall occurred immediately upstream of the sampling area (SLR, 2026)(Figure 4).

At the site 200 m downstream, the riparian vegetation remained dominated by tussock, spaniard, and low alpine shrubs, with moss present on shaded margins and instream surfaces. The stream flowed through a confined channel with a long run, and the bed was composed of small boulders, medium to large cobbles, and intermittent patches of coarse gravel (SLR, 2026)(Figure 4).

At the site 1500 m downstream, the site supported a more diverse and taller riparian vegetation assemblage, including *Phormium cookianum* (mountain flax), taller *Coprosma* species, and scattered *Discaria* (matagouri) and *Carmichaelia* (native broom), with vegetation overhanging the channel in places. The instream

habitat had a very steep gradient and consisted of continuous cascade and waterfall-type flow with very high velocities. Substrates were dominated by large boulders and bedrock, with only occasional small patches of finer gravel (SLR, 2026)(Figure 4).

Figure 4: Compliance Monitoring point Habitat (Source: SLR 2026).

Figure 5: Lake Alta outlet sampling within the Rastus Burn with didymo present (13/4/2025).

Table 3: Rastus Burn habitat at the Lake Alta Outlet.

Site	Rastus Burn
Boulder	-
Cobble	40
Gravel	60
Filamentous algae %	60 (didymo)
Macrophyte cover %	0
Moss cover %	0
Habitat assessment (RHA) 0-100	62

4.3 Periphyton

Periphyton growth has been assessed as minimal upstream and downstream of the current wastewater treatment plant infiltration dispersal field, with any periphyton community present dominated by red filamentous algae at less than guideline values (SLR, 2023). The monitoring site 50 m downstream typically has

the lowest algal diversity of the four sites, while the upstream control generally has the greatest diversity. This low algal cover is largely due to the cold, water temperatures, snow and ice limiting light at times and high water velocities preventing excessive algal biomass (Ludgate, *et al*., 2014).

Of the algal taxa reported as present in the 2025 consent monitoring report (SLR, 2026), *Audouinella* is reported as an oligotrophic taxa, *Cocconeis* more a generalist, *Cymbella* mesotrophic, *Gomphonema* varies depending on the species, *Naviculoid* oligotrophic to mesotrophic, *Pinnularia* mesotrophic to oligotrophic (Biggs, 2000). While a dissolved inorganic nitrogen (DIN) level of < 10 mg/m^3 and dissolved reactive phosphorus (DRP) level of < 1 mg/m^3 have been suggested to maintain benthic biodiversity in New Zealand (Biggs, 2000) these levels are low and considerably lower than what is currently present at the upstream control site within this low nutrient alpine stream.

Periphyton cover in alpine streams is naturally low during the summer snow melt phase and highest in more favourable stable autumn conditions. Spring low flow generally does not demonstrate an increase in periphyton biomass (Figure 6) (Uehlinger, *et al.,* 2010). Low temperatures slow algal growth rates, but periphyton biomass reaches higher levels if discharge and turbidity are low and snow cover is lacking (Uehlinger, *et al.*, 2010). The Rastus Burn currently has low nutrient concentrations recorded upstream of the wastewater dispersal fields although seasonal patterns are apparent with higher nutrient levels recorded in winter than summer and an apparent phosphorus source upstream (e3scientific 2026a).

Consent monitoring data collected in spring is utilised within this report as this was deemed in the previous resource consent process to be the time of year most likely to demonstrate impacts, if any were to be observed. This is because the vast majority of the wastewater is applied to land through winter and spring (see Table 6; e3Scientific, 2026a). The wastewater has been demonstrated to move through the land to the Rastus Burn within 1 month of the discharge (see Section 4.3.1.1 e3Scientific, 2026a), therefore, any wastewater related increase in periphyton growth would occur within 40 days (30 days for nutrients to get to the Rastus Burn and then 10 days for algal biomass to accrue) and limited to August to December. I therefore agree with the previous consent application that spring stable flow periods to be the time of year most likely to show any ecological impacts associated with the increase in wastewater applied to land. Autumn stable flows are typically the time of year when instream growth reaches its

maximum cover levels as shown in Figure 6; however as little nitrogen (1.46 - 9.49 mg/L) is applied to land in summer and autumn (e3Scientific, 2026a), the autumn concentrations observed will be equivalent to natural baseline levels and the reach has a low risk periphyton category.

The Rastus Burn is classified as having a Cold Wet climate (CW) and a mountain source of flow (M) under the River Environment Classification (REC) framework (Snelder, *et al.*, 2010). This classification has been used to refine predictions of periphyton cover and biomass based on chlorophyll *a* models, including Matheson *et al.* (2016; Tables 1–3), MfE (2020; Table 1), and Snelder *et al.* (2022; Table 19). These modelling approaches have estimated the instream total nitrogen (TN) concentrations required to maintain periphyton biomass below this threshold (see Table 4). For this alpine section of the Rastus Burn with moderate ecological values (See Section 5), the 5% protection level is appropriate. This corresponds to maintaining periphyton chlorophyll *a* below 50 mg/m^2 for 95% of the time.

The most recent approach in Table 4 below, presented by Snelder *et al.* (2022), indicates that TN concentrations should remain between 2-35 mg/m^3 to maintain benthic biodiversity. However, the datasets used to develop these models are based on regional and national river monitoring networks rather than small alpine streams. As a result, it is my opinion that the 2 mg/m^3 TN guideline is not directly applicable to the alpine reaches of the Rastus Burn. This interpretation is supported by existing monitoring data, where mean upstream TN concentrations already exceed this TN value (Figure 21; e3Scientific, 2026a), while periphyton cover has remained low across multiple assessments (for example, Ludgate, 2017; SLR, 2023; SLR, 2026).

Furthermore, a periphyton risk assessment has been undertaken and has assigned the periphyton risk associated with the proposed wastewater discharge to the Rastus Burn as low. This is largely due to the cold water temperatures, regular flushing flows, the algal taxa present and low light when nutrient levels are at their winter peak during the ski season. The risk assessment recommends that if nutrient based triggers are to be used for the Rastus Burn, then the low-risk guideline values of 150 mg/m^3 and DRP below 6 mg/m^3 from Matheson *et al.* (2012) are most suitable. It is recommended that these values are used as an initial trigger to prompt further monitoring and management actions.

Accordingly, direct monitoring of instream periphyton biomass is recommended as the most useful management approach. Monitoring should confirm that

chlorophyll *a* concentrations continue to remain below 50 mg/m^2 and this is proposed in condition WW 18. Management actions are then proposed in WW 19 to ensure any exceedances associated with the discharge are remediated.

Table 4: Nutrient and periphyton summary table.

Nutrient level	Periphyton level	Source
DIN < 150 mg/m^3 & DRP < 6 mg/m^3	Periphyton cover to remain below 50 (mg/m^2) Chl *a*	Matheson et al (2012)
DIN < 100 mg/m^3 in preceding 12 months	Periphyton cover to remain below 50 (mg/m^2) Chl *a* or 20 % cover. Summer guideline	Table 1-3; Matheson et al (2016)
TN > 38 (mg/m^3) – 10% spatial exceedance criteria	Periphyton cover to remain below 50 mg/m^2 Chl *a* 90 % of the time (50 mg/m^2 Chl *a* is the ecological threshold proposed by Biggs (2000).	Table 1; MfE (2020)
TN 5% protection = 2 (mg/m^3), 10% protection = 6 (mg/m^3), 15% protection = 17 (mg/m^3), 20% protection = 35 (mg/m^3)	Periphyton Chl *a* 50 (mg/m^2) Unshaded stream value used.	Table 19; Snelder et al (2022)

Didymo (*Didymosphenia geminata*) is known to have been in the Rastus Burn since 2023 and has been observed at the headwaters at the Lake Alta outlet during summer 2025 (Figure 5). This lake outlet provides stable flow and it appears that didymo biomass can reach high levels here. Once introduced to a new waterway, didymo blooms are known to occur in high light conditions and very oligotrophic water with low mean dissolved reactive phosphorus levels e.g. <2 mg/m^3 (Bothwell, *et al.*, 2014). Didymo stalk production (blooms) are in response to very low DRP and is a strategy to move cells out of the benthic boundary layer and into the water column where there is greater delivery of phosphorus (Bothwell, *et al*., 2014). Didymo is known to tend to bloom downstream of lake outlets where high light, low turbidity, stable substrate and stable flow are present along with low DRP levels (Bothwell, *et al*., 2014). Therefore, as didymo has newly arrived in the catchment and the Rastus Burn is downstream from Lake Alta with relatively stable flows, high light levels in summer and low phosphorus (DRP) levels,

didymo blooms may potentially occur in the Rastus Burn in the future and this would be unrelated to the wastewater discharge. As yet, didymo has only been recorded in consent monitoring 200 m downstream of the wastewater dispersal field in November 2025 and was considered "rare" at that time (SLR, 2026). It is expected that with suitable wastewater treatment, phosphorus levels will remain low (<2 mg/m^3) and didymo blooms may become an issue within the catchment.

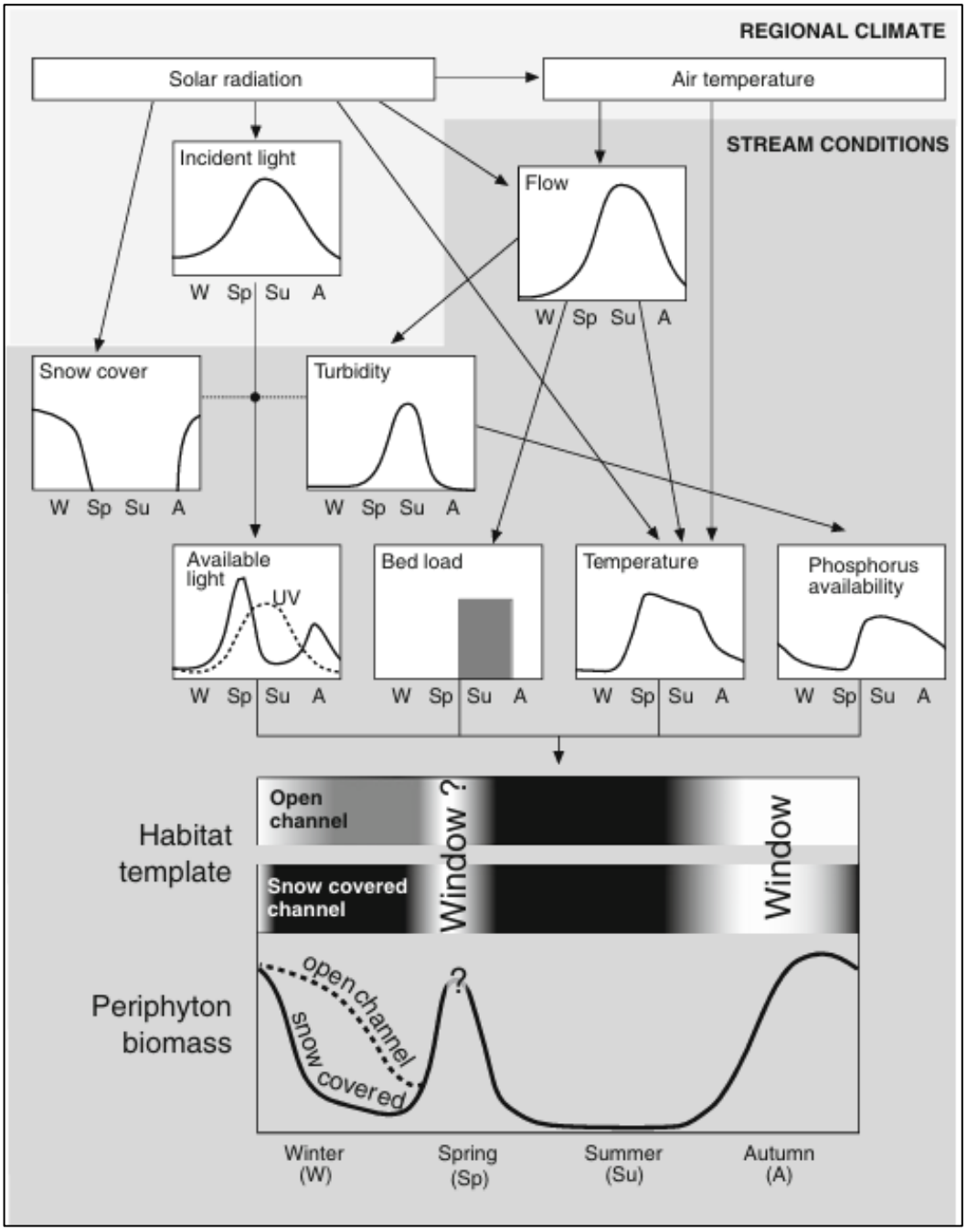

Figure 6: Stylised periphyton growth potential in alpine streams (Uehlinger *et al.*, 2010).

Overall, the current discharge of wastewater to land has maintained a low cover of periphyton near baseline levels. It is envisaged that the proposed increase in wastewater volume at reduced nutrient concentrations will continue to ensure low/rare cover of periphyton that prefer oligotrophic conditions. Noting there may be blooms of didymo that are unrelated to this activity.

4.4 Macroinvertebrates

The Rastus Burn macroinvertebrate compliance monitoring has demonstrated the stream is numerically dominated by *Deleatidium* mayflies, predatory flatworms and worms with a variety of stonefly and true fly larvae with the occasional beetle and caddisfly present (Ludgate, *et al*., 2014). The species present are generally considered to represent cool clear well oxygenated water and are indicative of 'good to excellent' conditions in 2014 (Ryder 2014; Ludgate *et al*., 2014), 'good to excellent' in 2017 (Ludgate, 2017), 'fair to good' in 2023 (SLR, 2023) and 'excellent' (SLR, 2026).

The stream ecology based on the macroinvertebrate community is considered a "healthy and diverse benthic macroinvertebrate communities typical of high gradient alpine streams" (Ludgate, 2017). Monitoring results supporting this opinion are provided in Table 5. The 2013/14 samples demonstrate "excellent" MCI and QMCI metric scores down gradient of the land dispersal site with the 2016/17 demonstrating "good" to "excellent" MCI scores. The 2022/23 results showed a decline in MCI and QMCI values before rising to "excellent" 1500 m downstream of the land dispersal site.

This decline in 2022/23 is likely to be related to elevated nutrient loads at that time although an effluent spill also occurred in 2023 (e3Scientific, 2026a). The results in 2024/25 demonstrate a return to metrics indicative of a macroinvertebrate community in "excellent" condition. In summary, if the increase in wastewater can be managed and treated to ensure there is no increase in total nutrient (nitrogen and phosphorus) load the macroinvertebrate community should remain in "excellent" condition and indicative of a healthy alpine stream.

Table 5: Summary of compliance ecological monitoring (Sources: Ludgate, *et al.*, 2014; Ludgate, *et al.*, 2017; SLR, 2023; SLR, 2026; e3Scientific, 2026a).

Table 6b: Ecological Monitoring		2013-2014	2016-2017	2022-2023	2024-2025	Average
Periphyton	All sites	Absent or rare across all sites	Absent or rare across all sites	Absent or rare across all sites	Absent or rare across all sites, didymo detected at 200 DS for the first time.	-
EPT Taxa%	Upstream	51	44	49	63	52
	50m DS	47	52	39	48	46
	200m DS	49	43	36	60	47
	1500m DS	-	49	54	54	52
MCI Score	Upstream	114	119	99	123	114
	50m DS	125	130	105	130	123
	200m DS	129	117	96	132	119
	1500m DS	-	116	118	134	123
SQMCI Score	Upstream	7.3	7.4	5.6	7.4	7
	50m DS	6.9	7.3	4.9	7.6	7
	200m DS	7.1	6.3	5.2	7.3	6.5
	1500m DS	-	7.1	7.2	7.9	7

Didymo blooms have the potential to alter the macroinvertebrate community present by shifting the species composition from that of larger bodied mayflies and stoneflies to a predominance of smaller bodied diptera larvae and worms (Kilroy, *et al.*, 2009). This can lead to increased macroinvertebrate relative abundance (Bray *et al.*, 2019) but a lowering of the macroinvertebrate metric scores.

Due to the low algal biomass (and low palatability, in the case of didymo) the sparse macroinvertebrate grazer community consists of macroinvertebrates sensitive to organic pollution and those that prefer cool well oxygenated water. The algal food resource will be supplemented with plant material such as tussock leaves that some macroinvertebrate shredders will be able to utilise. In the absence of fish, stonefly and flatworm predators comprise the top trophic level as the dominant macroinvertebrate predators. The macroinvertebrate community has consistently been assessed to be representative of a "good to excellent" macroinvertebrate community although there was a decline in 2023 to "fair to good" before recovering in 2025 to 'excellent" again based on MCI and SQMCI results (SLR, 2023; SLR, 2026).

The ORC Schedule 1A ascertion that rare macroinvertebrates are present above the NZSki base building (1600 m a.s.l.) appears to be based on a study undertaken by Patrick, *et al.*, (1992) that found *Tiphobiosis childi, T. montana, Hydrobiosis kiddi* and *Costachorema hebdomon* as present and considered them local species with aquatic larvae that are not often collected. *Hydrobiosis sp. aff. chalcodes*, which replaces the widespread and common *H. parumbripennis* in the South Island high country, was also found by Patrick, *et al.*, (1992). However, the New

Zealand Threat Classification for Freshwater Invertebrates (Grainger, *et al.*, 2018) does not consider any of these taxa threatened, with only *C. hebdomon* considered At Risk - Naturally Uncommon. Naturally Uncommon taxa are those "whose distribution is confined to a specific geographical area or which occur within naturally small and widely scattered populations, where this distribution is not the result of human disturbance" (Grainger, *et al.*, 2018). However, it is also possible that other data deficient taxa are also present within the waterway.

The instream ecological metrics were low (Fair MCI and Poor QMCI) for the Rastus Burn at the Lake Alta Outlet upstream of the wastewater discharge to land (Table 6) when sampled in autumn 2025 but this is largely driven by the low density and diversity community present in alpine lake outlets (Harding, 1994). Alpine environments have lower diversity due to limited dispersal by adult (flying insect) life stages of the instream macroinvertebrate larvae. Didymo is also known to influence benthic macroinvertebrate communities by increasing species richness (Bray, et al., 2019) and altering the size and type of organisms present to smaller taxa (Kilroy, et al., 2009; Ladrera, et al., 2018). The didymo bloom at the Lake Alta outlet overides the natural low diversity EPT dominated community that would otherwise be present. Whereas, the macroinvertebrate community present nearer the wastewater land dispersal field is still intact and assessed as in "excellent" condition in 2025 (Table 5).

Table 6: Macroinvertebrate raw data.

Macroinvertebrates	**Rastus Burn Lake Outlet**
Diptera	
Chironomus	3
Maoridiamesa	2
Orthocladiinae	1
Limonia	17
Ephemeroptera	
Deleatidium	17
Plecoptera	
Acroperla	1
Zelandobius	1
Trichoptera	
Hydrobiosis	2
Hudsonema	13

Macroinvertebrates	Rastus Burn Lake Outlet
Oligochaeta	64
Abundance	121
Taxa Richness	10
EPT % Abundance	28.1
EPT %Taxa Richness	50
EPT Richness	5
MCI	84
QMCI	3.4
ASPM	0.29
Shannon Diversity Index	1.47
Shannon Evenness	0.64

The majority of the wastewater discharge (63%) (see Table 6; e3Scientific, 2026a) occurs in winter and spring and this is therefore when the sampling is proposed. As such no summertime sampling other than that carried out at the Lake Alta outlet has been undertaken. Water temperature was measure in February 2026 and was 12 °C. This is warmer than the 1.7°C and 5.1°C reported during spring macroinvertebrate sampling but still well below the standardised 20 °C used for the species sensitivity distribution used to develop the DGV (ANZG, 2023).

Overall, the current discharge of wastewater to land was assessed to maintain a macroinvertebrate community indicative of "excellent" health during spring season monitoring by SLR (2026). It is my opinion that the proposed increase in wastewater volume at reduced nutrient concentrations will continue to maintain a macroinvertebrate community indicative of "excellent" health. This is further discussed in Section 6.2. At this altitude the Rastus Burn has a low diversity and abundance of algae and macroinvertebrates. We note that didymo blooms that are unrelated to this activity could alter the macroinvertebrate community at times in the future.

4.5 Fish

Fish have not been recorded in surveys undertaken in the Rastus Burn from 2006 to 2024. Ludgate *et al*. (2014) considered the lower 1 km of the Rastus Burn upstream of the confluence with the Kawarau River to be the only section potentially suitable for colonisation and use by fish. Spatial analysis suggests the lower 1.7 km (to approximately 450 m a.s.l.) is accessible for fish from the Kawarau

River but beyond this point waterfalls and bedrock chutes would exclude upstream fish access (Figure 3).

eDNA data from the Kawarau River at Chards farm collected in April 2025 by the ORC shows the presence of rainbow (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*), perch (*Perca fluviatilis*) and common bully (*Gobiomorphus cotidianus*) (Figure 3). Kōaro (*Galaxias brevipinnis*) and longfin eel (*Anguilla dieffenbachii*) are also known from Lake Whakatipu. eDNA results in this study collected from the lower Rastus Burn below the gorge sections in February 2026 identified the eDNA of kōaro, brown trout and rainbow trout. Trout are unable to pass the waterfalls and chutes within the Rastus Burn without human assistance, while kōaro are the only fish potentially able to migrate upstream past waterfalls and bedrock chutes. Notwithstanding this point it is very unlikely that kōaro would be present in the upper Rastus Burn due to the number waterfalls and the lack of kōaro recorded in the area above 1100 m a.s.l.

The absence of fish above the Rastus Burn Gorge and including Lake Alta is confirmed by reviewing nearby fish survey records from the NZFFDB and Wilderlab eDNA records.

4.6 Wetlands

Based on aerial photograph analysis two seepage wetlands are present in close proximity to the wastewater dispersal field. The potential wetlands are situated 32 and 80 metres down gradient and at distance of 130 and 250 m north-west of the wastewater dispersal fields in area A and potentially closer if identified in Area C (Figure 7). On a separate flow gauging trip e3s staff noticed wet areas (no wetland delineation was undertaken to confirm if they were natural inland wetlands) within area A approximately 130 m north-west of the dispersal fields (Figure 8). The hydraulic connection of the wetlands to groundwater is unclear. However, if connected, it is possible wetlands will experience a slight increase in flow in response to the proposed increase in wastewater volume.

Given the proposed nutrient loadings are similar to the current situation and only a slight increase in flow predicted, e3scientific would not expect to see a measurable effect on these wetlands.

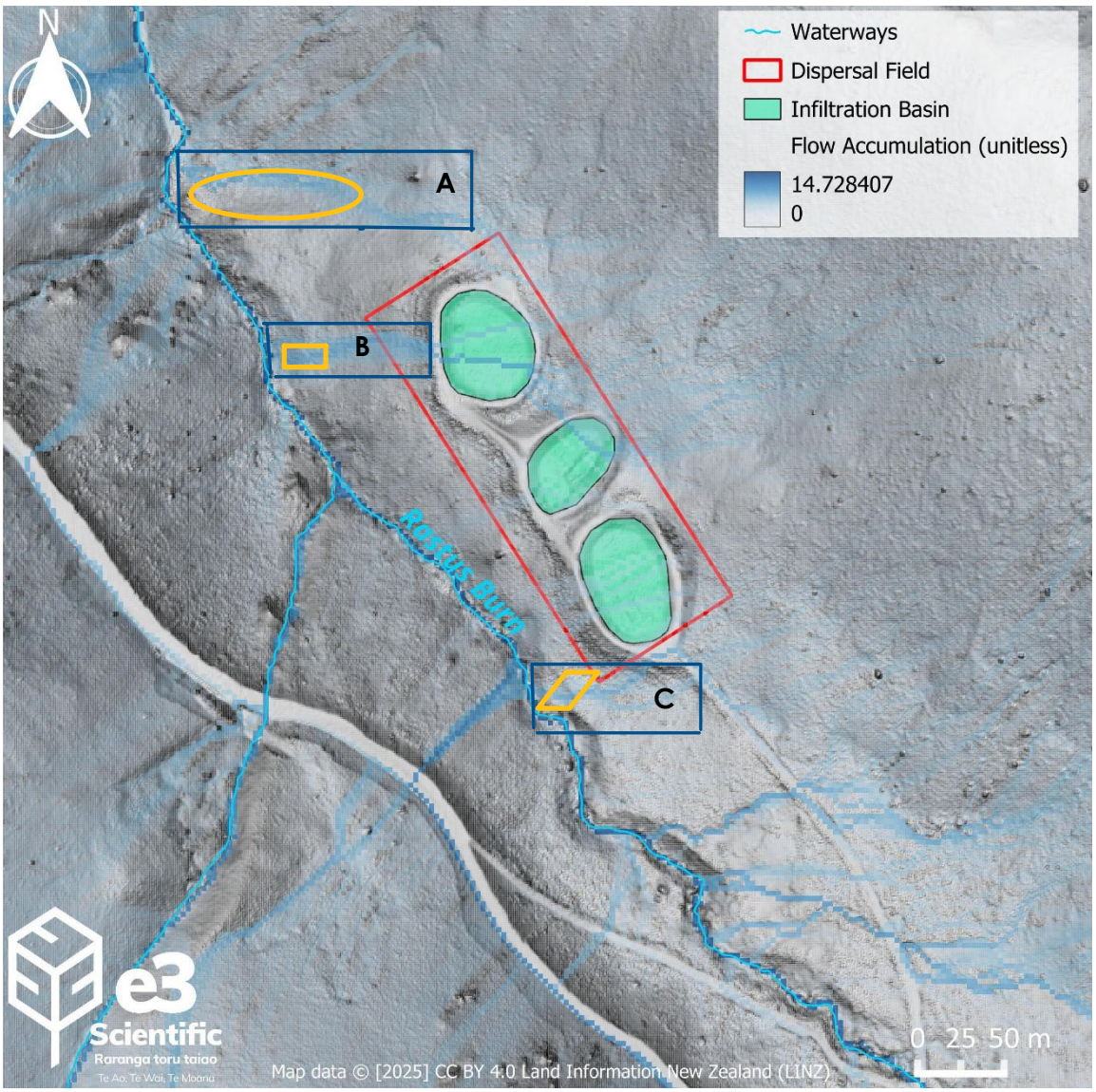

Figure 7: Flow paths near the dispersal field and potential wetland areas within 100 m marked with blue rectangles and likely wetland areas within orange shapes.

Figure 8: Example images of wet areas found within Area A.

5 Ecological Values

5.1 Assessment of Ecological Value following the EIANZ Guidelines

Under the EIANZ guidelines (Roper-Lindsay, 2018) ecological value is assigned based on the following assessment matters as summarised in Table 7 below:

- Representativeness
- Rarity and Distinctiveness
- Diversity and Pattern
- Ecological Context

The representative criteria is more difficult to utilise within the freshwater environment as it relies on a range of information to support the assessment. More easily incorporated into the EIANZ criteria are rarity, diversity and ecological context in the freshwater environment which is utilised to support an assessment of ecological value. These matters are each assessed on a five point scale from Negligible to Very High.

Representativeness

The representativeness value for the freshwater environment includes the extent to which the site is typical of the natural characteristics, catchment size, stream order, standing water characteristics and taxa present. Therefore, it is appropriate that sites classified as unmodified or representative are recognised with a higher value under the Representative criteria. An unmodified or more natural site or area is likely to be a better representative example than a more modified one; some people consider that representativeness is broadly equivalent to "naturalness".

Rarity / Distinctiveness

The New Zealand Threat Classification System (NZTCS) is used to assess the threat status of fish (Dunn, et al., 2025), freshwater macroinvertebrates (Grainger, et al., 2018), terrestrial and aquatic plants (de Lange, et al., 2023) and birds (Robertson, et al., 2021). This impact assessment has utilised these NZTCS reports to inform an assessment of rarity. However, rare habitats, communities or ecosystem types should also be considered.

Diversity and Pattern

The desktop research undertaken within this report of the NZFFD, Shannon Diversity Index and Richardson & Jowett (1996) provide the basis for an assessment of diversity at the proposed site. Diversity and pattern can include physical and biological diversity. Underlying physical patterns such as lower fish diversity at greater altitude or temporal gradients. Long-term trends and taxa density can also be considered.

Ecological Context

Ecological context describes an ecosystem's role in ecosystem functioning. Examples may include:

- freshwater and terrestrial habitat may provide an important food source for fish and/or birds.
- freshwater and terrestrial habitat may play an important part in the lifecycle of a species e.g. breeding or spawning locations for macroinvertebrate, bird or fish species.
- Macroinvertebrate metrics or TICI scores.

For the purpose of this assessment habitats that support Threatened and At - Risk species, are biologically diverse, provide an important food source or play a critical role in the lifecycle of a species are considered to have a high ecological value.

Table 7: Assessment of the Rastus Burn habitat using the ecological criteria in the EIANZ Guidelines.

Matter	Criteria	Score
Representativeness	The Rastus Burn is typical of an alpine stream in Otago with a steep rocky catchment. Permanent flow with a tarn in the headwaters. An algal and macroinvertebrate community representative of cool, clear water, where indigenous species dominate is present. Expected guilds and species assemblage present for this altitude. Reasonably low taxa richness due to the	High

Matter	Criteria	Score
	alpine cold conditions with snow covering the ground for at least 4 months of the year. Community likely to be very similar to 1840 baseline community.	
Rarity/distinctiveness	The Rastus Burn does not support any rare or threatened fish. It does support a population of At Risk - Naturally uncommon caddisfly upstream of the wastewater discharge site. High macroinvertebrate predator numbers due to the lack of fish.	Moderate
Diversity and pattern	There is naturally low diversity in the algal and macroinvertebrate community present instream and an absence of fish. Alpine stream environments have lower diversity due to limited dispersal by adult (flying insect) macroinvertebrate life stages.	Low
Ecological context	The harsh alpine environment limits the community able to reach the upper Rastus Burn, and the growth rates and survivorship of those that do. This leads to low instream productivity with a low diversity and abundance of instream algae and macroinvertebrates and a community that is fishless. This is similar to other alpine streams in the region.	Moderate

5.2 Summary of Ecological Values

In summary the cold, clear, well oxygenated water of the Rastus Burn and stable rock substrates free of fine sediment provide for an algal community typical of alpine environments with low cover of a few species including diatoms and filamentous red algae. The low algal biomass and allochthonous tussock leaves in turn provide a constrained food resource for the limited macroinvertebrate

community present that comprises of taxa sensitive to organic pollution and that prefer cool well oxygenated water.

The macroinvertebrate community has consistently been considered to be representative of a "good to excellent" macroinvertebrate community through consent monitoring downstream of the wastewater dispersal field. The recent introduction of didymo to the Rastus Burn catchment headwaters (Lake Alta outlet) could mean that blooms may occur in the future throughout the Rastus Burn and this could alter the macroinvertebrate community composition during didymo bloom events.

The EIANZ Guidelines provide guidance on how to combine the 4 matters assessed above. Combining the 1 High, 2 Moderate and 1 Low matter results in an overall **Moderate Ecological value** for the Rastus Burn near the NZSki site and wastewater dispersal fields.

6 Ecological Impact Assessment

6.1 Ecological Impact Assessment Methodology

This ecological impact assessment (FEcIA) follows the EIANZ Ecological Impact Assessment Guidelines for New Zealand. The guidelines are based on the assessment of the ecological values present within the disturbance area of the proposed wastewater dispersal field (see Section 2). The magnitude of the effect within the zone of influence and the wider context of species populations and extent of remaining freshwater habitat is then considered to establish the level of ecological effect.

The FEcIA guidelines provide a series of tables that assist with the assignment of value to the ecological features that will be disturbed and the magnitude of the activity. These tables are provided in Table 8 & 9 and referred to in the discussion below. A summary of the ecological effects and the measures employed to avoid and mitigate the ecological effects of the proposed works are presented in Table 9.

6.1.1 Assigning Magnitude of Effect

The EIANZ guidelines provide criteria for assigning the extent of the effects on the ecological values within the area that may be disturbed by the activity. This assessment adopts the criteria for describing magnitude of effect and is provided in 8 below.

Table 8: Criteria for describing magnitude of effect (Roper-Lindsay, *et al.*, 2018).

Magnitude	Description
Very High	Total loss of, or very major alteration to, key elements/features/ of the existing baseline conditions, such that the post-development character, composition and/or attributes will be fundamentally changed and may be lost from the site altogether; AND/OR Loss of a very high proportion of the known population or range of the element/feature.
High	Major loss or major alteration to key elements/features of the existing baseline conditions such that the post-development character, composition and/or attributes will be fundamentally changed; AND/OR Loss of a high proportion of the known population or range of the element/feature
Moderate	Loss or alteration to one or more key elements/features of the existing baseline conditions, such that the post-development character, composition and/or attributes will be partially changed; AND/OR Loss of a moderate proportion of the known population or range of the element/feature

Magnitude	Description
Low	Minor shift away from existing baseline conditions. Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances or patterns; AND/OR having a minor effect on the known population or range of the element/feature
Negligible	Very slight change from the existing baseline condition. Change barely distinguishable, approximating to the 'no change' situation; AND/OR having negligible effect on the known population or range of the element/feature

6.1.2 Assigning Level of Effect

The level of ecological effect is based on combining the ecological value of an environment that may be impacted by the proposed activities and the magnitude of the effect.

Table 9 is adapted from the EIANZ guidelines to provide a level of effect matrix. For the purpose of this assessment, where the level of effect is moderate or above, a management response is required to ensure potential environmental effects are managed appropriately. An effect level of Low or Very Low indicate the effect is ecologically less than minor.

Table 9: Criteria for describing level of effect (Roper-Lindsay, *et al.*, 2018).

		Ecological Value			
		Very High	**High**	**Moderate**	**Low**
Magnitude	**Very High**	Very High	Very High	High	Moderate
	High	Very High	Very High	Moderate	Low
	Moderate	High	High	Moderate	Low
	Low	Moderate	Low	Low	Very Low
	Negligible	Low	Very Low	Very Low	Very Low
	Positive	Net Gain	Net Gain	Net Gain	Net Gain

6.1.3 Residual Impact

The residual impact is the final impact level assigned to the proposed activity and potential effects once proposed mitigation/remediation options have been applied and is outlined in Table 9.

6.2 Wastewater Discharge Effects

The activity considered is the increase in wastewater volume from 127 m^3/day to 204 m^3/day discharged to a land infiltration system near the Rastus Burn Stream an increase of 77 m^3/day. Although it should be noted that further work is proposed to be undertaken to confirm the volume of wastewater and associated nutrient loads more accurately (e3Scientific, 2026a). E3s and Stantec have both proposed nutrient load performance criteria to maintain ecological values, there are known issues with bywash and the magflow meter that may explain the differences between the e3s and Stantec annual nutrient loads. The e3scientific performance criteria for nutrient loads are based on a current average annual load of 498 kg/N/Yr and 64 kg/P/Yr (e3Scientific, 2026a). However, the actual mean nutrient load may be as high as 750kg/N/yr or higher based on other modelled methods (Stantec, 2026). Further investigation is proposed to reconcile these numbers.

It is proposed that the wastewater treatment system will be upgraded to maintain water quality. This will enable the greater volume of wastewater to be treated and disposed to land without increasing the annual nutrient load above current levels. The current nutrient loads have been assessed to not be adversely affecting the freshwater ecology of the Rastus Burn (provided there are no discharges of untreated wastewater directly to the stream) (e3Scientific, 2026a).

Wastewater discharges can pose a particular risk to alpine streams because small increases in nutrient concentrations can cause large ecological responses in these naturally oligotrophic systems. Inputs of nitrogen and phosphorus can stimulate algal growth, shift periphyton communities toward nutrient-tolerant species, and alter food-web structure in streams that typically support very low productivity. These nutrient-driven changes may be compounded by associated stressors such as elevated water temperatures, reduced dissolved oxygen associated with microbial contamination, and the introduction of trace contaminants including pharmaceutical products. Alpine biota are poorly adapted to such changes, meaning wastewater discharges can influence ecological condition at relatively low loading rates and the potential effects of these are considered for the Rastus Burn in Sections 6.2.1 to 6.2.3.

6.2.1 Nutrient Enrichment

A potential effect of the discharge of wastewater to is to increase nutrient levels in the Rastus Burn and the downstream aquatic habitats. Increased nutrient loads have been shown to generally influence algal community growth rates and composition. Nitrogen and phosphorus have both been found to limit overall algal growth at low concentrations in streams although algal taxa vary in their nutrient requirements. In turn algae can have strong effects on the invertebrate community present. The Rastus Burn has a low diversity macroinvertebrate community dominated by pollution sensitive mayflies and is naturally fishless at this location. Small nutrient increases may increase algal growth rates and associated macroinvertebrate grazer densities as the system becomes more productive. A minor shift in in macroinvertebrate densities would suggest the ecosystem is absorbing the increased productivity. A shift in the spring or autumn algal composition and biomass and an associated shift in the macroinvertebrate composition would be indicative of a more degraded ecosystem.

It is proposed that the wastewater treatment system will be upgraded to provide enhanced treatment over the existing system. This will enable the greater volume of wastewater to be treated and disposed to land without increasing the annual nutrient load above the design levels of wastewater as per the currently proposed performance criteria (e3Scientific, 2026a; Stantec, 2026, Appendix B and C). The current nutrient loads have been assessed to not be adversely affecting the freshwater ecology of the Rastus Burn (provided nutrient loads remain below 2023 levels and there are no discharges of untreated wastewater directly to the stream) (Ludgate, 2017; SLR, 2026; e3Scientific, 2026a). There are complexities with the wastewater volumes, nutrient loads and compliance monitoring data utilised and uncertainties with ecological impacts present in 2023, as such further investigations are recommended.

The Rastus Burn currently has low nutrient concentrations recorded near the wastewater dispersal field but typically slightly elevated above background levels. Therefore, the predicted increase in wastewater volume to a maximum of 204 m^3/day and stable nutrient load maintained at no greater than the proposed performance criteria (Appendix B and C) will equate to a Low magnitude and a Low level of effect.

Nutrient triggers have been proposed as an early warning system for when nutrient levels may start to influence periphyton biomass. A dissolved inorganic

nitrogen (DIN) trigger of 150 mg/m^3 and dissolved reactive phosphorus (DRP) >6 mg/m^3 have been proposed. Nutrient concentrations above these levels may lead to periphyton growth that exceeds the proposed periphyton benthic biodiversity limits. Below this level the DIN and DRP levels are considered low risk (Matheson, *et al,* 2012). The nutrient levels predicted to relate to 50, 120 and 200 mg/m^3 of Chl *a* (the measure periphyton biomass) have all been developed for larger lower altitude waterways (Appendix D). However, the DIN and DRP values proposed are a useful indicator for the potential of periphyton growth beyond the present levels within this cold-water steep, incised alpine waterway.

The New Zealand Periphyton Guideline (Biggs, 2000) recommended a periphyton limit of 50 mg/m^2 of Chl *a* to maintain benthic biodiversity. The Rastus Burn through the zone of influence currently has low periphyton biomass and a benthic macroinvertebrate community with high proportions of sensitive taxa. Therefore, it is proposed to meet this guideline value to help ensure benthic biodiversity is maintained.

When existing nutrient (DIN and DRP) levels are assessed against the periphyton risk assessment bands of Matheson *et al.* (2012) the summer/autumn nutrient concentrations are on average lower than winter/spring concentrations for DIN within the Rastus Burn (Figure 9). The higher DIN levels observed in winter align with the peak ski season discharge occurring. The periphyton risk bands proposed for DIN are overlayed with the measured Rastus Burn nutrient concentrations. The data demonstrates the majority (93%) of summer/autumn samples are within the low or very low periphyton risk band. For the winter and spring results there is a higher proportion (~30% of samples) that are within the moderate or high risk bands; however, during this time periphyton is limited by environmental constraints (temperature and light).

The majority (93%) of summer/autumn DIN concentrations are within the low or very low periphyton risk band and therefore it is very unlikely that periphyton growth will exceed the 50 mg/m^2 of Chl *a* threshold (Figure 9). Thus, while the water temperatures will be warmer than 10 °C in summer the overall concentrations of DIN are small, enabling an acceptably low level of periphyton growth. Therefore, summer DIN concentrations alone are not expected to lead to excessive growths that would alter the benthic biodiversity. In autumn the temperatures are typically cooler than 10 °C, so while concentrations may slightly

increase as flows decrease, again the conditions are such that only an acceptably low level of periphyton growth occurs.

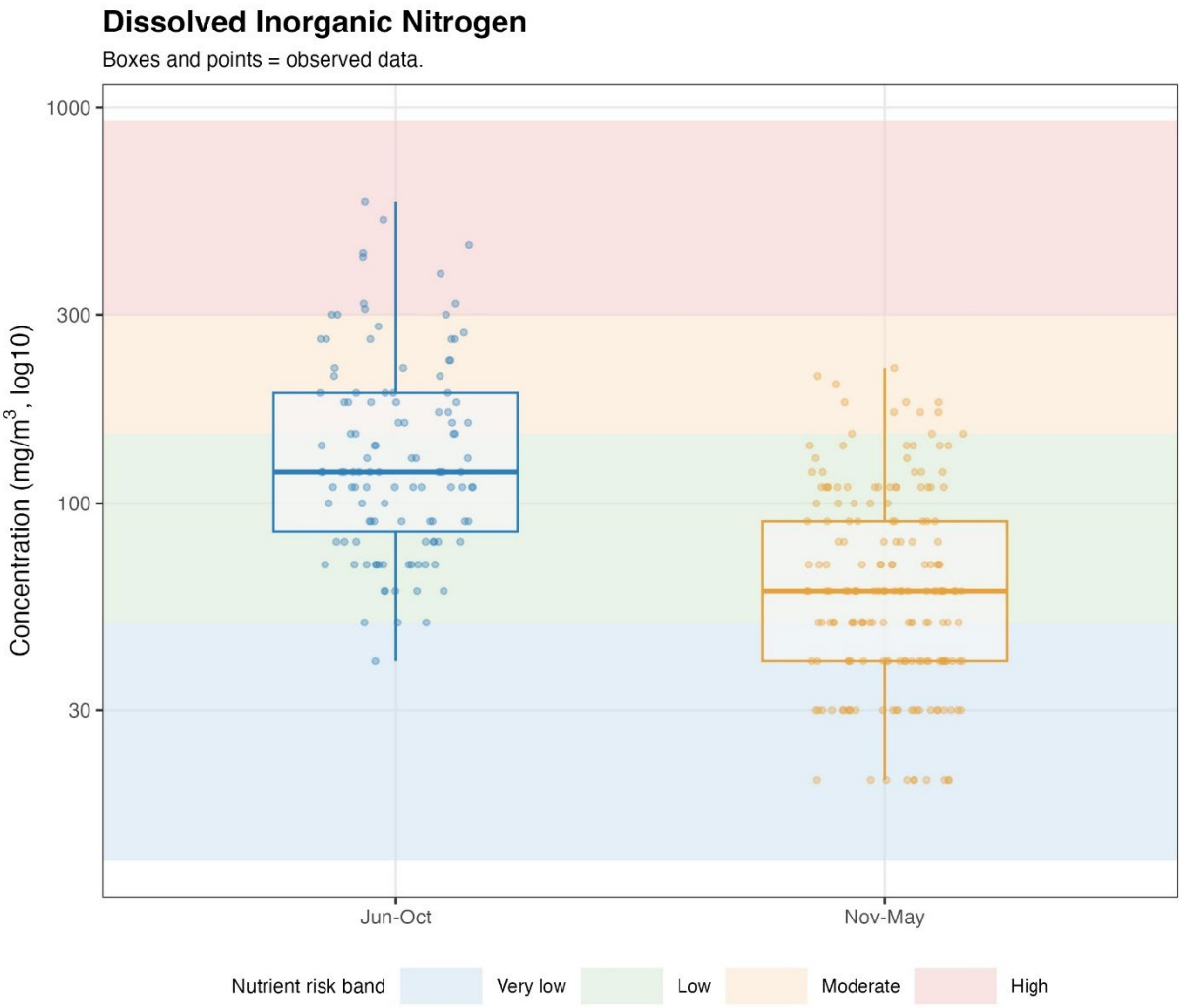

Figure 9: Seasonal dissolved inorganic nitrogen sample results from the Rastus Burn (modified from Ellis-Stanley (2026)) with DIN periphyton growth risk bands overlain.

For DRP the summer/autumn results show the majority (75%) of summer/autumn samples are within the low or very low periphyton risk band. With the majority of nutrient concentrations falling within the low to very low risk category it is very unlikely that periphyton growth will exceed the 50 mg/m^2 of Chl *a* threshold.

The winter/spring results show the majority (68%) of winter/spring samples are within the low-risk band but approximately 25% of results demonstrate moderate or high risk (Figure 10). However, due to the very cold winter water temperatures (~3 ^{o}C) algal growth is very unlikely at that time.

While 25 to 30% of samples across all seasons exceed the low risk band threshold it is unlikely that this will lead to excessive periphyton growth. This is because even in when water temperatures are warmer than 10°C other factors are more important than nutrient concentration alone, such as the amount of light reaching the streambed, the algal taxa present and the flow regime. This is demonstrated by prolific algal growths not being observed previously which suggests that dissolved reactive phosphorus (DRP) is not as important as other factors such as flow regime, light and water temperature for algal growth at this location. Therefore, there is a low periphyton growth risk associated with DRP.

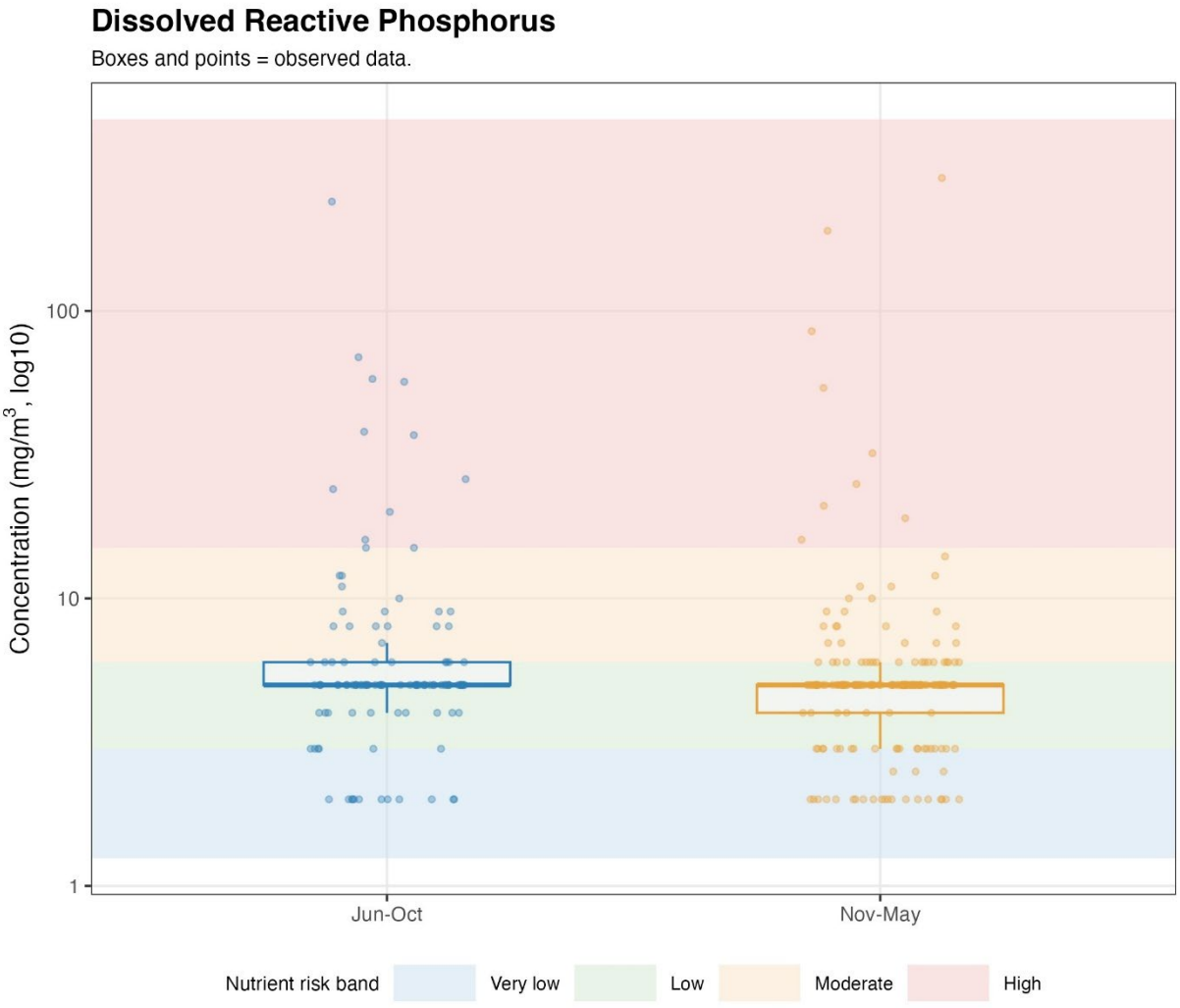

Figure 10: Seasonal dissolved reactive phosphorus sample results from the Rastus Burn (modified from Ellis-Stanley, (2026)) with DRP periphyton growth risk bands overlain.

However, continued monitoring is recommended and outlined below to ensure the level of effect is confirmed as Low;

- Every second year, monitoring of periphyton composition and biomass within the Rastus Burn upstream and downstream of the infiltration dispersal fields is recommended during Spring (November/December) and autumn (March/April). The periphyton biomass should be maintained below 50 mg/m^2 of Chl *a*.
- If measured Chl *a* exceeds 50 mg/m^2 at any downstream monitoring site this will trigger an assessment of whether the discharge of treated wastewater is responsible for the exceedance and propose mitigation measures to reduce algal biomass if required.
- Every second year, monitoring of macroinvertebrate taxa densities, community composition and EPT, MCI, SQMCI metrics within the Rastus Burn upstream and downstream of the infiltration dispersal field is recommended and is to be compared to previous surveys.

6.2.2 Ammonia Toxicity

The majority of the nitrogen load (ammonia) is applied to land in winter/spring and passes through the land and groundwater to the Rastus Burn within a month. Ammonia concentrations within the Rastus Burn during the ski season typically peak at levels of 0.2 mg/L, about an order of magnitude below the DGV of 0.55 (See Figure 12; e3Scientific, 2026a). As the ammonia concentrations are well below the toxicant guidelines adverse risks in relation to ammonia toxicity is low, although a documented July 2023 leak caused a short-term exceedance which we have treated as an anomaly (e3Scientific, 2026a). Ammoniacal nitrogen is toxic when concentrations exceed what aquatic fauna can process; however, because Rastus Burn's temperature and conductivity are below the generic DGV parameter thresholds (<10°C and <50 µS/cm), the 99% DGV for total ammoniacal nitrogen (TAN) at pH 7.2 and 10°C was conservatively applied. At such cold temperatures little unionised ammonia is expected, meaning the instream water quality meets the 99% DGV for ammoniacal nitrogen. Ammonia toxicity is known to increase with warmer water temperatures, but again given the reduced loading during summer and instream temperatures only reaching a range of ~8-12 °C (Ludgate, *et al*., 2014; e3Scientific, 2026a), impacts are not anticipated.

To-date ammonia toxicity within Rastus Burn has not been identified as occurring and the ecology of the stream shows no indication of this potential effect of

wastewater discharges (except for the potential leak event in 2023). Therefore, provided the proposed discharge maintains the current nitrogen loads and Ratus Burn total ammoniacal nitrogen at the same levels as currently present, ammonia toxicity is not anticiapted to be an issue. The following paragraphs outline further reasoning for this conclusion.

The ammonia levels currently found within the Rastus Burn are much lower than the 99% species protection toxicty level for the relevant seasonal pH and tempertures. The 99%ile DGV for ammonia at the maximum measured pH and temperature for each season are presented in Table 10 of e3Scientific, (2026a). Seasonal total ammoniacal nitrogen DGVs ranged from 330 mg/m^3 to 450 mg/m^3 for summer to winter and spring was lower at 180 mg/m^3 (Figure 11; ANZG, 2026). None of the seasonal specific guideline values have been exceeded to-date (Figure 12).

Summer, autumn and spring results are generally lower than winter sample results (Figure 11 and 12); however, winter and spring concentrations show greater variation (Figure 12).

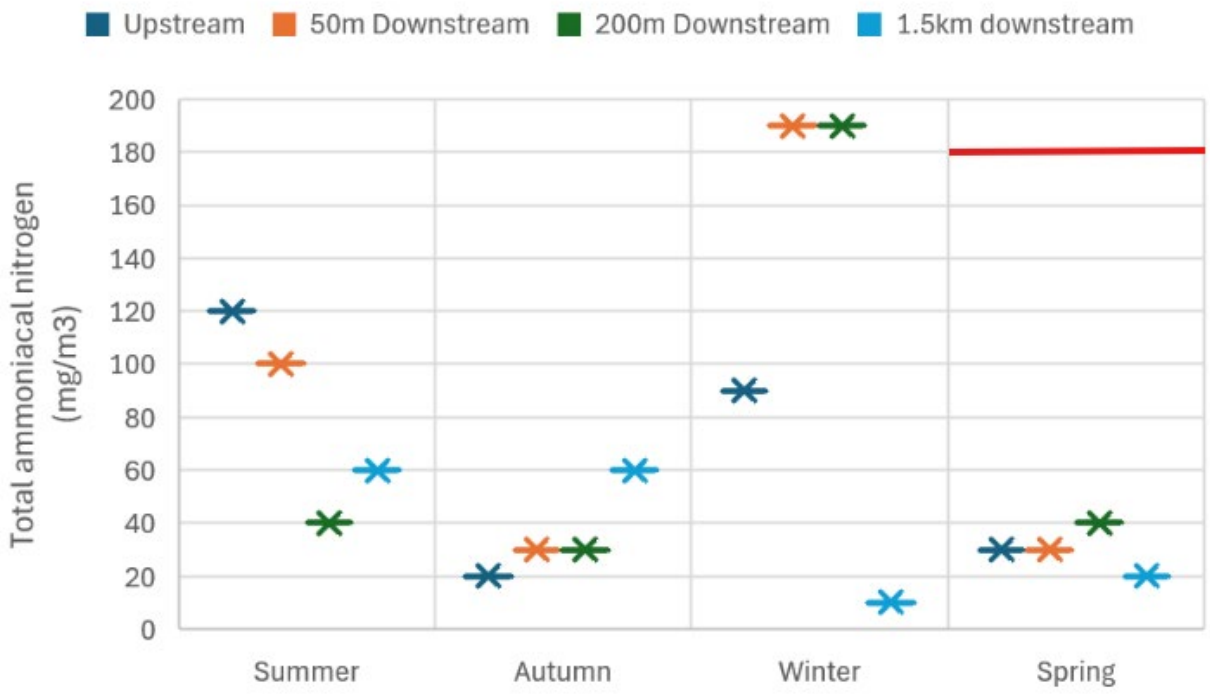

Figure 11: Maximum seasonal total ammoniacal nitrogen with 99%ile DGV shown in red for spring other seasons are beyond the graph scale).

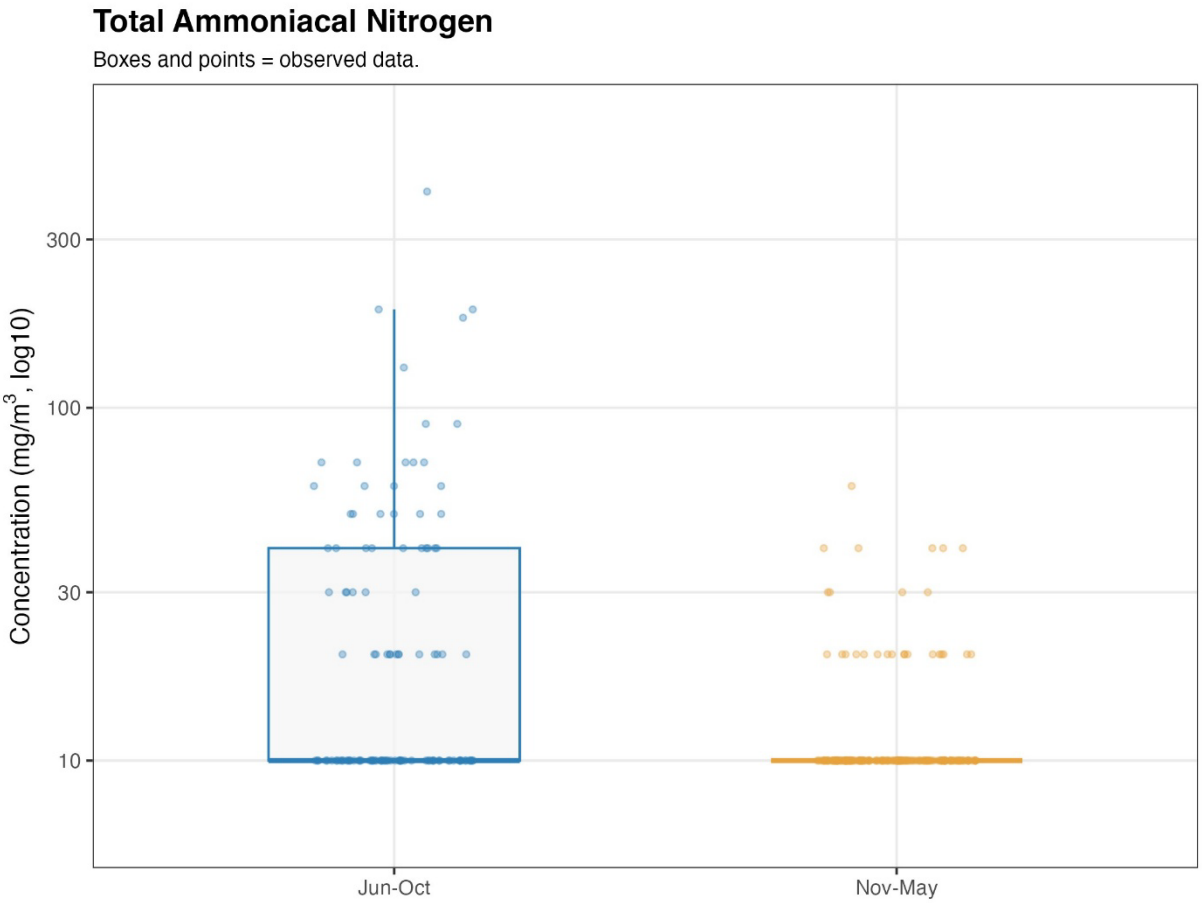

Figure 12: Seasonal total ammoniacal nitrogen consent monitoring results for all sites.

When specific macroinvertebrate taxa present have been specifically tested, they have all demonstrated ammonia toxicity susceptibility at levels much greater than that proposed to be present within the Rastus Burn. Specifically, the mayflies *Coloburiscus humeralis* 7200 mg/m^3 and *Deleatidium sp*. 3200 mg/m^3 along with the native snail *Potamopyrgus antipodarium* 4400 mg/m^3 (ANZG, 2026) all have toxicity thresholds higher than the current instream concentrations. Therefore, it is very unlikely the aquatic macroinvertebrate community present will be adversely affected due to ammonia toxicity.

Figure 13 demonstrates there is no trend in relation to stream flow with total ammoniacal nitrogen. A curve could not be fitted to the dataset although there is a spike at moderate flow that appears to be related to an upstream source. Once Rastus Burn flow data is available a TAN concentration:flow curve may be possible, but based on the current dataset it seems unlikely to be useful in demonstrating a relationship between TAN and flow.

As demonstrated within e3Scientific - Wastewater Discharge Impact Assessment, (2026a) all data is below the 99% ammonia toxicity guidelines. Based on the above, ammonia toxicity is not assessed to be an issue at any time of year or at any flow for the Rastus Burn provided nutrient loads are maintained at current levels.

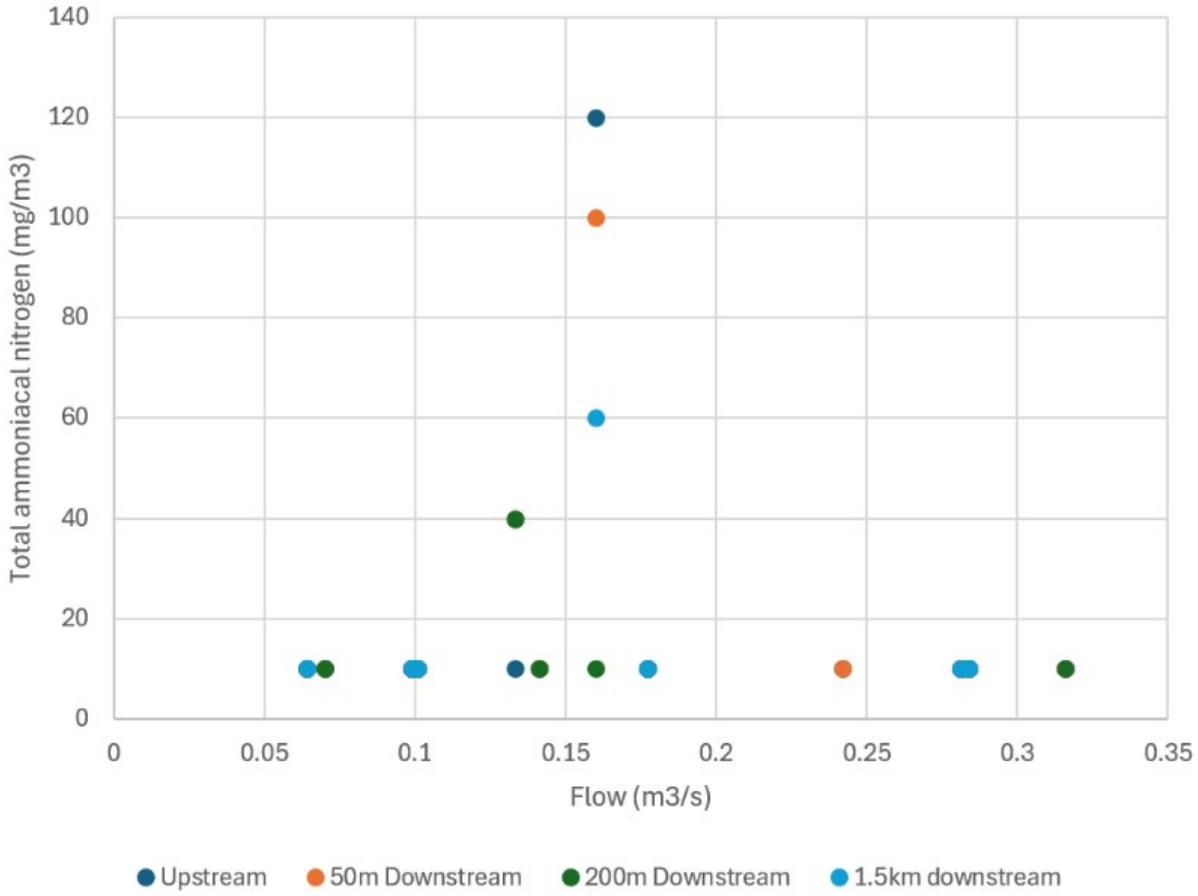

Figure 13: Total ammoniacal nitrogen for 2025 and 2026 with the associated modelled flow.

6.2.3 Reduced Dissolved Oxygen

The Rastus Burn is well oxygenated (near 100%) and a reduction to even 90% may be ecologically meaningful at this location. However, the wastewater discharge is to land via dispersal field soakage, and as such instead of organic material entering the Rastus Burn water column directly, it is intercepted by soil filtering and microbes. This strips out the organic matter that drive biological oxygen demand (BOD) before the water reaches the Rastus Burn. So, while a potential effect of the discharge of wastewater is reduced oxygen levels due to high oxygen

demand of the wastewater. This is unlikely provided the wastewater treatment system and infrastructure is installed and maintained to design specifications.

Therefore, the magnitude of effect is considered Negligible. The Moderate ecological value of the stream combined with the Negligible magnitude of effect results in a Very Low level of effect. Therefore, no management actions are recommended.

6.2.4 Thermal Change

The wastewater piping is to be thermally protected to protect against freezing. The treated wastewater is then pumped to the land infiltration site and the wastewater will approximate air temperature before soaking into the infiltration field and soils. The wastewater is expected to mix with cool groundwater before upwelling and entering the Rastus Burn.

The Rastus Burn is a cold water stream with low thermal buffering capacity. If the wastewater entering the stream was much warmer than the stream this can lead to thermal shock of cold adapted taxa. Warmer water may hold less oxygen and disrupt reproductive success of alpine adapted species with reduced egg viability or higher larval mortality in favour of more generalist taxa (Werry, *et al.,* 2026). The likelihood of thermal shock is extremely low due to the wastewater acclimatising to air temperature in the infiltration field at the land dispersal site and mixing with cool groundwater prior to entering the stream.

The predicted temperature change equates to a Negligible magnitude and a Very Low level of effect. Therefore, no management actions are required.

6.2.5 Wetland Hydrology

The proposed increased wastewater discharge volume has potential to alter receiving wetland hydrology. It is likely this will provide a positive effect to the wetlands with a greater stable winter supply of groundwater. However, it is recommended that the areas outlined in Figure 7 are delineated for the presence of wetlands. If present and within 100 m of the dispersal fields the wetlands should have their current status (wetland type, hydrology and vegetation community) characterised and be monitored (wetland hydrological regime and vegetation) to assess the potential effects of the increased wastewater discharge on the wetlands.

7 Conclusions and Recommendations

NZSki are anticipating an increase in customers and therefore an increase in the volume of domestic wastewater requiring treatment and discharge to land at the Remarkables Ski field area. The wastewater currently undergoes primary treatment and screening before being disposed to 3 dispersal fields for land infiltration. The nearby Rastus Burn has Moderate ecological values. The existing wastewater discharge to land has resulted in stable periphyton and macroinvertebrate communities, excluding the elevated loads and a systems failure in 2023. The proposed activity is for an increase in wastewater volume to 204 m^3/day. It is proposed that this increased volume of wastewater will have an enhanced treatment system underpinned by discharge performance criteria before discharging to land in the current location. Further work is proposed to be undertaken to confirm the volume of wastewater and associated nutrient loads more accurately. The performance criteria currently proposed are based on the best information currently available.

The proposed increased wastewater discharge is assessed within this report to have a "Low" level of effect on the aquatic ecology values (e.g. instream algae, alpine invertebrate community and ecological processes) present. However, monitoring is proposed to help ensure potential effects on the ecological values present are "Low" for the increased wastewater volume.

The project proposes to monitor DIN and DRP from 1 November to 31 May (off-season) as this is the time of year when periphyton growth is possible, based on environmental limiting factors of water temperature and light. Nevertheless, monitoring of nutrients across the off-season is proposed via a trigger and response system. This allows for monitoring to potentially initiate further investigation and then management actions, if ecological thresholds are exceeded (Table 10).

The periphyton assessment (Appendix D) has outlined that DIN at >150 mg/m^3 or DRP >6 mg/m^3 from Matheson *et al.* (2012) are appropriate trigger levels to maintain low periphyton biomass, at this location. If initial trigger levels are exceeded the response to collect further water samples is to identify if nutrient concentrations are ambient or if this was a discrete, short, spike in concentration or laboratory anomaly. Ambient concentrations are more likely to result in an

ecological (periphyton or macroinvertebrate) shift, whilst a one-off, discrete spike in concentration will not. Whilst undertaking this additional sample, observations of periphyton cover will assist in quickly understanding the nature of the exceedance (ambient or discrete). The results of this visual observation can also initiate trigger 2 responses, if >10% cover of periphyton is observed, it is more likely that the water sample does represent ambient conditions (Table 10). This allows for management responses to be actioned faster resulting in reduced likelihood of ecological effects.

Macroinvertebrates are the last ecological indicator to be affected in this response train, as communities will take time to exhibit an alteration based on nutrient input and periphyton presence (food source). However, if changes are identified then a full review of the wastewater treatment system and onsite practices is warranted, and to be undertaken with actions to remedy the source of the nutrients and periphyton growth to be provided to the Otago Regional Council (ORC) for certification within 20 working days of the macroinvertebrate sampling results.

Table 10: Summary of proposed monitoring, triggers and response actions.

Trigger		Response
Trigger 1	If a monthly water quality monitoring result collected between 1 November and 31 May (n =7) at any downstream site exceeds the site-specific trigger limit for: - Dissolved inorganic nitrogen (DIN) of >150 (mg/m^3); and/or - dissolved reactive phosphorus (DRP) of > 6 (mg/m^3).	- Undertake an additional water quality monitoring round, including temperature and visual assessment of periphyton cover. and; - Review of nutrient exceedance against upstream sample results within 2 weeks of receiving the of the water quality results.
Trigger 2	If monitoring required under Trigger 1 response also demonstrates an exceedance of the nutrient triggers OR if obvious (>10% cover) periphyton is observed	- Undertake Chl *a* sampling (Periphyton monitoring).

Trigger		Response
Trigger 3	If monitoring required under Trigger 2 demonstrates an exceedance of the periphyton trigger (50 mg/m^2 Chl *a*).	- Undertake macroinvertebrate sampling and review results against the upstream control, if macroinvertebrate metrics of two of the three metrics are 10% lower in comparison to the upstream control this would be deemed an adverse ecological impact. - An audit and review of the wastewater treatment system and onsite practices to identify the reason for any elevated nutrient concentrations, and any potential measures to reduce them. This assessment is to be supplied to ORC within 20 working days of the trigger exceedance. - Provide a response plan to ORC within 3 months of receiving the results. The plan should include a review of the relevant wastewater treatment measures and the likely source of the periphyton exceedance and propose remedial actions.

The management framework provides strong ecological safeguards by ensuring wastewater treatment to meet performance criteria and control discharge volumes. Land-based infiltration further reduces contaminant loading to the Rastus Burn, while robust operation, maintenance, and risk-management planning to meet defined performance criteria enables environmental protection thresholds to be met. A comprehensive monitoring programme covering periphyton, macroinvertebrates, and downstream wetland condition provides early detection of ecological change. The proposal promotes the avoidance and mitigation of adverse effects to protect stream health.

The recommended monitoring actions are summarised below:

- Every second year, monitoring of periphyton composition and biomass within the Rastus Burn upstream and downstream of the infiltration dispersal fields is recommended during Spring (November/December) and autumn (March/April). The periphyton biomass should be maintained below 50 mg/m^2 of Chl *a*.

- If measured Chl *a* exceeds 50 mg/m^2 at any downstream monitoring site this will trigger an assessment of whether the discharge of treated wastewater is responsible for the exceedance and propose mitigation measures to reduce algal biomass if required.
- Every second year, monitoring of macroinvertebrate taxa densities, community composition and EPT, MCI, SQMCI metrics within the Rastus Burn upstream and downstream of the infiltration dispersal field is recommended and is to be compared to previous surveys.
- If measured EPT, MCI or SQMCI metrics exceed the upstream control score at any of the downstream monitoring sites for two of the three metrics this will trigger an assessment of whether the discharge of treated wastewater is responsible for the change and propose mitigation measures to reduce impacts on benthic ecology.

- Wetland delineation of area downgradient and within 100 m of the land dispersal field.
- Monitoring of any delineated wetlands downgradient (within 100 m) of the land dispersal field for wetland hydrological regime and vegetation community to ensure wetlands remain healthy every two years.

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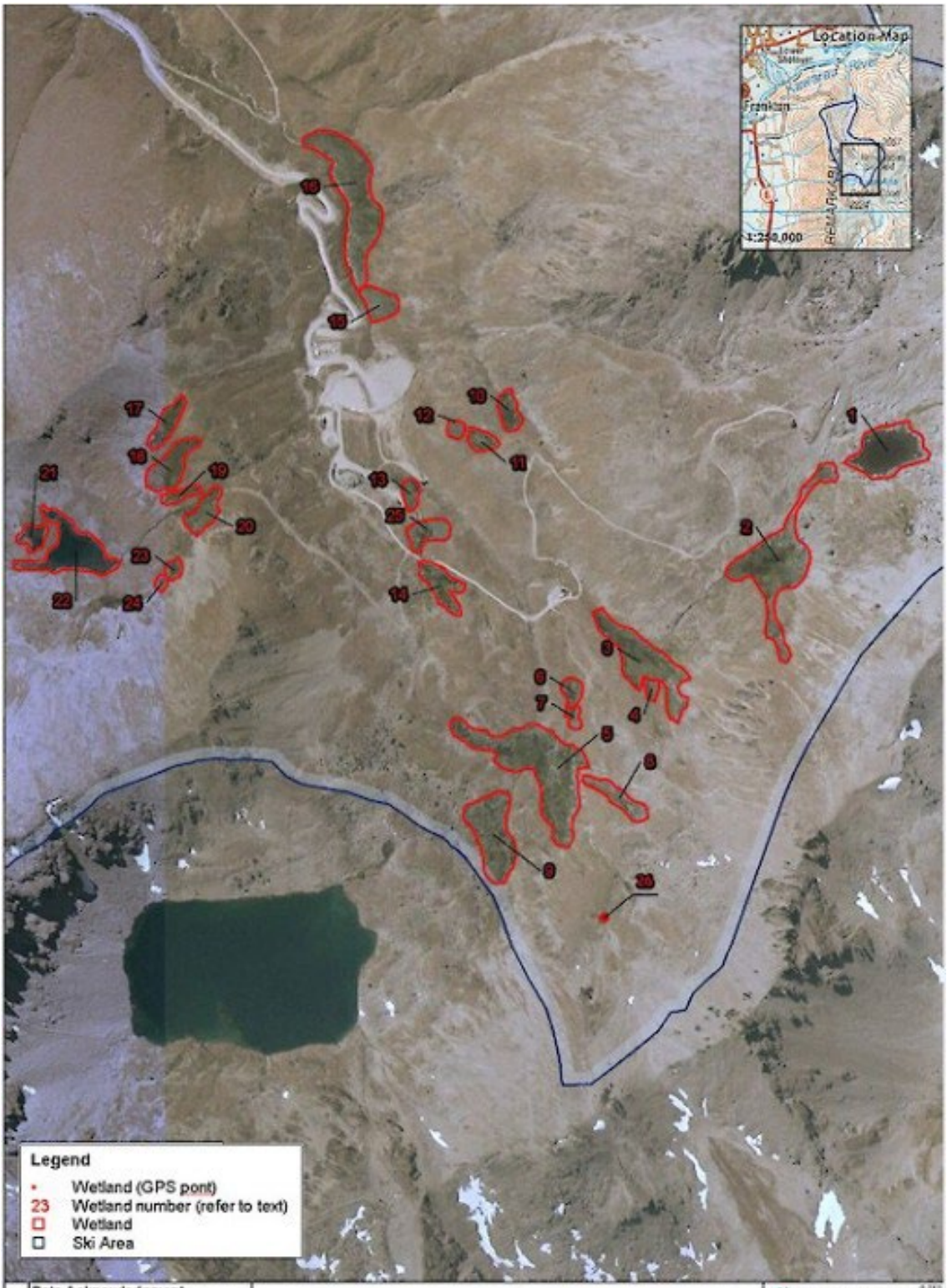
Appendices

Appendix A: Wetlands mapped in upper catchment (Source: Wildlands Accessed 2026).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Remarkables Ski Area wetlands
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Cartographer: FM
Format: A4

Appendix B: Proposed Performance Criteria (Source: e3Scientific, 2026a)

Parameter	Criteria	Rationale
Nitrogen Load	Five-year rolling mean is ≤500 kg nitrogen/year	The average value (rounded) of reported loads
	Must not exceed 600 kg nitrogen/year in any calendar year	Potential threshold from lower of values reported for 2022/2023
Phosphorus Load	Five-year rolling mean is ≤65 kg phosphorus/year	The average value (rounded) of reported loads
	Must not exceed 85 kg phosphorus/year in any calendar year	Halfway between the average value and the maximum possible load as per Table 13.
TSS Concentration	Five year rolling mean is ≤40 mg/L TSS	Average concentration (rounded) of the compliance monitoring dataset at the discharge pipe
	Five year rolling 95%ile is ≤110 mg/L TSS	95%ile value (rounded) of the compliance monitoring dataset at the discharge pipe
BOD Concentration	Five year rolling mean is ≤80 mg O2/L (BOD5)	The average value (rounded) of reported loads
	Five year rolling 95%ile is ≤320 mg O2/L (BOD5)	95%ile value (rounded) of the compliance monitoring data
E. coli	No criterion	A performance criterion for human faecal pathogens is not required as the natural die-off rates are high, and there are no sensitive receptors in the affected downstream reach.

Appendix C: Proposed Performance Criteria (Source: Stantec 2026)

Appendix C: Proposed Nutrient Load Performance Criteria (Stantec 2026).

Parameter	Limit
Total Nitrogen	Must not exceed an annual maximum load of 750 kg in any calendar year
Total Phosphorus	Must not exceed an annual maximum load of 155 kg in any calendar year

Appendix D: Periphyton Risk Assessment – Rastus Burn Wastewater

To:	NZSki	Ref:	26028_3
Cc:	Mitchell Daysh		
From:	e3Scientific		
Date:	28/8/2026		
Subject:	NZSki Remarkables Ski Area Upgrade - Periphyton Risk Assessment		

9 Introduction

As part of the consent application for an increase in wastewater dicharge volume from the Remarkables Ski Field, a periphyton risk assessment was requested by Torlesse, the technical reviewer engaged by the Otago Regional Council (ORC). During a technical expert workshop on 11 August 2026 it was agreed to try to develop nutrient targets to maintain periphyton biomass below 50 mg/m^2 Chlorophyll *a* (Chl *a)*. This memo aims to provide a periphyton risk assessment and establish potential nutrient thresholds to maintain low periphyton biomass and high benthic macroinvertebrate metric characteristics. This is done via proposed thresholds and adaptive management triggers within a management framework. In addition, an assessment of ammonia toxicity likelyhood is undertaken.

Within this periphyton risk assessment we assert that while measured nutrient concentrations may exceed proposed threshhold values at times, the actual risk of periphyton growth exceeding the propsed 50 mg/m^2 biomass limit is low due to the environmental[i] and the timing of the exceedances. We propose an appoach to utilise the low risk categories of Matheson, *et al.* (2012) to maintain less than 150 mg/m^3 of dissolved inorganic nitrogen (DIN) and less than 6 mg/m^3 of dissolved reactive phosphorus (DRP) within the Rastus Burn over the off-season

[i] i.e. threshold exceedances are primarily during the ski season (1 June to 31 October) when environmental constraints such as water temperature and light availability, on periphyton growth are present.

(1 November to 31 May) and to use these levels as initial trigger levels for an adaptive management approach with further actions required if these levels are exceeded. The following sections provide information included in the freshwater ecological impact assessment report (FEcIA) prepared by e3Scientific in August 2026; however, it is summarised here for completeness in alignment with a standard periphyton risk assessment, as requested by Torlesse.

10 Receiving Environment – Rastus Burn

This section of the Periphyton Risk Assessment summarises the background information provided within the Wastewater Discharge Impact assessment (e3Scientific, 2026a) and Rastus Burn Wastewater FEcIA (e3Scientific, 2026e).

Waterbody type: Hard-bottom alpine stream.

Hydrological setting: The NIWA flow model for the Rastus Burn estimates a median flow of 0.133 cumecs, mean flow of 0.2 cumecs, and lowest flow in July (due to snow). February mean flow is predicted to be 9.6% higher than the annual daily mean flow and the Rastus Burn has□□□.

Dilution modelling: High dilution see Section 4.4; e3Scientific, (2026a).

Zone of influence: Slight measurable effects on water quality have been measured 1500 m downstream. Therefore, the 1500 m reach of the Rastus Burn below the wastewater discharge infiltration field is considered the zone of influence.

Residence time: Less than 1 month to reach the stream.

Geomorphology: Gravel, cobble, and boulder bed substrate, with a steep incised channel, shading is limited to natural landform shading from the steep sided valley with some edge shading of the stream from tussocks. The Rastus Burn runs from south east to the Kawarau River in a northerly direction. Riparian conditions provide a naturally low level of shading.

Existing nutrient sources: There are no other upstream point sources, there is some diffuse catchment inputs from wetlands and rock weathering.

Ecological values: Assessed as Moderate based on the macroinvertebrate community present and natural absence of fish.

11 Baseline Periphyton Condition

Historical monitoring data: Low algal biomass and algal cover as measured in November every second year. Visual observations demonstrated low algal cover in February 2026.

Seasonal patterns: Previous spring monitoring has not demonstrated high periphyton biomass and autumn has not been sampled previously. It is therefore assumed increased periphyton growth rates will occur in summer/autumn with warmer temperatures. The Executive Summary and Section 3.1 of e3Scientific (2026a) provides additional context to clarify that this is primarily a winter/spring discharge with 2 to 3 times the wastewater volume and 17 times the total nitrogen concentrations (Table 7; e3Scientific, 2026a) contributed to the wastewater infiltration field in winter/spring compared to summer/autumn (see Table 6 and Table 7; e3Scientific, 2026a). Therefore, two consent monitoring periphyton sampling events have been proposed, one in spring close to the timing of the activity (winter ski season wastewater discharge) and one in autumn when warmer temperatures and more sunlight might results in more algal growth given sufficient nutrients and stable flows.

Drivers: The key drivers for periphyton growth are sufficient sunlight and water temperatures, suitable substrate for attachment, and a nutrient source. Flood events remove periphyton biomass and reset the process. Water temperatures above 10 °C are only recorded in the Rastus Burn during December to February which coincides with longer daylight hours. For the remainder of the year cold water temperatures of <10 °C and lower sunlight hours limits periphyton growth rates. Spring snow melt increases base flows and there are approximately 11 flood events modelled per year. Additionally, the streambed's hard rock substrate is suitable for algal attachment. The algal community and growth forms have developed to survive very cold water rather than to produce high summer biomass, the exception being didymo. There are nutrient sources within the stream's catchment (e.g. from natural sources and from the wastewater discharge) which at times are in excess of the guidelines to maintain periphyton

levels below 50 mg/m^3. Therefore, while typically the nutrient concentrations are low, at times they will exceed that predicted to protect benthic biodiversity.

Current state: Historical assessments of the NPS-FM band for chlorophyll *a* have not been undertaken but based on the nutrient concentrations are expected to fall within A or B band (<120 mg/m^2 Chl *a*) based on the periphyton taxa and descriptions provided in consent monitoring reports. No known excessive periphyton growth events have been recorded in Rastus Burn below the discharge fields; however, a *Didymosphenia gemenata* (didymo) bloom has occurred at the headwaters (Lake Alta) and a small growth was observed in the Rastus Burn near the 'downstream 200 m' monitoring point (e3Scientific, 2026e).

12 Discharge Characterisation

Wastewater quality: The proposal is to maintain the current nutrient load levels of 750 kg of nitrogen in any one calendar year and 100 kg of phosphorus in any calendar year (Stantec, 2026). Noting that these numbers are to be confirmed via a review early in the life of the consent. See proposed consent condition WW.37.

Flow and load: During the ski season the mean total nitrogen concentration of the wastewater is 51 mg/L and in the off-season the mean concentration is 3 mg/L (Table 7; e3Scientific, 2026a). Mean load peaks in August at 179 kg/month with a minimum load in February at 1.2 kg/month.

Discharge configuration: Discharge to land, seeps into Rastus Burn along an extended reach as a diffuse discharge within 1 month of discharge to land.

Receiving environment dilution: High dilution, see Section 4.4; e3Scientific, (2026a).

13 Risk Characterisation

Consent monitoring has shown with the existing wastewater discharge the nutrient concentrations are currently in B band or above for the relevant NPS-FM nutrient

parameters (Ministry for the Environment, 2020). Periphyton levels are also assumed to be within B band or above, but as periphyton biomass has not been directly measured this assumption is based on the lack of growth observed and the growth forms of the algal species identified within previous consent monitoring reports (Ludgate, 2017; SLR, 2023; SLR, 2026). July is predicted to be the month with the lowest stream flow (NIWA, 2026). This aligns with the winter ski season and peak wastewater discharge, however due to the cold winter conditions (<10 °C, and low light for photosynthesis) little algal growth is expected at that time. The main driver for the algal community present will be the ability to withstand very cold temperatures. At this location this is more important than being able to convert nutrients rapidly into periphyton biomass as is more typical in lower altitude rivers with filamentous green algae present rather than a community dominated by diatoms.

As conditions warm in spring, snowmelt will maintain cool instream conditions and elevated flows. During summer, water temperatures and daylight hours increase so conditions will be more conducive to algal growth; however, during this time the nutrients contributed from the NZSki wastewater treatment system will be at their lowest (Figure 10; e3Scientific, 2026a). In Autumn, flows taper off towards seasonal low flow which increases the background nutrient concentration due to less dilution, temperatures are mild but likely less than 10 °C, and the wastewater discharge occurring under 'off-season' conditions (e.g. low nutrient load). Based on the above, due to the cold winter temperatures coinciding with peak discharge times and low nutrient discharge during peak algal growth times it is very unlikely periphyton biomass will be altered to a level that will impact the macroinvertebrate community present.

Therefore, we propose the periphyton risk for the Rastus Burn is low.

14 Stressor – Response Assessment

14.1 Environmental Guideline Values Assessment

14.1.1 Nutrient Guideline Values

The following bullet points summarise the methods used and the pros and cons of the main nutrient guidelines developed in New Zealand to try to maintain periphyton biomass below 50 mg/m^2 of Chl *a*. This is the periphyton level below

which is described to maintain healthy benthic biodiversity and the agreed target for the Rastus Burn. The nutrient guideline levels are summarised in Table 1 below.

- Biggs (2000) originally suggested nutrient concentrations that varied by periphyton accrual time (since the last flood). In practise this is difficult to manage as the guideline values to be met regularly shift. Table 1 below uses the 30 day accrual guideline of 10 mg/m^3 dissolved inorganic nitrogen (DIN) and 1 mg/m^3 dissolved reactive phosphorus (DRP) (based on 365 days in a year divided by 11.4 flood events a year = 32). It should be noted however that when reviewed by Matheson *et al.* (2016) it was considered that this guideline was based on a very small dataset and is unlikely to be representative of the conditions at the Rastus Burn.
- Matheson *et al.,* (2012) recommended that there would be a low risk of periphyton biomass exceeding 50 mg/m^2 if DIN is maintaned below 150 mg/m^3 and DRP below 6 mg/m^3. This guideline has been described as having reasoable performance but was designed and tested against the NIWA national river monitoring dataset only (Matheson *et al*., 2016), and is again unlikely to be representative of the alpine conditions found within the Rastus Burn.
- Matheson, *et al.,* (2016) then went on to undertake further regression analysis and the report findings from the dataset used were more robust for dissolved inorganic nitrogen (DIN) and total phosphorus (TP) rather than total nitrogen (TN) or dissolved reactive phosphorus (DRP). They presented proposed guidelines for the preceeding 12 months and the preceeding spring and recommended compliance with the 85%ile (presented in Table 1 below) and utilised NIWA and regional council datasets to derive the guideline values. The data used to establish the guidelines did not include poorly represented river environment classification (REC) classes such as the cool wet mountain source like the Rastus Burn.
- MfE (2020) provided updated guideline values in relation to the NPS-FM (2020) that was also released at that time. The regression analysis provided guideline values for REC climate and source of flow classes and a range of spatial exceedance options to be choosen from. For the purposes of this project, the 20% spatial exceedance guideline which provided a TN value of 90 mg/m^3 and 0.3 mg/m^3 for DRP was applied in Table 1 below. These guideline values were considered by the authors to be inherently uncertain and suggested only monitoring of periphyton can confirm the actual biomass present (MfE, 2020).

- Snelder *et al*., (2022) used modelled data and regression analysis to derive guideline values for shaded and unshaded waterways based on REC climate and source of flow. Snelder *et al*., (2022) provides a number of options based on the level of protection risk utilised by the project. We present the 20% under protection risk (80% protection) values in Table 1.

Table 11: Summary of relevant nutrient guideline values (mg/m^3) to maintain <50 mg/m^2 of periphyton Chl *a*.

Nutrient	Biggs (2000)	Matheson *et al.* (2012)	Matheson *et al.* (2016)	MfE (2020)	Snelder *et al.* (2022)	
					Unshaded	Shaded
TN	na	na	na	90	35	165
DIN	10	150	100	na	13	114
TP	na	na	14	na	na	na
DRP	1	6	na	0.3	1	2
na = no nutrient concentration guideline suggested or data did not enable a useful guideline to be developed.						

14.1.2 Nutrient Guideline Value Recommendation

All of the methods outlined in Table 1 have pros and cons, but the consistent theme across the reports is that the data used to establish the regressions is largely based on data gathered from rivers (rather than streams) and the models used have an unknown level of error within them. Therefore, there are a number of reasons why these thresholds are unlikely to be particularly accurate for this section of the Rastus Burn. Primarily the data used to create the thresholds is largely from larger rivers, at lower altitudes, with more turbid, warmer water from across the country (Snelder *et al*., 2022). The Rastus Burn has cold water, a steep sided alpine catchment, fast turbulent flow and seasonal spring melt. Due to these reasons, all guideline options in Table 1 lack aspects of applicability to this stream (and activity) and therefore are not appropriate to be considered as a 'hard limit' for consenting purposes. The most applicable option of the above is to align the risk assessment of 'low' from Section 5 with the low-risk guideline values of 150 mg/m^3 and DRP below 6 mg/m^3 from Matheson *et al.* (2012).

Matheson *et al.* (2012) proposed periphyton risk bands to aid in decision making with regard to risk assessments. In alignment with this, the proposed approach is to utilise the low risk categories of <150 mg/m^3 of DIN and <6 mg/m^3 of DRP as initial trigger levels to then initiate further water quality investigations and periphyton surveys. We suggest these DIN and DRP values are more likely to reflect

the actual potential of periphyton growth at this cold-water steep, incised waterway.

Table 12: Periphyton risk categories after Matheson *et al.* (2012).

Risk category	DIN (mg/m³)	DRP (mg/m³)
Very Low Risk	<50	<3
Low Risk	50 - 150	3 - 6
Moderate Risk	150 - 300	6 - 15
High Risk	>300	>15

14.1.3 Nutrient Guideline Value Use

Provided the total nutrient load from the expanded wastewater discharge in the Rastus Burn is maintained at the recommended levels (Section 4, Wastewater Quality- e3Scientific, 2026a), then the existing low periphyton cover is predicted to remain as the other key environmental drivers will generally remain the same (e.g. sunlight hours, water temperature, frequency of flushing events).

It is proposed that the DIN and DRP guideline values (Matheson *et al*. 2012) should only be used in an adaptive management framework rather than as a hard compliance limit to be met. This is because the data used to establish nutrient criteria for a known amount of instream periphyton varies greatly and in an unpredictable way. To illustrate this complexity, Figure 1 below (adapted from Snelder *et al*., 2022) demonstrates a theoretical good dataset for regression analysis to identify a threshold relevant for a guideline where low periphyton biomass relates to low nutrient levels and high nutrient levels relate to high periphyton levels. However, the real datasets Matheson *et al*. (2016) used to establish nutrient:periphyton relationships vary in a much less predictable way with low nutrient levels equating to high periphyton biomass almost as frequently as low biomass, and high nutrient levels relating to low algal biomass levels almost as frequently as high biomass (Figure 2). Therefore, it is reasonable to consider other algal growth factors to be equally as important if not more important that nutrients alone in this cold alpine stream.

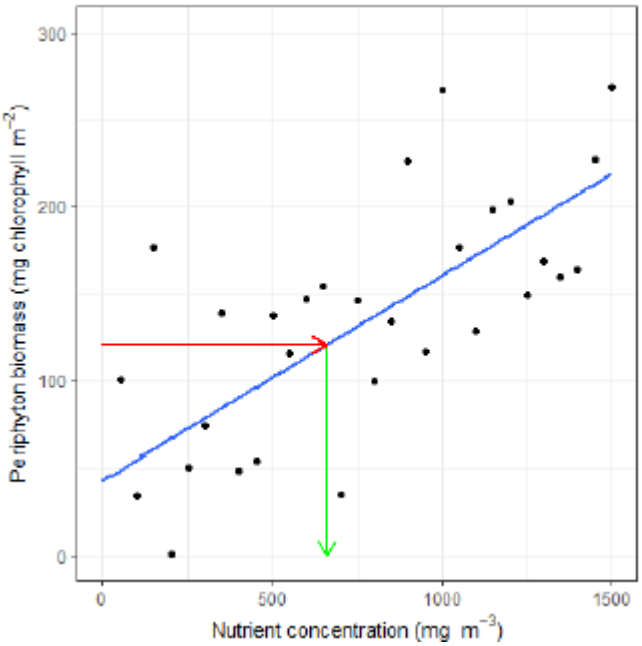

Figure 14: Stylised representation of nutrient criteria based on hypothetical data (Snelder *et al.*, 2022).

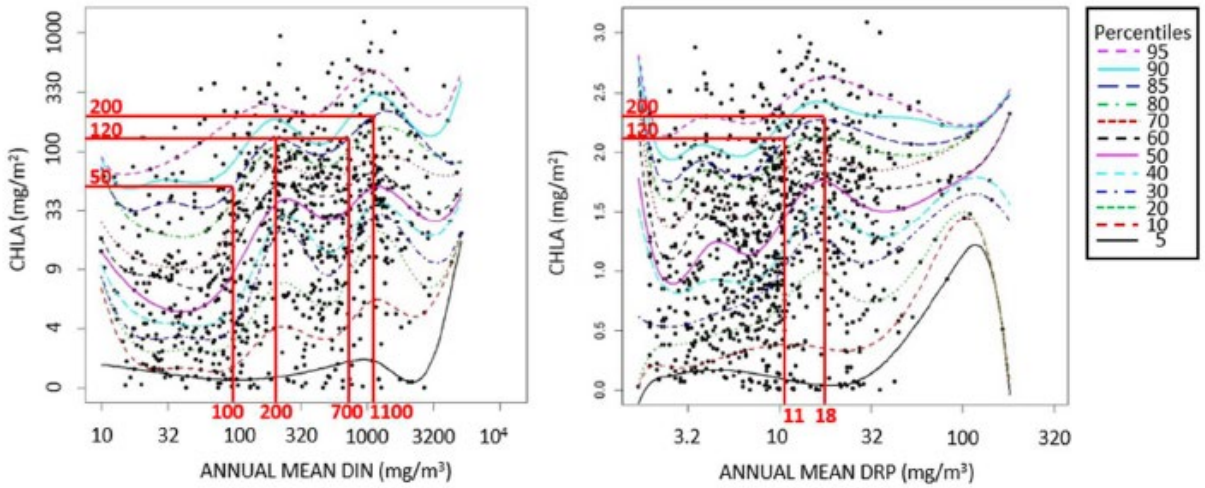

Figure 15: Actual data used for guideline development from Matheson *et al.* (2016).

14.2 Stressor (Nutrient) – Response (Periphyton Growth)

Key nutrients: DRP, DIN, ammoniacal nitrogen

The below assessment of current Rastus Burn nutrient status is undertaken in comparison to 150 mg DIN/m^3 of and <6 mg DRP/m^3 guideline values suggested by Matheson *et al*. (2012). It is expected that these nutrient guideline values will provide an indication of when further monitoring and assessment may be

warranted. The periphyton threshold of <50 mg/m^2 of Chl *a* has been proposed and agreed upon by the ORC technical experts (Torlesse Environmental). This periphyton guideline level is lower than 120 mg Chl-*a*/m^2 which is typically used to maintain river aesthetics but is considered appropriate to maintain the current ecological status of the Rastus Burn based on the environmental characteristics described. The expert agreement of this Chl *a* threshold also recognises the non-standard attributes of the Rastus Burn and recognises that site-specific thresholds and targets are an acceptable approach for this location.

14.2.1 Dissolved Inorganic Nitrogen (DIN)

Summer/autumn nutrient concentrations are on average lower than winter/spring concentrations for DIN within the Rastus Burn (Figure 3). The higher DIN levels observed in winter align with the peak ski season discharge occurring. The periphyton risk bands proposed for DIN are overlayed with the measured Rastus Burn nutrient concentrations. The data demonstrates the majority (93%) of summer/autumn samples are within the low or very low periphyton risk band. For the winter and spring results there is a higher proportion (~30% of samples) that are within the moderate or high risk bands; however, during this time periphyton is limited by environmental constraints (temperature and light).

The majority (93%) of summer/autumn DIN concentrations are within the low or very low periphyton risk band and therefore it is very unlikely that periphyton growth will exceed the 50 mg/m^2 of Chl *a* threshold (Figure 3). Thus, while the water temperatures will be warmer than 10 ^{o}C in summer the overall concentrations of DIN are small, enabling an acceptably low level of periphyton growth. Therefore, summer DIN concentrations alone are not expected to lead to excessive growths that would alter the benthic biodiversity. In autumn the temperatures are typically cooler than 10 ^{o}C, so while concentrations may slightly increase as flows decrease, again the conditions are such that only an acceptably low level of periphyton growth occurs.

The winter/spring results show the majority (61%) of winter/spring samples are within the low risk band but approximately 30% of results demonstrate moderate or high risk (Figure 3). However, due to the very cold winter water temperatures (~3 ^{o}C) algal growth is very unlikely at that time.

Overall, the periphyton growth risk associated with DIN is low. However, it is proposed to undertake spring and autumn monitoring to confirm periphyton growths are low and maintain benthic biodiversity.

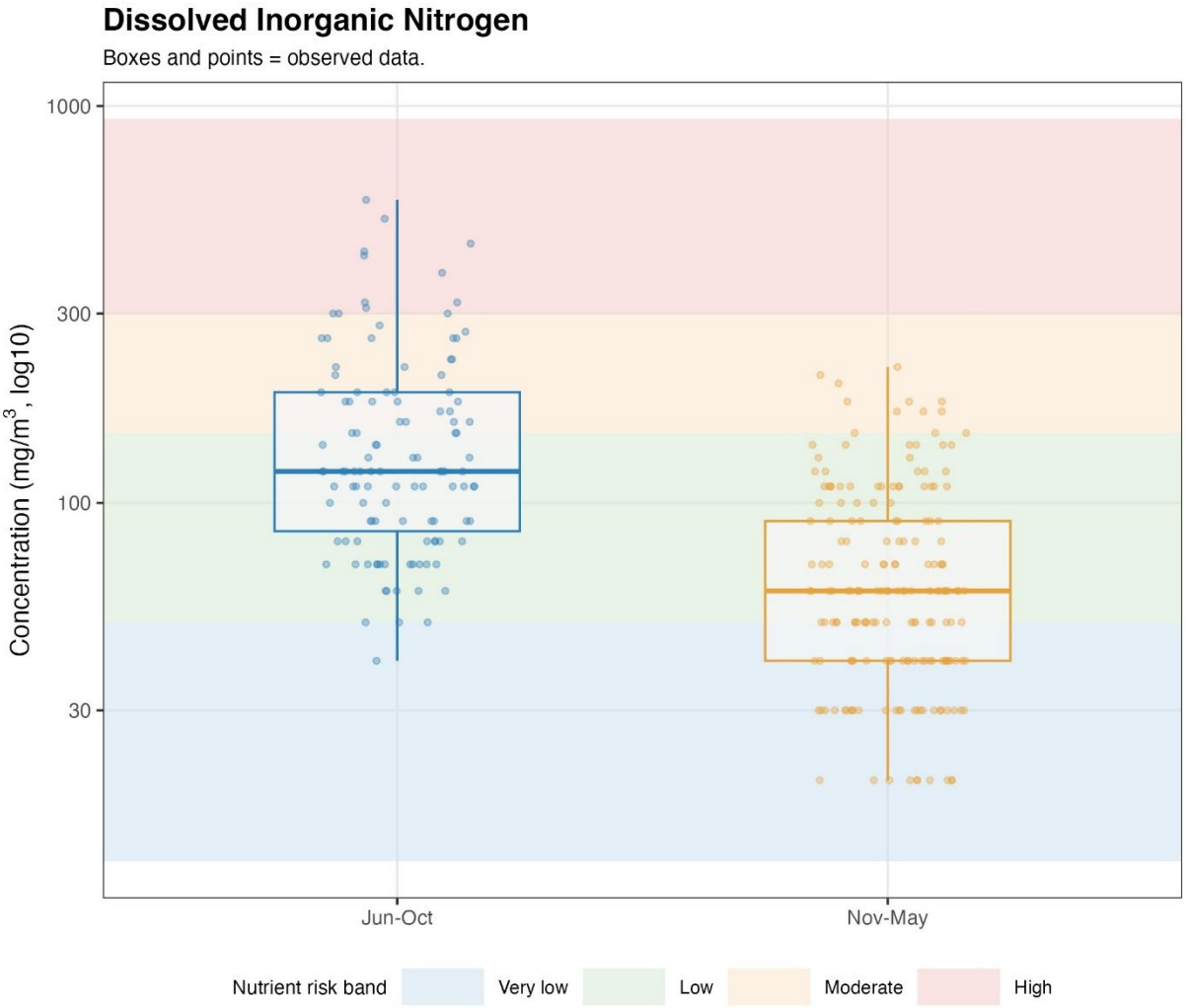

Figure 16: Seasonal dissolved inorganic nitrogen sample results from the Rastus Burn (modified from Ellis-Stanley (2026)) with DIN periphyton growth risk bands overlain.

The relationship between DIN and Rastus Burn flows suggests low confidence in a nutrient concentration curve based on the data collected to date. The DIN concentration curves across a range of flows was assessed by plotting measured DIN results from May 2025 to June 2026 against modelled flow for that same date. Flows were modelled based off the flow characteristics measured within the nearby Doolans Creek Right Branch. This modelled data add some uncertainty and the model may be improved once Rastus Burn water level loggers have been retrieved and a Rastus Burn rating curve established. The 2025/26 hydrological year was not a particularly low flow year and a relatively small sample result

dataset has been used along with modelled flow based on the Doolans Basin which may behave slightly differently.

There is a weak trend (with a low R^2 value) for dissolved inorganic nitrogen (DIN) concentrations to be generally higher when flows are lower (Figure 4 below). The modelled nutrient concentration curve suggests a peak in DIN concentrations at flows of 0.15 m^3/s and then decreasing concentrations as flows increase (Figure 4). The data gives coarse guidance that the DIN levels are expected to remain below 150 mg/m^3 threshold predicted to maintain periphyton biomass below 50 mg/m^2 at intermediate flows (Figure 4). This data should be treated as a guide only, even so, DIN levels exceeding 150 mg/m^3 appear unlikely and are still unlikely to lead to periphyton growth of greater than 50 mg/m^2 of Chl *a* due to the cold water, steep catchment and regular flood events.

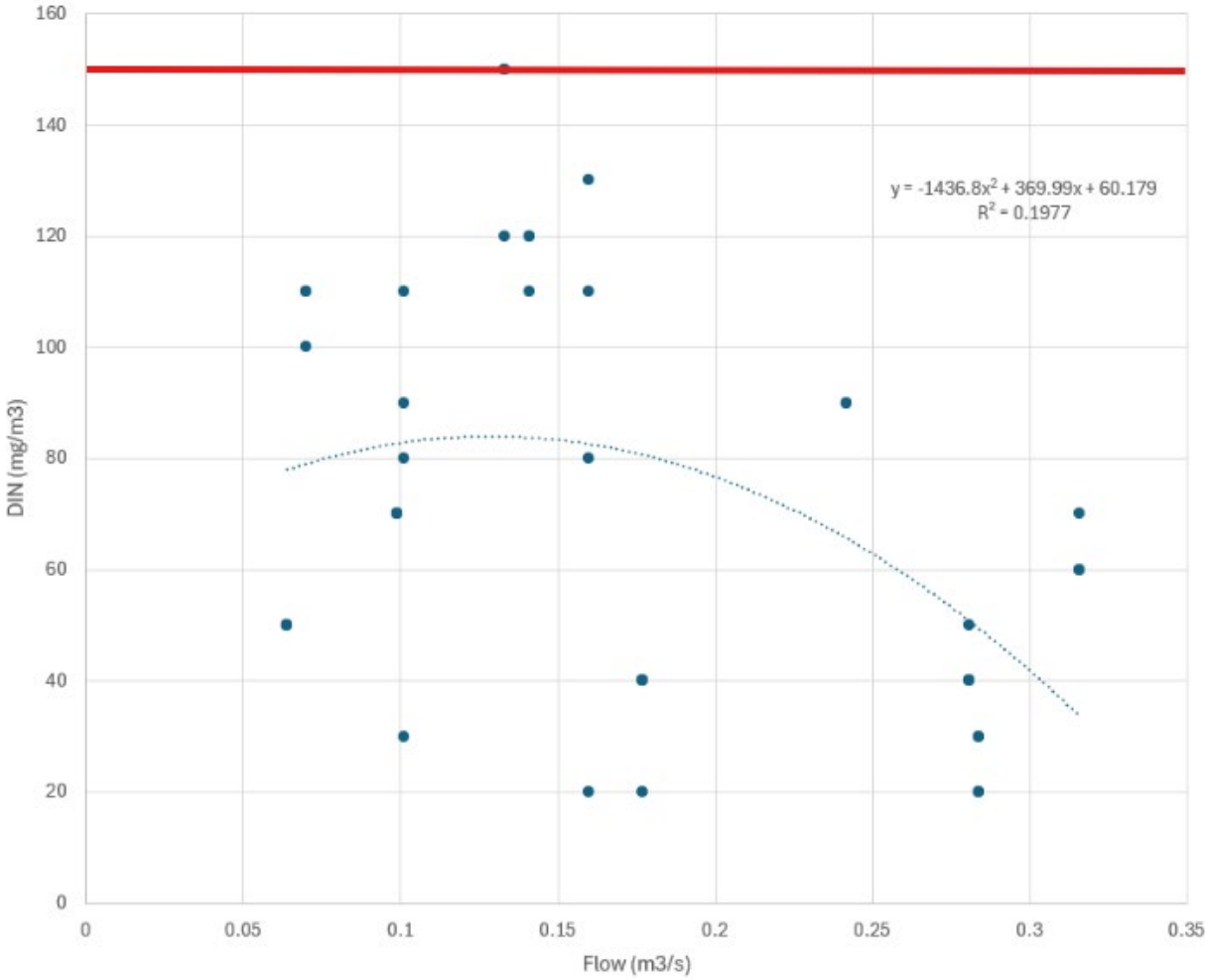

Figure 17: Dissolved inorganic nitrogen associated with modelled flow for the 2025/26 samples for all 4 monitoring sites. With DIN periphyton growth thresholds shown (150 mg/m^3 from Matheson *et al.* (2012).

Site specific DIN results have been interrogated to aid in identifying a suitable indicator site for consent conditioning. When assessing the consent monitoring sites individually, the upstream site has the lowest dissolved organic nitrogen (DIN) levels, which then increase at the 50 m downstream and 200 m downstream sites before receding to levels similar to the upstream baseline by the 1500 m downstream site (e3Scientific, 2026a). There maybe be a short duration (spatially and temporally) increase in DIN levels; however, current data demonstrates the nutrient levels return to that of the upstream baseline by 1500 m downstream.

14.2.2 Dissolved Reactive Phosphorus (DRP)

Overall, summer/autumn and winter/spring DRP concentrations from all monitoring locations show very similar ranges and medians (Figure 5).

The summer/autumn results show the majority (75%) of summer/autumn samples are within the low or very low periphyton risk band. With the majority of nutrient concentrations falling within the low to very low risk category, it is very unlikely that periphyton growth will exceed the 50 mg/m^2 of Chl *a* threshold.

The winter/spring results show the majority (68%) of winter/spring samples are within the low-risk band but approximately 25% of results demonstrate moderate or high risk (Figure 5). However, due to the very cold winter water temperatures (~3 ^{o}C) algal growth is very unlikely at that time.

While 25 to 30% of samples across all seasons exceed the low risk band threshold it is unlikely that this will lead to excessive periphyton growth. This is because even in when water temperatures are warmer than 10^{o}C other factors are more important than nutrient concentration alone, such as the amount of light reaching the streambed, the algal taxa present and the flow regime. This is demonstrated by prolific algal growths not being observed previously which suggests that dissolved reactive phosphorus (DRP) is not as important as other factors such as flow regime, light and water temperature for algal growth at this location. Therefore, there is a low periphyton growth risk associated with DRP.

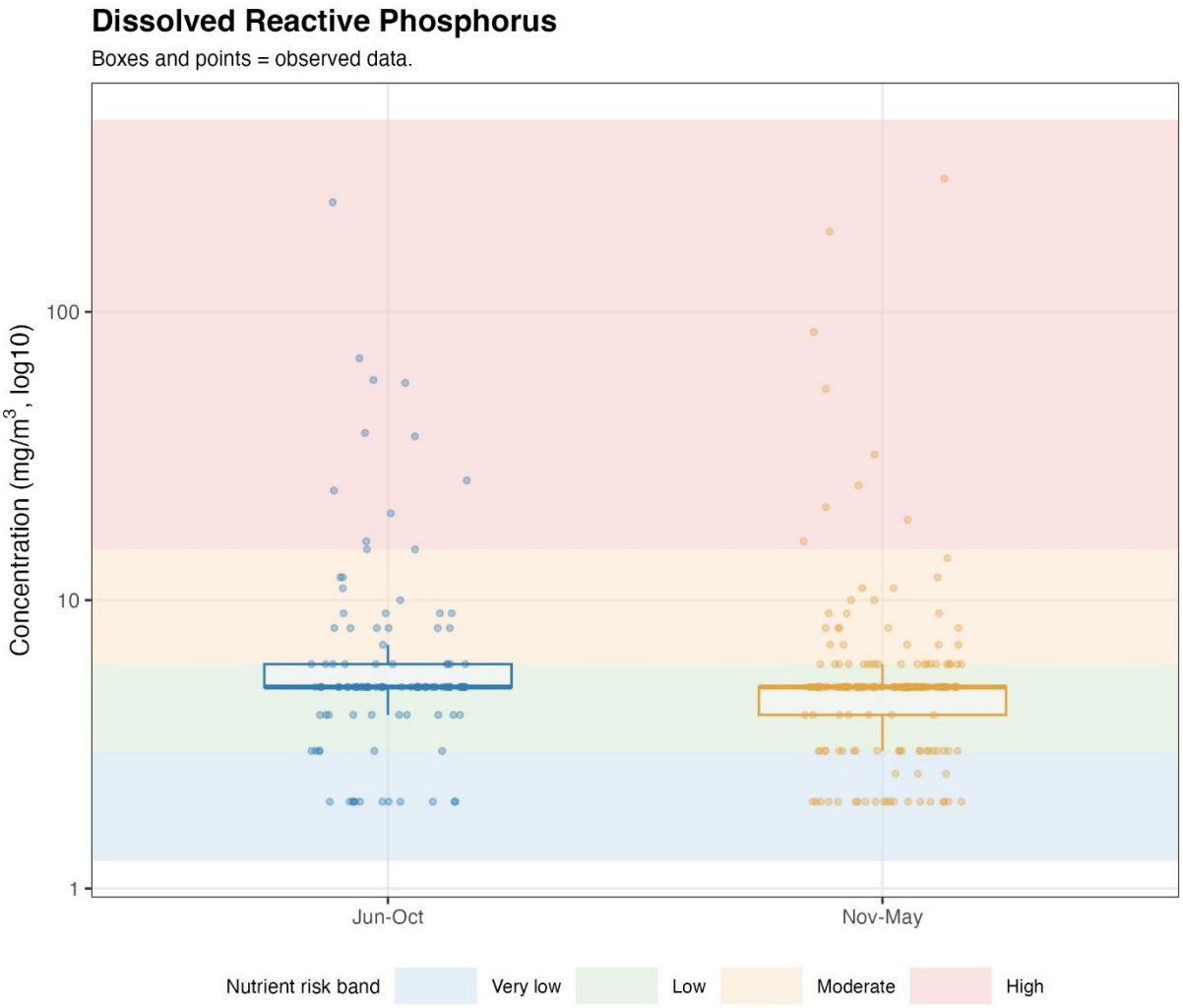

Figure 18: Seasonal dissolved reactive phosphorus sample results from the Rastus Burn (modified from Ellis-Stanley, (2026)) with DRP periphyton growth risk bands overlain.

The relationship between measured DRP and modelled Rastus Burn flows does not provide a high R^2, this means most of the scatter on the graph is not accounted for by the flow variable, flow does not describe changes in DRP well and therefore suggests low confidence in the nutrient concentration curve. The DRP concentration curve plots measured DRP results from May 2025 to June 2026 against modelled flow for the same dates. As described previously flows were modelled using data from Doolans Creek Right Branch. This timeframe is used as flow data is available for Doolans Creek Right Branch as part of the wider Remarkables Ski area development. Therefore, some uncertainty remains with regard to the accuracy of the modelled flow.

There is a weak trend (with a low R^2 value) for dissolved reactive phosphorus (DRP) concentrations to be generally higher when flows are lower (Figure 6). For the

reasons described above the nutrient:flow curve should be used to give an indication only of the nutrient concentrations at a given flow rate. However, Figure 6 suggests there are generally lower DRP concentrations at higher flow rates.

All samples collected since May 2025 have been within the low-risk band (Figure 6), suggesting that regardless of flow rate, DRP is unlikely to be an issue for the Rastus Burn.

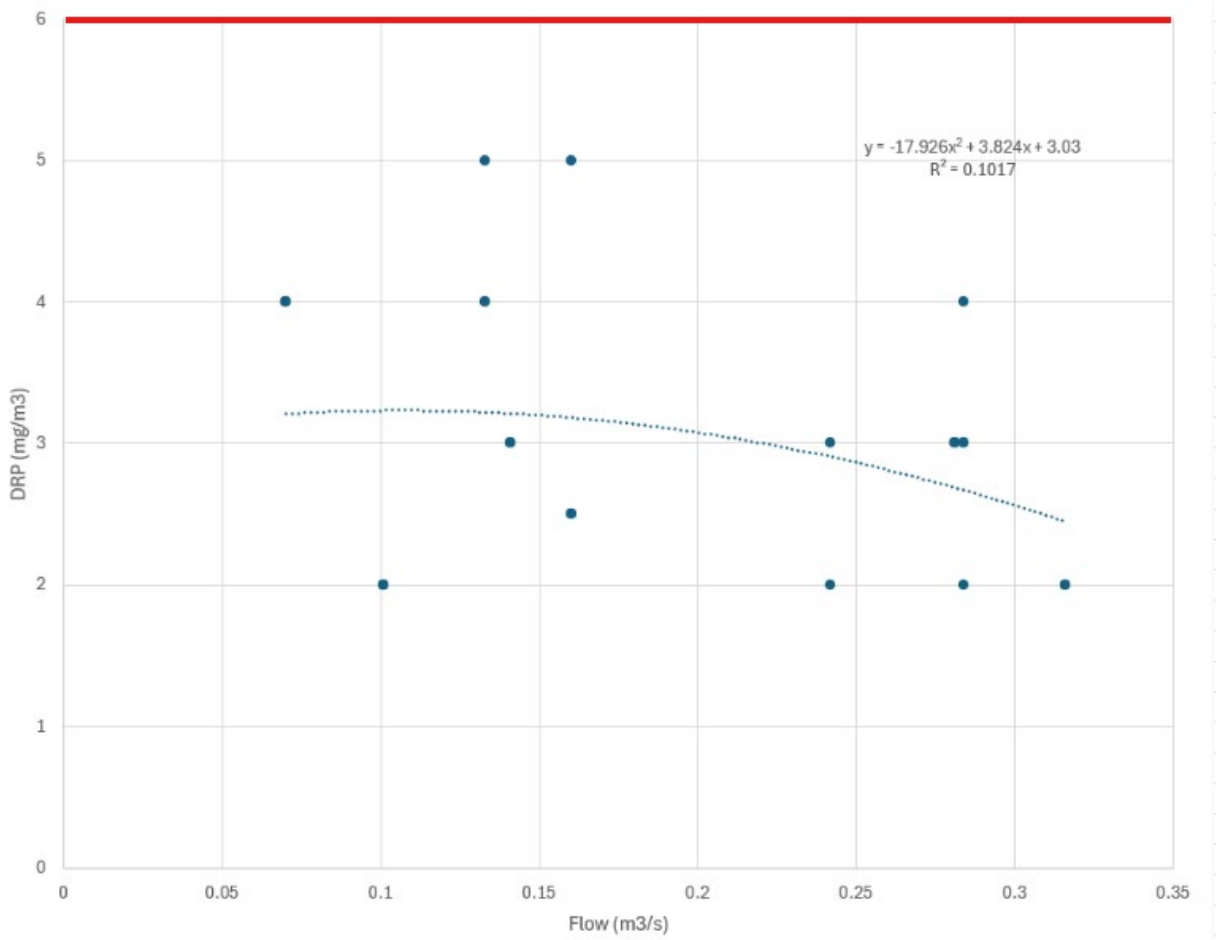

Figure 19: Dissolved Reactive Phosphorus for the monitoring sites associated with modelled flow for the 2025/26 samples for all 4 monitoring sites. DRP periphyton growth threshold shown (6 mg/m³ from Matheson *et al.* (2012)).

14.2.3 Light–Nutrient Interaction

Riparian cover and turbidity are low. A review of historical satellite imagery (Google Earth) demonstrates that the upstream Control Site receives significant shading from the mountainside to the east from June to August. The sites 50 m and 200 m downstream are significantly shaded from June to September when the highest instream nutrient concentrations are observed, while the 1500 m

downstream site is not shaded (unless covered in snow) but as noted previously, concentrations have generally decreased to near background by 1500 m downstream of the discharge.

14.2.4 Flow–Nutrient Interaction

There are 11 flood events per year predicted for the Rastus Burn (NIWA, 2026). This relates to just less than one per month, although they are likely to be concentrated around snowmelt and spring storm events.

14.3 Stressor – Response Summary

Based on the assessment of risk being low and the low applicability of several NZ guidelines, Matheson *et al*. (2012) guideline values of <150 mg/m^3 of DIN and <6 mg/m^3 of DRP, based on a low periphyton growth risk assessment are utilised alongside the expert agreed upon <50 mg Chl-*a*/m^2. Section 6.2 shows the current (and proposed) DIN and DRP concentrations are not anticipated to result in an exceedance of the periphyton guideline <50 mg/m^2 Chl *a* due to the discharge activity.

Instream nutrient concentrations are higher in winter and spring coinciding with peak wastewater nutrient load discharged to land, however the excess nutrients are not expected to enable excessive periphyton growth due to other limiting factors (sunlight, water temperature, floods). Further to this, the nutrient:periphyton interaction is not linear due to photosynthesis requirements, light availability, flow regime and water temperatures that are more strongly linked to periphyton biomass accrual than nutrients alone. During warmer temperatures where more light is available, DIN and DRP concentrations are primarily within the low or very-low risk band.

Therefore, the proposed use of nutrient guidelines in an adaptive management framework supported by biennial spring and autumn biological monitoring events is a suitably conservative approach for assessing whether periphyton growth rates are low benthic biodiversity is maintained.

15 Mitigation Measures

15.1 Adaptive Management Triggers

The project proposes to monitor DIN and DRP from 1 November to 31 May (off-season) as this is the time of year when periphyton growth is possible, based on environmental limiting factors of water temperature and light. Nutrient contributions to the Rastus Burn are expected to remain low at this time of year and the periphyton risk from the activity remains low. Nevertheless, monitoring of nutrients across the off-season is proposed via a trigger and response system. This allows for monitoring to potentially initiate further investigation and then management actions, if ecological thresholds are exceeded (Table 3).

This periphyton assessment has outlined that DIN concentrations of >150 mg/m^3 or DRP concentrations of >6 mg/m^3 from Matheson *et al.* (2012) are appropriate trigger levels to maintain low periphyton biomass, at this location. If initial trigger levels are exceeded the response to collect further water samples is to identify if nutrient concentrations are ambient or if this was a discrete, short, spike in concentration or laboratory anomaly. Ambient concentrations are more likely to result in an ecological (periphyton or macroinvertebrate) shift, whilst a one-off, discrete spike in concentration will not. Whilst undertaking this additional sample, observations of periphyton cover will assist in quickly understanding the nature of the exceedance (ambient or discrete). The results of this visual observation can also initiate trigger 2 responses, as if >10% cover of periphyton is observed, it is more likely that the water sample does represent ambient conditions (Table 3). This allows for management responses to be actioned faster resulting in reduced likelihood of ecological effects.

Macroinvertebrates are the last ecological indicator to be affected in this response train, as communities will take time to exhibit an alteration based on nutrient input and periphyton presence (food source). However, if changes are identified then a full review of the wastewater treatment system and onsite practices is warranted, and to be undertaken with actions to remedy the source of the nutrients and periphyton growth to be provided to the Otago Regional Council (ORC) for certification within 20 working days of the macroinvertebrate sampling results.

Table 3 provides a summary of the above triggers and associated management actions.

Table 13: Summary of proposed monitoring, triggers and response actions.

Trigger		Response
Trigger 1	If a monthly water quality monitoring result collected between 1 November and 31 May (n =7) at any downstream site exceeds the site-specific trigger limit for: - Dissolved inorganic nitrogen (DIN) of >150 (mg/m^3); and/or - dissolved reactive phosphorus (DRP) of > 6 (mg/m^3).	- Undertake an additional water quality monitoring round, including temperature and visual assessment of periphyton cover. and; - Review of nutrient exceedance against upstream sample results within 2 weeks of receiving the of the water quality results.
Trigger 2	If monitoring required under Trigger 1 response also demonstrates an exceedance of the nutrient triggers OR If obvious (>10% cover) periphyton is observed	- Undertake Chl *a* sampling (Periphyton monitoring).
Trigger 3	If monitoring required under Trigger 2 demonstrates an exceedance of the periphyton trigger (50 mg/m^2 Chl *a*).	- Undertake macroinvertebrate sampling and review results against the upstream control, if macroinvertebrate metrics of two of the three metrics are 10% lower in comparison to the upstream control this would be deemed an adverse ecological impact. - An audit and review of the wastewater treatment system and onsite practices to identify the reason for any elevated nutrient concentrations, and any potential measures to reduce them. This assessment is to be supplied to ORC within 20 working days of the trigger exceedance. - Provide a response plan to ORC within 3 months of receiving the results. The plan should include a review of the relevant wastewater treatment measures and the likely source of the periphyton exceedance and propose remedial actions.

15.2 Monitoring Considerations

The thresholds of 150 mg/m^3 DIN or 6 mg/m^3 of DRP at each downstream consent monitoring site should be assessed alongside the upstream control site nutrient concentrations. It is recommended that a 3-yearly review of the DIN and DRP

triggers is undertaken and these values can be refined as more site-specific data becomes available through time. If reviews find the thresholds are not appropriate an alternative approach could be to consider the 80%ile of the upstream control site DIN and DRP concentrations. This would aid in confirming if the elevated DIN and DRP are associated with the wastewater discharge or within natural variability for reference conditions.

Periphyton monitoring shall also include an assessment of algal taxa present. If didymo is present and is deemed the cause of periphyton (Chl *a*) limits to be exceeded, then this should be assessed and addressed within the reviews. Therefore, further actions would then only be recommended if the assessment deems the didymo unrelated and to not greatly influence the Chl *a* readings.

16 References

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Appendix 1: Total Nitrogen (TN)

This report makes the decision to use the periphyton risk bands developed by Matheson *et al.*, (2012) which utilises DIN and DRP as the primary nutrients that control periphyton growth below 50 mg/m^2. Therefore, these nutrients are assessed for the proposed periphyton bands throughout this report. However, total nitrogen information is attached here for completeness.

Summer and autumn median total nitrogen concentrations are currently below two of the three proposed TN guidelines (Figure 10). Noting that these guidelines have limitations regarding applicability to this site as discussed in Section 6.1 and are therefore not utilised to set thresholds for this activity. Seasonal data shows winter and spring to have the greatest total nitrogen concentrations.

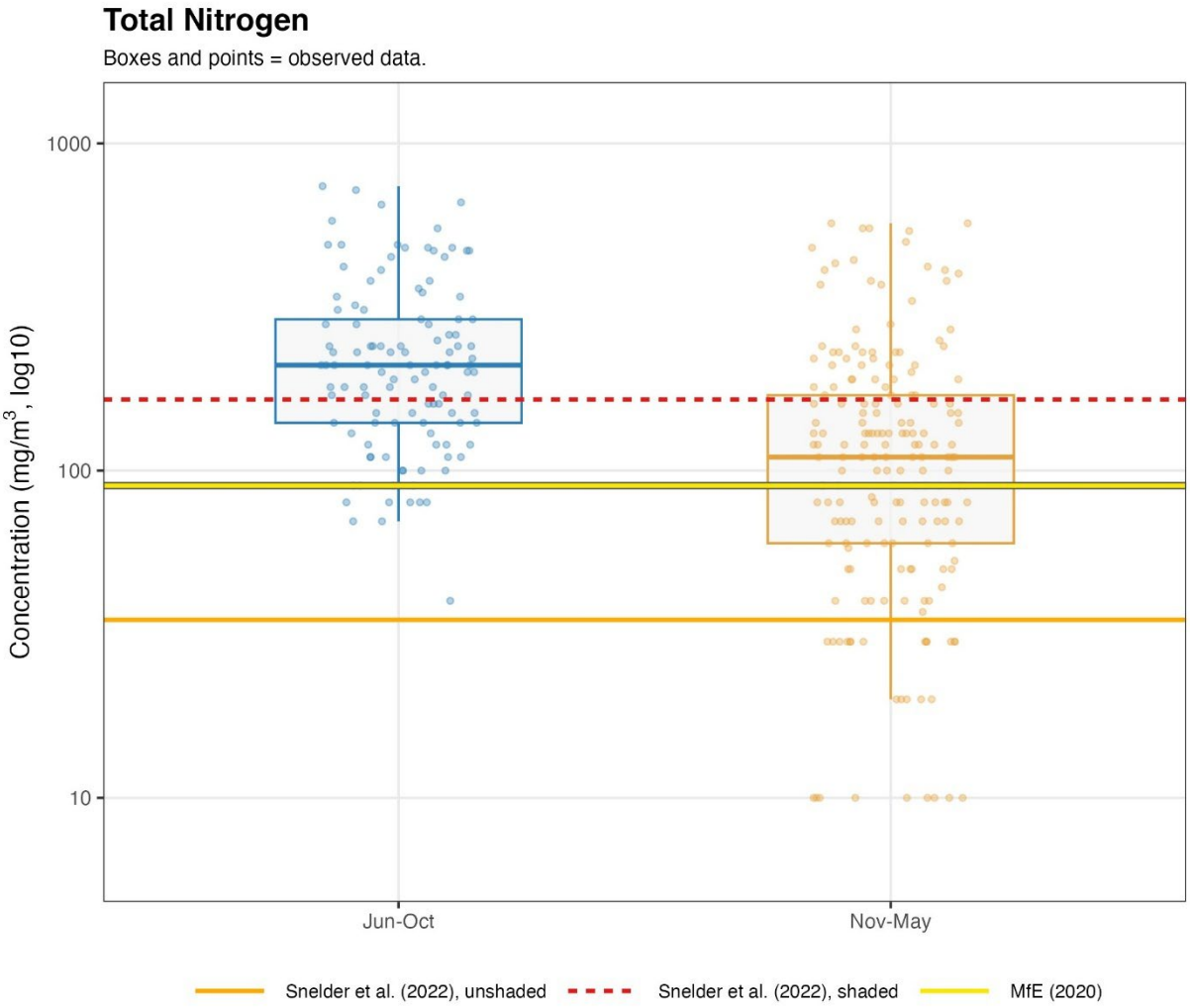

Figure 20: Total Nitrogen seasonal data with nutrient thresholds shown.

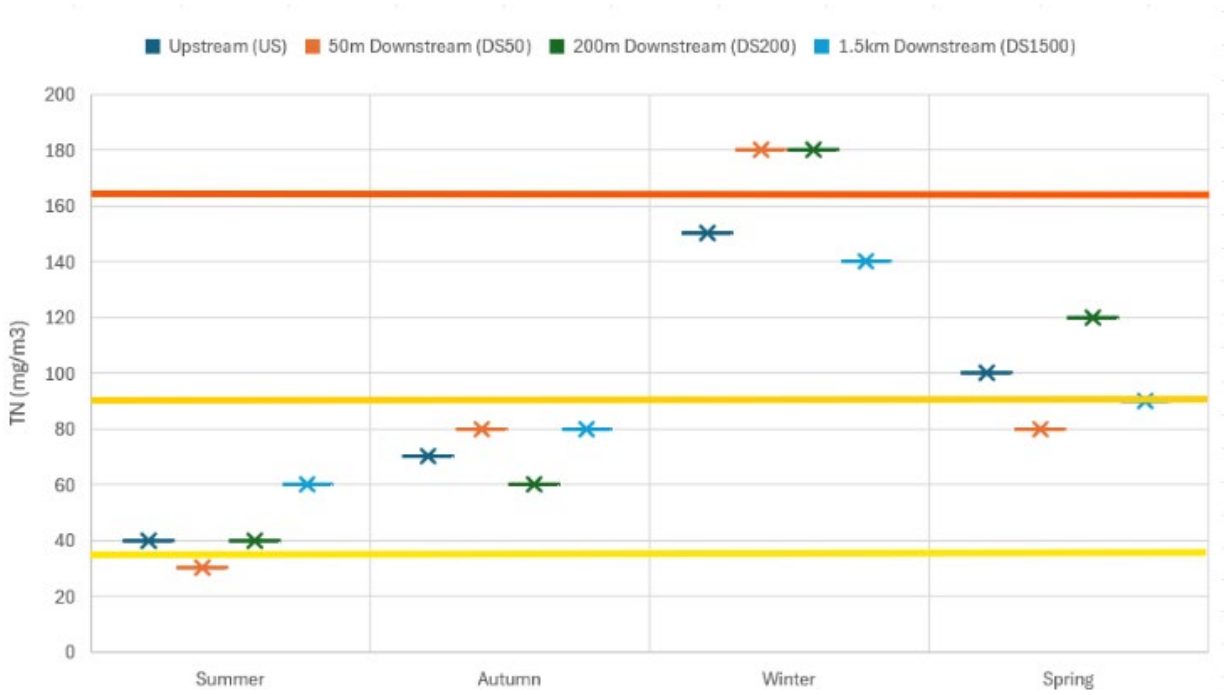

Figure 21: Median total nitrogen (TN) concentration at the monitoring sites by season (e3scientific 2026a) with periphyton growth thresholds shown (35 mg/m^3 for unshaded waterway, 165 mg/m^3 for shaded waterway from Snelder *et al.* (2022); and 90 mg/m^3 MfE (2020)).