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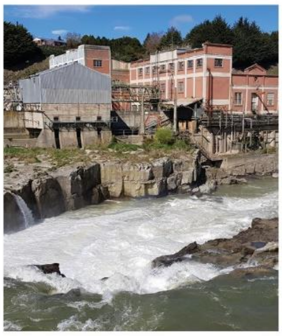

April 2023

Barrytown Mineral Sand Mine
Ecological Effects Assessment

Submitted to:

TiGa Minerals and Metals Limited

water fauna flora land

Quality Assurance

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1.0 Introduction

1.1 Background

TiGa Minerals and Metals are seeking resource consents from the West Coast Regional Council (WCRC) and Grey District Council (GDC) to authorise mineral sand mining and processing and associated buildings and transport of materials to obtain ilmenite, garnet and other minerals over an area of approximately 63ha (covered by Mining Permit MP 60785) at land near Barrytown owned by Nikau Deer Farm Ltd, known as the Cowan Block, and referred to here as 'the site'.

The site is located approximately 36 km north of Greymouth between State Highway 6 and the Tasman Sea as shown in Figure 1. The mining area is located on farmland which has been drained via humping and hollowing and adjoins artificially constructed and natural wetlands which provide habitat for a range of indigenous bird species, including coastal species, some of which are considered to be threatened or 'At Risk' (Robertson et al. 2021).

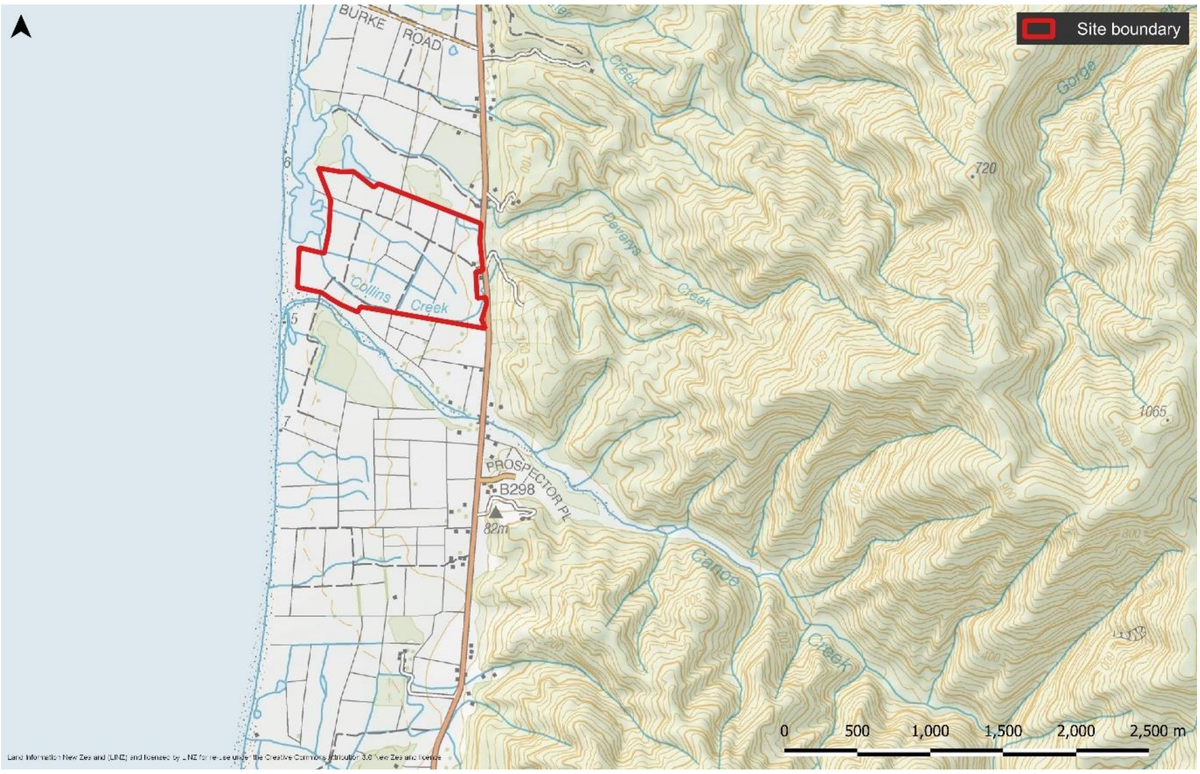

Figure 1: Location of the site at 3261 Coast Road, Barrytown.

The site is traversed by Collins Creek and an unnamed channelised watercourse along the northern boundary (referred to here as Northern Drain). Canoe Creek and Deverys Creek are located to the south and north of the site respectively. There are a number of artificial drains constructed through the centre of the site as part of the 'humping and hollowing' undertaken to enable farming of the site.

The site is currently used for dairy/dairy support. There are springs on the adjacent property to the south of the site utilised for domestic and livestock water supply. Drains and waterbodies within and bordering the site have generally not been fenced to exclude livestock and other than limited riparian vegetation for a small section of Collins Creek, the banks of waterbodies are unstable and subject to erosion due to livestock access and a lack of riparian vegetation.

The site is located within the Mineral Extraction Zone under the Te Tai o Poutini Proposed Plan, and is within the Coastal Environment and Pounamu Management overlays. Because it is located within the Coastal Environment, Policy 11 of the New Zealand Coastal Policy Statement applies. Policy 11(a) requires that adverse effects on threatened and at-risk species present in the Coastal Environment be avoided, whilst Policy 11(b) requires that significant adverse effects on important habitats in the Coastal Environment be avoided and other effects be remedied or mitigated.

1.2 Proposed Mining Activity

Mining will progress in strips approximately 100 m wide and 300 m long. The active sand extraction zone, typically 75 m by 80 m, would progress generally from west to east in strips that would generally progress from south to north as shown in Figure 2.

Twenty metre mining setbacks will apply to the northern and southern property boundaries, Collins Creek and the coastal lagoon area. The area south and west of Collins Creek is also excluded from the mining area.

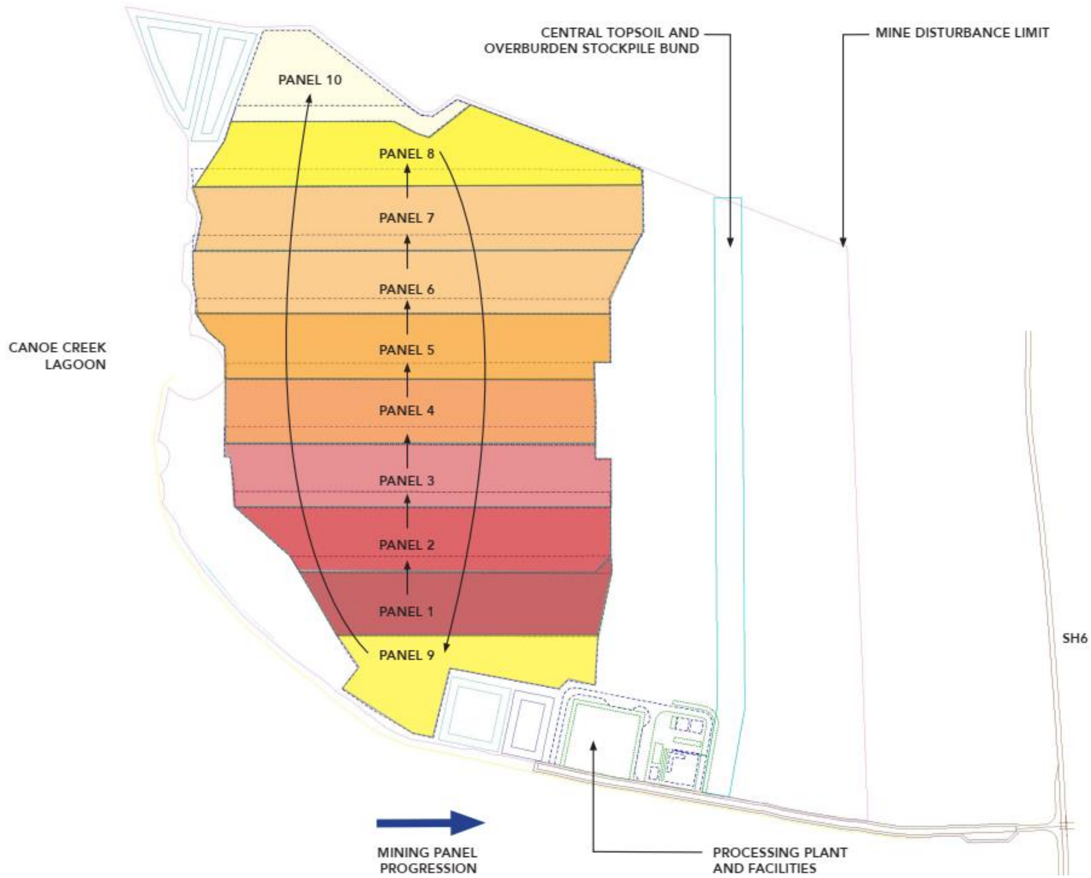

Figure 2: Site plan showing mining progress across the site (From Glasson Huxtable Landscape Architects).

The active mine pit area will be approximately 3 ha, with 0.5 ha of stripping occurring ahead of the mine pit and 0.5 ha of active rehabilitation occurring behind the mine pit as shown indicatively in Figure 3. A total disturbed area of up to 8 ha is proposed which takes into account rehabilitated sites where the vegetation is slow to grow.

It is proposed that extraction activities will take place seven days per week between the hours of 0700 and 2200 between 01 February and 30 November and between 0630 and

2130 between 01 December and 31 January. This is to avoid activities during the hours of darkness[1] coinciding with the peak fledging period for tāiko when young birds are most at risk of being disoriented by lighting. Starting 30 minutes earlier and finishing 30 minutes earlier during this period ensures all mining occurs during daylight hours when there is an elevated risk for the tāiko/Westland petrel. Processing activities will take place 24 hours a day, seven days per week.

Trucking of Heavy Mineral Concentrate ('HMC') from the site could either head north (to Westport) or south (to Greymouth) and would occur between 0500 and 2200 on the southbound route. On the northbound route trucking will avoid the hours of darkness in order to avoid adverse effects on tāiko leaving or returning to the colony located north of the site.

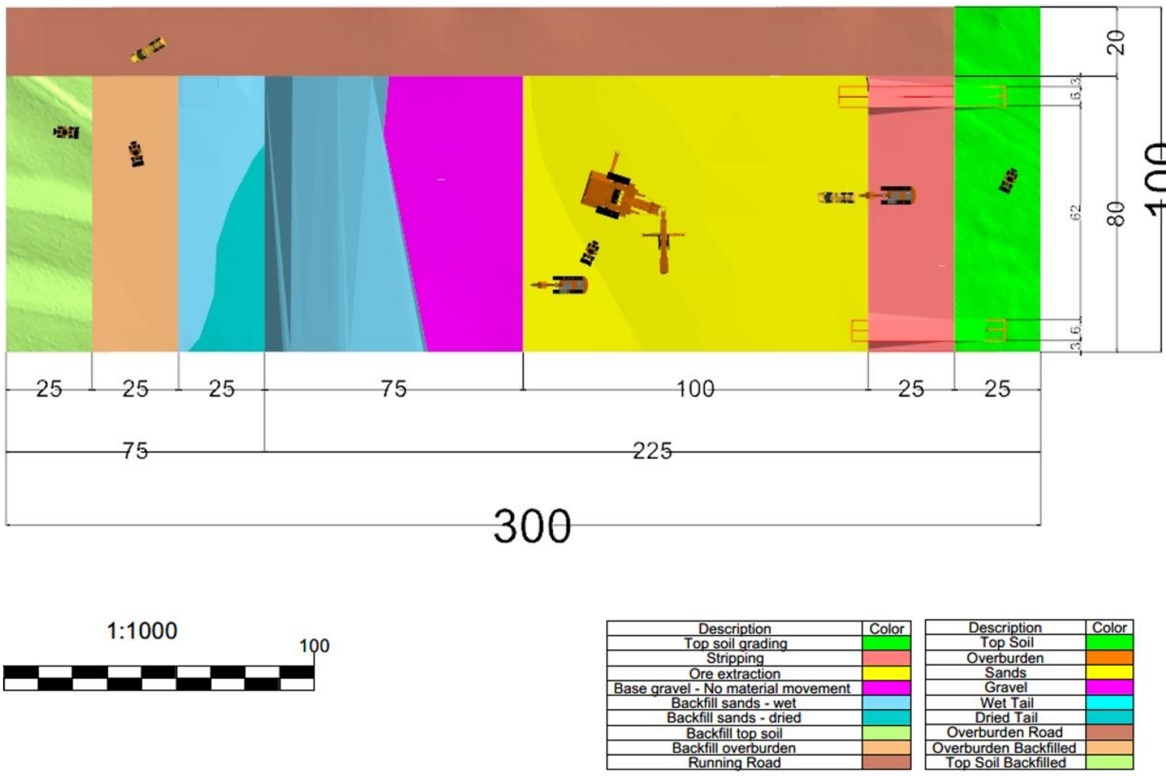

Figure 3: Indicative mining sequence.

Pre-mining works would commence with the construction of the proposed screening bund on the eastern boundary of the block adjacent to State Highway 6. This bund would be created and contoured using an excavator and then planted with native species. A central drain would then be installed with an excavator (generally following the contour of an existing drain running through the site). The installation of this drain would include sediment traps along the length of the drain as described in the Erosion and Sediment Control Plan for the site. Limestone weirs/rip rap would also be placed in the central drain during construction to assist in water treatment. Installation of the central drain would be followed by the construction of the mine settling pond and water management infrastructure which would be followed by construction of the access road from State Highway 6, Processing Plant and the mine starter pit. The mine starter pit will allow tailings to be deposited in the mine void once mining commences.

Part of the water management infrastructure (Pond 4) located in the northwest of the project

[1] The hours of darkness are defined as the period between 30 minutes after local sunset and 30 minutes prior to local sunrise.

area will be used for water management during mining and retained at the end of mine life to increase the extent of wetland habitat at the site.

Mining would start in the southwest of the site and progressively move eastwards in 100 m wide strips. Mining will progress in this sequence at a rate of approximately 5 m per day, or 35 m per week. Each subsequent strip of mining would generally be located north of the previous strip as shown in Figure 2. Mining along each strip would always be oriented from the west to the east. Maximum mining depth will be 9 m.

The proposed mining activity will involve the removal and stockpiling of topsoil and excavation of mineral sands by an excavator. The mineral sands will be pumped to the onsite Processing Plant. Specifically, this includes:

(a) Topsoil, approximately 0.2–0.6 m thick, and overburden will be removed and preserved (stockpiled) for rehabilitation using an 85-tonne excavator, and 40-tonne articulated trucks. Once in mining sequence, top soil will be removed ahead of mining and placed straight onto rehabilitated ground behind the mining pit.

(b) The sand ore will be mined via excavator and deposited onto a mining bench. The ore will then be picked up by front end loader directly to the in-pit mining hopper. The slurry will pass through a trommel and desliming circuit before being pumped to the Wet Concentrator Plant (Processing Plant). Reject large material from the trommel and slimes will be returned to the mine pit. Mining will occur at a faster rate than processing, and the excess ore will be stored at the Processing Plant and used overnight to keep the Processing Plant running 24/7. Heavy minerals will be separated from the ore using a water and gravity circuit, then drained of excess moisture and stored at the Processing Plant in a farm implement building with a concrete floor.

(c) Excavated material will be processed at the Processing Plant to extract the Heavy Mineral Concentrate ('HMC'). Un-mineralised sands will be pumped back to the pit cavity where a cyclone will be used to remove the water from them before they are discharged to the mining void, which will be progressively filled as the mine pit progresses. Pumped tailings will be spread across an approximate 1 hectare area of the mining void. Tailings will be levelled and contoured by excavators and bulldozers so as to be ready to receive the pre stripped overburden and soil as mining proceeds, i.e., the mining void will be progressively rehabilitated as mining advances. Vegetative (pasture) cover will be established, and the area will be considered to be rehabilitated (i.e., removed from the 'disturbed area') once 80% vegetative cover is achieved.

The excavated land will be backfilled, levelled and contoured to reinstate the land to a landform similar to, or improved from, pre-mining for the purpose of dairy grazing pasture. Any soil previously stockpiled will be spread out and used as a growing medium. In order to achieve a smooth landform and minimise ground level reduction at the western end of the mine, material will be borrowed from the paddocks which will not be mined near the State Highway, and used to maintain smooth slope gradients and a sufficient height of ground above ground water level for farming. Initial vegetation cover will be established as soon as practicable (for example by using hydroseeding) to minimise erosion potential from the site. Depending on the volume of ore and weather conditions during rehabilitation, each mining panel is expected to take between four and six months to be mined and rehabilitated.

Other revegetation at the site would include:

- Visual screening in the form of a 1.8 m high bund with planting on top and in front along part of the eastern road boundary and screening planting along a section of the northern internal boundary (subject to consultation with the neighbouring property owner), planting of the southern part of the 4.5 m high stockpile bund to screen the eastern and part of the northern sides of the Processing Plant location;

- Coastal revegetation planting in the form of a 6 m wide strip of indigenous planting adjacent to the coastal lagoon area and 10 m wide strip along the open coastline in the south western corner of the site. This planting will assist in visual screening the site from the coast as well as creating additional habitat for indigenous fauna;
- A constructed wetland/pond area adjacent to the coastal lagoon which will form part of water management for the site during mining and will be retained following the cessation of the mining activity and planted with ecologically appropriate species to increase the extent of wetland at the site compared to pre-mining;
- Indigenous riparian planting in the form of a 3 m wide strip fenced and planted along both sides of Collins Creek (where required) and the southern edge of the Northern Drain.

The resulting HMC will be trucked offsite (via heavy vehicle containing 30 tonnes per truck) either towards Westport or Greymouth. HMC may be shipped from either port or railed to Lyttleton in containers. An average of 50 heavy vehicle movements per day associated with the HMC removal is proposed and these movements would occur between the hours of 0500 and 2200 and could occur in either direction (Westport or Greymouth). If the northern route is selected, trucking would not occur during the hours of darkness so as to avoid travelling directly past the tāiko (Westland petrel, *Procellaria westlandica*) colony located north of the site during these hours.

The resource estimates for the proposed mining activity indicate that there are approximately 4.8 million tonnes of recoverable sand ore, with the yield being approximately 250,000 tonnes of HMC per year (1.1 million tonnes HMC in total). Actual mining is expected to take approximately 5–7 years to complete based on a sand ore extraction rate of 350 tonnes per hour with some contingency built in. TiGa Minerals and Metals Limited are seeking a 12-year consent term, to allow for rehabilitation, contingencies and to provide operational certainty.

The Processing Plant and mineral storage facilities area will be housed in a building similar to typical farm implement buildings. This building will be located at the southern end of the site as shown in Figure 4 and retained at the end of mining. The Processing Plant, other buildings and associated facilities will cover an area of approximately 2.0 ha, plus an additional 0.5 ha associated with the mine access road and parking. Including the mining area, the total disturbed area of the mine and associated buildings at any one time is approximately 8 ha, which provides for approximately 2 ha of rehabilitation contingency to establish 80% vegetative cover during unfavourable growing conditions.

The buildings will not exceed 15 m in height and lighting will be limited and managed to protect wildlife. This includes the Processing Plant having no windows, orienting openings away from the coast, screening of the Mine Plant and Workshop Area via the bunds and planting along part of the northern and all of the eastern sides and along the eastern bund as well as specific lighting controls in accordance with the Australasian Commonwealth light pollution guidelines to protect wildlife (Australian Commonwealth 2020). There will be limited fixed lighting in the mine area, which may include lighting around the pump to allow for the pump circuit to be checked overnight.

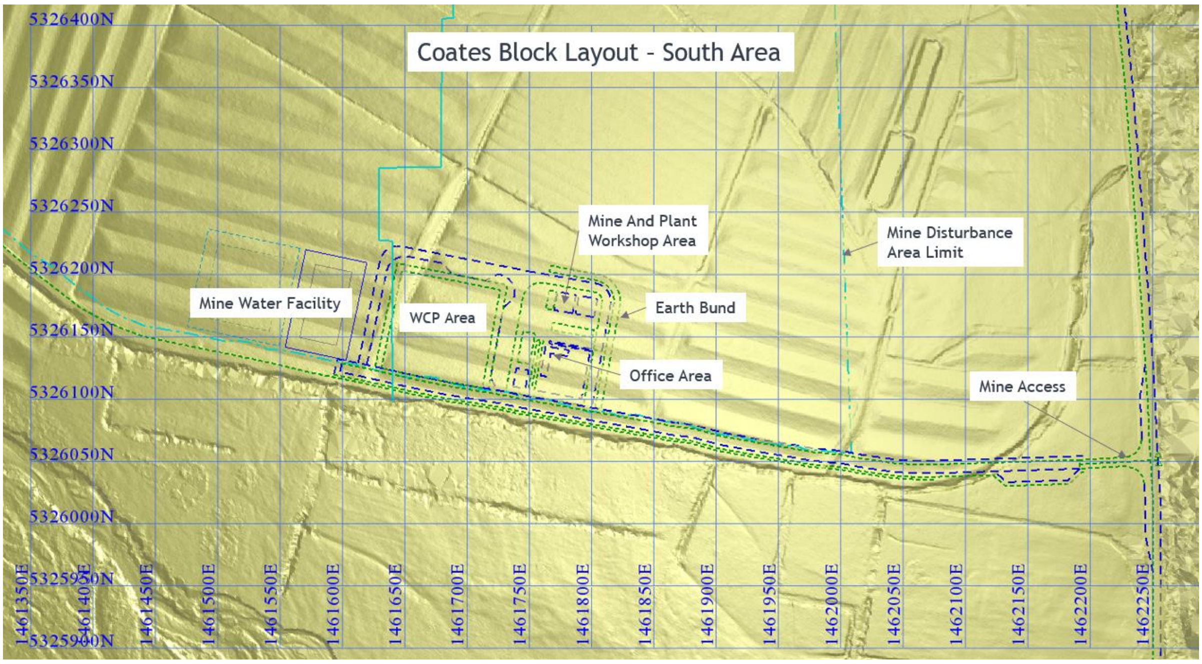

Figure 4: Indicative location of buildings at the site.

The Processing Plant may require an initial water take from Canoe Creek to fill up the Processing Plant circuit including the fire water tank. This take would be located adjacent to the existing farm access track near the coast with a maximum rate of 63 litres/second. In addition, water takes from the same location may be required sporadically during mining to top up the water circuit as required. This water take may be via a direct surface take or an infiltration gallery.

Processing Plant water will be recovered mechanically from the HMC product and un-mineralised sands via a series of cyclones and recirculated for reuse. Some of the process water will be retained in the HMC and some will be pumped back to the pit cavity with the unmineralized sand slurry.

Stormwater generated in the Processing Plant area will be captured and directed to settling ponds via pumping to the treatment ponds (referred to as Ponds 1 and 2) before treated water discharges to the central drain which will convey discharged water from the mine water facility to finishing ponds (Ponds 3 and 4) in the north-western corner of the site.

Water from the mining void and stormwater runoff from the process plant area will also be diverted or pumped to Pond 1 and Pond 2. Pond 1 includes two separate forebay impoundments which are designed to capture most of the sediment prior to flow into the main body of Pond 1 and then over a level spreader to Pond 2. Where sediment laden water will enter the Pond 1 forebay a flocculant will be added to the water to assist with sediment settlement. The specific flocculant to be used on site will be determined prior to works commencing.

Clean water from Pond 2 will then discharge via a pump to the central drain or be used in the process plant. The central drain will have a series of rock check dams installed and these will assist with flow reduction and also will capture some sediment over time.

Water in the central drain will flow to a finishing pond and the clean water facility (referred to as Ponds 3 and 4) in the southwestern corner of the site. Excess water from Pond 3 will overflow (or be pumped) into the clean water facility (Pond 4) before discharging to the environment via drains.

Excess water from Pond 4 will be directed to infiltration trenches in the first instance to so as to recharge groundwater and avoid surface water depletion. Any water that cannot be directed to infiltration trenches will be discharged from the finishing pond into the drain which discharges to Canoe Creek Lagoon provided that water quality, including visual clarity, allows.

If the water quality or visual clarity is insufficient to allow discharge to the drain which discharges to Canoe Creek Lagoon, then the discharge water will be managed as follows (in order of preference):

i) If there is capacity in the system, the water will be recirculated into the Processing Plant and mine water facility;

ii) The water will be left to flood the mine void until such a time as water quality is acceptable and/or the water management system is amended; and

iii) The water will be discharged to further infiltration trenches around the perimeter of the mine, with excess water being pumped to the Canoe Creek infiltration basin.

The Canoe Creek infiltration basin makes use of an existing structure (a former cattle stand-off pad) which is now vegetated with blackberry/gorse and has occasional small, common native species regenerating amongst the weeds. The proposed sand extraction would result in a lowering of water table by up to 9 m below ground surface in the deepest active excavation zone as a result of in-pit pumping (Kōmanawa Solutions Limited 2023). Surrounding groundwater levels, hydraulic gradients and hydrologically connected water bodies (creeks, wetlands and freshwater lagoons) could be affected by this lowering of the water table in the absence of a water management system to avoid adverse hydrological impacts.

The proposed water management system includes returning the pit inflow water to the ground contemporaneously with mining activities along the northern boundary and southwestern boundary using infiltration trenches and, if necessary, recharge barrier wells in order to avoid the potential for effects associated with groundwater extraction. Additional augmentation of water pressures and levels would be provided using direct flow augmentation of Collins Creek and the Northern Drain.

The groundwater at the site has naturally elevated concentrations of some dissolved metals including aluminium, arsenic, chromium, copper, nickel and zinc as described in Kōmanawa Solutions Limited (2023). With respect to surface water, six metals including aluminium, cobalt, copper and zinc were recorded with concentrations above the ANZG 95% species protection values (Kōmanawa Solutions Limited 2023). Mine water treatment and focused hardness adjustment is proposed to be used to ensure that surrounding water bodies and biota would be protected.

1.3 Scope of Report

Ecological Solutions Limited was engaged to undertake the baseline terrestrial and aquatic surveys necessary to inform the resource consent application, contribute to the mine planning in order to avoid adverse effects on the ecological values where required and /or practicable, to prepare an assessment of environmental effects of the proposed activities and provide recommendations to mitigate and/or remedy effects which cannot be avoided (where that approach is appropriate).

Because the site is located in the coastal environment and adjoins streams and wetlands, the New Zealand Coastal Policy Statement (2010) and the New Zealand National Policy Statement for Freshwater Management (2020) both apply. Ecological Solutions Limited was asked to consider the proposal in the light of these policy documents.

In addition, clearance of indigenous vegetation is a restricted discretionary activity under Rules ECO-R5, NC-R3 and NC-R4 in the Proposed Te Tai o Poutini Plan. Ecological Solutions Limited was also asked to consider the relevant matters in Rule ECO-R5 in relation to the clearance of a small area of planted indigenous vegetation (primarily harakeke (New Zealand flax, *Phormium tenax*) which was planted near one of the feed pads for shelter purposes and the individual scattered mature native trees at the site.

This report includes 12 sections as follows:

- An introduction (Section 1).
- A description of the ecological setting of the site based on a literature review (Section 2).
- A description of the methods used to survey the site (Section 3).
- A description of the results of the surveys with respect to terrestrial flora and fauna (Section 4).
- The findings with respect to wetlands at the site (Section 5).
- A description of the results with respect to streams and aquatic habitats at the site (Section 6).
- A summary of the groundwater quality at the site (Section 7).
- An assessment of ecological value for each of the ecological attributes present (Section 8).
- An assessment of the effects of the proposal (Section 9).
- A description of the mitigation actions proposed to reduce these effects (Section 10).
- A consideration of the relevant planning matters (Section 11).
- A list of references used in preparing this report (Section 12).

2.0 Ecological Setting

The site is located within the Punakaiki Ecological District (ED) and North Westland Ecological Region (McEwen 1987). The Punakaiki ED was distinguished on the basis of geology, climate, land use, topography and vegetation. Punakaiki ED includes the western slopes and alpine crests of the Paparoa Ranges and associated synclines, as well as the coastal plains to the west (often referred to as 'the Barrytown flats'). The Barrytown flats are an elongated area approximately 17 km long (N-S) by 2 km wide (E-W), flanked to the east by the Paparoa Ranges and to the west by the Tasman Sea (Burlet and Lee 2019). Nearly all of the Barrytown Flats have been modified by forest clearance and drainage for timber harvesting, mining, and farming, but the majority of the steeper areas in the ED remain in indigenous forest vegetation. The Punakaiki ED also includes extensive areas of pākihi in the previously logged areas of the Tiropahi Valley (McEwen 1987). Most of the Barrytown area has at some time been under licence for prospecting ilmenite and gold (Wilms 1985).

The Barrytown flats are comprised of a complex sequence of old dune ridges and alluvial deposits, which would have been entirely covered in lowland (coastal) forest and wetland before clearance for farming. Nearly all of the Barrytown flats have been modified by forest clearance and drainage for timber harvesting, mining, and farming, although remnants of wetland and forest remain, including Maher Swamp located north of Burke Road (north of the site).

Maher Swamp was originally set aside as a Flax Reserve and flax was harvested there (and at Razorback Swamp at the northern end of the Barrytown flats) until the early 1950s and milled at Barrytown (Gardner 1992). Unlike most swamps in the region Maher Swamp is comparatively nutrient rich. Gardner (1992) reported characteristic pakihi species such as wire rush (*Empodisma minus*), tangle fern (*Gleichenia dicarpa*) and *Centrolepis pallida* were lacking and mānuka (*Leptospermum scoparium* agg.) bracken (*Pteridium esculentum*) and *Lepidosperma australe* were very infrequent at Maher Swamp. He also noted only a single species of *Sphagnum* (*S. cristatum*). At that time Maher Swamp had large areas of raupō (*Typha orientalis*) and of harakeke/flax (*Phormium tenax*) and lesser amounts of *Carex sinclairii* with *Coprosma tenuicaulis*, *Machaerina rubiginosa* and the exotic *Juncus canadensis* with sphagnum on the almost dry places. There was no willow. Gardner considered that *J. canadensis* had become the primary invader of disturbed peat there and that the floristic diversity was concentrated at the swamp's edges.

Plant species of interest included *Myriophyllum robustum* (which is regarded as 'At Risk (declining)' (de Lange et al. 2021)) in the large drain on the eastern side and swamp millet (*Isachne globosa*) and *Amphibromus fluitans* which are both uncommon in the South Island. Norton (1991[2]) also recorded sand coprosma (*Coprosma acerosa*) at Maher Swamp. Sand coprosma is also regarded as 'At Risk (declining)'. Maher Swamp is located on public conservation land and is identified as a significant wetland in the West Coast Regional Plan. An area adjacent to Maher Swamp is identified in Schedule 4 (Significant Natural Areas) of the Proposed Te Tai o Poutini Plan as Site PUN-044, which is described as "lowland forest and wetland adjoining Maher Swamp with adjacent coastal hill forest. Mix of kahikatea forest with northern rata and sparse rimu in places, but also extensive areas of flax and sedgeland. Provides an ecological corridor between the Maher Swamp and the forested land to the east of the road." Parts of Maher Swamp itself are identified as both Schedule 1 and Schedule 2 wetlands in the West Coast Regional Land and Water Plan as shown in Figure 5.

Since approximately 2010, there has been a concerted effort to rehabilitate sand plain forest on the 80 ha former Rio Tinto property at the northern end of the Barrytown flats (adjoining Nikau Scenic Reserve and known as Te Ara Tāiko Nature Reserve) with the aim of restoring ecological connection between the coast and habitats inland.

Because of the topography and elevation of the site, original freshwater habitats in the area would have been characterised by low order, moderate energy watercourses connected to large wetland swamps and perhaps fens. The steep upper catchments would have increased water velocity in streams, whilst nearer the coast, occasional flooding combined with poorly drained soils and high ground water would have maintained large wetland areas. These wetland areas functioned to attenuate water flows and acted as slow-release water storage areas reducing sediment load at the coast and minimising flooding. Wetland areas would have harboured a variety of native terrestrial and aquatic flora and fauna, including a high diversity of native macroinvertebrates and fish species.

McEwen (1987) considered that there was a very high diversity of vegetation types throughout the Punakaiki Ecological District according to the variety of drainage and fertility presented by an equally high diversity of landforms. She also considered the district unusual in the variety and quality of the indigenous forests that remain. Partly because of the diversity of habitat types, there is a high diversity of insects and birds and the ED is home to the only known tāiko (Westland petrel, *Procellaria westlandica*) breeding colony (McEwen, 1987).

[2] https://www.nzpcn.org.nz/publications/plant-lists/plant-lists-by-region/maher-swamp-barrytown-mahy/

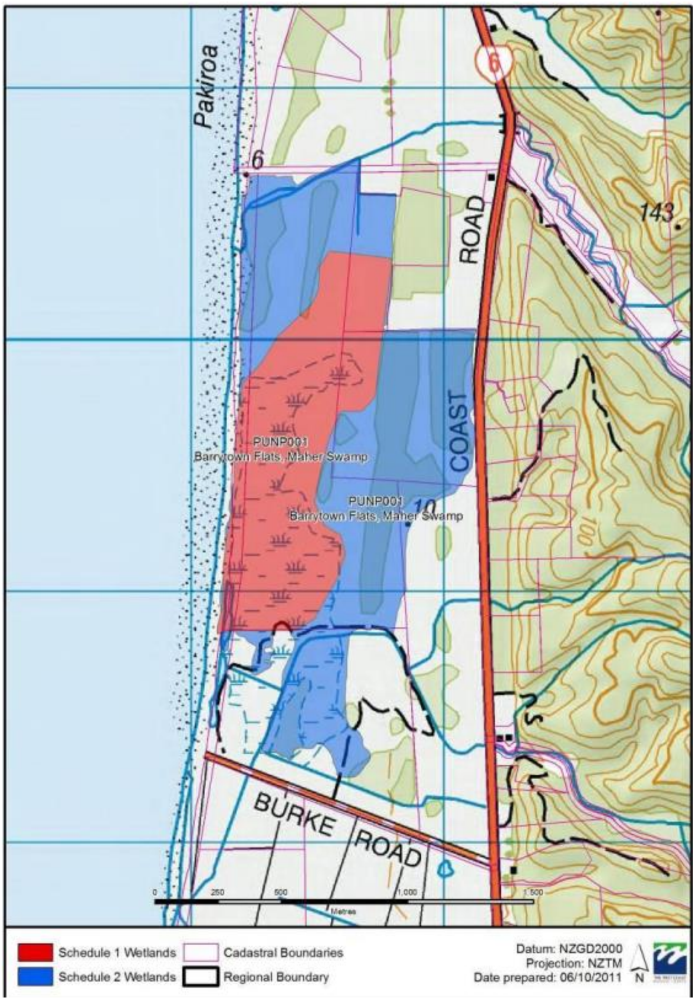

Figure 5: Location of Schedule 1 and 2 wetlands at Maher Swamp, Barrytown.

Onley (1980) carried out 117 bird counts in five different low altitude forest types in the Punakaiki Ecological District including Karst forest, Coastal forest, Old Tertiary forest, Limestone talus forest and cutover forest. The forests were all located below 170m asl. Coastal forest was dominated by kāmahi (*Pterophylla racemosa*) with emergent rimu (*Dacrydium cupressinum*) and conspicuous northern rātā (*Metrosideros robusta*) and hīnau (*Elaeocarpus dentatus*). Coastal forest had the lowest number of species per count overall (9), with Old Tertiary forest having 10 native species and Karst forest having 13. These observations combined with information from the Land Environments of New Zealand and Threatened Environments Classification, indicate that the Punakaiki ED is relatively intact with respect to species, habitats and ecological functioning.

Boffa Miskell undertook the task of identifying significant natural areas within the Grey District on behalf of GDC in 2006/2007. To the north and west, the application site is bordered by an area identified by Boffa Miskell as Barrytown Flats, Canoe Creek Lagoon (Site PUN-W034, Boffa Miskell 2006). This area has been modified and included in Schedule 4 (Significant Natural Areas) of the Proposed Te Tai o Poutini Plan as Punakaiki Lagoon and Coastal Wetland sequence, which is described as “a lagoon and series of small lakes bordered by flax wetlands and coastal forest. Significant vegetation and ecosystem sequence.” Site PUN-W034 as defined by Boffa Miskell originally covered 40ha, including the area immediately around the lagoon to the west of the proposed mine site and two other areas of open water to the north that were created as a result of mining activities there between 1932 and 1948. The highest value habitats described by Boffa Miskell (2006) were the indigenous turf vegetation present on the lagoon edge and the diversity of bird habitats found there including shallow edges for wading birds, deeper vegetated edges for waterfowl, moderately deep open water for shags, dense reedland for Australasian bittern (*Botaurus poiciloptilus*) and perhaps marsh crake (*Zapornia pusilla*) and dense shrubland for fernbirds (*Poodytes punctatus*) (Boffa Miskell 2006).

The area identified by Boffa Miskell has been reduced in size and adjusted at some locations (including to exclude the Collins Creek lagoon at the site) and included in the Proposed Te Tai o Poutini Plan as shown in Figure 6.

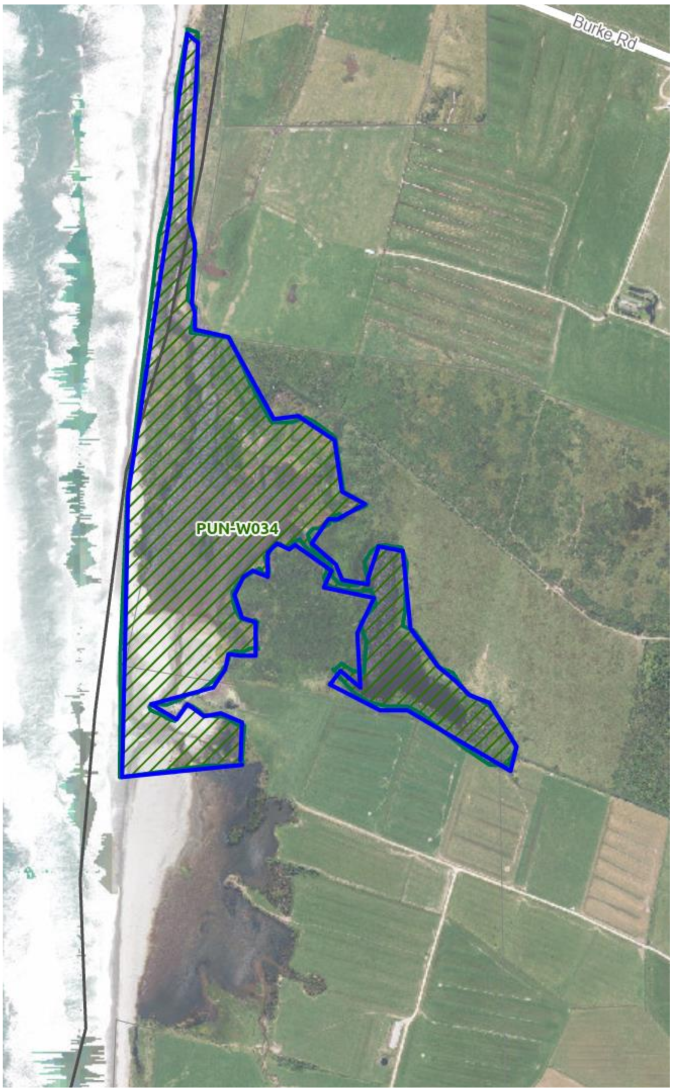

Figure 6: Site PUN-W034 as included in the Proposed Te Tai o Poutini Plan.

As alluded to above, the northern boundary of the site is approximately 3.6 km south of the only known tāiko (Westland petrel) colony which is located between Punakaiki River and Waiwhero Creek. Tāiko have a conservation threat status of ‘At Risk (naturally uncommon)’ with the qualifiers “one location” and “stable” (referring to the population, Robertson et al. 2021). Naturally uncommon species are those which are thought to number fewer than 20,000 mature individuals (unless they occupy an area of <1000 km^2) and have a distribution 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. The total population of tāiko is estimated to be 7,900–13,700 individuals or around 4,000 breeding pairs (Waugh and Bartle 2013, Birdlife International 2021).

Tāiko productivity is estimated to be around 50-60% on average, but can be as low as 0% in the presence of nest predators (Waugh and Bartle 2013). This productivity is thought to be sufficient to maintain the population, which was estimated to slowly increase at a rate of 1.8% per year between 1970 and 2012, but those data are not particularly reliable (Waugh et al. 2015). Eggs are laid in May and hatch in July. Land based threats include landslides and storm events, the impact of goats, dogs, feral pigs and other mammals on breeding habitat and mortality due to disorientation caused by artificial lighting. Tropical Cyclone Ita (2014) was reported to have significantly affected the tāiko breeding colony (prior to breeding commencing), but the longer-term effect of that event, if any, on the population remains unknown.

Immature petrels leave the colony at fledging and do not return until first breeding, typically between the ages of five and ten (most commonly around seven years of age). They are most vulnerable within the several days after they commence that first flight to sea.

One of the largest causes of tāiko mortality identified to date is grounding due to disorientation caused by artificial lighting. Most grounded petrels have been collected between November and January (271 of 296 birds collected, 92%) with a peak in the first half of December. An average of 17 birds per year were collected as grounded birds over the period 2007 – 2023 (data supplied by S van Smit, Department of Conservation, pers. comm. 27 March 2023).

Grounded birds are assumed to have been disoriented and have been collected from a wide geographical area including as far north as Westport, as far south and inland as Lake Kaniere (inland and south of Hokitika). Not all groundings are fatal and the potential exists for rehabilitating any birds collected alive after grounding. Adult birds leaving to forage at sea or returning appear to be less affected by lighting than juvenile birds, but some adults are still disoriented by lights.

Of 296 tāiko discovered after a grounding between 2007 and 2023 where the location was known, 180 (61%) were collected in the Punakaiki area, 61 (21%) in and around Greymouth, 34 (11%) from the Westport area and 21 (7%) from the Hokitika or Charleston area (data supplied by S van Smit, Department of Conservation, pers. comm. 27 March 2023). Thus, the Punakaiki area is important core habitat for tāiko.

3.0 Methodology

3.1 Terrestrial Flora and Fauna

3.1.1 Vegetation

Vegetation at the site was surveyed during a walk-through survey undertaken 5 and 6 July 2021.

3.1.2 Avifauna

A list of birds potentially using the site was derived from observations recorded in the eBird database and downloaded 20 February 2023. EBird.org is a free, open-source database maintained by the Cornell Lab of Ornithology which stores observations, photos and recordings of birds from anywhere in the world. Anyone with a user account can enter an observation in the eBird database electronically, but any unusual observations, such as rare species or unusually high numbers of birds, are automatically flagged and reviewed by knowledgeable local volunteers before being made publicly available. Some historical data have been added. Users include amateur ornithologists and professional researchers. Users can request data relating to species or locations and this is typically used for research, management and conservation purposes. This format has been adopted by Birds

New Zealand for collection of data to inform the development of the third New Zealand Bird Atlas (2019–2024), superseding the more manual methods used in the previous two atlases (1969–1979 and 1999–2004).

In addition to the historical records available in eBird, four seasonal avifauna surveys were undertaken at the site in April 2022 (autumn), September 2022 (late winter), December 2022 (early spring/summer) and January 2023 (summer). The purpose of these surveys was to confirm the presence and specific locations of more secretive birds that may be present in the coastal lagoon and wetlands surrounding the site throughout the year.

The seasonal surveys employed a combination of five-minute bird counts (5MBC) and digital acoustic recorders. Five-minute bird counts have been the standard method of monitoring birds in New Zealand since the 1970s (Dawson and Bull 1975). They allow data to be collected on multi-species bird populations in a range of habitats. Acoustic recorders have the advantages of increasing detectability, avoiding disturbance due to an observer, easily increasing survey area or duration without substantial additional effort and providing permanent recordings (which can be shared with others if required, e.g., to identify rare species). Here, six acoustic recorders (DOC AR4) were used in conjunction with fifteen 5MBC undertaken by a trained and experienced observer across the habitat types present at the site. Each acoustic recorder was given a unique identifier and deployed for at least seven days per survey. During September, recorders were set to record between 17:00hrs and 06:00hrs. During the other surveys the recorders were set to record for 23 hours and 55 minutes each day. The monitoring locations used in each survey at Barrytown are described in Table 1 and presented in Figure 7.

Table 1: Description of quarterly avifauna monitoring locations at Barrytown.

Station	Monitoring method		Habitat Type	Easting	Northing
	AR	5MBC			
BAR01 40	✓	✓	Scrub/Grassland	146 1732	532 6884
BAR02 26	✓	✓	Scrub/Grassland	146 1533	532 6953
BAR03 53	✓	✓	Flaxland/Grassland	146 1347	532 7047
BAR04 47	✓	✓	Flaxland/Grassland	146 1068	532 6974
BAR05 49	✓	✓	Flaxland/Grassland	146 1137	532 6788
BAR06 32	✓	✓	Grassland (developed and undeveloped)	146 1102	532 6557
BAR07	-	✓	Lagoon	146 0938	532 6548
BAR08	-	✓	Grassland	146 1319	532 6569
BAR09	-	✓	Grassland	146 1390	532 6798
BAR10	-	✓	Grassland	146 1601	532 6719
BAR11	-	✓	Grassland	146 1549	532 6526
BAR12	-	✓	Grassland	146 1504	532 6337
BAR13	-	✓	Grassland	146 1678	532 6238
BAR14	-	✓	Grassland	146 1727	532 6445
BAR15	-	✓	Grassland	146 1778	532 6630

Note: Station codes are formatted as the first two numbers being site location, and second two numbers being the AR identifier.

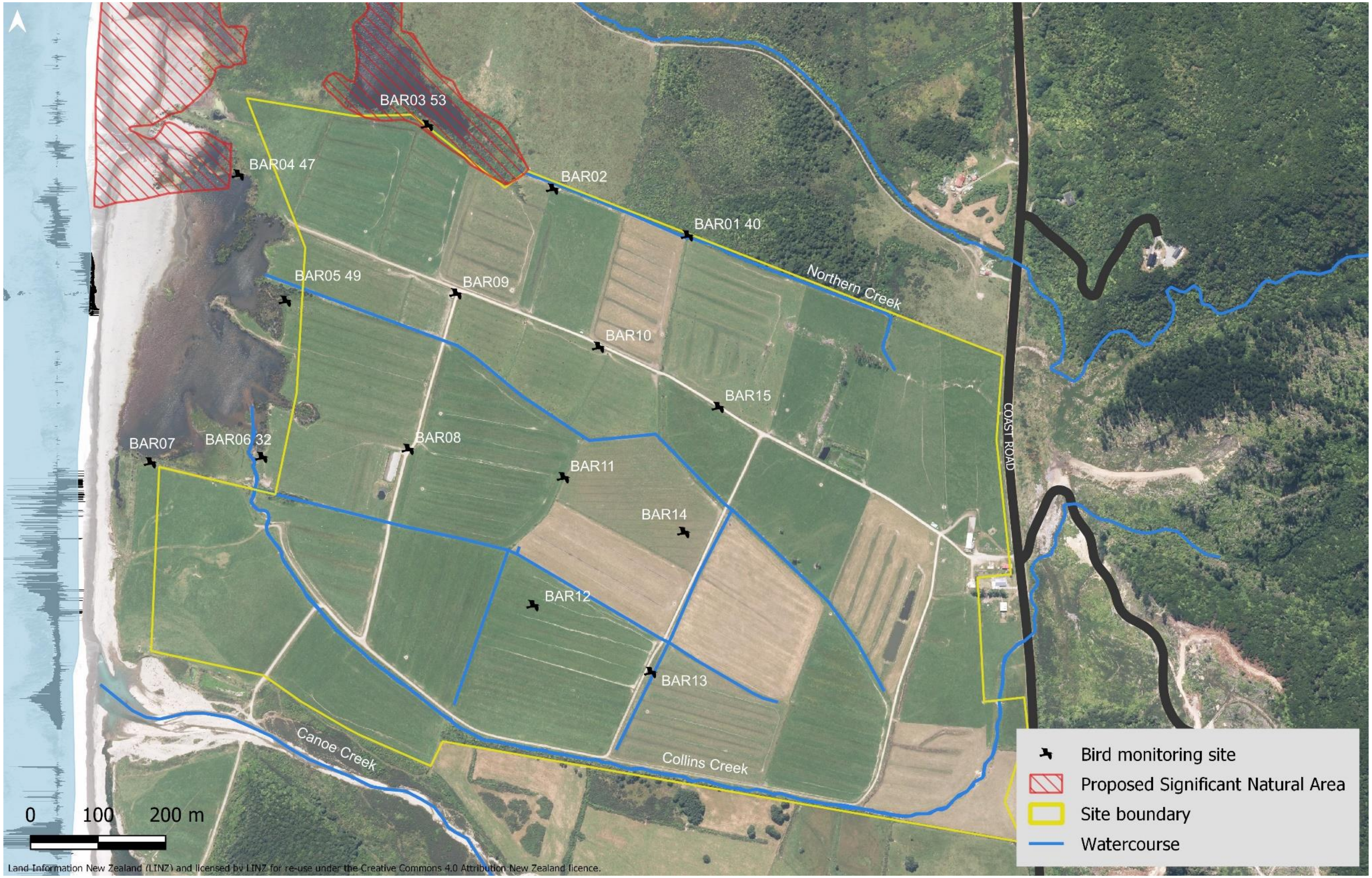

Figure 7: Quarterly avifauna monitoring sites at Nikau Deer Farm, Barrytown.

3.1.3 Herpetofauna

A search for herpetofauna records within 5 km of the site using the Department of Conservation Bioweb database was undertaken on 17 February 2023.

3.2 Wetlands

No natural inland wetlands as defined by the National Policy Statement for Freshwater (2020) (NPS-FM) were located within the site itself. We have not been allowed access to potential wetland areas to the north and south which would be within 100 m of the proposed mining area. We have assumed here that natural inland wetlands are present near the site (i.e., within 100 m). According to the policy direction provided by the NPS-FM, effects on those wetlands will need to be avoided in the first instance via maintaining surface flows and groundwater levels and inputs.

3.3 Streams

3.3.1 Sampling Sites

Four sites were surveyed during the stream ecological survey undertaken on 6 and 7 September 2022. Site details are presented in Table 2 with locations shown in Figure 8.

Table 2: Aquatic Sampling site details.

Location	Site	Description	NZTM 2000	
			Northing	Easting
Northern Drain	1	Mid-section of Northern Drain	5326827.2	1461861.7
Collins Creek (upper)	2	Upper section of Collins Creek	5326390.9	1461142.9
Collins Creek (lower)	3	Lower section of Collins Creek	5326031.6	1462013.4
Canoe Creek	4	Lower reaches of Canoe Creek	5326176.7	1461033.6

3.3.2 Water Quality

Water physico-chemical parameters, viz., temperature, dissolved oxygen, conductivity and pH were measured at each of the ecological survey sites using a calibrated hand held YSI meter. The time of day that measurements were made was also recorded. In addition, more comprehensive surface water quality parameters were investigated by Kōmana Solutions Ltd (2023) at four sites: Collins Creek (upstream of State Highway 6 and downstream at the farm ford), the Northern Drain and in the Canoe Creek Coastal Lagoon as shown in Figure 9.

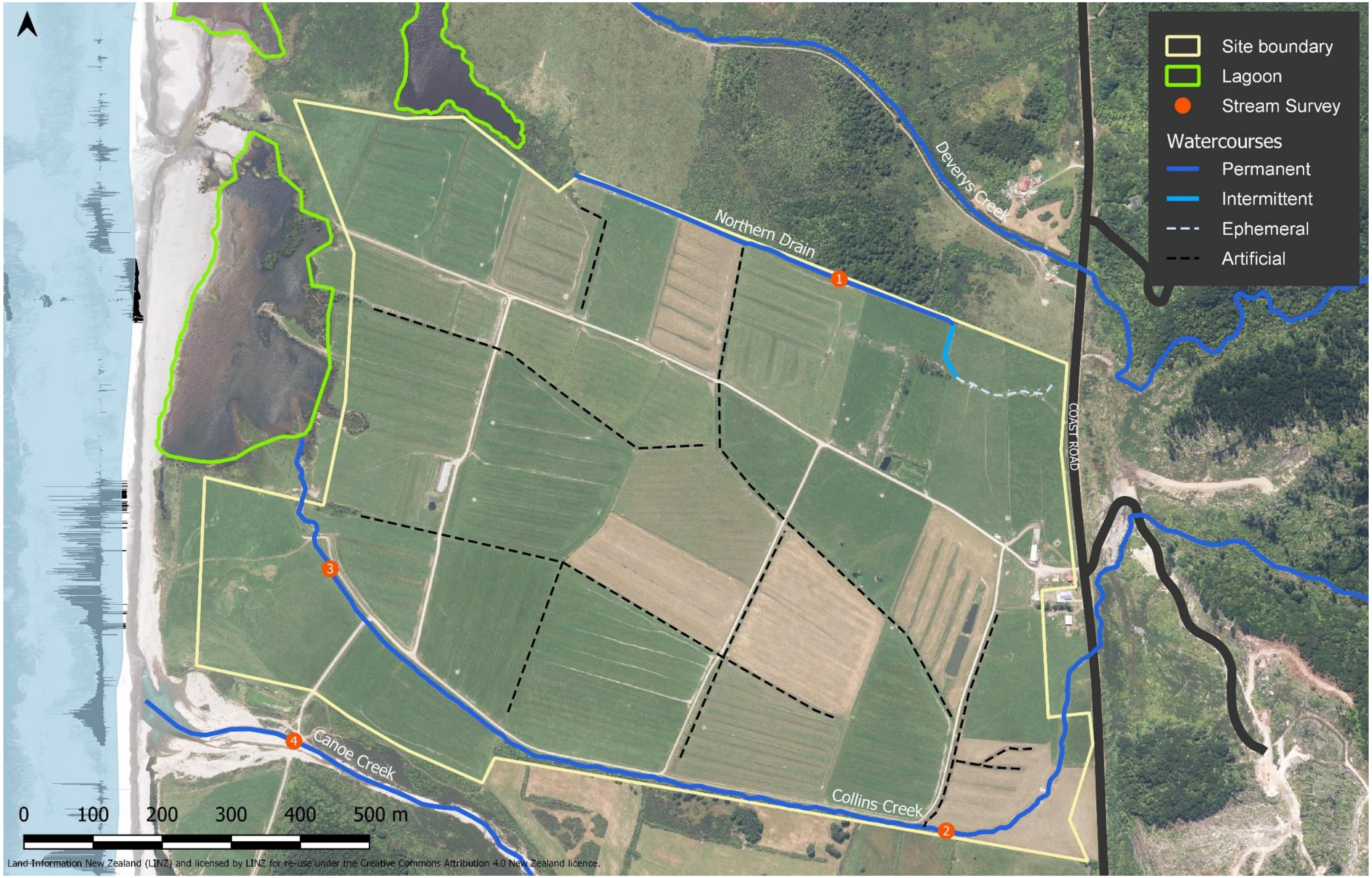

Figure 8: Location of aquatic survey sites at Nikau Deer Farm, Barrytown.

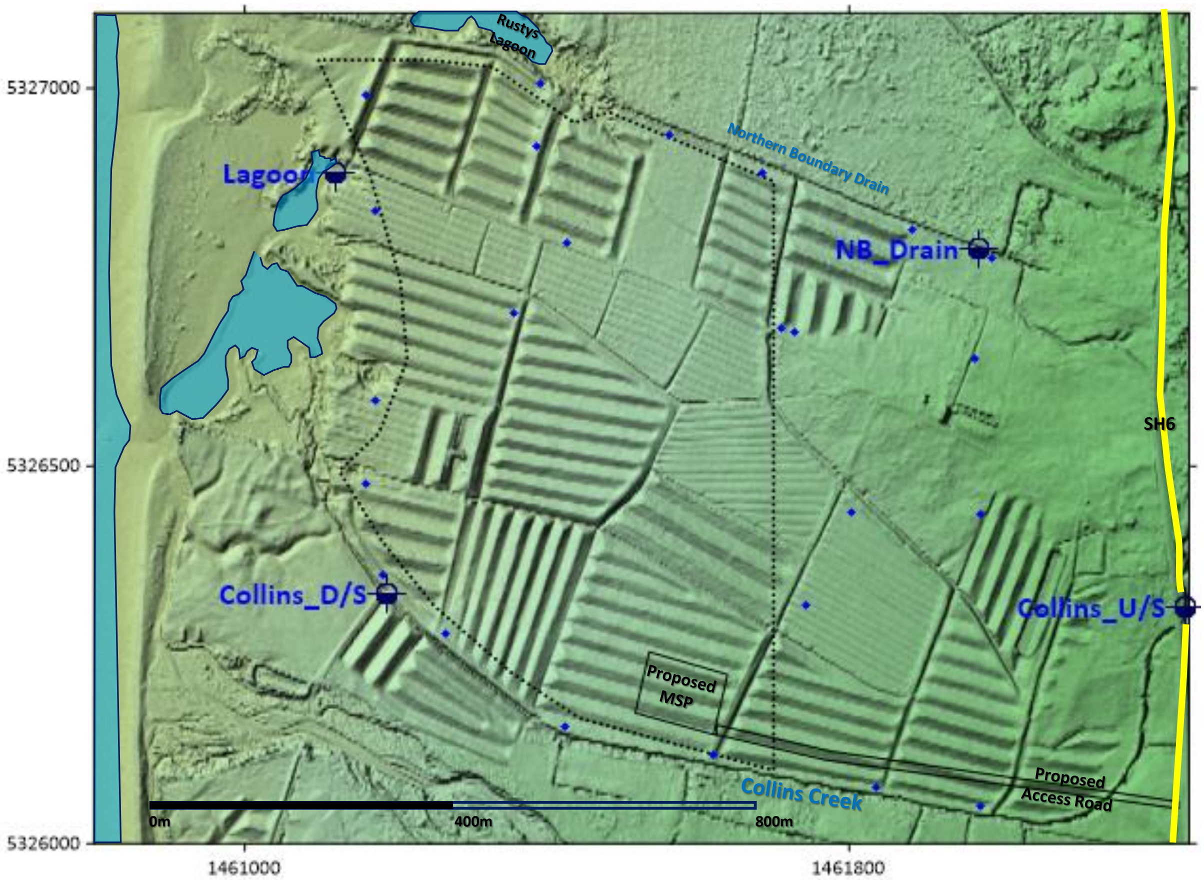

Figure 9: Location of water quality sampling sites sampled by Kōmanawa Solutions.

3.3.3 Habitat Characteristics

Aquatic and riparian habitat data was collected at each site. Habitat can influence periphyton and benthic invertebrate communities so this data was collected to assist in the interpretation of results. The following habitat data was collected:

- Wetted channel width and water depth at transects on each stream.
- Water velocity.
- Habitat type (run, riffle, pool).
- Streambed substrate composition.
- Streambank erosion and bed scour (%).
- Organic matter content (leaf litter, woody debris).
- Riparian habitat characteristics.
- Channel shade (%).

3.3.4 Macrophytes and Periphyton

Macrophyte (aquatic plants) and periphyton cover was assessed at transects across the stream at each site. The method involved assessing macrophyte cover and the species present at five points along five transects following the method in Collier et al. (2014). Periphyton cover was assessed in accordance with the Rapid Assessment Method 2 (RAM-2) in Biggs and Kilroy (2000). Periphyton cover was recorded at five points along four transects and compared with guidelines in Biggs (2000).

3.3.5 Benthic Macroinvertebrates

Five benthic macroinvertebrate samples were collected from each site using a Surber sampler (area 0.1 m^2; 500 µm net mesh) in accordance with the National Environmental Monitoring Standards for Macroinvertebrates (NEMS 2020). Samples were processed following Protocol P3 (full count with subsampling) outlined in Stark et al. (2001).

The following invertebrate metrics and indices were calculated from community data:

- *Community composition* – relative abundance of the main taxonomic groups making up the macroinvertebrate communities recorded from each watercourse. This metric can be used to provide a general indication of stream health based on the relative proportions of water quality and habitat sensitive and tolerant taxonomic groups.
- *Taxa number* – a measure of the overall health of the benthic macroinvertebrate community and habitat and water quality. In general, high taxa number can be an indication of a healthy waterway. The number of taxa present at a site can be highly variable and can fluctuate depending on many factors including habitat, water quality and sampling effort.
- *Abundance* – a measure of the total number of individuals in a sample. Total abundance tends to increase in the presence of organic/nutrient enrichment, but declines in the presence of toxic pollution.
- *Macroinvertebrate Community Index (MCI)* – presence/absence-based index for measuring stream health in soft-bottomed streams. Individual taxa scores range from 1 (pollution tolerant) to 10 (highly pollution sensitive). MCI scores range from <80 (poor) to >120 (excellent) and interpreted using the guidelines in Table 3 (Stark and Maxted 2007). The National Policy Statement for Freshwater Management 2020 (MfE 2020) (NPS-FM) presents MCI thresholds that categorise stream health into four attribute bands (A, B, C and D) (Table 4) (MfE 2020).
- *Quantitative Macroinvertebrate Community Index (QMCI)* – the QMCI is a quantitative variant of the MCI and used to measure stream health for soft-bottomed streams. QMCI scores range from <4.00 (poor) to >6.00 (excellent) and is interpreted following the guidelines in Table 3 (Stark and Maxted 2007). The NPS-FM (MfE 2020) also presents QMCI thresholds that categorise stream health into four attribute bands (A, B, C and D) (Table 4) (MfE 2020).
- *EPT taxa number* – a measure of the overall health of the community and of habitat and water quality. A community that has a higher number of water quality and habitat sensitive taxa from the groups Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) (EPT) indicates a healthier waterway.
- *Percent EPT (%EPT)* – another measure of suitability of the waterway for supporting water quality and habitat sensitive taxa. A benthic macroinvertebrate community that has a higher percentage of water quality and habitat sensitive taxa from the EPT groups indicates a healthier waterway.
- *Average Score Per Metric (ASPM)* – the average score of the normalised MCI-sb, EPT and %EPT. ASPM was introduced into the NPS-FM (MfE 2020) and uses the methodology of Collier (2008). Scores range between 0 (low ecological integrity) and 1 (high ecological integrity) and interpreted based on the guidelines outlined in Table 4.

Table 3: MCI / MCI-sb and QMCI / QMCI-sb quality classes (Stark and Maxted 2007).

Stream health	Descriptions	MCI-sb	QMCI-sb
Excellent	Clean water	>120	>6.00
Good	Doubtful quality/possible mild pollution	100–119	5.00–5.99
Fair	Probable moderate pollution	80–99	4.00–4.99
Poor	Probable severe enrichment	<80	<4.00

Table 4: MCI, QMCI and ASPM attribute bands (MfE 2020).

Attribute Description [a,b]		MCI	QMCI	Description [c]	ASPM
A	Macroinvertebrate community indicative of pristine conditions with almost no organic pollution or nutrient enrichment.	≥130	≥6.50	Macroinvertebrate communities have high ecological integrity, similar to that expected in reference condition.	≥0.6
B	Macroinvertebrate community indicative of mild organic pollution or nutrient enrichment. Largely composed of taxa sensitive to organic pollution / nutrient enrichment.	≥110 and <130	≥5.5 and <6.5	Macroinvertebrate communities have mild-to-moderate loss of ecological integrity.	<0.6 and ≥0.4
C	Macroinvertebrate community indicative of moderate organic pollution or nutrient enrichment. There is a mixture of taxa sensitive and insensitive to organic pollution / nutrient enrichment.	≥90 and <110	≥4.5 and <5.5	Macroinvertebrate communities have moderate-to-severe loss of ecological integrity.	<0.4 and ≥0.3
National bottom line		**90**	**4.5**		**0.3**
D	Macroinvertebrate community indicative of severe organic pollution or nutrient enrichment. Communities are largely composed of taxa insensitive to organic pollution / nutrient enrichment.	<90	<4.50	Macroinvertebrate communities have severe loss of ecological integrity.	<0.3

Note: [a] MCI; [b] QMCI; [c] ASPM.

3.3.6 Fish Fauna

A search of the New Zealand Freshwater Fish Database (NZFFD) was carried out to check for existing records of fish within the site and wider Canoe Creek and Collins Creek catchments. The NZFFD search involved identifying records obtained since 1985.

In addition, fish were surveyed at each sampling site using an electric fishing machine (EFM300). The fishing effort and area fished at each site was standardised (i.e., 30m^2). All fish captured were identified, measured and returned to the streams.

One environmental DNA (eDNA) sample was collected from each stream to provide an indication of the fish species present. Samples were filtered, preserved and sent to Wilderlab laboratory for analysis using the multi-species test.

3.4 Groundwater

Groundwater hydrology of the site has been reviewed by Kōmanawa Solutions Limited (2023) who drew primarily on three investigations: Coffey Partners (1991), Vidanovich (2008) and Rekker (2020).

Coffey Partners (1991), Vidanovich (2008) and Rekker (2020) defined aquifer properties and water level patterns to the immediate north and south of the proposed sand extraction zone. In addition, Kōmanawa Solutions Ltd conducted further groundwater investigations in

2022 with a focus on the proposed sand extraction zone. This included the determination of groundwater levels and flows, hydrological properties and groundwater quality. This report has been informed by the conclusions presented by Kōmanawa Solutions Ltd (2023).

3.5 Assessment of Ecological Values Approach

Ecological values were assigned following the approach outlined in the Environment Institute of Australia and New Zealand's (EIANZ) Ecological Impact Assessment guidelines (EcIAG) (Roper-Lindsay et al. 2018). The EcIAG outline a standardised approach for defining ecological values. The approach involves assessing four matters including representativeness, rarity/Distinctiveness, diversity/pattern and ecological context with consideration of the attributes outlined in Table 7 of the EcIAG. The overall ecological values within the site and vicinity were assigned based on the four matters outlined above and using the scoring system outlined in Table 6 of the EcIAG.

3.6 Assessment of Effects Methodology

The level of effects was assessed using the method recommended by the EcIAG (Roper-Lindsay et al. 2018). This method involves assigning ecological values as above and determining the magnitude of effects based on criteria outlined in Table 5 below and assigning the overall level of effect using the matrix in Table 6 below. The magnitude of the effects was considered at the site level (unless otherwise indicated).

Table 5: Criteria for describing magnitude of effect.

Magnitude	Description
Very high	Total loss or very major alteration to key elements/ features of the baseline conditions such that the post development character/ composition/ 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 baseline (pre-development) conditions such that post development character/ composition/ 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 baseline conditions such that post development character/composition/attributes of baseline will be partially changed; AND/OR Loss of a moderate proportion of the known population or range of the element/feature.
Low	Minor shift away from baseline conditions. Change arising from the loss/alteration will be discernible but underlying character/composition/attributes of baseline condition will be similar to pre-development circumstances/patterns; AND/OR having a minor effect on the known population or range of the element/feature.
Negligible	Very slight change from 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.

Table 6: Criteria for describing level of effects.

Effect level	Ecological value				
	Very high	***High***	***Moderate***	***Low***	***Negligible***
Very high	Very high	Very high	High	Moderate	Low
High	Very high	Very high	Moderate	Low	Very low
Moderate	High	High	Moderate	Low	Very low
Low	Moderate	Low	Low	Very low	Very low
Negligible	Low	Very low	Very low	Very low	Very low
Positive	Net gain	Net gain	Net gain	Net gain	Net gain

4.0 Terrestrial Flora and Fauna

4.1 Vegetation

Vegetation across the majority of the site comprised high producing exotic pasture as shown in Figure 10. Indigenous vegetation was limited to riparian areas which cattle cannot access, i.e., the true left of part of Collins Creek (shown in Figure 11) and the true right of the drain at the northern boundary of the property, as well as three isolated kahikatea trees (one of which had epiphytic species including broadleaf (*Griselinia littoralis*) and kowharawhara (*Astelia solandri*)). There were also planted areas of native species which cattle cannot access near the two feed pads on the property as shown in Figure 12. There were occasional sedges (mainly rautahi, *Carex geminata*) and flaxes which have persisted near drains as shown in Figure 13), although these had been heavily grazed at some locations.

Figure 10: Exotic pasture at Nikau Deer Farm, Barrytown.

Figure 11: Riparian vegetation at the mid-section of Collins Creek.

Figure 12: Planted vegetation near a livestock feed pad.

Figure 13: *Carex* growing in a drain at Nikau Deer Farm.

Surrounding the lagoon and artificial ponds, the vegetation was more natural and was dominated by harakeke (New Zealand flax, *Phormium tenax*) with common blackberry (*Rubus fruticosus* agg.) and sedges (*Carex* spp., including *C*. *geminata*), and occasional rushes (*Juncus* spp.) and tī kouka (Cabbage tree, *Cordyline australis*). Examples of this vegetation are shown in Figure 14 and Figure 15.

Figure 14: Vegetation surrounding Rusty Pond which adjoins Nikau Deer Farm.

Figure 15: Vegetation surrounding Canoe Creek Lagoon, Barrytown.

To the north of the property, north of the Northern Drain, is vegetation which appears to be consistent with the area comprising one or more natural inland wetlands as defined by the NPS-FM, including *Juncus* rushland and kahikatea (*Dacrycarpus dacrydioides*) swamp forest. We note that we have not had access to that property to confirm the status of the vegetation there, but have assumed that these areas are natural inland wetlands and effects must therefore be avoided in accordance with the NPS-FM.

4.2 Avifauna

4.2.1 eBird database

A search of the eBird database for records within 10 km of the site revealed 1,276 records comprising 72 taxa including seabirds, coastal birds and land birds. Twenty-nine species of conservation interest have been identified, many of which are coastal birds (Table 7). The majority of these coastal birds are likely to be using the lagoon or adjacent wetland habitats for feeding and nesting. Three of these species of conservation interest could not be identified to species level but were parakeets (*Cyanoramphus sp*), albatross (*Thalassarche sp*), and shearwater (family Procellariidae).

4.2.2 Birds recorded during seasonal surveys

Bird species recorded during the seasonal surveys are presented in Table 8. Species present were generally exotic or common native species and the avifauna community generally reflects the highly modified state of the rural environment at the site. Many of the species recorded are considered typical of urban and rural environments, however eight species recorded are of conservation interest including black shag (*Phalacrocorax carbo*, At Risk (relict)), black-billed gull (*Chroicocephalus bulleri* (At Risk (declining)), Caspian tern (*Hydroprogne caspia* (Threatened (Nationally vulnerable)), grey duck (*Anas superciliosa* (Threatened (Nationally vulnerable)), red-billed gull (*Chroicocephalus novaehollandiae* (At Risk (declining)), South Island pied oystercatcher (*Haematopus finschii* (At Risk (declining)), Variable oystercatcher (*Haematopus unicolor* (At Risk (recovering)) and white fronted tern (*Sterna striata* (At Risk (declining)).

Table 7: Birds of conservation interest recorded on eBird within 10 km of Nikau Deer Farm, Barrytown.

Common name	Scientific name	Conservation status
Australasian Pipit	*Anthus novaeseelandiae*	At Risk: Naturally Uncommon
Banded Dotterel	*Charadrius bicinctus*	At Risk: Declining
Bar-tailed Godwit	*Limosa lapponica*	At Risk: Declining
Black-billed Gull	*Chroicocephalus bulleri*	At Risk: Declining
Black Shag	*Phalacrocorax carbo*	At Risk: Relict
Black-fronted Tern	*Chlidonias albostriatus*	Threatened: Nationally Endangered
Caspian tern	*Hydroprogne caspia*	Threatened: Nationally Vulnerable
Eurasian Coot	*Fulica atra*	At Risk: Naturally Uncommon
Fernbird	*Poodytes punctatus*	At Risk: Declining
Fluttering Shearwater	*Puffinus gavia*	At Risk: Relict
Great Spotted Kiwi	*Apteryx haastii*	Threatened: Nationally Vulnerable
Little Penguin	*Eudyptula minor*	At Risk: Declining
Little Shag	*Microcarbo melanoleucos*	At Risk: Relict
New Zealand Falcon	*Falco novaeseelandiae*	At Risk: Recovering
Pacific Black Duck	*Anas superciliosa*	Threatened: Nationally Vulnerable
Pied Shag	*Phalacrocorax varius*	At Risk: Recovering
Red-billed Gull	*Chroicocephalus scopulinus*	At Risk: Declining
Sooty Shearwater	*Ardenna grisea*	At Risk: Declining
South Island Pied Oystercatcher	*Haematopus finschi*	At Risk: Declining
Spotted Shag	*Phalacrocorax punctatus*	Threatened: Nationally Vulnerable
Variable Oystercatcher	*Haematopus unicolor*	At Risk: Recovering
White-capped Albatross	*Thalassarche cauta*	At Risk: Declining
White-fronted Tern	*Sterna striata*	At Risk: Declining
White Heron	*Ardea alba*	Threatened: Nationally Critical
Westland Petrel	*Procellaria westlandica*	At Risk: Naturally Uncommon
Yellow-crowned Parakeet	*Cyanoramphus auriceps*	At Risk: Declining

In addition to the birds recorded during the seasonal surveys, a pair of Pacific reef heron (*Egretta sacra*) were seen during the July 2021 site visit. Pacific reef heron are regarded as Threatened (nationally endangered) (Robertson et al. 2021).

No rōroa (*Apteryx haastii*), mātātā/fernbird or Australasian bittern were recorded at the site, nor were any tāiko recorded, although the absence of tāiko is not unexpected given the methods used. The absence of rōroa, mātātā and bittern is likely due to an absence of sufficient suitable habitat, although being highly mobile, bittern may visit the site on occasion. The audio records of ducks (*Anas* spp.) were unable to be separated into the exotic mallard (*Anas platyrhynchos*) or native grey duck (*Anas superciliosa*, which is regarded as nationally vulnerable) which are indistinguishable audibly and can be difficult visually to tell apart. It is most likely that the birds heard were hybrids between the two, which are regarded as 'not threatened' (Robertson et al. 2021).

All native birds are protected under the Wildlife Act 1953 except those listed in Schedule 5 of the Act.

Table 8: Bird species confirmed within or near the site during seasonal surveys using five-minute bird counts and acoustic recorders.

Common name	Scientific name	Conservation status
Australasian Harrier	*Circus approximans*	Not Threatened
Australian Magpie*	*Gymnorhina tibicen*	Introduced and Naturalised
Black Shag	*Phalacrocorax carbo*	Relict
Black Swan	*Cygnus atratus*	Not Threatened
Black-billed gull	*Chroicocephalus bulleri*	Declining
Eurasian blackbird*	*Turdus merula Linnaeus*	Introduced and Naturalised
Canada Goose*	*Branta canadensis*	Introduced and Naturalised
Caspian Tern	*Hydroprogne caspia*	Nationally Vulnerable
Chaffinch*	*Fringilla coelebs*	Introduced and Naturalised
Domestic rooster*	*Gallus gallus domesticus*	Introduced and Naturalised
Dunnock*	*Prunella modularis*	Introduced and Naturalised
Goldfinch*	*Carduelis carduelis*	Introduced and Naturalised
Grey Warbler	*Gerygone igata*	Not Threatened
Mallard duck*	*Anas platyrhynchos*	Introduced and Naturalised
Grey duck	*Anas superciliosa*	Nationally vulnerable
Gull species	*Chroicocephalus sp.*	–
Morepork	*Ninox novaeseelandiae*	Not Threatened
Oystercatcher	*Haematopus sp.*	–
Paradise Duck	*Tadorna variegata*	Not Threatened
Pied Silt	*Himantopus himantopus*	Not Threatened
Pūkeko	*Porphyrio melanotus*	Not Threatened
Red-billed Gull	*Chroicocephalus novaehollandiae*	Declining
Scaup	*Aythya novaeseelandiae*	Not Threatened
Shining cuckoo	*Chrysococcyx lucidus*	Not Threatened
Silvereye	*Zosterops lateralis*	Not Threatened
Skylark*	*Alauda arvensis*	Introduced and Naturalised
Song Thrush*	*Turdus philomelos*	Introduced and Naturalised
South Island Fantail	*Rhipidura fuliginosa fuliginosa*	Not Threatened
South Island Pied Oystercatcher	*Haematopus finschi*	Declining
Southern black-backed Gull	*Larus dominicanus*	Not Threatened
Spur-winged Plover	*Vanellus miles*	Not Threatened
Starling	*Sturnus vulgaris*	Introduced and Naturalised
Tui	*Prosthemadera novaeseelandiae*	Not Threatened
Variable Oystercatcher	*Haematopus unicolor*	Recovering
Welcome Swallow	*Hirundo neoxena*	Not Threatened
Western Weka	*Gallirallus australis australis*	Not Threatened
White fronted Tern	*Sterna striata*	Declining
White-faced Heron	*Egretta novaehollandiae*	Not Threatened
Yellowhammer*	*Emberiza citrinella*	Introduced and Naturalised

* Indicates introduced and naturalised species

Of the eight species of conservation interest recorded at the site during the seasonal surveys none are likely to rely on the pasture habitat within the site, but gulls, dotterels, and perhaps oystercatchers may visit pasture areas (particularly where soils have recently been turned over) for feeding or loafing. Black shag are usually seen alone either near or travelling between wetlands and streams where they feed on fish. Terns (Caspian tern and white fronted tern) are coastal species which feed on small fish in lagoons and coastal waters.

Black-billed gulls mostly breed on sparsely-vegetated gravels on inland riverbeds, but disperse to the coast between breeding in the South Island and are commonly seen feeding on invertebrates in pasture or bare soil.

Red-billed gulls are the commonest gull around the New Zealand coastline and (particularly juveniles) are similar in appearance to black-billed gulls. They are also commonly seen using pasture and bare soil, and also scavenge food in towns and cities. They nest near the coast.

Grey duck are associated with open water and hybridise with the exotic mallard. Despite being threatened they are also a game bird.

South Island pied oystercatcher occur throughout New Zealand and usually breed in the eastern South Island on river beds, farmland and high country tussockland, but they have been known to breed in coastal areas, including lagoons.

Variable oystercatcher also occur throughout New Zealand, but are more restricted to coastal areas where they occupy a range of rocky and sandy shore habitats and estuaries. Variable oystercatchers will use pasture areas near the coast for foraging.

Pacific reef heron, also recorded at the site, are most often seen in the north of the North Island, and normally occupy rocky shore habitat or estuaries, but are occasionally seen on sandy beaches.

4.3 Herpetofauna

A search of the herpetofauna database for records within 5 km of the site revealed four records comprising two identified taxa and one undetermined skink species. The introduced species, the southern bell frog (*Litoria raniformis*), accounted for two of those records and brown tree frog (*Litoria ewingii*) accounted for the other. The majority of the site comprised grazed pasture, which does not provide suitable habitat for lizards. Potential lizard habitats at the site, including the coastal area, remnant vegetation along Collins Creek and forest habitat to the north of the site would not be cleared as part of the proposal and is well separated from the proposed mining and other activities, so a lizard survey was not considered necessary.

5.0 Wetlands

5.1 Introduction

Any original wetlands within the site have been reclaimed by 'humping and hollowing' for agricultural purposes. These modifications have resulted in a near complete loss of wetland ecosystem types from the area. The ecosystem services provided by wetland systems including flow attenuation and water quality improvement have also been lost.

As discussed in Section 3.2, we have not assessed any of the potential wetlands within 100 m of the site because of lack of access. Rather we have assumed that wetlands are present and that effects on wetlands outside the site will need to be avoided.

Either Canoe Creek or the coastal lagoon via the central drain and via Collins Creek will be the ultimate receiving environment for water discharges. The coastal has varied in size over time but averages around 5.95 ha in extent[3]. It is typically disconnected from the larger (approximately 40 ha) lagoon described by Boffa Miskell (2006) which extends from south of Burke Road to north of Canoe Creek and included the coastal lagoon described here. Collins Creek flows into the lagoon from the south and it may at times receive water

[3] Based on measurements derived from Google Earth images between 2012 and 2021 (range 5.5–6.2 ha, n=5)

from the Northern Drain and the larger lagoon to the north. Given its coastal location and tidal and rainfall influences, the lagoon is a highly dynamic environment and subject to frequent changes in extent and likely saltwater intrusion. The water levels in the lagoon also appear to vary considerably. The values of the coastal lagoon are discussed in more detail below.

5.2 Coastal Lagoon

With respect to vegetation, the shoreline is typically sparsely vegetated as shown in Figure 16. Coastal vegetation includes oioi (*Apodasmia similis*), giant umbrella sedge (*Cyperus ustulatus*) and pōhuehue (*Muehlenbeckia complexa*) with local harakeke and raupō. Inland, harakeke dominates, with raupō extending into the lagoon. Other vegetation present included oioi, *Carex sinclairii*, *C*. *virgata*, *Juncus* spp., blackberry (*Rubus fruticosus* agg.), swamp kiokio (*Parablechnum minus*), gorse and pasture species (mostly Yorkshire fog, (*Holcus lanatus)* and lotus (*Lotus pedunculatus*)). A band of turf vegetation was observed above the waterline on the coastal side of the lagoon. This vegetation was mostly indigenous and included species such as *Myriophyllum triphyllum*, *Potamogeton suboblongus*, *Centella unfilora*, bachelor's button (*Cotula coronopifolia*) and *Lobelia anceps*. The extent of this turf vegetation is probably affected to a high degree by changes in the water level and may have been more extensive and diverse in the past (Boffa Miskell 2006).

Brown trout have been caught in the lagoon and giant kōkopu were recorded in Rusty's Pond (Boffa Miskell 2006). Other diadromous fish present in Collins Creek, Deverys Creek and the Northern Drain are also likely to use the lagoon when accessing aquatic habitats inland.

Water quality in the coastal lagoon has been measured on two occasions (23 August and 21 September 2022, J. Rekker pers. comm.). Results indicate that the turbidity is generally low (10.1 and 7.6 NTU respectively) and the pH circumneutral (7.1 and 7.4 respectively). Aluminium values are perhaps slightly elevated (0.055 g/m^3 on one occasion, which is equivalent to the ANZG (2018) 95% species protection value), as are copper (0.0014 on one occasion, also equivalent to the ANZG (2018) 95% species protection value).

Figure 16: Coastal Lagoon at Nikau Deer Farm, Barrytown (Taken February 2023).

6.0 Streams

6.1 Stream Survey Physico-chemistry

There was 59 mm of rainfall within the 7-days prior to the survey on 6 and 7 September 2022 and 86 mm of rain within the two weeks prior to the survey recorded at the Greymouth Aero EWS (National Climate Database).

Stream temperatures during the survey ranged between 9.7 and 12.0°C at Canoe Creek and lower Collins Creek, respectively as shown in Table 9. All sites were well oxygenated with dissolved oxygen (DO) concentrations ranging from 10.6 to 11.7 g/m^3 and saturation from 97.9 to 104%. Stream pH was near-neutral at the Northern Drain and upper Collins Creek (7.1 and 7.4, respectively) and slightly alkaline at sites on the lower Canoe Creek and lower Collins Creek (7.8 and 8.2, respectively). Electrical conductivity was low at all sites and ranged between 6.6 mS/m at Canoe Creek and 11.4 mS/m at the upper site on Collins Creek.

Water physico-chemistry recorded at all sites would not have been limiting aquatic biota at the time of the survey. However, high macrophyte cover recorded in the Northern Creek can result in a wide diurnal range in DO concentrations that has potential to stress aquatic biota with higher DO requirements and limit their presence. Poor channel shading along the Northern Creek and Collins Creek may result in elevated temperatures in summer months during low flow conditions.

Table 9: Water physico-chemistry during the ecological survey.

Site	Code	Date	Time	Temp. (°C)	Dissolved oxygen (g/m^3)	Dissolved oxygen (%)	pH	Conductivity (mS/m)
Northern Drain	1	06-09-2022	4:30 p.m.	11.9	11.2	104	7.1	7.9
Collins Creek upper	2	07-09-2022	4:20 p.m.	10.2	11.0	97.9	7.4	11.4
Collins Creek lower	3	06-09-2022	2:30 p.m.	12.0	10.6	98.4	8.2	9.5
Canoe Creek	4	06-09-2022	1:00 p.m.	9.7	11.7	103	7.8	6.6

6.2 Surface Water Quality

In May 2022 Kōmanawa Solutions Ltd conducted two rounds of surface water sampling at the Collins Creek downstream site, and one round of sampling each at the Collins Creek upstream, Northern Drain site, and the Canoe Creek Lagoon sites as shown in Figure 17. Analysis of the samples was conducted to determine the total fraction of a range of parameters.

Further, between July and November 2022, Kōmanawa Solutions Ltd conducted four rounds of surface water sampling at the Collins Creek upstream and downstream sites, three rounds of sampling at the Northern Drain site, and two rounds of sampling at the Canoe Creek Lagoon site. Analysis of the samples was conducted to determine the dissolved fraction of a range of parameters.

Full data on the dissolved fractions is provided in Appendix 3 and 4 of the Kōmanawa Solutions Ltd (2023) report. Data only for key parameters on both total and dissolved fractions is summarised here in Table 10 and Table 11.

The streams exhibited near neutral pH, slightly acidic in the Northern Drain and slightly alkaline at other sites, most notably in Collins Creek. Conductivity was low, as was turbidity, with the exception of the Canoe Creek Lagoon site, which saw up to 10.1 NTU.

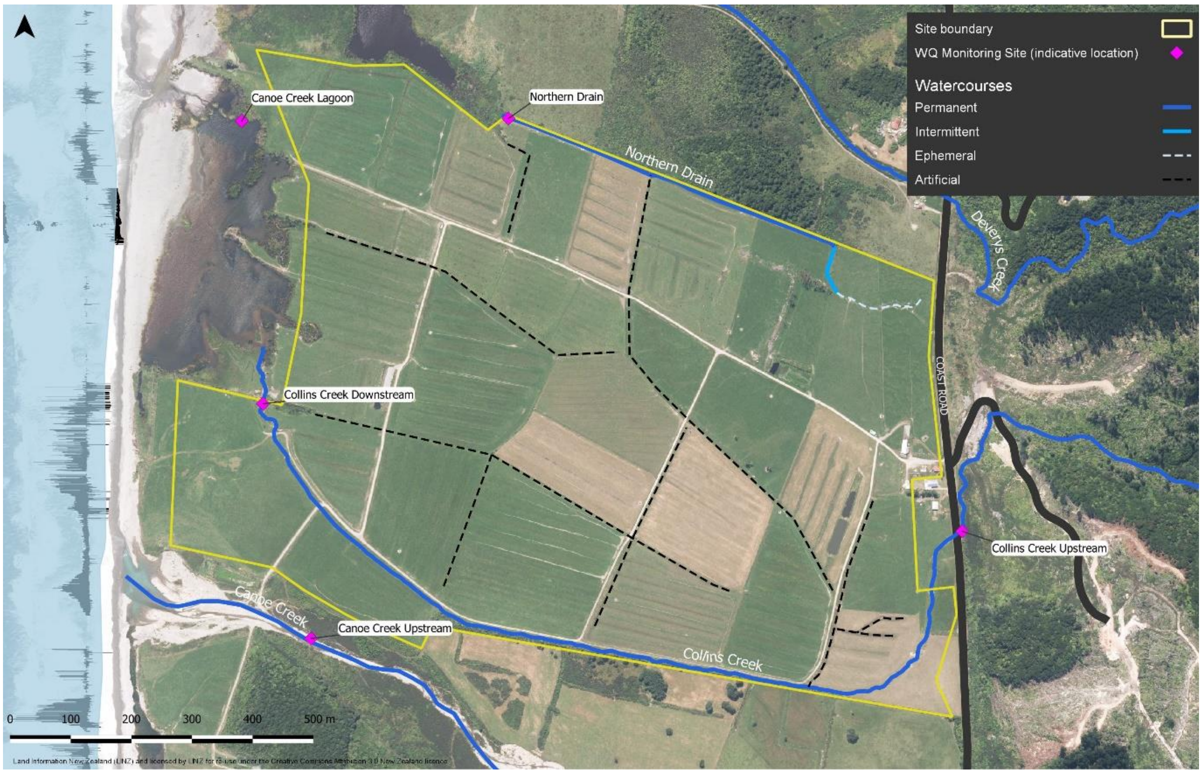

Figure 17: Location of water quality monitoring sites used by Kōmanawa Solutions Limited (2023).

Table 10: Summary of key surface water quality parameters – total fraction.

Parameter	Northern Drain	Collins Creek upstream	Collins Creek downstream	Canoe Creek Lagoon[A]
pH (pH units)	6.4	7.5	7.5-7.7	7.2
Electrical Conductivity (mS/m)	11.1	10.3	10.8-12.4	12.9
Turbidity (NTU)	3.5	2.5	1.3-6.4	13.7
Hardness (as $CaCO_3$)	31	29	32-38	34
Arsenic	0.0019	< 0.0011	< 0.0011	0.0018
Boron	0.008	0.0094	0.0098-0.013	0.012
Cadmium	0.0002	< 0.000053	< 0.000053	< 0.000053
Chromium	0.00069	< 0.00053	< 0.00053	< 0.00053
Copper	0.0056	0.00062	0.00059-0.00078	0.00075
Iron	0.73	0.52	0.15-0.81	2.4
Lead	0.0021	0.0003	0.00013-0.00046	0.00037
Manganese	0.057	0.036	0.011-0.050	0.13
Nickel	0.0043	0.00058	< 0.00053-0.00073	0.00082
Zinc	0.048	0.0011	< 0.0011-0.0013	0.0016
Ammoniacal-N	0.062	0.033	< 0.010-0.054	0.16
Nitrate-N	0.32	0.26	0.06-0.15	0.21
Phosphorus	0.037	0.015	0.012-0.020	0.05

Notes: units g/m^3 unless stated; [A]range of two results.

Table 11: Summary of key surface water quality parameters – dissolved fraction.

Parameter	Northern Drain	Collins Creek US[A]	Collins Creek DS	Canoe Creek Lagoon	Canoe Creek[B]	Guideline
pH (pH units)	6.9 (6.5-7.3)	7.7 (7.6-7.8)	7.5 (7.3-7.6)	7.2 (7.1-7.4)	7.6	6-9[G]
EC (mS/m)	9.6 (8.2-17.6)	12.5 (11.1-15.6)	10.0 (9.5-10.3)	16.8 (12.0-297)	8.3	NA
Turbidity (NTU)	5.3 (2.7-22)	0.82 (0.60-1.2)	1.4 (0.43-6.6)	7.6 (3.1-10.1)	0.13	5.6[H]
TSS	5 (<3-25)[B]	< 3[C,D]	< 3 (< 3 - 4)	4, 6[D]	< 3	NA
Hardness (as $CaCO_3$)	26.1 (17.6-35.5)	33.0 (30.0-48.2)	27.0 (26.0-29.3)	35.0 (27.0-327)	28.9	NA
Aluminium	0.083 (0.043-0.13)	0.029 (0.014-0.044)	0.011 (0.003-0.028)	0.017 (< 0.003-0.055	0.003	0.40[I,J]
Arsenic	0.0008 (< 0.0010-0.0027)	< 0.0010[C]	< 0.0010[C]	< 0.0010 (< 0.0010-0.0012)	< 0.0010	0.013[H,K]
Boron	0.009 (0.007-0.012)	0.011 (0.010-0.012)	0.009 (0.007-0.010)	0.015 (0.011-0.18)	0.005	0.94[L]
Cadmium	<0.00005 (< 0.00005-0.00008)	< 0.00005[C]	< 0.00005[C]	< 0.00005[C]	< 0.00005	0.0002[H,M]
Chromium	< 0.0005[C]	< 0.0005[C]	< 0.0005[C]	< 0.0005 (< 0.0005-0.0008)	< 0.0005	0.0033[H,M,N]
Copper	0.0028 (0.0014-0.0029)	< 0.0005[C]	< 0.0005[E] (< 0.0005-0.0006)	0.0014 (< 0.0005-0.0018)	< 0.0005	0.0039[O,P]
Iron	0.65 (0.12-2.3)	0.090 (0.05-0.12)	0.21 (0.15-0.25)	0.88 (0.04-1.2)	< 0.02	1.0[Q]
Lead	0.00034 (0.00019-0.00081)	< 0.00010[C]	< 0.00010[E] (< 0.00010-0.00011)	0.00012 (< 0.00010-0.00028)	< 0.00010	0.0034[H,M]
Manganese	0.045 (0.031-0.23)	0.0073 (0.0049-0.012)	0.021 (0.0078-0.034)	0.10 (0.0071-0.26)	0.0036	1.9[H]
Nickel	0.0023 (0.0013-0.0025)	< 0.0005[C]	< 0.0005[E] (< 0.0005-0.0005)	0.0006 (0.0005-0.0013)	< 0.0005	0.011[H,M]
Zinc	0.009 (0.0023-0.017)	< 0.0010[C]	< 0.0010[C]	0.0016 (0.0005-0.0019)	< 0.0010	0.008[H,M]
Ammoniacal-N	0.040 (0.023-0.15)	< 0.010[E] (<0.010-0.016)	0.026[E] (< 0.010-0.065)	0.10 (0.045-0.15)	< 0.010	Notes[R,S,T]
Nitrate-N	0.093 (0.020-0.26)	0.032 (0.023-0.036)	0.092 (0.035-0.15)	0.068 (0.016-0.11)	0.018	Notes[S,U]
DRP	0.066 (0.018-0.32)	0.008 (0.005-0.081)	0.008 (0.006-0.009)	0.056 (0.023-0.075)	< 0.002	Notes[V,W]
TOC	8.0 (4.6-22)	2.2 (1.9-3.3)	1.6 (1.5-3.3)	4.3 (4.1-8.8)	< 0.5	NA

Notes: US = upstream; DS = downstream; EC = electrical conductivity; TSS = total suspended solids; DRP = dissolved reactive phosphorus; TOC = total organic carbon; units g/m^3 unless stated; [A]median (range); [B]single sample; [C]result for all samples; [D]2 samples only; [E]half the detection limit used in calculation; [G]WCRC (2014); [H]ANZECC (2000) default trigger; [I]USEPA (2018); [J]hardness=40 g/m^3 $CaCO_3$, pH=7.0, Dissolved Organic Carbon (DOC)=2 g/m^3; [K]As(V); [L]ANZECC (2018); [M]hardness=30 g/m^3 $CaCO_3$;[N]Cr(III); [O]USEPA (2007); [P]hardness=25 g/m^3 $CaCO_3$, pH=7.0, DOC=2.0 g/m^3; [Q]USEPA (1986); [R]≤ 0.05; > 0.05 and 0.43 NPS-FM (2020); [S]attribute A; B annual medians; [T]pH=7.5; [U]≤ 1.0; > 1.0 and ≤2.4; [V]≤0.006; > 0.006 and ≤0.010; > 0.018, attribute A,B;D median, respectively; [W]total fraction on filtered sample.

Concentrations of metals and metalloids were low across all sites and, generally, met relevant guideline value concentrations. Exceptions were total iron in Canoe Creek Lagoon (2.4 g/m^3 versus 1.0 g/m^3), dissolved iron in Canoe Creek Lagoon (1.2 g/m^3 versus 1.0 g/m^3). Also, zinc concentrations in the Northern Drain were greater than the hardness adjusted ANZECC (2000) 95%-ile trigger value on two occasions; viz., 0.015 g/m^3 versus 0.005 g/m^3, and 0.017 versus 0.005 g/m^3.

Ammoniacal-nitrogen and nitrate-nitrogen concentrations at the freshwater sites (i.e., not Canoe Creek Lagoon) positioned them as Attribute State A. Elevated phosphorus (taken as dissolved reactive phosphorus since it was a total phosphorus analysis on a filtered sample) concentrations at the Northern Drain and Collins Creek upstream site positioned them as Attribute State D, whereas the Collins Creek downstream site was attribute State B.

6.3 Habitat Characteristics

The following sections describe the general habitat conditions and characteristics at each of the sites. General habitat conditions along each of the streams within and adjacent to the site at the time of the survey are shown in Figure 18 (for the Northern Drain) and Figure 19 (for upper Collins Creek). Habitat characteristics recorded at each site are summarised in Table 12.

Table 12: Habitat data collected at sites during the survey.

Site	Code	Depth (m)	Width (m)	Max. velocity (m/s)	Shade (%)	Substrate	Woody Debris
Northern Creek	1	0.14–0.34	1.2–1.8	0.05–0.2	0	Sand/Silt	-
Collins Creek upper	2	0.08–0.49	1.8–3.1	0.2–0.9	0-5	Cobble/Gravel	Occasional
Collins Creek lower	3	0.16–0.36	1.8–2.3	0.5–1.0	5	Cobble/Gravel	Occasional
Canoe Creek	4	0.13–0.38	8–28	0.4–1.6	0	Cobble/Gravel	Occasional

6.3.1 Northern Drain

Typical habitat conditions along the Northern Drain at the time of the survey are shown in Figure 18. The Northern Drain originates within the site as an ephemeral flow path in the north-eastern corner of the site that is also fed by an artificial drain running along the western side of State Highway 6. The Northern Drain is a modified natural watercourse that has been realigned into its current flow path along the northern boundary of the site. The Northern Drain was surveyed at Site 1 in the mid-upper reaches within the site which was representative of the general habitat conditions along the stream length.

The Northern Drain is a highly modified soft-bottomed (sand/silt) watercourse with a straight channel alignment. The Northern Drain flows into a coastal lagoon located off-site near the north-western corner of the property. The Northern Drain had a wetted channel width ranging between 1.2 – 1.8 m and water depths between 0.14 – 0.34 m along the survey reach. Water velocities were sluggish and ranged between 0.05 – 0.2 m/s. Aquatic habitat was uniform and limited to runs and small pools.

The channel was poorly shaded due to a lack of tree/shrub riparian vegetation near the channel. The drain was unfenced on the true-left bank but fenced some 3 – 5 m away from the edge on the true-right bank, behind which was a stand of vegetation that included large kahikatea trees. Livestock had unrestricted access to both streambanks resulting in pugging of the streambank and direct channel disturbance. The poorly shaded channel was choked with macrophytes. The Northern Drain provides poor quality aquatic habitat.

Figure 18: Typical habitat conditions along the Northern Drain (Site 1).

6.3.2 Collins Creek

Collins Creek is a highly modified natural watercourse which has historically been realigned to flow along the southern boundary of the site. Collins Creek was surveyed in the upper and lower reaches of the section that drains within the site (Sites 2 and 3) (Figure 19 and Figure 20).

Collins Creek had wetted channel widths of 1.8–3.1 m, with water depths ranging between 0.08 m and 0.49 m. Aquatic habitat type and quality was variable and included riffles, runs and small pools with diverse water velocities ranging between 0.2–1.0 m/s. Riffle habitat was more abundant at the upper Collins Creek site, whilst runs were more common downstream. The streambed was generally stable and diverse and comprised cobble, gravel and sand, but a fine layer of silt was observed on instream surfaces, particularly at the lower site.

Streambanks were steep, unstable, pugged and eroding/slumping within the site. There was generally sparse riparian vegetation along Collins Creek limited to grazed pasture and occasional native/exotic shrubs (e.g., gorse (*Ulex europaeus*), tree ferns (*Alsophila*, Sphaeropteris and *Dicksonia* spp.), tī kōuka), however there was an approximate 350 m long section along the the middle section of the true-left bank of Collins Creek with native/exotic vegetation (shown in Figure 11). Collins Creek provides moderate-poor quality aquatic habitat and reflects its highly modified state and bank instability.

Figure 19: Typical habitat conditions along the upper Collins Creek (Site 2).

Figure 20: Typical habitat conditions along the lower Collins Creek (Site 3).

6.3.3 Canoe Creek

Canoe Creek was the largest of the watercourses surveyed and is a moderate sized natural river that drains to the coastline south of both the site and Collins Creek. The lower reach of Canoe Creek was surveyed at Site 4 as shown in Figure 21. Canoe Creek was in a natural state with wetted channel widths ranging 8 – 28 m and water depths of 0.13–0.38 m. The streambed was diverse and comprised boulder, cobble and gravel with a small proportion of sand. Aquatic habitat was diverse and included runs, riffles and pools. The wetted channel meandered within a wider cobble/gravel floodplain and was poorly shaded. Water velocities were swift in run and riffles and ranged between 0.4 – 1.6 m/s. Canoe Creek drains a steep catchment and is naturally a highly disturbed aquatic environment, but nonetheless provides high-quality habitat for invertebrates and native fish.

Figure 21: Typical habitat conditions along lower Canoe Creek (Site 4).

6.4 Macrophytes and Periphyton

Periphyton was sparse at all sites at the time of the survey. No periphyton was recorded at sites within the Northern Drain or Canoe Creek. The Northern Drain had a soft-bottomed streambed and supported high macrophyte cover and is not an environment that would typically support high periphyton cover. Canoe Creek is a hard-bottomed river that drains a steep indigenous vegetated catchment and is a high energy and low nutrient environment that would likely limit the periphyton community to thin films.

The upper Collins Creek site supported very low cover of short filamentous green algae (<2%) whilst the lower Collins Creek site supported thick green mat (1%), thick black mat (6%) and short green filamentous algae (5%). The thick black mat recorded in lower Collins Creek was most likely *Phormidium* (cyanobacteria). The poorly shaded Collins Creek may be susceptible to high periphyton cover during summer low flows.

Macrophytes were only recorded in the soft-bottomed and poorly shaded Northern Drain. Macrophyte species recorded included watercress (*Nasturtium officinale*), starwort (*Callitriche stagnalis*) and *Isolepis* sp. Macrophytes are unlikely to occur in Canoe Creek due to its coarse streambed and highly disturbed, high-energy nature. Macrophytes may grow in Collins Creek in summer when flow is lower and stable.

6.5 Macroinvertebrates

6.5.1 Community Composition

Relative abundance of the taxonomic groups making up invertebrate communities at sites is presented in Figure 22. Northern Drain was soft-bottomed and supported high proportions of tolerant species of Diptera (true-flies; 56%) and Mollusca (snails; 40%). Canoe Creek supported very low invertebrate abundance (mean = 2 individuals), so community composition results are not meaningful. The upper and lower Collins Creek sites supported high proportions of Oligochaeta (worms; 43–50%) and moderate-high proportions of Ephemeroptera (mayflies; 14–43%). Diptera were more abundant at the lower Collins Creek site (20%) compared with upstream (4%) and corresponded with a downstream increase in thick mat algae, filamentous algae and silt smothering instream surfaces. Coleoptera (beetle), Trichoptera (caddisfly) and Plecoptera (stonefly) also made up a small proportion of the community at the upper Collins Creek site.

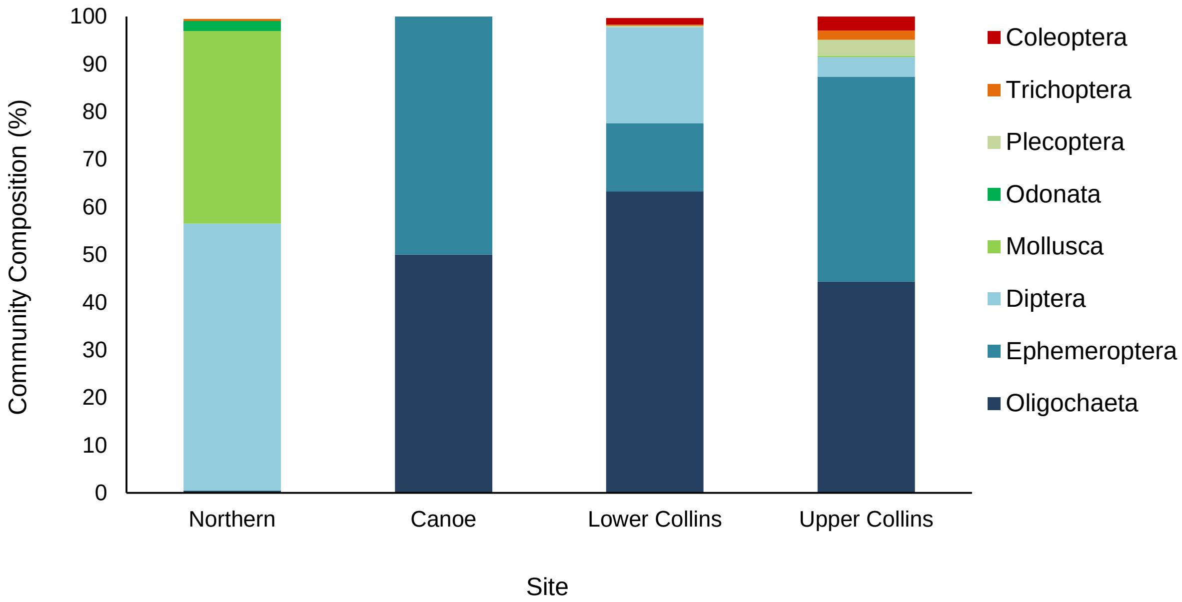

Figure 22: Relative abundance of macroinvertebrate groups during the survey.

6.5.2 Taxa Number and Abundance

A total of 31 invertebrate taxa were collected across all sites. Mean taxa number was low to very-low at the four sites and ranged between 0.8 ± 0.2 taxa at Canoe Creek and 7.2 ± 0.4–1.1 taxa at Northern Drain and the upper and lower Collins Creek sites (Figure 23).

Mean abundance was also low at sites during the survey and ranged between 1.2 ± 0.5 individuals/0.1 m^2 at Canoe Creek and 272 ± 42 individuals/0.1 m^2 at Northern Drain (Figure 24). Mean abundance was very low in the lower reaches of the Canoe Creek site, which most likely reflects the highly disturbed and low productivity environment (i.e., low macrophyte cover; see Section 6.4). Highest abundance of relatively tolerant species at the Northern Drain most likely reflects habitat conditions including the soft-bottomed streambed, low gradient, sluggish flow and high proportion of aquatic plant cover (see Section 6.4).

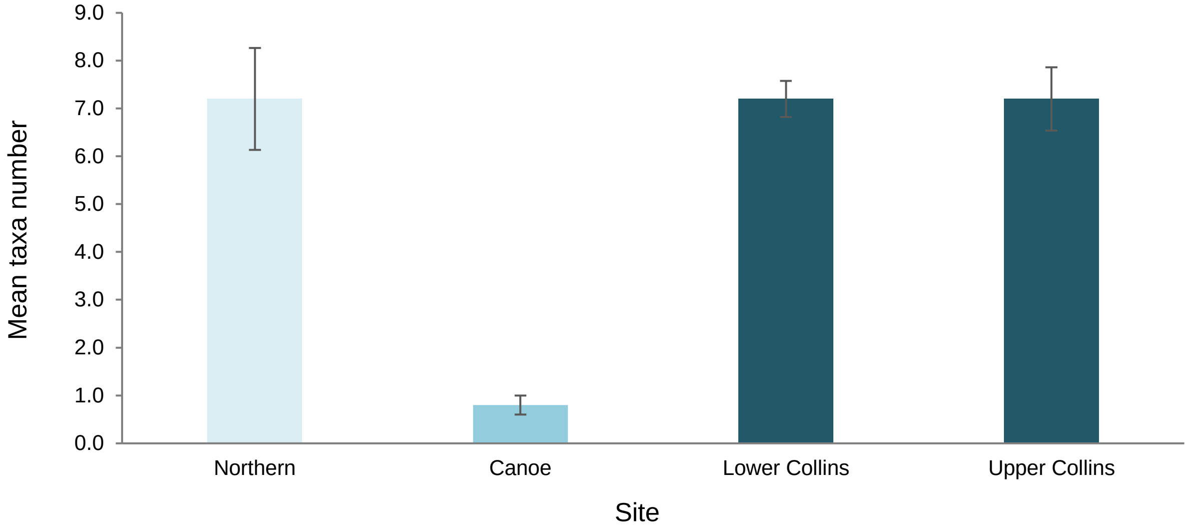

Figure 23: Mean (± S.E.) taxa number for sites during the survey.

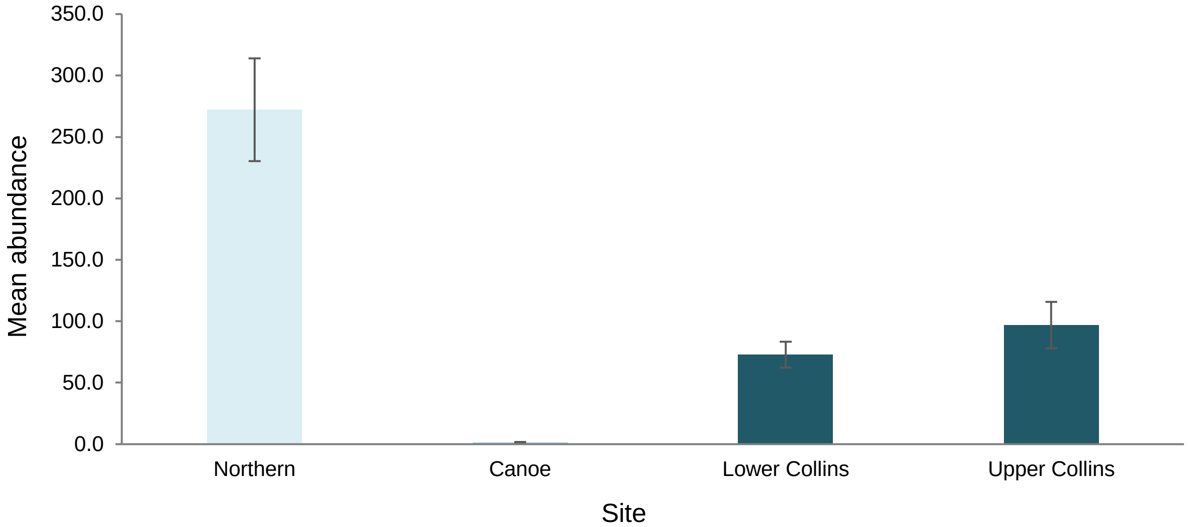

Figure 24: Mean (± S.E.) abundance for sites during the survey.

6.5.3 EPT and Percent EPT

Mean EPT taxa number was variable across sites and ranged between 0.4 ± 0.2 at Canoe Creek and 3.6 ± 0.4 at the upper Collins Creek site (Figure 25).

Northern Drain and Canoe Creek supported a similarly low number of EPT taxa with single *Deleatidium* mayflies recorded in two samples from Canoe Creek and single *Zephlebia*, *Hydrobiosis* and *Pycnocentria* recorded in one sample from the Northern Drain.

Upper Collins Creek supported seven EPT taxa including *Coloburiscus*, *Deleatidium* (mayflies), *Acroperla*, *Stenoperla* (stoneflies) and *Hydrobiosella*, *Hydrobiosis* and *Psilochorema* (caddisflies). Lower Collins Creek supported three EPT taxa including *Deleatidium*, *Acroperla* and *Hudsonema* (caddisfly). Lower EPT taxa richness in the lower Collins Creek may reflect the higher proportion of slower flowing run habitat, higher cover of thick mat and filamentous algae and silt smothering parts of the stream bed.

Mean percent EPT abundance (%EPT) ranged between 0.3% ± 0.26 in the Northern Drain and 47% ± 10 in upper Collins Creek (Figure 26). Very low invertebrate abundance in

Canoe Creek means that the %EPT result is not meaningful. Upper Collins Creek had moderate-high %EPT (47% ± 10), which decreased to 15% ± 4 in lower Collins Creek due to a downstream decrease in *Deleatidium* mayflies and increase in worm abundance between the two sites.

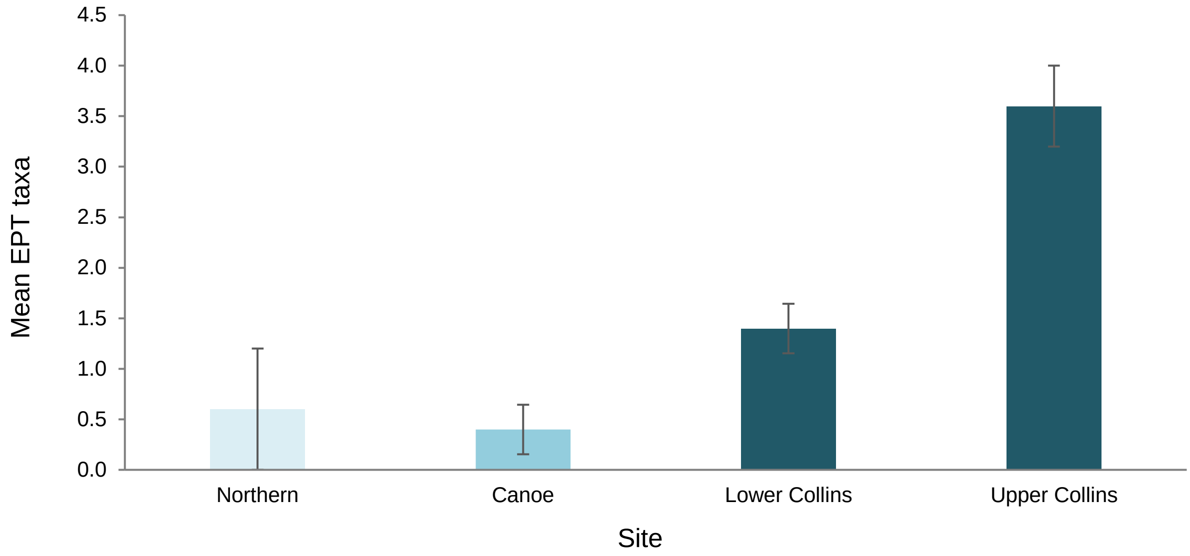

Figure 25: Mean (± S.E.) EPT taxa number for sites during the survey.

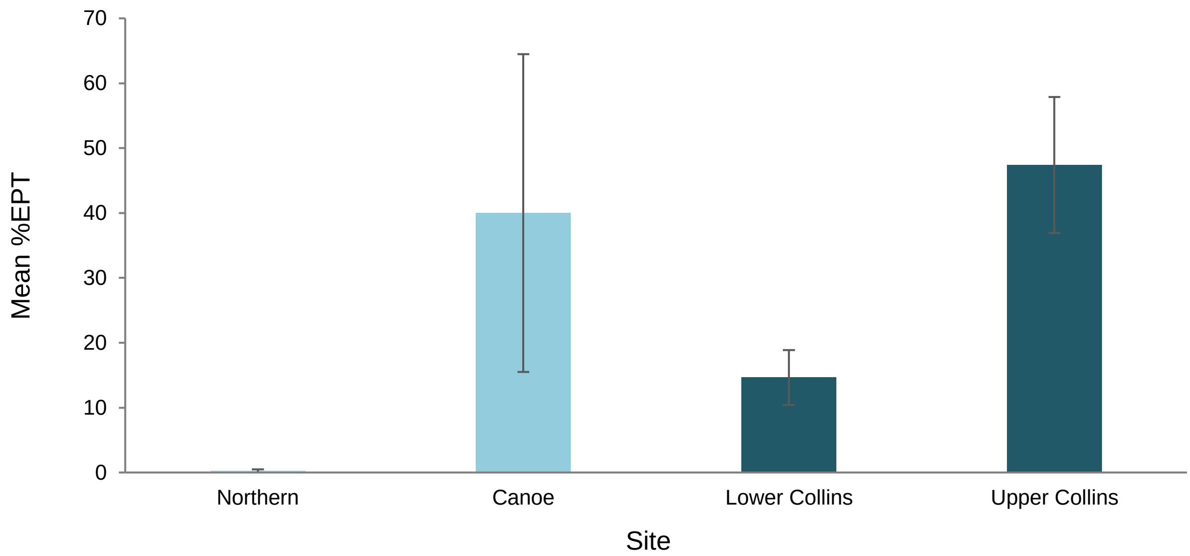

Figure 26: Mean (± S.E.) percent EPT abundance (%EPT) at sites during the survey.

6.5.4 MCI and QMCI

MCI

Mean MCI / MCI-sb scores were variable across sites and ranged between 62 ± 6.7 for the Northern Drain and 114 ± 6.4 for the upper Collins Creek site (Figure 27).

The Northern Drain had an MCI-sb score of 62 ± 6.7 which reflects the soft-bottomed streambed, sluggish flow, high cover of aquatic plants and the community comprising a higher number of low-scoring taxa that are more typically recorded in these environments. The MCI-sb score for Northern Drain was indicative of 'poor' stream health (Stark and Maxted 2007) and below the National Bottom Line (Attribute D) of the NPS-FM and indicative of severe nutrient enrichment.

The MCI score for Canoe Creek has not been presented due to the very low number of taxa recorded at the site (mean = 0.8 taxa/sample) resulting in an MCI score that does not provide a meaningful indication of overall stream health.

There was a decrease in MCI score between the upper and lower Collins Creek sites from 114 to 90 and a corresponding decrease in indicative stream health from 'good' to 'fair' (Stark and Maxted 2007). The higher MCI score for the upper Collins Creek site reflects the greater number of high-scoring EPT taxa, which were not recorded from the lower site. The MCI score for the upper Collins Creek site was within Attribute B of the NPS-FM and indicative of mild nutrient enrichment whilst the score for the lower Collins Creek site was just within Attribute C of the NPS-FM and indicative of moderate nutrient enrichment.

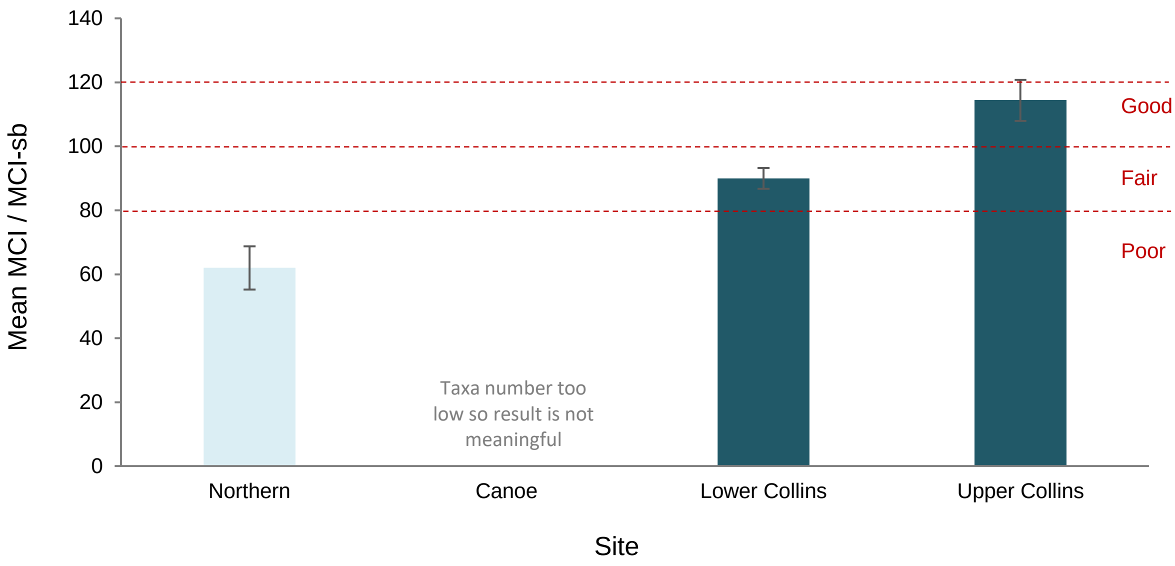

Figure 27: Mean (± S.E.) MCI / MCI-sb scores for sites during the survey.

QMCI

Mean QMCI / QMCI-sb scores were variable across sites and ranged between 2.7 ± 0.37 for lower Collins Creek and 4.6 ± 0.7 for upper Collins Creek (Figure 28).

The QMCI-sb score for Northern Drain was low (QMCI-sb = 3.1) and reflects the relatively high abundance of low scoring (i.e., tolerant) *Austrosimulium* (sandfly) and *Potamopyrgus* (snail), which have MCI-sb indicator scores of 3.9 and 2.1 (out of 10) respectively and which combined made up 86–98% of community abundance in this stream. The QMCI-sb score for the Northern Drain was indicative of 'poor' stream health (Stark and Maxted 2007) and below the National Bottom Line (Attribute D) that indicates severe nutrient enrichment.

The QMCI score for Canoe Creek has not been presented due to the very low abundance recorded at the site (mean = 1.2 individuals/sample) resulting in a QMCI score that does not provide a meaningful indication of overall stream health.

The QMCI scores for Collins Creek decreased from 4.6 to 2.7 between the upper and lower sites. The upper Collins Creek site had a higher QMCI score due to the higher relative abundance of high-scoring mayflies compared with the lower site. The lower Collins Creek site also supported higher relative abundance of low-scoring Diptera compared with upstream and corresponded with higher cover of thick mat and short filamentous algae and probable nutrient enrichment. The QMCI score for the upper site was indicative of 'fair' stream health (Stark and Maxted 2007) and within Attribute C of the NPS-FM that indicates moderate nutrient enrichment. The QMCI score for the lower Collins Creek site was indicative of 'poor' stream health (Stark and Maxted 2007) and below the National Bottom Line (Attribute D) in the NPS-FM indicating severe nutrient enrichment.

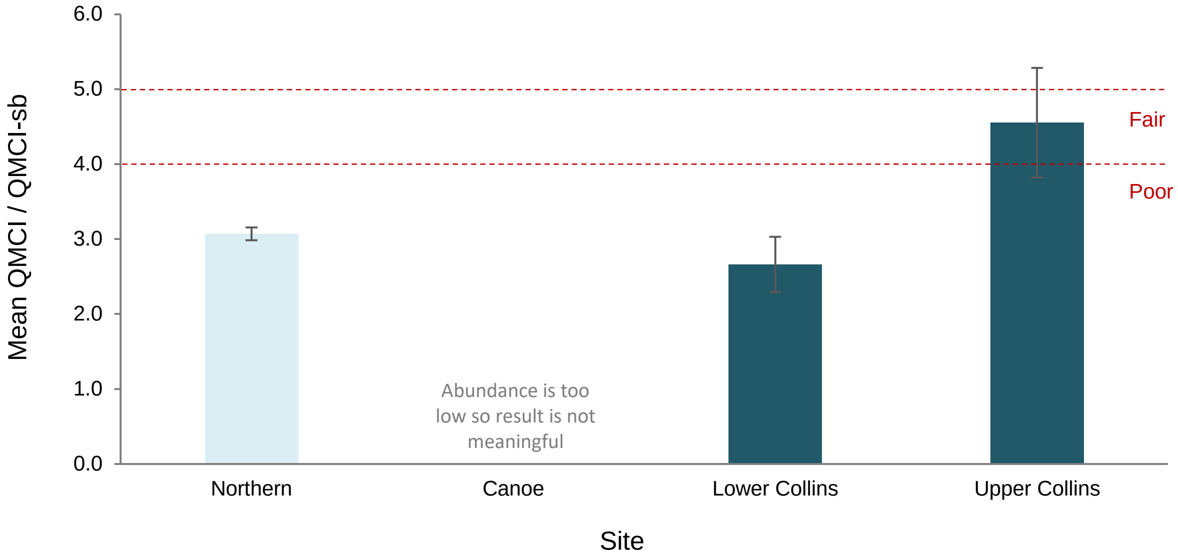

Figure 28: Mean (± S.E.) QMCI / QMCI-sb scores for sites during the survey.

6.5.5 ASPM

Mean Average Score Per Metric (ASPM) scores were low and ranged between 0.11 ± 0.02 for the Northern Drain and 0.39 ± 0.02 for upper Collins Creek (Figure 29).

The low mean ASPM score for the Northern Drain is a reflection of the low MCI-sb score, low number of water and habitat sensitive EPT taxa and low proportion of EPT taxa making up community abundance. An ASPM score for Canoe Creek has not been presented as the number of taxa and abundance at the site was too low to provide a meaningful result.

Mean ASPM scores for Collins Creek decreased from 0.39 ± 0.02 to 0.21 ± 0.01 between the upper and lower sites. The higher ASPM score for the upper site reflects the higher MCI score, higher EPT taxa richness and greater relative abundance of EPT taxa at this site when compared with the lower site. Collins Creek ASPM scores indicate the community recorded upstream is of higher quality than that recorded downstream.

The mean ASPM score for the Northern Drain and lower Collins Creek were below the National Bottom Line (Attribute D) of the NPS-FM (ASPM <0.4 and ≥0.3) and indicates the macroinvertebrate communities at these sites have severe loss of ecological integrity. The mean ASPM score for upper Collins Creek was in Attribute C of the NPS-FM and indicates the macroinvertebrate community at this site has moderate-severe loss of ecological integrity.

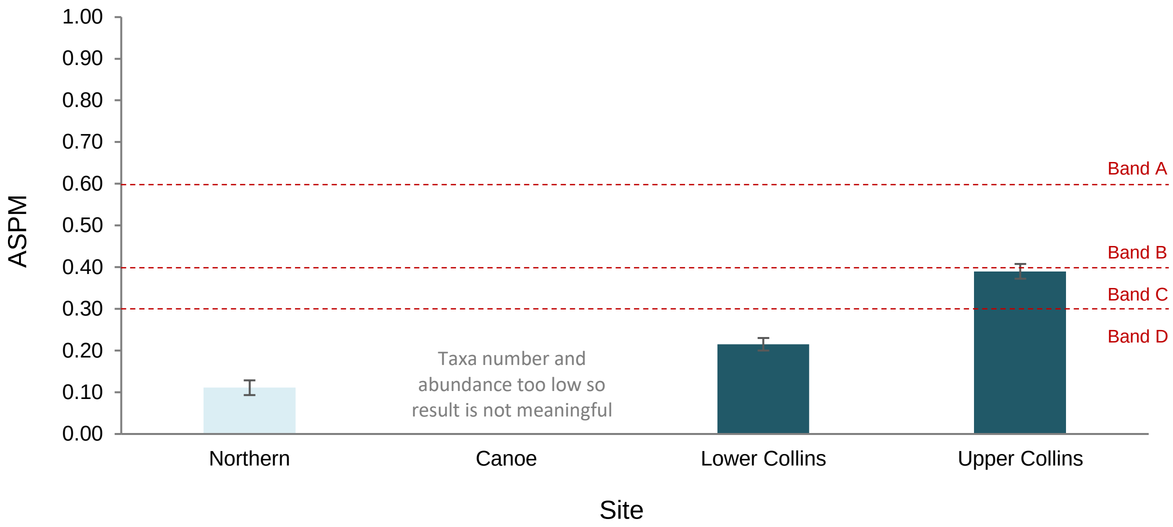

Figure 29: Mean (± S.E.) ASPM scores for sites during the survey.

6.6 Fish Fauna

6.6.1 New Zealand Freshwater Fish Database

The New Zealand Freshwater Fish Database (NZFFD) holds records for 13 surveys undertaken since 1985 in the lower reaches of Canoe Creek, Northern Drain, Collins Creek and Deverys Creek (north of the site) (Figure 30). Eleven surveys were carried out on streams to the west of SH6 and two surveys to the east of SH6 on Canoe Creek.

Collins Creek was surveyed within the site at three locations in 1985. Fish species recorded from Collins Creek during the 1985 survey included longfin eel *(Anguilla dieffenbachii)*, common bully (*Gobiomorphus cotidianus*), bluegill bully (*Gobiomorphus hubbsi*), redfin bully (*Gobiomorphus huttoni*) and brown trout (*Salmo trutta*). Longfin eel and bluegill bully have an 'At Risk (declining)' threat status (Dunn et al. 2017).

The lower reaches of the Northern Drain downstream of the site was surveyed in 1985–1986 with species recorded including shortfin eel (*Anguilla australis*), longfin eel, common bully, giant kōkopu (*Galaxias argenteus*) and brown trout. Giant kōkopu have an 'At Risk (declining)' threat status (Dunn et al. 2017).

NZFFD records Deverys Creek and Canoe Creek which drain to the north and south of the site respectively were surveyed between 1985–1987 and 1984–2012, respectively. Fish species recorded from Deverys Creek included shortfin eel, longfin eel, īnanga (*Galaxias maculatus*), common bully, redfin bully and brown trout. Canoe Creek is a higher energy environment with NZFFD records for this site including longfin eel, torrentfish (*Cheimarrichthys fosteri*), kōaro (*Galaxias brevipinnis*), banded kōkopu (*Galaxias fasciatus*), common bully, redfin bully, bluegill bully and brown trout.

The most commonly recorded species from streams draining the site and near vicinity based on NZFFD records were brown trout, redfin bully, longfin eel and common bully. The least commonly recorded fish species were giant kōkopu, kōaro and banded kōkopu. Of the species listed in the NZFFD, species that prefer swift flow and overhead cover such as kōaro and those that prefer deep pool habitat and overhead cover such as giant kōkopu and banded kōkopu are unlikely to occur in the sections of Collins Creek and Northern Drain within the site because of a lack of suitable habitat.

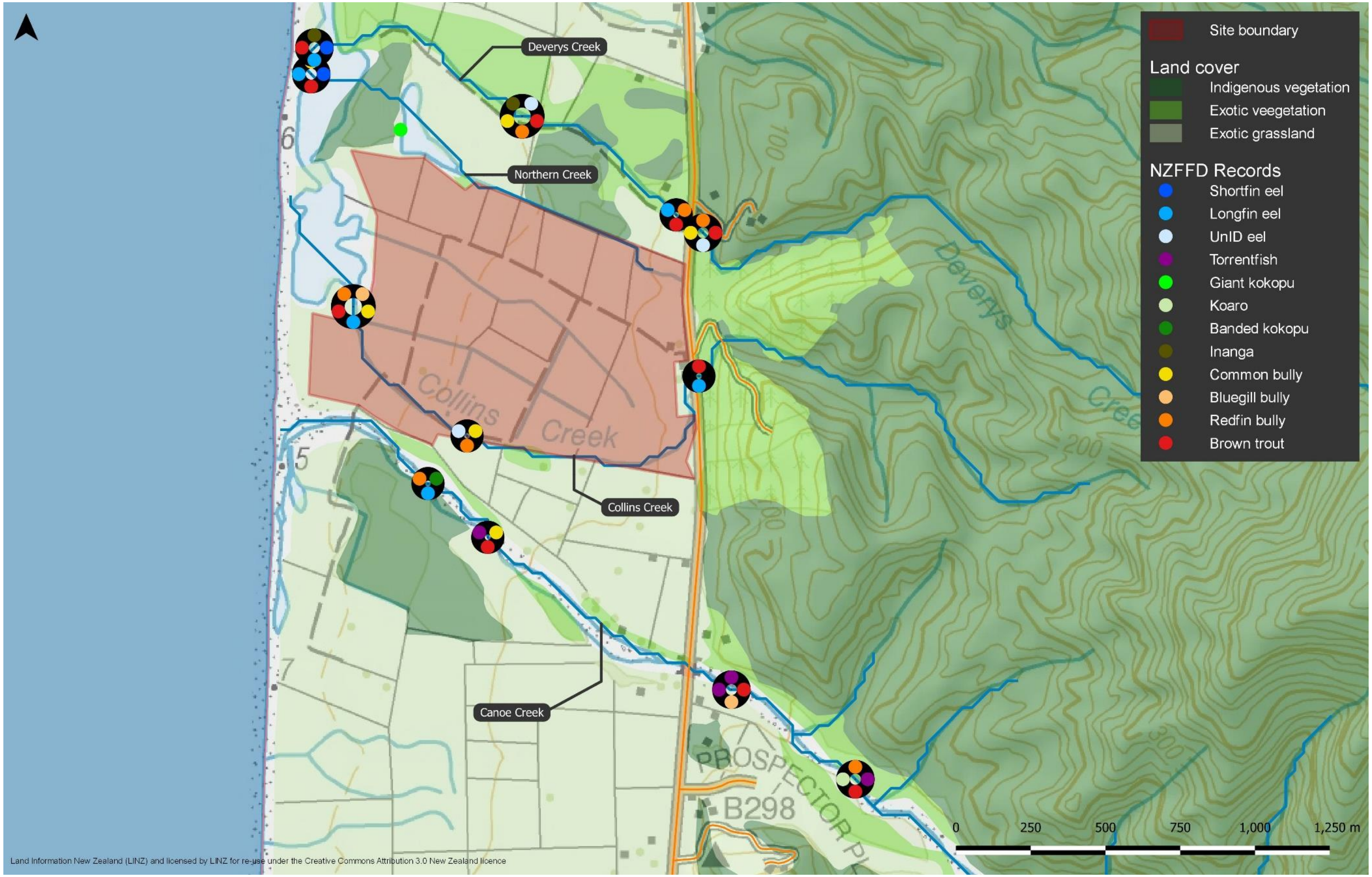

Figure 30: New Zealand Freshwater Fish Database records since 1985.

6.6.2 Electric Fishing Survey Results

Eight fish species were recorded across the four streams during the 2022 survey. The abundance of each fish species recorded from streams during the survey is shown in Figure 31. Fish species recorded included longfin eel, shortfin eel, common bully, redfin bully, bluegill bully, unidentified galaxiid (whitebait), torrentfish and juvenile brown trout (Figure 32). The most abundant species were common bully and bluegill bully.

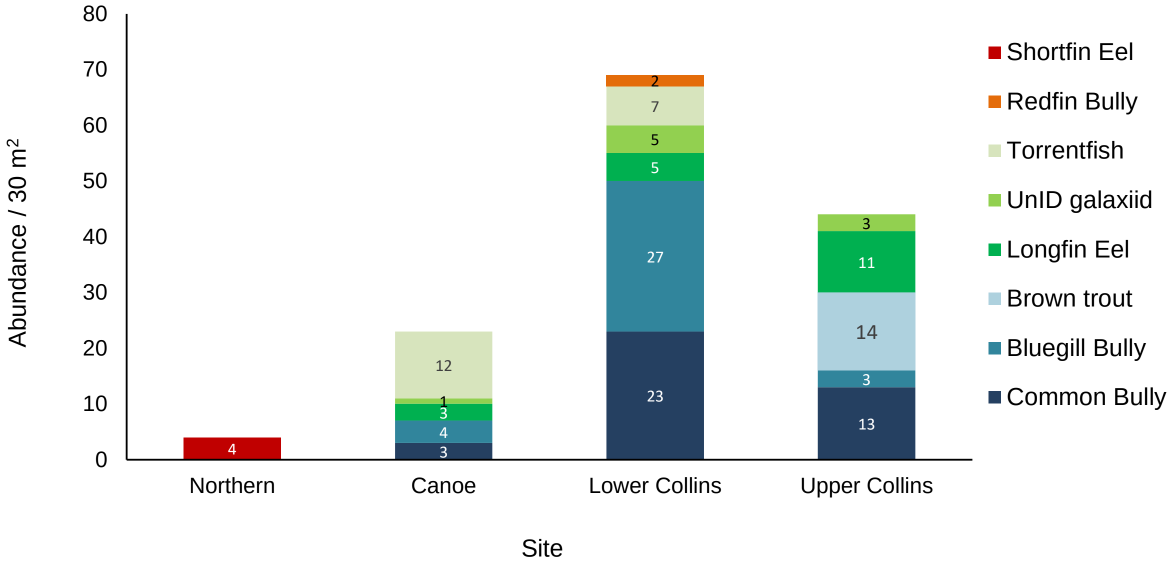

Figure 31: Fish species and abundance recorded in streams during the 2022 survey, Nikau Deer Farm.

Collins Creek

Lower Collins Creek supported the most diverse and abundant fish fauna with six species and 69 individuals/30 m^2 recorded. The upper Collins Creek site supported a generally similar fish community with five species and 44 individuals/30 m^2 recorded. Juvenile brown trout (26–30 mm length; 14 individuals/30 m^2) were recorded at the upper Collins Creek site but not at the lower site. Redfin bully and torrentfish were recorded at the lower Collins Creek site but not at the upstream site. Collins Creek provides habitat for juvenile brown trout and an unidentified galaxiid (whitebait).

The presence of diadromous bluegill bully, common bully and an unidentified galaxiid in upper Collins Creek indicates there are no 'total' barriers preventing upstream migration between the lower and upper sites. The section of Collins Creek within the site is unlikely to provide spawning habitat for īnanga due to its location about the zone of tidal influence and the disturbed streambanks nor is it likely to provide spawning habitat for galaxiid species that migrate into headwater streams to spawn as adults (e.g., kōaro, banded kōkopu).

Collins Creek supported a fish community with high ecological value due to the presence of 'At Risk (declining)' species (Dunn et al. 2017) including bluegill bully, longfin eel and torrentfish and juvenile brown trout (sports fish).

Northern Drain

The only fish species recorded from the soft-bottomed Northern Drain with high emergent macrophyte cover were shortfin eel in low abundance (4 individuals/30 m^2). Northern Drain supports a sparse fish community limited to shortfin eel and has low ecological value.

Figure 32: **Torrentfish, bluegill bully, juvenile brown trout and unidentified galaxiid (from top to bottom) recorded from streams during the 2022 survey.**

Canoe Creek

The lower Canoe Creek adjacent to the site supported five species of native fish including common bully, bluegill bully, longfin eel, torrentfish and an unidentified galaxiid (whitebait) with an abundance of 23 individuals/30 m^2. The NZFFD also lists banded kōkopu and kōaro in lower Canoe Creek, so the unidentified whitebait recorded in 2022 may have been one of those species. Torrentfish were the most abundant species recorded from lower Canoe Creek in 2022 in swift flowing riffles. Canoe Creek supported low-moderate density of native species with an 'At Risk (declining)' threat status (Dunn et al. 2017) (e.g., torrentfish, bluegill bully, longfin eel, potentially kōaro) with the community being of high ecological value.

6.6.3 Environmental DNA Results

Environmental DNA (eDNA) results can provide an indication of the fish species present for each stream and are presented in Table 13. Generally, the results of the eDNA analysis supported the other sampling methods.

Results of eDNA sampling indicates Collins Creek supports the most diverse fish fauna with nine species recorded including longfin eel, unidentified eel, banded kōkopu, kōaro, bluegill bully, unidentified bully, redfin bully, torrentfish and brown trout. Sequence counts for kōaro, bluegill bully and torrentfish were low (Table 13), but bluegill bully and torrentfish were both recorded during electric fishing. Collins Creek does not provide suitable habitat for kōaro (e.g., turbulent, overhead cover, boulder/cobble bed) so their presence within the site is unlikely. Banded kōkopu were recorded in eDNA samples from upper Collins Creek, but were not recorded during the electric fishing survey or listed in the NZFFD. Unidentified galaxiid whitebait were recorded from the stream during electric fishing and based on eDNA results may have been banded kōkopu.

Environmental DNA data for Canoe Creek indicated the presence of three species including kōaro, bluegill bully and unidentified bully and did not detect longfin eel or torrentfish, which were both recorded during electric fishing. No fish were recorded in eDNA samples collected from Northern Drain even though shortfin eel were recorded during electric fishing.

Table 13: eDNA sampling results from each stream at Nikau Deer Farm.

Common name	Scientific name	Sequence count			
		Northern	Upper Collins	Lower Collins	Canoe
Longfin eel	*Anguilla dieffenbachii*	-	152	58	-
Eels	*Anguilla*	-	94	-	-
Banded kōkopu	*Galaxias fasciatus*	-	247	-	-
Kōaro	*Galaxias brevipinnis*	-	-	4	190
Bluegill bully	*Gobiomorphus hubbsi*	-	7	195	360
Bully spp.	*Gobiomorphus*	-	1,111	1,650	852
Redfin bully	*Gobiomorphus huttoni*	-	2,960	4,175	-
Torrentfish	*Cheimarrichthys fosteri*	-	-	8	-
Brown trout	*Salmo trutta*	-	1,043	467	-

6.7 Summary

The Northern Drain was a highly modified, soft bottomed stream with aquatic habitat limited to runs and small pools. It was poorly shaded, was occupied by macrophytes and provided poor quality aquatic habitats reflected in its low EPT score, MCI and QMCI scores of 'poor' and an ASPM below the national bottom line and indicative of a severe loss of ecological integrity. Only one fish species was detected in the Northern Drain. The Northern Drain is of low ecological value.

Collins Creek was also highly modified, but provided more variable aquatic habitats (riffles, runs and pools) with diverse water velocities and a diverse stream bed. The periphyton cover was low in both the upper and lower reaches of Collins Creek and the most invertebrates were captured there, along with the highest diversity of invertebrates. The MCI and QMCI scores were indicative of 'fair' (downstream) and 'good' (upstream) habitats. The ASPM in the lower portion of Collins Creek was below the national bottom line, and the ASPM in the upper reach was indicative of moderate to severe loss of ecological integrity. The fish population in Collins Creek was the most diverse and abundant sampled. Collins Creek provides good fish habitat and is of high ecological value.

Canoe Creek was the largest and least modified of the three streams and provided high quality habitats for fish. Few invertebrates were captured, making presentation of MCI, QMCI and ASPM scores unreliable. Nonetheless Canoe Creek is of high ecological value.

7.0 Groundwater

In May 2022, Kōmanawa Solutions Ltd conducted a round of groundwater quality sampling from eight piezometers within the proposed sand extraction zone. The focus of the chemical analysis of the samples was to determine the total metals/metalloids concentrations. The sampling was repeated in November 2022, with the addition of one more piezometer and the focus of the chemical analysis of the samples on that occasion was to determine the dissolved metals/metalloids concentrations.

The results for the May 2022 groundwater samples are summarised for key parameters in Table 14. The metals/metalloids data is reported on a total basis. It is evident from physico-chemical parameters, notably turbidity, that the samples underwent post-sampling modification (e.g., precipitation) prior to analysis; this would not have affected true total metals concentrations, but the reported pH, electrical conductivity and turbidity values are not representative of *in situ* groundwater quality.

The results for the November 2022 groundwater samples are summarised, also only for key parameters, in Table 15. Full data is provided in Appendix 2 of the Kōmanawa Solutions Ltd (2023) report. The metals/metalloids data represents the dissolved fraction on samples, post-modification, i.e., as might be observed following groundwater detention in a settling pond, such as is proposed via primary treatment ponds – the post-sampling modification is clearly evidenced by highly elevated total suspended solids concentrations.

A comparison between the two sets of groundwater samples reveals a marked reduction in metals/metalloids concentrations between the raw groundwater (total fraction) and the simulated post-settling pond groundwater. Most notable is the reduction in iron from an average of 70 g/m^3 to an average of 0.44 g/m^3 due to oxidation of ferrous ions and precipitation of iron oxyhydroxide, and there are parallel reductions for all metals/metalloids via binding to iron floc and precipitation, the latter is particularly evident via the reduction in hardness (i.e., calcium and magnesium) concentrations.

Table 14: Summary of key groundwater quality parameters: total metals/metalloids basis.

Parameter	PZ-15	PZ-08	PZ-17	PZ-13	PZ-06	PZ-18	PZ-02	PZ-01
pH (pH units)	7.0	7.5	7.5	6.6	7.5	7.5	7.4	6.8
Electrical Conductivity (mS/m)	25.7	9.7	10.0	11.4	8.9	9.2	9.9	17.6
Turbidity (NTU)	3,000	23,000	270	1,280	640	270	600	2,200
Hardness (as $CaCO_3$)	172	260	61	82	113	69	133	141
Arsenic	0.10	0.033	0.010	0.017	0.010	0.013	0.41	0.44
Boron	0.021	0.014	0.0076	0.011	0.0083	0.0069	0.0084	0.012
Cadmium	0.0013	0.00014	< 0.000053	0.00020	0.00012	0.000075	0.00077	0.00060
Chromium	0.28	0.12	0.024	0.048	0.049	0.031	0.11	0.085
Copper	0.95	0.28	0.077	0.20	0.075	0.050	0.17	0.25
Iron	105	153	23	50	58	32	67	69
Lead	0.23	0.099	0.032	0.11	0.061	0.028	0.17	0.24
Manganese	1.63	1.80	0.44	0.58	0.68	0.30	0.55	0.69
Nickel	0.18	0.14	0.024	0.059	0.047	0.037	0.11	0.079
Zinc	0.65	0.53	0.16	0.21	0.30	0.21	0.42	0.38
Ammoniacal-N	2.3	0.019	< 0.010	0.023	< 0.010	< 0.010	0.28	1.4
Nitrate-N	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Dissolved Reactive Phosphorus	3.8	2.5	1.14	1.91	1.83	0.63	1.29	2.8

Notes: units g/m^3 unless stated.

Table 15: Summary of key groundwater quality parameters: dissolved metals/metalloids basis

Parameter	PZ-15	PZ-08	PZ-17	PZ-13	PZ-06	PZ-18	PZ-02	PZ-01	PB-01
pH (pH units)	7.4	7.7	7.6	7.5	7.6	7.6	7.6	7.6	7.3
Electrical Conductivity (mS/m)	20.6	10.7	11	12.3	9.5	10.2	9.7	14.8	14.9
Turbidity (NTU)	240	880	22	118	75	176	1.45	166	121
Total suspended solids	610	1,440	112	183	880	640	60	310	19
Hardness (as $CaCO_3$)	47	30	31	33	25	28	29	43	40
Aluminium	0.10	0.005	0.005	< 0.003	0.012	0.008	0.009	0.007	< 0.003
Arsenic	0.0091	0.011	0.0021	0.0021	0.0017	< 0.0010	0.036	0.0025	0.0081
Boron	0.014	0.008	0.007	0.009	0.006	0.006	0.006	0.009	0.011
Cadmium	< 0.00005	< 0.00005	< 0.00005	0.0001	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Chromium	0.0035	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0008	< 0.0005	< 0.0005
Copper	0.0019	0.0014	0.0017	0.0018	< 0.0005	0.0055	0.0026	0.0020	< 0.0005
Iron	3.2	< 0.02	0.16	< 0.02	0.03	0.02	0.03	0.04	11.1
Lead	0.0011	< 0.00010	0.0003	< 0.00010	0.00038	0.00017	0.00023	0.00013	< 0.00010
Manganese	0.29	0.0076	0.059	0.031	0.11	0.018	0.011	0.11	0.29
Nickel	0.010	< 0.0005	0.0006	0.0019	< 0.0005	0.045	0.0053	0.12	0.0012
Zinc	0.068	0.015	0.039	0.074	0.0012	0.020	0.10	0.046	0.012
Ammoniacal-N	1.2	< 0.010	< 0.010	0.106	< 0.010	0.022	0.087	0.73	0.72
Nitrate-N	1.42	0.29	0.33	0.77	0.030	0.023	0.20	0.052	< 0.02
Dissolved Reactive Phosphorus	0.70	1.1	0.081	0.27	0.13	0.27	0.040	0.25	0.18
Total Organic Carbon	6.7	2.4	0.8	1.1	2.2	1.2	1.4	3.0	4.7

Notes: units g/m^3 unless stated.

In addition to the marked reduction in groundwater metals/metalloids concentrations, reported physico-chemical parameters are also informative; notably with respect to the potential for pH changes, solids formation, and nutrient status. Ferrous oxidation and precipitation, such as that associated with pyritic mineralogy, might ordinarily result in a pH reduction. Yet, among a carbonaceous mineralogy as found at the site, it is not unexpected that a shift in the carbonate equilibrium, brought about partially by ferrous oxidation and precipitation, might bring about a pH increase. Hence, the pH observed across the 'total fraction' groundwater samples is typically (average = 7.2, range 6.6-7.5) lower than that observed for the corresponding primary treatment simulated groundwater samples (average = 7.6, range 7.4-7.7).

Unsurprisingly, total suspended solids concentrations are elevated in the primary treatment simulated groundwater samples (average = 529 g/m^3, range 19-1,440 g/m^3). The appearance of nitrate-N in the primary treatment simulated groundwater samples at the expense of ammoniacal-N is also fully expected based on the shift to an oxidising environment, whereas a reduction in phosphorus concentrations in primary treatment simulated groundwater samples (average = 0.36 g/m^3, range 0.040-1.1 g/m^3) versus raw groundwater (average = 2.0 g/m^3, range 0.63-3.8 g/m^3) reflects co-flocculation with iron and precipitation of phosphates.

8.0 Ecological Values

8.1 Terrestrial Flora and Fauna

The majority of the vegetation at the site is exotic except for a small number of mature trees, remnants of natural riparian vegetation along Collins Creek and some drains, and planted areas near the two feed pads.

The exotic pasture at the site is of negligible ecological value. It comprises mostly exotic species, does not provide important habitat for native species and serves to disconnect natural habitats from each other. It does provide limited ecosystem services by reducing sediment mobilisation to streams and the coast.

The native shrubland growing near Collins Creek is of low ecological value. It includes a significant proportion of weeds, is not representative, nor particularly diverse. It includes common native species. It does provide limited ecological connection between the forested habitats east of State Highway 6 and the coast, but it is not continuous. It also serves to protect Collins Creek to a small degree from surrounding land uses.

The flaxland and rushland near the coast is representative indigenous vegetation, although weeds are present to a relatively minor degree. Vegetation of this type is reduced in extent in the ecological district and it is well connected to both the lagoon and the coastal environment. This vegetation provides habitat for avifauna, although no threatened or 'At Risk' species have been confirmed using it. The flaxland and rushland vegetation is of moderate ecological value.

The planted area of flax near the existing livestock feed pad is not representative, is poorly connected and buffered, comprises only a small number of native species and those species are common and widespread. It does provide a small amount of poor-quality habitat for birds (particularly seasonally), but only common native and exotic species. The planted flax is of negligible ecological value.

8.2 Wetlands

There are no wetlands within the site and we have not been able to access any wetlands which may exist to the north of the site. We have assumed that wetlands are present in this area and will need to be protected from adverse effects.

The coastal lagoon provides habitat for threatened and 'At Risk' bird and fish species and is surrounded by mostly indigenous vegetation (the flaxland and rushland described above). The lagoon is well connected to other wetland areas immediately nearby and is buffered to some degree from adjoining farming activities by the flaxland vegetation. The turf vegetation has a moderate diversity and there is a diversity of habitat types. The coastal lagoon is of very high ecological value.

8.3 Streams

Macroinvertebrate communities recorded from Northern Drain, lower Collins Creek and Canoe Creek were of poor quality whilst the community recorded from upper Collins Creek was of moderate quality due to higher diversity and abundance of EPT taxa.

Eight fish species were recorded across the four streams during the survey including longfin eel, shortfin eel, common bully, redfin bully, bluegill bully, unidentified galaxiid (whitebait), torrentfish and juvenile brown trout. The presence of fish species that have an 'At Risk (declining)' threat status (Dunn et al. 2017) in Collins Creek and Canoe Creek results in these streams having high fish ecological value. The fish community recorded from Northern Drain was sparse and has low ecological value.

8.4 Summary

The areas of moderate or higher ecological value are located outside the area to be mined and include the coastal lagoon and surrounding flaxland and rushland to the west, Collins Creek and Canoe Creek to the south and perhaps wetland areas to the north of the site. These areas would not be affected directly by the proposal, but could be indirectly affected via effects including, but not limited to, fluctuations in ground or surface water, an increase in human activity and disturbance and an increase in artificial lighting at the site. Birds leaving or returning to the tāiko colony to the north of the site are also of high ecological value and may be directly affected by human activity and an increase in lighting at the site if these activities are not managed. The ecological values of the site are summarised in Table 16 and Table 17.

Table 16: Summary of terrestrial ecological values following the EcIAG (Roper-Lindsay et al. 2018).

Feature	Representativeness	Rarity and Distinctiveness	Diversity and pattern	Ecological Context	Overall score	Comments
Native and exotic shrubland adjoining Collins Creek	Low	Overall = Low Vegetation/habitat = Low Avifauna values = Low Herpetofauna values = Low Bat values = Negligible	Low	Low	Low	The trees and shrubs comprise common native and exotic species that are not representative of any former forest or other vegetation type and are compromised by weeds (particularly gorse). Trees and shrubs present provide low-moderate nesting habitat for a range of common native and exotic birds. It is possible small shrubs and woody debris may provide habitat for native skinks and geckos. If present, skinks and geckos are only likely to be in very low density due to the grazed nature and isolation of the site. Overall, habitat for native lizards is of low quality.
Pasture and occasional native species (flax, *Carex*, shrubs) in the Canoe Creek Infiltration Basin	Low	Overall = Low Vegetation/habitat = Low Avifauna values = Low Herpetofauna values = Negligible Bat values = Negligible	Low	Low	Low	Native species present are common and widespread. The vegetation is not representative of an indigenous community.
Flaxland near the feed pad and three mature kahikatea trees within the site	Negligible	Overall – Low Vegetation/habitat – Negligible Avifauna values – Low Herpetofauna values – Low Bat values – Negligible	Negligible	Negligible	Negligible	Small planted area surrounded by pasture and the existing livestock feed pad. Trunks (and likely the surface roots) of the trees are damaged by livestock access.
Rushland and flaxland surrounding Rusty Pond and Canoe Creek lagoon	Moderate	Overall – Low Vegetation/habitat – Moderate Avifauna values – Low Herpetofauna values - Low Bat values – Negligible	Low	Moderate	Moderate	Vegetation provides dense cover for nesting and habitat for bird species, and also buffers open water habitat and the coastal area from farming and other activities at the site. No threatened or At Risk species have been confirmed using this habitat.
Pasture	Negligible	Overall – Negligible Vegetation/habitat – Negligible Avifauna values – Low Herpetofauna values – Negligible Bat values – Negligible	Negligible	Negligible	Negligible	Pasture provides seasonal/occasional feeding habitat for coastal birds (such as gulls and oystercatchers)-

Table 17: Summary of ecological values of watercourses following the EcIAG (Roper-Lindsay et al. 2018).

Feature	Representativeness	Rarity and Distinctiveness	Diversity and pattern	Ecological Context	Overall score	Comments
Northern Drain	Negligible	Negligible	Low	Low	Low	The Northern Drain is characteristic of a rural grazing affected, channelised and highly modified watercourse. The ASPM score was 0.11 and indicative of severe loss of ecological integrity and function. The stream has a low level of diversity and pattern and no rare or distinctive features or species.
Collins Creek	Moderate	High	Moderate	Moderate	High	Collins Creek has damage characteristic of rural, grazed streams that drain small catchments. The ASPM scores of Collins Creek ranged between 0.21 – 0.39 and are indicative of moderate to severe loss of ecological integrity, with upstream habitats being more valuable than downstream habitats. Collins Creek supports representative fish fauna, including at risk species. Collins Creek has moderate values with regard to ecological context as it provides a migration pathway for fish, has some natural riparian habitat, and contributes to ecological pathways.
Canoe Creek	High	High	High	High	High	Canoe Creek is the least modified of the watercourses near or within the site and supports 'At Risk' fish species.
Artificial Drains	Negligible	Negligible	Negligible	Negligible	Negligible	The artificial drains associated with the humping and hollowing s are a man-made unnatural feature that provides still water habitat of low quality and low ecological value.

9.0 Assessment of Effects

9.1 Introduction

This section assesses the potential ecological effects associated with the proposed development of the mining operation at Barrytown as described in Section 1.2 and shown on the plan presented in Figure 2.

Activities that have potential to result in adverse ecological effects are:

Terrestrial Flora and Fauna

- Terrestrial vegetation clearance.
- Effects on avifauna due to vegetation clearance (loss of habitat, potential for mortality of eggs, chicks and adults), increased human disturbance and activity at the site and increased artificial lighting (including vehicle lighting).
- Effects on threatened and 'At Risk' species in the coastal environment due primarily to increased human disturbance and activity (including lighting).

Ground and Surface Water Hydrology

Changes to the local hydrology, either within the site or effects that extend beyond the site, have the potential to affect ecological values include flora and fauna in wetlands and streams. The potential hydrological effects of the proposed sand extraction identified by Kōmanawa Solutions Limited are:

- Water table fluctuation and the potential for lowering of the water table outside the site due to in-pit dewatering. This could result in flow depletion in streams and/or a lowering of water levels in wetlands and the coastal lagoon if not managed.
- Interruption of drainage patterns.
- Liberation of sediment and/or chemicals (metals/metalloids) affecting water quality via direct discharge and/or discharge of affected water into more sensitive environments).
- Effects due to flocculants.
- Accidental discharge of fuels, oils or lubricants entering surface water or groundwater.

The potential effects of these changes on wetlands and streams are considered in more detail below.

Wetlands Adjoining the Site

- Vegetation changes resulting from any changes in the hydrology – particularly reductions in either water levels and the extent of water as well as changes to the periodicity (duration, frequency) of wetted areas.
- Effects due to discharge of sediments, metalloids or flocculants in the central drain and ultimately the coastal lagoon on aquatic flora and fauna.
- Effects due to increased human disturbance and activity on fauna using the adjoining wetlands.

Streams

Effects on aquatic habitats and native fish due to changes in water quality and quantity include the following:

- Effects due to sediment mobilisation.

- Changes in the amount and/or quality of aquatic habitats due to groundwater or surface water hydrology changes.
- Effects on fauna due to metalloids or flocculants.
- Effects on fish passage due to the culvert installation in Collins Creek.
- Effects of reduced flows in Canoe Creek due to the 63 L/s take at the commencement of mining and any water takes during mining.

9.2 Effects on Terrestrial Flora and Fauna

9.2.1 Terrestrial Vegetation Clearance

The vegetation to be removed at the site comprises predominantly exotic pasture of negligible ecological value and individual native trees which provide roosting and nesting habitat for common native and exotic species as well as a small (167 m^2) area of planted flax. Only up to 8 ha of the site would be affected at any one time with mined sites being progressively rehabilitated as mining proceeds. Riparian planting of Collins Creek, screen planting using native species and buffer planting of the coastal area and the new wetland are proposed. Overall, the level of effects due to vegetation clearance is negligible.

9.2.2 Effects on Avifauna

Although interrogation of the eBird database suggested up to 18 species of ‘threatened’ or ‘at risk' birds potentially use the site and the adjoining SNA, seasonal surveys have confirmed that not all of these species are likely to be present, at least not continuously. Ten species of conservation interest have been confirmed using the site or likely to be at risk of adverse effects including black shag (At Risk (relict)), black-billed gull (At Risk (declining)), Caspian tern (Threatened (Nationally vulnerable)), grey duck (Threatened (nationally vulnerable)), red-billed gull (At Risk (declining)), South Island pied oystercatcher (At Risk (declining)), white fronted tern (At Risk (declining)), Pacific reef heron (Threatened (nationally endangered)), variable oystercatcher (At Risk (recovering)) and tāiko (At Risk (naturally uncommon)).

Effects on avifauna include loss of habitat, increased human disturbance and activity at the site and lighting (including vehicle lighting). Different species are expected to be affected by different activities. With the exception of tāiko, the species listed above all use the coastal lagoon, open water or coastal (beach) area, although some (oystercatchers and gulls particularly) might also use pasture for feeding occasionally throughout the year. Seasonal monitoring undertaken over one calendar year has confirmed that none of these species use the site in such a way that they would be directly affected by vegetation removal, but they could be affected by noise, human activities and vehicle movements near their habitats, particularly during the breeding season. For these species the following management actions are proposed as set out in the draft Avian Management Plan prepared by Ecological Solutions Limited and incorporated into the proposed mine planning:

- Commencement of mining at least 100 m from the edge of the coastal lagoon which is achieved via starting in Panel 1 (the starter pit) and monitoring of birds during mining to inform later management.
- Maintenance of a 20 m buffer from the edge of mining to the lagoon area. This boundary is to be permanently marked so as to avoid crossing it inadvertently.
- Planting of a 5 m wide buffer with flax and other native species set out in the planting plan for the site so as to visually screen the mining activities from the lagoon and contribute to reducing noise levels.

- Avoidance of mining the parts of the strips closest to the highest quality habitats (the lagoon and provisional SNA area, strips 5–7 and 10) between the months of September and December (inclusive) in order to provide separation from activities.

The purpose of this avoidance is to provide spatial separation for breeding birds from the mining activities when they are most susceptible to effects. Ongoing seasonal monitoring of birds using the site is proposed to inform future management as mining proceeds across the site, noting that with the current mine plan, the area adjoining the coastal lagoon would be among the last to be mined allowing up to five or six years (depending on mine progress) to confirm any changes to bird presence or habitat use by birds prior to mining there. In addition to ongoing seasonal monitoring, monthly, fortnightly and weekly monitoring as required to identify birds and nests that are at risk and allow their management via an exclusion zone, predator control and other management as required is proposed to avoid adverse effects on these species. Together these actions are expected to reduce the level of effects on avifauna to 'low'.

With respect to tāiko, they are not expected to use the site, but are expected to travel past it, when they could be influenced by lighting there if it is not appropriately managed. Since mine operations would occur between 0700 hrs and 2200 hrs seven days a week between 01 February and 30 November and 0630 hrs and 2130 hrs between 01 December and 31 January the need for lighting for mining operations would be avoided during the highest risk period for tāiko. Processing would occur continuously at the site and artificial lighting would be used to enable processing operations during parts of the day (particularly during winter).

Lighting management at the site is proposed in the draft Avian Management Plan in accordance with the Commonwealth of Australia National Light Pollution Guidelines for Wildlife (Commonwealth of Australia 2020) or subsequent amendments in order to avoid and/or further minimise effects due to fixed lighting at the site.

Some of the management actions proposed to reduce fixed light spill from the site include use of best practice design including:

- Starting with natural darkness and only adding light for specific purposes where and when required. This means no fixed external lights are proposed on the Processing Plant.
- Using adaptive light controls such as timers, dimmers and motion sensors to manage light timing, intensity and colour.
- Lighting only the object or area intended – keep lights close to the ground, directed and shielded to avoid light spill. This applies particularly to mobile lighting used outside.
- Use of the lowest intensity lighting appropriate for the task.
- Use of non-reflective, dark-coloured surfaces.
- Using lights with reduced or filtered blue, violet and ultra-violet wavelengths.

Periodic lighting audits are proposed to ensure the lighting management is maintained over time. Other methods intended to reduce lighting spill from the Processing Plant, mobile mining plant and vehicles include the use of bunds and screen planting on the eastern side and part of the northern side of the Processing Plant to reduce visibility when approached from the direction of the tāiko colony, construction of the Processing Plant with no windows, and doors located only the southern and eastern walls. Any mobile lighting used for mining during the hours of darkness would only be used as required and would be low intensity, filtered, shielded and directed down so as to reduce spill. Furthermore, since lights from moving vehicles poses a risk to tāiko, vehicle movements within the site would be speed limited to 15 kilometres per hour and there would be restrictions on truck movements entering or leaving the site occurring within the hours of darkness ('night time movements').

There are two possible routes for trucks leaving the site, either north past the tāiko colony to Westport or south to Greymouth. The preferred route is yet to be chosen, but if the northern route is selected there would be no night time truck movements in order to reduce the risk of tāiko encounters with vehicles. The draft Avian Management Plan also sets out a process for dealing with and reporting grounded seabirds if any occur within the site so as to maximise the chances of successful rehabilitation of any affected birds. Tāiko are a high value species and the mitigations proposed are expected to reduce the magnitude of effects to 'low'.

9.2.3 Effects on threatened and 'At Risk' species in the coastal environment

As described above, there are ten species of threatened and 'At Risk' species known to use the site and which could potentially be affected by the proposal. None of these species would be directly affected by the proposal and the management proposed is expected to enable adverse effects on these species to be avoided.

9.3 Effects on Wetlands

Water table drawdown extending beyond the limits of the active mining area has the potential to affect wetlands north of the property boundary, including the flax wetlands on the upstream side of Rusty Lagoon and the area of kahikatea wetland in the vicinity of PZ-12, but potentially connected by the shared groundwater system. In particular, having considered the proposed mining period and the groundwater modelling results for the site, Kōmanawa Solutions Limited consider that later stage sand extraction (Years 4 and 5, when mining is closest to the northern boundary) would result in lowering in the groundwater levels, affecting groundwater – surface water interactions and ultimately the water levels in the Northern Drain, wetlands to the north of the property boundary and Rusty Lagoon in the absence of appropriate management.

Water table drawdown in the southern parts of the mine could affect the springs located on the adjoining property to the south (Langridge's) and Collins Creek and ultimately the coastal lagoon (which is fed by Collins Creek). This is most likely during years 1–3, when mining is closest to the southern part of the site.

Prevention of mining related groundwater level declines at the site boundary using the methods proposed would avoid hydrological impacts on these areas (Kōmanawa Solutions Limited 2023).

The potential for saline intrusion related to water table decline is also regarded as very low (Kōmanawa Solutions Limited, 2023).

Kōmanawa Solutions Limited (2023) has proposed a suite of water management actions designed to avoid changes to hydrology such that wetland vegetation and fauna would not be affected. Given the comprehensive ground and surface water monitoring proposed to inform the water management at the site and ensure the appropriate water quality parameters are achieved and that the mitigation hierarchy is applied to managing effects, the level of effects on groundwater quantity is expected to be low.

The proposed management concept would maintain ground water levels at or above the pre-mining median at the site boundary and therefore in the adjoining wetlands. This would likely reduce the upper water levels to some degree (i.e., the wetlands wouldn't get as wet following large rain events), and also raise the lower levels (i.e., they wouldn't get as dry during periods of low rainfall). This 'flattening' of groundwater levels for the period of mining is unlikely to significantly affect vegetation and habitats because the species known to be present in the wetland areas are relatively hardy and can cope with a wide variation in periodicity, frequency and range of water levels without having their survival or productivity substantially affected.

The monitoring of ground and surface water levels combined with flow augmentation as required is expected to maintain the median natural pre-mining median water level and hydrological function of the surrounding wetlands and maintain both their extent and ecological values.

Beca (2008) defined the potential risk of ecological change associated with changes in water levels in wetlands as follows:

- Low – <0.2 m change in median water level and patterns of water level seasonality (summer vs. winter levels) remain unchanged from the natural state.
- Medium – > 0.2 m and < 0.3 m change to median water level and patterns of water level seasonality show a reverse from the natural state (summer relative to winter).
- High – >0.3 m change to median water level; and, patterns of water level seasonality show a reverse from the natural state (summer relative to winter).

Given the water management proposed at the site, changes in water levels would sit at the low end of the "low" scale devised by Beca (2008). The species present in the wetlands (flax, *Carex* spp., raupō) that we have had access to are common and relatively robust to short term and/or small changes in water level. Considering a worst-case scenario, where water levels in wetlands drop and are not able to be restored immediately, these species would be expected to persist for several months to a year before effects such as dieback or poor health were evident.

9.4 Effects on Surface Waters and Groundwater

9.4.1 Introduction

Kōmanawa Solutions Ltd (2023) provides a broad water management plan that outlines the mitigation and treatment options which will accompany the proposed sand extraction activities. These mitigation and treatment options include:

- Minimising the areas of land disturbance and excavation.
- Augmenting surface water flows via groundwater, and directly via treated clean process water or abstracted clean water from Canoe Creek.
- Augmenting groundwater flows by injection of treated clean process water and/or abstracted clean Canoe Creek water via a mine perimeter infiltration system.
- Settling and clarifying of mine-affected water via ferrous precipitation coupled with hardness enhancement in various treatment ponds and site drains.
- Discharge of excess process water at the coastal lagoon or Canoe Creek infiltration basin depending on water quality.

Together with comprehensive monitoring, these water management actions are expected to maintain ground and surface water levels such that adverse effects on watercourses will be avoided, and if not avoided, minimised.

9.4.2 Earthworks and Sedimentation Effects

Earthworks works associated with mining the site has the potential to result in fine sediment mobilisation and runoff into streams and wetlands. The addition of fine sediment to stream environments has the potential to alter water chemistry, increase turbidity and decrease light penetration, which in turn affects primary production and feeding for some fish species. The deposition of sediment can also smother instream surfaces, decrease interstitial spaces and decrease the amount of suitable habitat available for benthic invertebrates.

Provided that the installation of the culvert in upper Collins Creek for access to the Processing Plant is completed so as to minimise effects due to sedimentation and ensure fish passage is maintained, no lasting adverse effects due to the culvert placement are expected.

The Erosion and Sediment Control Plan ('ESCP') for the site prepared by Ridley Dunphy Limited (2023) provides the overarching approach to water management and monitoring on site and incorporates Auckland Council GD05 guidelines and a consideration of the specific physical conditions to be encountered on the site and the previous knowledge of the project team (from other similar projects).

Prior to any work activity a detailed Site-Specific Erosion and Sediment Control Plan (SSESCP) will be established which will include detailed design and provide for additional technical input and any changes required as a result on ongoing monitoring as mining proceeds. Ridley Dunphy Limited conclude that while the proposed works are considered low risk because of the underlying soil types/geology and low slopes, the main effect is likely to be due to groundwater infiltration, in particular the volumes of groundwater that are expected to be encountered. Groundwater infiltration is therefore a key consideration in the ESCP in order to achieve the desired environmental outcome.

ESCP measures will be based on a range of structural (physical) measures and non-structural measures (methodologies and construction sequencing) combined with a tool-box type approach to match any local challenges and opportunities. A monitoring and management approach is proposed which will allow a response to monitoring outcomes observed with respect to water quality (turbidity and other contaminants). Both qualitative monitoring (which will include visual surveys and recording of any discharges and the downstream environment) and quantitative monitoring (which will include sample collection and analysis) are proposed.

Water pumped from the mine pit will contain suspended sediment associated with plant operation and localised erosion of the pit walls by rainfall and groundwater seepages (Kōmanawa Solutions Limited 2023). The presence of clay material in the overburden in some areas of the mine site may contribute to high levels of turbidity for part of the mine life.

The ESCP describes a water treatment train which is expected to achieve a discharge standard of approximately 15 mg/L of suspended sediment in the Pond 4 outlet. The turbidity of the Pond 4 water will be dependent on the exposure to clay materials in the mine excavation and the settling properties of the clay. It is possible that turbidity will be significantly elevated above the low levels of background turbidity in Canoe Creek Lagoon, Collins Creek and to a lesser extent the Northern Boundary Drain during some periods of the mining operation. The ESCP explains that removal of this turbidity to the levels that would be required to avoid any conspicuous change in visual clarity in these water bodies may not be feasible for the proposed mining operation. Where turbidity standards cannot be met, discharge to land at the Canoe Creek infiltration basin will be used to dispose of treated water. At this location the water will either discharge to ground or overflow from the basin and discharge into Canoe Creek directly, where dilution is expected to be sufficient to reduce and/or minimise effects.

With regard to water treatment, clean water diversions will be put in place around the pit and water from the mining void and stormwater runoff from the process plant area will be diverted or pumped to Pond 1 and Pond 2. Pond 1 includes two separate forebay impoundments which are designed to capture most of the sediment prior to flow into the main body of Pond 1 and then over a level spreader to Pond 2. Lime dosing or similar is proposed to alter water hardness and manage elevated metalloid concentrations naturally present in groundwater at the site. Flocculants may also be used in Pond 1 if required to remove metalloids. The clean water from Pond 2 will then discharge via a pump to the central drain or be used in the process plant. Rock check dams will be present in the central drain to slow flows and trap some sediment. The central drain will flow to a finishing pond and the clean water facility (referred to as Ponds 3 and 4) in the southwestern corner of the property. Excess water from Pond 3 will overflow into the clean water facility (Pond 4) before discharging to the environment via drains. Pond 4 would be retained post-mining as a wetland to provide additional habitat for wetland species.

In the event that flocculants are required their use to comply with industry best practice and any relevant Materials Safety Data Sheet(s). Flocculants are considered low risk because if used in accordance with manufacturer's instructions, they generally do not enter the receiving environment in their active state, do not bioaccumulate, do not persist and become tightly adsorbed to sediments, whereupon they become inactive. Furthermore, the benefits of reduced sedimentation are thought to outweigh any adverse effects of flocculants for most species.

9.4.3 Effects on Water Quantity

The diversion of water away from the natural catchment of streams has the potential to affect flow and reduce habitat in streams.

Kōmanawa Solutions Ltd (2023) has reported that, apart from short-term transient spikes and declines, current median groundwater levels will be maintained at the northern boundary of the proposed sand extraction zone. Hydrological modelling indicates the proposed infiltration system is expected to recharge at rates that will maintain current median groundwater levels at the northern boundary. Hence, it is stated that water levels in Rusty Pond and nearby wetlands, as well as flows in the Northern Drain, will also be maintained at their pre-mining medians.

Further, Kōmanawa Solutions Ltd (2023) has reported that, at the southern boundary, the proposed sand extraction will result in a reduction of groundwater levels in the absence of appropriate water management. The proposed mitigation involves the installation of an infiltration trench system and, if required, recharge barrier wells. In addition, flows in Collins Creek will be augmented in order to avoid flow reductions. Augmentation will also be required in order to mitigate the potential reduction of groundwater flows to Canoe Creek Lagoon. The performance of the groundwater infiltration systems will be verified during the proposed construction.

Approximately 6.5 ha of the proposed mine area drains to the Northern Boundary Drain with the remainder draining to Canoe Creek Lagoon via farm drains, or via the lowest reach of Collins Creek. Drainage patterns from part of the Northern Boundary Drain catchment outside of the mine area, but within the disturbed area footprint, could also be affected by the proposed activity. The final landform will be contoured to re-establish the existing distribution of drainage such that the catchment area draining to the Northern Boundary Drain does not change by more than 15% (i.e., 1 ha). This recontouring will ensure that the runoff rates to Rusty Lagoon and Canoe Creek Lagoon do not change as a result of mining.

9.4.4 Effects on Water Quality

Overall Water Management

With respect to potential surface water quality effects, these include:

- Reduced visual clarity in receiving surface waters due to discharge of potentially turbid water from the sediment treatment system; and

- Mobilisation of metals/metalloids and phosphorus to surface water bodies associated with discharge of groundwater inflows with elevated levels of these elements from the pit.

The requirements for mitigation of turbidity and chemical parameters in waters circulating within the managed mine water systems requires the construction and commissioning of ponds and associated plant to allow for settling, aeration, hardness adjustment and flocculation (as necessary), the establishment of a supplementary water supply intake adjacent to Canoe Creek for make-up water to be used in augmentation if required and establishment of a supplementary water discharge system at the Canoe Creek Infiltration Basin to allow balancing discharges of treated water.

Effects on water quality would be addressed via the site-specific water management plan including management actions such as minimising the area disturbed to reduce sediment mobilisation, deployment of a treatment train approach via primary treatment ponds (1 and 2), flocculant and limestone lined drains/lime dosing in Ponds 1–3 and/or the central drain and terminal treatment ponds (3 and 4), discharge of treated water to ground where possible, increasing discharge water hardness to precipitate metals and metalloids and discharging any treated water which does not meet the water quality thresholds for Canoe Creek Lagoon/Collins Creek/Northern Boundary Drain to an alternative (land based) location (Kōmanawa Solutions Limited 2023). The location of discharges to the perimeter infiltration system would vary according to the location of mining within the site at the time.

Management is required to address the potential for the water quantity effects identified in Section 9, in particular the potential for a reduction in flows and/or water levels in surface water bodies due to drawdown and re-arranged hydraulic gradient diverting groundwater from creeks, drains, springs, wetlands or lagoons previously receiving groundwater seepage into the mine pit. The proposed water management and monitoring concept is shown in Figure 44 of Kōmanawa Solutions Limited (2023) and would be accompanied by modelling to inform discharge decisions as required.

In accordance with the proposed broad water management plan, Kōmanawa Solutions Ltd (2023) has provided various hydrological management actions for maintaining groundwater levels and surface water flows. The proposed water management concept is hierarchical based on avoiding effects whilst being operationally efficient. Depending on the particular effects to be managed, these actions include discharging treated water from Pond 4 to:

- Collins Creek (to augment surface flows if required)
- The Northern Drain (to augment surface flows if required)
- Infiltration trenches at the northern and southern boundaries of the site (to maintain median groundwater levels as necessary)
- The drain supplying the coastal lagoon (to remove water)
- The Canoe Creek Infiltration Basin (to deal with sediment affected water if required)
- Canoe Creek itself (to remove water).

Each of these alternative management actions would have different effects which are considered in more detail below.

Augmentation of Surface Flows

The main aim of the water treatment infrastructure is to produce water of an appropriate quality in the terminal pond (Pond 4) for either use in surface flow augmentation structures (infiltration trenches, recharge infiltration wells, or Canoe Creek Lagoon/Collins Creek/Northern Drain direct discharge) or discharge via the Canoe Creek Infiltration Basin.

To assist in understanding whether treated water would meet the required standards for discharge to the Northern Drain, Collins Creek and Canoe Creek, modelling of the surface water quality changes for those waters that are proposed to receive treated clean process water has been undertaken using the ion-association aqueous model, PHREEQC (USGS, 2021).

Modelling inputs were based on the median of estimated treated clean process water (refer Table 15) mixed with median quality of the receiving water (refer Table 11). Conservative estimates of dilutions were used, being those provided by Kōmanawa Solutions Ltd (2023); hence the various modelled scenarios are as follows:

- Canoe Creek: treated clean process water mixed with Canoe Creek downstream water in a 1:15 ratio applicable to median flows and a 1:5.3 ratio applicable to MALF conditions.
- Collins Creek: treated clean process water mixed with Collins Creek upstream water in a 1:2 ratio, i.e., worst-case augmentation.
- Northern Boundary Drain: treated clean process water adjusted to a hardness of 350 g/m^3 directly into the drain with zero dilution, i.e., worst-case.
- Canoe Creek Lagoon: treated clean process water mixed with Canoe Creek Lagoon water in a 1:2 ratio, i.e., worst-case.

The hardness and pH of the treated clean process water were adjusted to 350 g/m^3 (as $CaCO_3$) and 9.0, respectively, based on a realistic target in the proposed treatment ponds (via lime dosing) and drains (via limestone rip-rap, or similar). For modelling purposes, the hardness was adjusted only by the addition of calcium ions. Accordingly, the estimated average post-mixing Canoe Creek water quality is presented in Table 18, Collins Creek in Table 19, Northern Boundary Drain in Table 20, and Canoe Creek Lagoon in Table 21.

Modelling indicates that discharges, at the stated ratios, of median quality hardness adjusted (to 350 g/m^3 as $CaCO_3$) treated clean process water to receiving waters, also at median water quality, will not result in exceedances of relevant metals/metalloids guidelines.

The modelled average ammoniacal-nitrogen concentrations in the receiving waters situates them within either the NPS-FM (2020) A or B-bands. No attribute state change for ammoniacal-nitrogen is expected in any of the receiving waters modelled, noting that when the Northern Boundary Drain is dry (i.e., therefore having no definable attribute state) it is estimated to fall within the B-band when it receives treated clean process water. An important factor in reducing ammoniacal nitrogen concentrations in treated clean process water in the passive treatment ponds is the process of aeration at elevated pH. Modelled nitrate nitrogen concentrations situates receiving waters within the NPS-FM (2020) A-band.

Modelling indicates no expected change from the appropriate NPS-FM (2020) dissolved reactive phosphorus (DRP) B-bands in Canoe Creek under either median flow (median attribute state) or MALF conditions (95%-ile attribute state). Likewise, the DRP attribute state of Canoe Creek Lagoon will remain within the D-band and, similarly, the attribute state for the Northern Boundary Drain when dry and receiving treated clean process water is estimated to be in the D-band, i.e., the same as when it is flowing. At the Collins Creek downstream site, the baseline DRP attribute state is within the B-band. Without treatment of groundwater in the primary ponds, such as is proposed via alum or iron flocculation, there is potential for a change in attribute state to the D-band. With the treatment proposed it is likely phosphorus concentrations at the Collins Creek downstream site will result in a positive change in the attribute state to the A-band (i.e., an improvement).

Table 18: Canoe Creek modelled surface water quality parameters, post-mixing – dissolved fraction.

Parameter	Canoe Creek Median flow	Guideline	Canoe Creek MALF	Guideline
pH (pH units)	7.3	6-9[A]	7.9	6-9[A]
Hardness (as $CaCO_3$)	34.4	NA	79.3	NA
Aluminium	0.0029	0.40-0.71[B,C]	0.0033	0.72-1.2[B,C]
Arsenic	0.0010	0.013[D,E]	0.0046	0.013[D,E]
Boron	0.009	0.94[F]	0.005	0.94[F]
Cadmium	< 0.00005	0.0002[C,D]	< 0.00005	0.0005[C,D]
Chromium	< 0.0005	0.0037[C,D,G]	< 0.0005	0.0073[C,D,G]
Copper	< 0.0001	0.0039-0.0079[C,H]	< 0.0001	0.0079-0.0138[C,H]
Iron	0.24	1.0[I]	0.009	1.0[I]
Lead	< 0.0001	0.0040[C,D]	< 0.0001	0.012[C,D]
Manganese	0.029	1.9[C]	0.012	1.9[C]
Nickel	< 0.0005	0.012[C,D]	< 0.0005	0.025[C,D]
Zinc	0.0028	0.0089[C,D]	0.0044	0.018[C,D]
Ammoniacal-N	0.011	≤ 0.06[J]	0.014	≤ 0.03[J]
Nitrate-N	0.17	≤ 1.0[K]	0.055	≤ 1.0[K]
Phosphorus[L]	0.010	> 0.006 and ≤ 0.010[M]	0.030	> 0.021 and ≤ 0.030[N]

Notes: units g/m^3; [A]WCRC (2014); [B]USEPA (2018); [C]hardness and pH as stated, Dissolved Organic Carbon (DOC)=2.5 g/m^3 for aluminium 2.0 g/m^3 for copper; [D]ANZECC (2000) default trigger; [E]As(V); [F]ANZECC (2018);[G]Cr(III); [H]USEPA (2007); [I]USEPA (1986); [J]NPS-FM attribute A annual median, pH adjusted; [K]NPS-FM attribute A annual median; [L]modelled as dissolved reactive phosphorus; [M]NPS-FM attribute B median; [N]NPS-FM attribute B 95%-ile.

Table 19: Collins Creek modelled surface water quality parameters, post-mixing – dissolved fraction.

Parameter	Collins Creek	Guideline
pH (pH units)	8.4	6-9[A]
Hardness (as $CaCO_3$)	137	NA
Aluminium	0.019	1.4-1.7[B,C]
Arsenic	0.0012	0.013[D,E]
Boron	0.010	0.94[F]
Cadmium	< 0.00005	0.0008[C,D]
Chromium	< 0.0005	0.012[C,D,G]
Copper	< 0.0001	0.015-0.031[C,H]
Iron	0.052	1.0[I]
Lead	< 0.0001	0.023[C,D]
Manganese	0.068	1.9[C]
Nickel	0.0008	0.040[C,D]
Zinc	0.0043	0.029[C,D]
Ammoniacal-N	0.012	≤ 0.02[J]
Nitrate-N	0.13	≤ 1.0[K]
Phosphorus[L]	0.051	> 0.018[M]

Notes: units g/m^3; [A]WCRC (2014); [B]USEPA (2018); [C]hardness and pH as stated, Dissolved Organic Carbon (DOC)=2.5 g/m^3 for aluminium 2.0 g/m^3 for copper; [D]ANZECC (2000) default trigger; [E]As(V); [F]ANZECC (2018);[G]Cr(III); [H]USEPA (2007); [I]USEPA (1986); [J]NPS-FM attribute A annual median, pH adjusted; [K]NPS-FM attribute A annual median; [L]modelled as dissolved reactive phosphorus; [M]NPS-FM attribute D median.

Table 20: Northern Boundary Drain modelled surface water quality parameters,

post-mixing – dissolved fraction.

Parameter	Northern Boundary Drain	Guideline
pH (pH units)	8.9	6-9[A]
Hardness (as $CaCO_3$)	343	NA
Aluminium	0.0070	1.2-1.6[B,C]
Arsenic	0.0025	0.013[D,E]
Boron	0.008	0.94[F]
Cadmium	< 0.00005	0.0018[C,D]
Chromium	< 0.0005	0.024[C,D,G]
Copper	< 0.0001	0.039[C,H]
Iron	0.028	1.0[I]
Lead	< 0.001	0.075[C,D]
Manganese	0.058	1.9[C]
Nickel	0.0018	0.087[C,D]
Zinc	0.023	0.063[C,D]
Ammoniacal-N	0.037	> 0.006 and ≤ 0.051[J]
Nitrate-N	0.30	≤ 1.0[K]
Phosphorus[L]	0.061	> 0.018[M]

Notes: units g/m^3; [A]WCRC (2014); [B]USEPA (2018); [C]hardness and pH as stated, Dissolved Organic Carbon (DOC)=2.5 g/m^3 for aluminium 2.0 g/m^3 for copper; [D]ANZECC (2000) default trigger; [E]As(V); [F]ANZECC (2018);[G]Cr(III); [H]USEPA (2007); [I]USEPA (1986); [J]NPS-FM attribute B annual median, pH adjusted; [K]NPS-FM attribute A annual median; [L]modelled as dissolved reactive phosphorus; [M]NPS-FM attribute D median.

Table 21: Canoe Creek Lagoon modelled surface water quality parameters, post-mixing – dissolved fraction.

Parameter	Canoe Creek Lagoon	Guideline
pH (pH units)	7.7	6-9[A]
Hardness (as $CaCO_3$)	138	NA
Aluminium	0.0067	0.73-1.1[B,C]
Arsenic	0.0011	0.013[D,E]
Boron	0.013	0.94[F]
Cadmium	< 0.00005	0.0008[C,D]
Chromium	< 0.0005	0.011[C,D,G]
Copper	< 0.0001	0.0087-0.015[C,H]
Iron	0.35	1.0[I]
Lead	< 0.0001	0.024[C,D]
Manganese	0.085	1.9[C]
Nickel	< 0.0005	0.040[C,D]
Zinc	0.011	0.029[C,D]
Ammoniacal-N	0.056	> 0.05 and ≤ 0.43[J]
Nitrate-N	0.17	≤ 1.0[K]
Phosphorus[L]	0.087	> 0.018[M]

Notes: units g/m^3; [A]WCRC (2014); [B]USEPA (2018); [C]hardness and pH as stated, Dissolved Organic Carbon (DOC)=2.5 g/m^3 for aluminium 2.0 g/m^3 for copper; [D]ANZECC (2000) default trigger; [E]As(V); [F]ANZECC (2018);[G]Cr(III); [H]USEPA (2007); [I]USEPA (1986); [J]NPS-FM attribute B annual median, pH adjusted; [K]NPS-FM attribute A annual median; [L]modelled as dissolved reactive phosphorus; [M]NPS-FM attribute D median.

Water clarity was not modelled in the receiving waters, firstly since there was insufficient data to develop a total suspended solids versus turbidity relationship and, secondly, because controlling turbidity via flocculation, as is proposed in the primary treatment ponds, is standard practice and readily achievable.

Also of potential concern in relation to surface waters is the possibility for elevated nutrient discharge via surface run-off. The modified land relief will improve pasture quality and reduce potential for nutrient discharge to waterways. Soil drainage will also be improved by mixing of more permeable sand deposits from the deeper profile with the heavy soil overburden currently present at the surface. This is expected to reduce nutrient runoff and increase infiltration rates and the storage of nutrients in the soil for plant uptake. In addition, the riparian planting along Collins Creek is expected to assist with removal of nutrients from runoff prior to it reaching the stream. The proposed management actions, including the rehabilitation design are therefore likely to reduce nutrient concentrations in downstream receiving waters relative to the status quo (Kōmanawa Solutions Limited 2023).

Ground Water Recharge

Kōmanawa Solutions Limited (2023) propose that effects due to groundwater drawdown be addressed via groundwater recharge at the site boundary using infiltration trenches and recharge barrier wells and direct flow augmentation (i.e., discharge of treated (clean) water or water abstracted from Canoe Creek) to affected waterbodies as prescribed by the site-specific Water Management, Monitoring and Mitigation Plan supported by comprehensive monitoring of levels, flows and discharges and which employs the mitigation hierarchy (i.e., prioritises avoidance) as set out in Section 6.3 of their 2023 report and described above.

On a qualitative basis, the augmentation of groundwater flows by injection of treated clean process water and abstracted clean Canoe Creek water via the various proposed infiltration systems will mostly result in an improvement in groundwater quality since both sources exhibit superior quality versus the extant groundwater. Assuming Canoe Creek surface water quality is similar to that found in Collins Creek (refer Table 10) and that treated clean process water quality is that similar to simulated post-settling pond groundwater (refer Table 14), groundwater quality post-injection will exhibit lower concentrations of metals/metalloids.

Without the addition of hardness via the proposed addition of lime to ponds and limestone to drains, there would be a reduction of hardness concentrations of injected groundwater – this since the average hardness concentration of raw groundwater in the sand extraction zone is 129 g/m^3 (as $CaCO_3$), whereas the average (predicted) Canoe Creek and simulated post-settling pond groundwater hardness concentrations are 37-32 g/m^3 and 34 g/m^3 (as $CaCO_3$), respectively. Hence, a target for passive treated clean process water hardness concentrations of approximately 350 g/m^3, would maintain groundwater hardness concentrations at or above the existing average value.

The modified post-mining land relief is expected to assist in maintaining groundwater levels beneath the site at or above the pre-mining elevation. In relation to nutrient status, higher rates of nutrient infiltration into the potentially anoxic underlying groundwater may also result in increased attenuation of nitrate losses from future agricultural activity on the land. No change in nitrogen status is expected, but on injection of treated water the ratio of ammoniacal-nitrogen to nitrate-nitrogen will favour the oxidised state. Since the treated water delivery is to shallow groundwater it is not predicted that the reduced state will be restored. A reduction of phosphorus concentrations in ground water is expected.

9.4.5 Effects on Stream Ecology

Without appropriate mitigation the proposal has the potential to have the following adverse stream ecology effects:

- Entrain small fish into the Canoe Creek intake (if water is needed from Canoe

Creek).

- Increased phosphorus concentration could stimulate periphyton and macrophyte growths in Collins Creek and the Northern Drain.
- Elevated turbidity and effects on visual feeding by fish.

Ecological Solutions understands that shallow ground water would be extracted from Canoe Creek via a subsurface gallery or a direct surface water take with an appropriate fish screen. This method of take should avoid any risk of fish becoming entrained and 'relocated' from Canoe Creek to Colins Creek and thus avoid this potential adverse effect. A water take limit of 63 L/s from Canoe Creek is proposed which comprises 10% of the annual MALF. A water take of this magnitude is expected to maintain instream conditions (i.e., habitat quality, native fish abundance) since the frequency of higher flushing and channel maintenance flows would remain mostly unchanged.

The water quality modelling indicates that the phosphorus concentrations in Collins Creek could increase and result in the NPS-FM changing from Band B to Band D although at present the upstream phosphorus concentration is currently Band D. In order to mitigate the risk of nuisance algal growths it is proposed to increase the stream channel shading by planting the riparian margins of the stream.

Kōmanawa Solutions (2023) concludes that turbidity may be elevated above the low background levels in Collins Creek during some periods of the mining operation. Collins Creek supports juvenile brown trout and is likely to provide brown trout spawning habitat, but the stream is too small to support adult trout. Brown trout use various foraging strategies, including drift feeding on aquatic insects in the water column; increased turbidity can potentially reduce such foraging efficiency. If turbidity is elevated over prolonged periods, reducing feeding rates, juvenile brown trout growth rates could be reduced (Cawthron 2004). The potential discharge of water with elevated turbidity is expected to be infrequent and for short periods, and as a result, effects on juvenile brown trout feeding efficiency are expected to be short-term and, therefore, should not result in prolonged periods of reduced visual feeding efficiency or affect growth rates

The potential effects on juvenile brown trout associated with elevated turbidity will be minimised by discharging excess water to the Canoe Creek infiltration basin and potentially to the bed of the river at the mouth. Collins Creek has highly eroding streambanks in its current state. The proposed riparian planting, fencing, and removal of grazing stock on both banks of Collins Creek will increase streambank stability, minimise sediment inputs derived from streambank erosion, and improve brown trout spawning and juvenile brown trout habitat quality. The periodic nature of potentially elevated turbidity in the receiving environment and the implementation of the above mitigation measures results in an overall 'low' level of effect on visual feeding by fish. On that basis the overall level of effects is also considered to be low.

With respect to metals and metalloids, modelling has indicated that at median water quality, the discharge of treated water as a result of the proposal will not result in exceedances of relevant metals/metalloids guidelines. On that basis, effects on aquatic habitats due to elevated levels are not expected.

10.0 Mitigation

With respect to water quality and quantity, no specific mitigations beyond the riparian planting proposed and the mitigation actions set out in the water management plan for the site are considered necessary.

With respect to birds, an avian management plan which provides for regular monitoring of birds and implementation of management to avoid or reduce effects in the event that it is required (e.g., if mining would occur near the coastal lagoon during the breeding season) is required. The avian management plan also manages lighting at the site and prescribes what would happen in the event of a bird grounding within or near the site.

It is recommended that the riparian margins of the Northern Stream and Collins Creek be planted to provide stream channel shading and reduce the risk of nuisance algal growths occurring.

A wetland and riparian planting and management plan is also proposed to provide for restoration of the approximately 1 ha of the site to be returned to wetland habitat at the completion of mining as well as riparian planting at the site.

The overall level of effects given the mitigations proposed is set out in Table 22.

Table 22: Magnitude and level of effects for the proposed development before and after mitigation.

Activity	Effect	Ecological value	Magnitude of effect	Level of effect (no mitigation)	Proposed mitigation measures	Level of effect (with mitigation)
Terrestrial vegetation clearance - pasture	Loss of botanical values	Negligible	Low	Very low	None	Very low
Terrestrial vegetation clearance – trees/shrubs	Loss of botanical values	Low	Moderate	Low	Planting of bund and other vegetation	Very low
Terrestrial vegetation clearance - flaxland	Loss of botanical values	Low	Low	Very low	Planting adjoining the coastal lagoon and open coastline	Net gain
Terrestrial vegetation clearance – effects on avifauna	Direct mortality of eggs and chicks if Habitat clearance occurs during breeding season	Low	Low	Very low	Avoid vegetation clearance September to February inclusive. If this is not possible check trees prior to felling and if a native species is nesting, leave the tree standing until the nest can be declared empty	Very low
Terrestrial vegetation clearance – trees and shrubs	Loss of potential habitat for common terrestrial lizards.	Low	Negligible	Negligible	None	Very low
Earthworks	Sedimentation and smothering of stream bed in onsite watercourses and the downstream catchment	Low-HIgh	High	Moderate - High	Erosion and sediment controls implemented in accordance with Erosion and Sediment Control Plan (Ridley Dunphy Limited 2023) and GD05 will reduce magnitude of effect to 'low'	Low-very low
Restoration of stream habitat	Weed control and restoration planting of Collins Creek and the southern side of the Northern Drain resulting in improved habitat and water quality.	Low-moderate	Positive	Net gain	Implement programme of pest management and riparian planting in accordance with wetland planting plan	Net gain
Restoration of wetland habitat	Weed control and restoration planting of wetland area resulting in increased habitat within the site for terrestrial species such as avifauna.	Negligible	Positive	Net gain	Not applicable	Net gain
Dewatering of the mine pit leading to changes in	Changes to local hydrology reducing flows and inputs to wetlands. Likely	High	Moderate - High	Moderate - High	Implementation of the site water management plan (Kōmanawa Solutions	Very low

Activity	Effect	Ecological value	Magnitude of effect	Level of effect (no mitigation)	Proposed mitigation measures	Level of effect (with mitigation)
ground and surface water flows	to extend beyond the site.				Ltd 2023)	
Effects due to fixed lighting on seabirds, including tāiko	Potential for grounding which can result in bird mortality	High	Low	Low	Implementation of Avian Management Plan and management of lighting in accordance with Commonwealth of Australia (2020)	Very low
Night time vehicle movements	Potential for grounding or direct mortality of seabirds, including tāiko.	High	:Low	Low	Avoid traffic movements north during hours of darkness. Limit vehicle speed on site. Alter hours of operation December – January and implement lighting management at the site in accordance with light pollution guidelines. Avian Management Plan provides for management of any grounded birds found.	Very low
Increased activity and human disturbance	Loss of foraging and/or reproductive success for birds using the coastal lagoon and adjoining vegetation	High	Moderate	Moderate	Implementation of Avian Management Plan including commencing mining in the south west, avoiding habitats during the breeding season and monitoring birds for the life of mining to inform management decisions.	Very low
Discharge of treated mine water	Effects on water quality in downstream receiving environment.	Low - Moderate	Moderate	Moderate	Construction of proposed water treatment ponds that will treat water generated from the site to required standards prior to discharge. This includes hardness adjustment and other treatment as required. Implementation of water management plan for the site will reduce magnitude of effects to low	Low-very low
Post-mining contouring and rehabilitation	Elevating existing drains above ground water table could reduce nitrate losses and improve water quality	Low - High	Positive	Positive	None	Positive

11.0 Planning Matters

11.1 Proposed Te Tai o Poutini Plan

11.1.1 Rule ECO-R5

With respect to Rule ECO-R5 in the Proposed Te Tai o Poutini Plan, the only indigenous vegetation to be cleared comprises approximately 167 m^2 of planted flaxland. It is not within:

- A Significant Natural Area identified in Schedule Four.
- An area of land environment of category one or two of the Threatened Environment Classification.
- An Outstanding Natural Landscape identified in Schedule Five.
- An Outstanding Natural Feature identified in Schedule Six.
- An area of High Coastal Natural Character identified in Schedule Seven.
- An area of Outstanding Coastal Natural Character identified in Schedule Eight.

Discretion is restricted to:

i) Whether there are other regulations impacting the site that have meant the land is unable to be used for economic rural uses.

ii) Constraints imposed by functional or operational need of network utilities and critical infrastructure.

iii) Effects on habitats of any threatened or protected species.

iv) Effects on the threat status of land environments in category one or two of the Threatened Environments Classification.

v) Effects on ecological functioning and the life supporting capacity of air, water, soil and ecosystems.

vi) Effects on the intrinsic values of ecosystem.

vii) Effects on recreational values of public land.

viii) The matters outlined in Policies ECO - P6 and ECO - P7.

Matters iii – vi and viii are ecological matters. In relation to matter iii, the vegetation does not provide habitat for any threatened or protected species. With respect to matter iv, the area is located within the level four land environment O1.4a. This land environment is not within Category 1 or Category 2 of the Threatened Environment Classification since more than 30% of it remains in indigenous vegetation. With regard to matters v and vi, the area is located immediately next to a livestock feed pad (presumably as shelter) and has not ecological connectivity or intrinsic value. No effects on ecological functioning, the life supporting capacity or the intrinsic values of ecosystems are expected.

Since the vegetation is planted, covers a small area, comprises common species and would not trigger the criteria for ecological significance, ECO – P6 and ECO – P7 would not apply.

11.1.2 Rule NC- R3

Rule NC-R3 of the Te Tai o Poutini Plan provides for indigenous vegetation clearance and earthworks within riparian margins which do not meet the permitted activity status set out in Rule NC-R1 as a discretionary activity. Earthworks and vegetation clearance are required to reinstate the existing infiltration basin for use as an infiltration basin, parts of which may be within the riparian margin of Canoe Creek. Rule NC-R1 cannot be complied with because of the volume of earthworks required. The vegetation affected would not be considered significant vegetation.

Although ecological matters feed into an assessment of natural character, natural character is not an ecological matter.

11.1.3 Rule NC-R4

Rule NC-R4 of the Te Tai o Poutini Plan provides for buildings and structures within riparian margins which do not meet the permitted activity status set out in Rule NC-R2 as a discretionary activity. Because the infiltration basin is considered a structure, parts of which may be within the riparian margin of Canoe Creek, consent under Rule NC-R4 is required.

As stated above, although ecological matters feed into an assessment of natural character, natural character is not an ecological matter.

11.2 National Policy Statement for Freshwater Management

11.2.1 Effects Management Hierarchy

The National Policy Statement for Freshwater Management (2020) ('the NPS-FM') requires proposals that would affect wetlands, rivers and fish passage to be assessed against the "effects management hierarchy". That hierarchy is defined in NPS-FM clause 3.21(1) as:

"effects management hierarchy, in relation to natural inland wetlands and rivers, means an approach to managing the adverse effects of an activity on the extent or values of a wetland or river (including cumulative effects and loss of potential value) that requires that:

a) adverse effects are avoided where practicable; then
b) where adverse effects cannot be avoided, they are minimised where practicable; then
c) where adverse effects cannot be minimised, they are remedied where practicable; then
d) where more than minor residual adverse effects cannot be avoided, minimised, or remedied, aquatic offsetting is provided where possible; then
e) if aquatic offsetting of more than minor residual adverse effects is not possible, aquatic compensation is provided; then
f) if aquatic compensation is not appropriate, the activity itself is avoided".

The effects of this proposal on natural inland wetlands, rivers and fish passage are assessed below.

In summary, the proposal's locational requirements mean that the potential for adverse effects on wetlands and rivers cannot be avoided completely, however in general the ecological values within the site itself are low and the proposed management concept would maintain median groundwater levels at the boundary therefore maintain water levels in adjacent wetlands at or above the pre-mining median level. The natural variation in water level fluctuation would be reduced for the life of the mine, but given the nature of the plant communities present in the coastal lagoon and nearby, they are expected to be tolerant of this change and on that basis effects on wetlands and rivers are able to be avoided. Fish passage could be affected by the water take from Canoe Creek and by any reduction in flows in adjoining watercourses, or by the improper installation of the culvert across Collins Creek. The comprehensive monitoring of ground and surface water across the site proposed, combined with prioritisation of the mitigation hierarchy in formulating the management approach mean that adverse effects on rivers and fish passage are also able to be avoided via effective implementation of the Water Monitoring and Management Plan for the site.

With regard to minimisation, the project design including setback from sensitive areas, the water management plan, the avian management plan, the location, design and layout of the Processing Plant, the proposed planting, the hours of operation, trucking (including avoidance of the tāiko colony and reduced speed limits on site) and management of lighting are all intended to minimise effects. The use of riparian and coastal planting as part of the proposal will minimise effects on streams and more than replace the very limited indigenous vegetation present at the site currently. Therefore, the subsequent effects management hierarchy step of “remediation” is not required. Nonetheless, the creation of new wetland habitat (in the form of the former water treatment pond retained at the end of mine life) will result in an increase in the amount of wetland habitat at the site, and improve the connectivity and ecological function of the adjoining Significant Natural Area (PUN-034). These measures are expected to diminish (or, “minimise”) the adverse effects of the proposal to the greatest degree practicable and improve water and aquatic habitat quality in the longer term (or “remediate”) above the status quo and address the expected effects of the proposal.

No more than minor residual effects on wetlands and streams are anticipated to endure after the recommended minimisation measures are employed and positive effects are expected to accrue as the proposed riparian and reservoir edge plantings develop. As such, no further steps in the effects management hierarchy, such as aquatic offsetting or aquatic compensation are considered necessary.

11.2.2 NPSFM Clause 3.22 Natural inland wetlands

The definition of natural inland wetlands excludes wetlands in the coastal marine environment. Nonetheless, the lagoon areas adjoining the site would be protected by Clause 11(a) of the New Zealand Coastal Policy Statement (2010) (discussed in more detail below). We have assumed that there are natural inland wetlands adjoining the site that we have not had access to. Relevant considerations are:

- The effects of the proposal on ground and surface water levels and quality during mining are proposed to be minimised by the implementation of the water management concept for the site and riparian planting.
- The proposal will result in the gain of approximately 1 ha of wetland and associated flaxland and rushland vegetation. This is expected to result in a net gain in the extent of wetland habitats at the site in the long term, thereby reducing the proposal’s adverse effects on the species using wetland habitats adjoining the site in the medium to longer term as more habitat becomes available.

The proposal is not expected to reduce either the extent of wetlands or the ecological value of wetlands adjoining the site in either the short or longer term.

11.2.3 NPSFM Clause 3.24 Rivers

Clause 3.24(3) (Rivers) of the NPS-FM seeks to avoid the loss of river extent and values unless inter alia the effects of the proposal are managed by application of the effects management hierarchy.

The proposal's effects on the extent and values of rivers is assessed against the effects management hierarchy as follows:

- Avoidance – The proposed construction avoids directly affecting Collins Creek, Canoe Creek and the Northern Drain.
- Minimisation – Minimisation of effects has been applied by avoiding crossing Collins Creek and implementing the comprehensive water monitoring required to inform water management according to the mitigation hierarchy.
- Remediation of effects has been applied in the form of the proposed riparian planting along Collins Creek and the southern side of the Northern Drain.

With respect to remediation and mitigation, proven methods are available to improve aquatic habitats within the downstream watercourses, including riparian planting, and these are also expected to improve terrestrial ecological values. No more than minor residual adverse effects are anticipated to endure after the recommended minimisation measures are employed and positive effects are expected to accrue as the proposed riparian and new wetland edge plantings develop. As such, no further steps in the effects management hierarchy, such as aquatic offsetting or aquatic compensation are considered necessary.

11.2.4 NPSFM Clause 3.26 Fish passage

Clause 3.26 (Fish passage) of the NPS-FM seek that "The passage of fish is maintained, or is improved, by instream structures, except where it is desirable to prevent the passage of some fish species in order to protect desired fish species, their life stages, or their habitats".

Collins Creek in particular provides good habitat for native fish and the ecological value of that stream is considered to be high. The potential for reductions in flows in lower Collins Creek whilst the mining is located nearby is addressed via the water management proposed for the site and augmentation of surface flows using treated water is proposed in the first instance (provided the water quality is suitable). If the water quality is not suitable, other options, including shallow groundwater recharge using infiltration trenches and/or diverting from Canoe Creek, provide redundancy in the water management approach such that effects on fish passage can be avoided.

Provided that the culvert across Collins Creek and the water take from Canoe Creek are appropriately designed and installed in accordance with permitted activity rules and regulations, reductions in fish passage due to these elements of the proposal can also be avoided.

11.3 New Zealand Coastal Policy Statement

Policy 11 of the New Zealand Coastal Policy Statement (2010) ('the NZCPS') relates to indigenous biological diversity (biodiversity). Policy 11(a) is to avoid adverse effects on indigenous taxa that are listed as threatened or 'At Risk' in the New Zealand Threat Classification System lists and/or taxa that are listed by the International Union for Conservation of Nature and Natural Resources as threatened. Westland petrel qualify under both categories. Policy 11(a) also relates to indigenous ecosystems and vegetation types including indigenous ecosystems and vegetation types that are threatened in the coastal environment, or are naturally rare (Policy 11(a)iii) and areas set aside for full or partial protection of indigenous biological diversity under other legislation (Policy 11(a)vi). These categories do not apply to the area of the proposed mine, but do apply to the wetland habitats outside the mine which might be affected by groundwater effects, including Maher Swamp.

In relation to the tāiko, a number of management actions are proposed to avoid adverse effects on the tāiko population including limiting the hours of mine operation for the part of the year when tāiko are most likely to be grounded, avoiding truck movements north during the hours of darkness, limiting the speed on vehicles on the site, reducing the visibility of the Processing Plant via bunding and planting, avoiding windows and external lighting on the Processing Plant, management of other lighting at the site to avoid light pollution and management and reporting of any grounded birds. The monitoring proposed as part of the draft avian management plan would detect grounded birds at the site and specifies that if a mortality is discovered, the company will take action to avoid further effects (i.e. shut down the Processing Plant until the likely cause has been identified and removed or mitigated).

Policy 11(b) the NZCPS is to avoid significant adverse effects and avoid, remedy or mitigate other adverse effects of activities on habitats in the coastal environment that are important during the vulnerable life stages of indigenous species and indigenous ecosystems and habitats that are only found in the coastal environment and are particularly vulnerable to modification including lagoons and coastal wetlands such as those found at the site. The effects on those habitats would principally be either those brought about by changes to hydrology, which would be managed in accordance with the mitigation hierarchy so as to avoid effects where possible, or due to increased disturbance and human activity when mining is located near the coastal lagoon. Seasonal monitoring undertaken thus far has failed to detect birds which are likely to be significantly affected by these activities (i.e. those which are restricted to the wetland/flaxland/coastal lagoon habitats or use them for breeding). It is proposed to continue this monitoring throughout mining in order to confirm no new birds take up residence in those areas and to inform avian management as mining proceeds. Physical separation and the use of planting as a screen is proposed. Mining would also be avoided from the panels closest to the lagoon during the peak breeding season for the species confirmed as present.

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