Waikanae River Catchment & Estuary: Biodiversity Information Review, Summary of Pressures, and Recommendations

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Prepared for Department of Conservation

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1 INTRODUCTION

The Waikanae River is part of the Department of Conservation (DOC) Ngā Awa River Restoration Programme, whose purpose is to take a 'mountains to sea' approach to restoring the values of 14 whole river catchments. This report has been commissioned by DOC as a contribution to that programme.

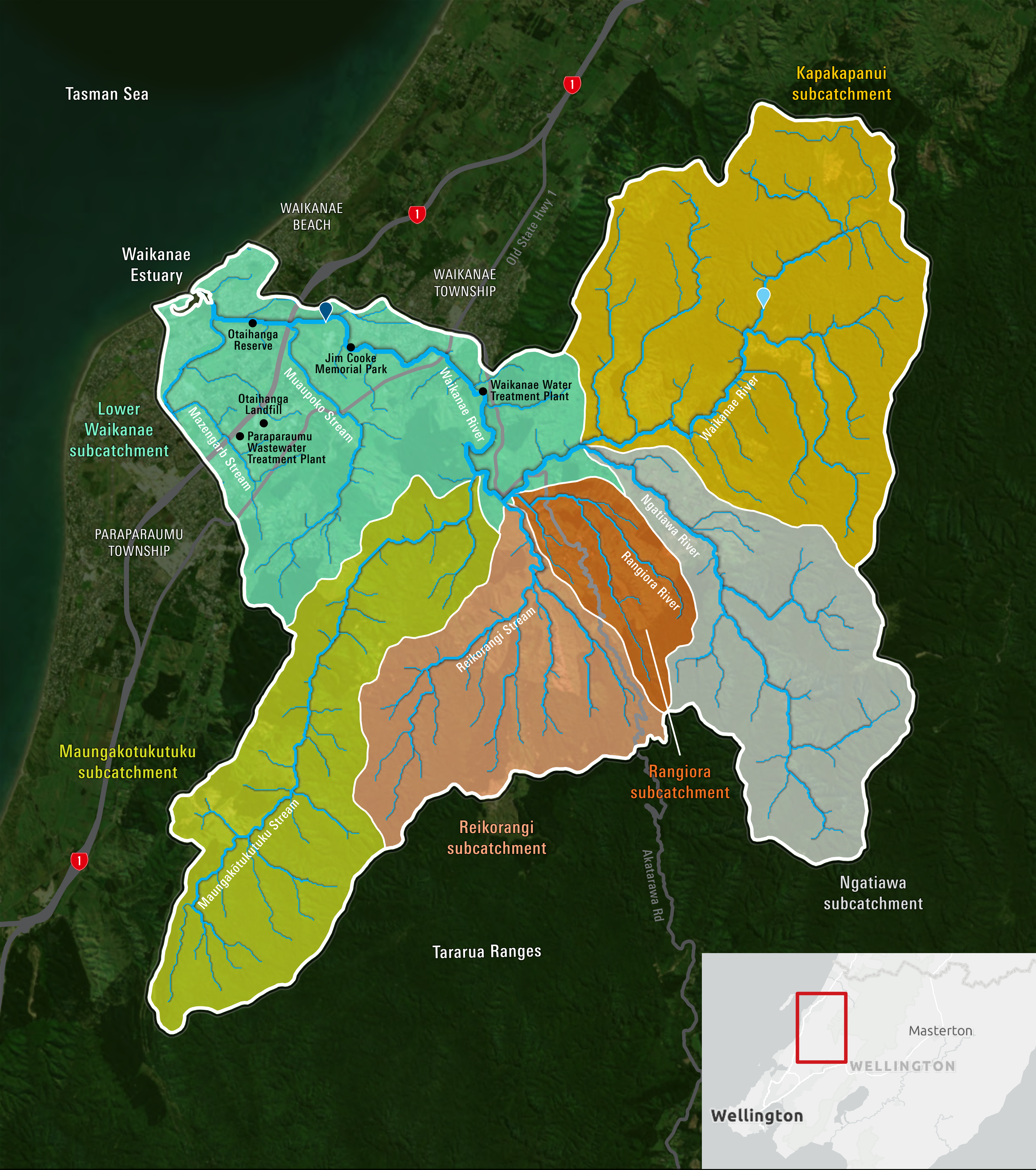
To implement Ngā Awa's purpose for Waikanae, DOC entered a Treaty House partnership in 2019 with mana whenua, Ātiawa ki Whakarongotai (ĀKW), Kapiti Coast District Council (KCDC), and Greater Wellington Regional Council (GWRC), who together have established the Waikanae ki Uta ki Tai (WKUKT) project. The partnership and project share a commitment to helping implement ĀKW's Kaitiakitanga Plan (TĀKW Kaitiakitanga Plan V6; teatiawakikapiti.co.nz; ĀKW, 2019). WKUKT's vision is of "Waiora - this community working together, under a treaty house partnership, to enhance the lifeforce, vitality and special nature of the whole of the Waikanae Awa". WKUKT is built on six foundational kaupapa or values: whakapapa, mana, mauri, wairua, māramatanga, and te ao turoa (ĀKW, 2021). See more at www.waikanaeawa.org.nz

Recently, the WKUKT partners established the Waikanae Jobs for Nature project, focussed on animal and plant pest management, sustainable land management, riparian management, and training/development in the catchment. The Waikanae community has also had a long history of work in the catchment, with groups such as the Waikanae Estuary Care Group and the Friends of the Waikanae River contributing to restoration and enhancement projects over many years.

Within this context, the purpose of this report is to provide a comprehensive review of aquatic biodiversity information that is available for the Waikanae River catchment and estuary. The goal of the report is to identify and summarise the biodiversity values of the catchment and estuary and describe the main pressures impacting on both biodiversity and river use. To achieve this, existing scientific information and monitoring data will be gathered and summarised. It is anticipated that by gathering the available information, gaps and overlaps may become apparent, and these will enable recommendations to be made for further data gathering in the catchment and estuary. It is understood that there is significant customary knowledge of the aquatic biodiversity of the Waikanae catchment, but the inclusion of this information is largely outside the scope of this review, except where this information is included in the published or grey literature sourced for this review.

The Waikanae River catchment covers an area of around 14,900 ha and includes the Waikanae township, Waikanae Beach, Waikanae Estuary Scientific Reserve, as well as the Waikanae River (Figure 1). The catchment is in the Greater Wellington Region, in the lower North Island of New Zealand. The mainstem of the river flows for around 25 km, from its headwaters on the steep southwestern slopes of the Tararua Ranges, through the coastal plains to the estuary at Waikanae Beach. The catchment includes several major tributaries, such as the Maungakōtukutuku Stream, Reikorangi Stream, Rangiora River, and Ngatiawa River, as well as small waterways like Kapakapanui Stream in the headwaters, and Mazengarb Stream in the lower reaches. The estuary is a tidal river mouth which faces moderate to high human usage, has moderate habitat diversity, and provides reasonable habitat for native fish and tidal flat organisms (Robertson & Stevens, 2007). A rain gauge at the Waikanae Water Treatment Plant (Waikanae WTP) shows that the average annual rainfall at that location is 1231 mm (1991–2016; Harkness, 2017), which is within the typical range for New Zealand, although higher annual rainfalls are observed for the upper catchment within the Tararua Ranges (e.g., average annual rainfall of 2319 mm for Akatarawa River at Warwicks rainfall site).

Figure 1 *…figure over page…* Waikanae River catchment map, including major subcatchments and the locations of Greater Wellington Regional Council (GWRC) long term water quality monitoring sites.



Waikanae River Catchment: Subcatchments

GWRC WATER QUALITY MONITORING SITES

- Waikanae River at Mangaone Walkway
- Waikanae River at Greenaway Road

- Catchment
- Subcatchments
- Waterways

0 0.5 1 2 Kilometers

N

Layer source: waterways: REC; catchments & sites: Greater Wellington Regional Council.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

2 KEY PRESSURES ON BIOLOGICAL VALUES IN THE CATCHMENT & ESTUARY

2.1 Land Use & Land Cover

The landscape and vegetation of the Waikanae catchment has changed substantially with human settlement. While much of the steeper headwaters of the catchment within the Tararua Forest Park retain either old-growth forest or regenerating indigenous forest or shrubland (59%), large areas of the catchment have been developed for farming (21%) and exotic forestry (15%; Figure 2). Between the foothills of the Tararua Ranges and the coast lies an extensive coastal sand dune system, and it is in this area that farming, and urbanisation have transformed the land cover of the Waikanae catchment. While the influence of the urban parts of the catchment may be substantial, the urban area covers an area of only around 4% of the catchment. Prior to European settlement, the Waikanae floodplain included swamp forest, wetlands, open water and raupō swamp (GWRC, 2014), but this began to change from the 1880s, as land was cleared and drained to facilitate settlement and farming.

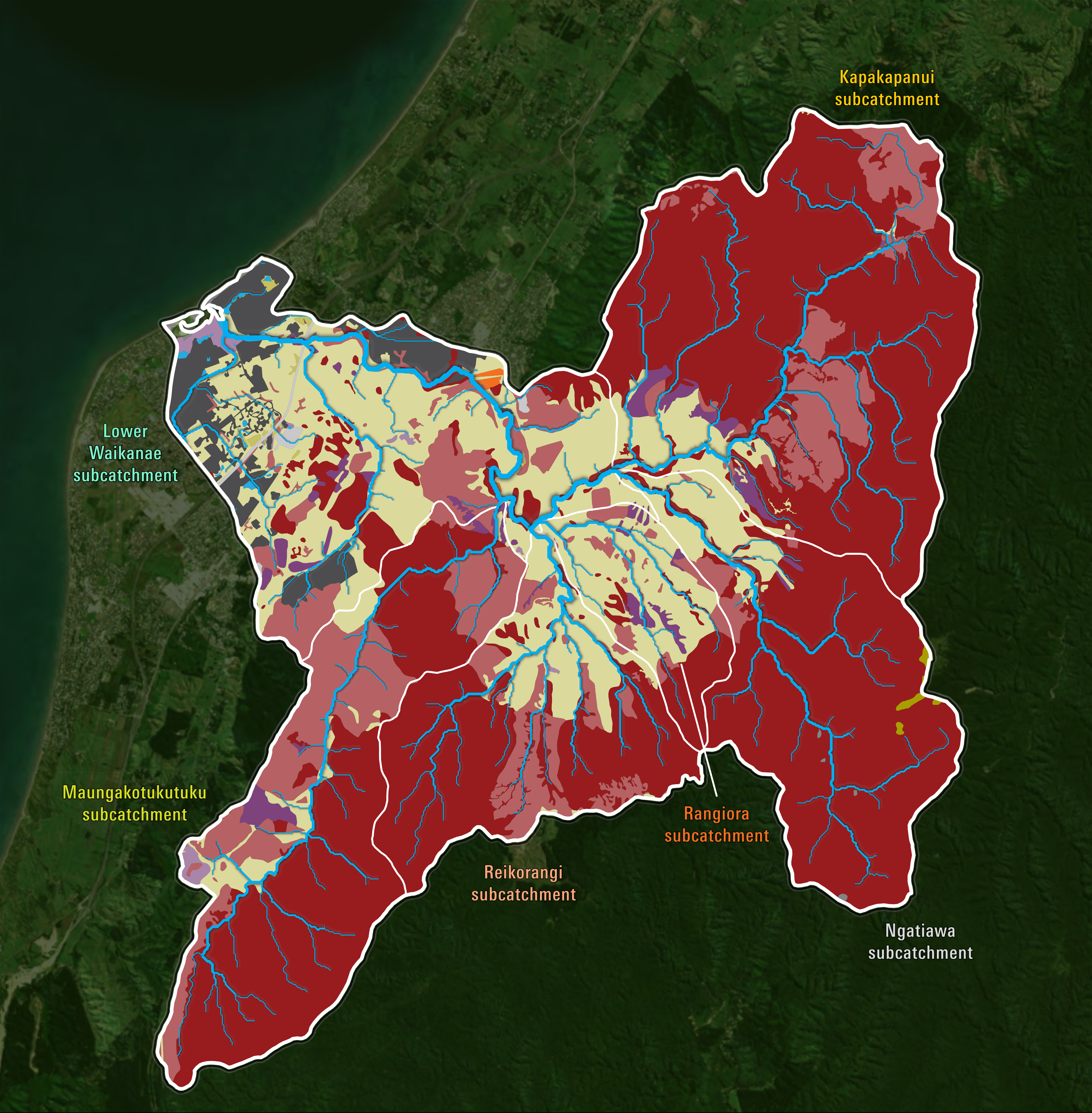
Along with urbanisation, comes the need to dispose of stormwater and wastewater, as well as to manage river flood plains to protect residents from flood hazard. The Waikanae River Floodplain Management Plan sets out the methods that GWRC use to reduce the flood hazard to the community from the Waikanae River (WRC, 1997). These methods include controlling land use in flood prone areas, structural measures like stop banks and road raising, and river management methods such as erosion protection, gravel extraction, and channel realignment (WRC, 1997). GWRC undertake many of these river management and maintenance activities in the Waikanae River between the Waikanae Water Treatment Plant (Waikanae WTP) and the river mouth (Tonkin & Taylor Ltd, 2016). Instream works within this reach include gravel extraction, bed recontouring, channel realignment, and the construction of rock groynes, as well as the planting of willows and vegetative buffer zones on the banks (Cameron, 2016).

Wastewater from the communities of Waikanae, Paraparaumu, and Raumati is treated to a high standard at the Paraparaumu Wastewater Treatment Plant (WWTP) before being discharged to the Mazengarb Stream, which is a tributary of the lower Waikanae River (Figure 1). Wastewater treatment includes a process of biological nutrient removal (KCDC, 2022a). During storm conditions, consented overflows to the Mazengarb Stream may also occur, which means that untreated wastewater occasionally enters the waterway.

Another characteristic of urban areas is the presence of hazardous or contaminated sites. The Selected Land Use Register (SLUR) for the Wellington Region lists sites where hazardous activities or industries are located and where there is potential for land to be contaminated, either because of current or historical activities. SLUR listed sites within the Waikanae catchment include the WWTP, several landfills, a concrete manufacturing site, fuel storage and vehicle refuelling facilities, and the chemical storage area for the treatment of drinking water at the Waikanae WTP (GWRC, 2022).

The impact of urban development is especially evident near the Waikanae Estuary. Historical aerial photographs illustrate the progressive encroachment of housing at the edges of the estuary between the 1940s and 1990s (Figure 3). With this urban encroachment has come the need for a more stable river outlet and a more highly managed estuary environment (Todd *et al.*, 2016). The lower part of the Waikanae Estuary has historically been disturbed by artificial opening of the channel to the sea, whereas the middle and upper estuary have provided areas of stable estuarine habitat, including saltmarsh and tidal flats (Robertson & Stevens, 2007). There are also floodgates that create an artificial lake known as Waimanu Lagoon.

Figure 2 *...figure over page...* Map of land use and land cover for the Waikanae River catchment and subcatchments.



Waikanae River Catchment: Land Use & Cover

LAND USE & COVER

- Artificial bare
- Natural bare/ lightly-vegetated
- Urban area
- Cropping/horticulture
- Exotic forest
- Indigenous forest
- Exotic grassland
- Other herbaceous vegetation
- Tussock grassland
- Exotic scrub/shrubland
- Indigenous scrub/shrubland
- Water bodies

- Catchment
- Subcatchments
- Waterways

0 0.5 1 2 Kilometers

N

Layer source: waterways: REC; catchments: Greater Wellington Regional Council; land cover: Landcare Research.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Figure 3 **Aerial photos illustrating the changes to Waikanae Estuary and the encroachment of urban development between 1942 and 1991.** Images from https://retrolens.co.nz

2.2 Sediment

There is evidence that gravels are building up in the lower reaches of the Waikanae River. Local knowledge suggests that the lower reaches of the river, which formerly provided ample depth for yachts has not been possible to navigate for at least a decade (Stuff, 2022), and surveys of the lower river support this view. As part of the Waikanae Floodplain Management Plan (WRC, 1997), full cross-sectional surveys are undertaken of the Waikanae River every five years or following each 20-year flood event (WRC, 2005). These surveys have shown that both aggradation and degradation of the riverbed occurs for different reaches over time, whilst bank erosion is also evident in some places (WRC, 2005). However, the general trend is for river aggradation between the river mouth and Jim Cooke Memorial Park, with minor degradation upstream of this (Tunnicliffe & Brierley, 2021). The river substrate in the reaches that include the Waikanae WTP and Jim Cooke Memorial Park is dominated by gravel and fine gravel (Figure 4), although there is an increase in the proportion of finer material (sand and mud) further downstream (Watts, 2003).

To counteract river aggradation, gravel extraction is undertaken in the lower reaches of the Waikanae River. Gravel extraction has been undertaken in the Waikanae River since the 1950s, with annual extraction rates generally decreasing over time, from an average of 10,000 m^3/year between 1957–1987, to less than 500 m^3/year for the 2010–2014 period (Tonkin & Taylor Ltd, 2018). The intention of current gravel extraction activities in the Waikanae River are to maintain the riverbed levels and flood capacity at the 1991 surveyed reference levels. The volumes of gravel extraction required to achieve this are an ongoing 6,000 m^3/year, following a one-off extraction of around 43,700 m^3 that has accumulated, to return bed levels to 1991 survey levels (Tonkin & Taylor Ltd, 2018).

Gravel does not form a significant component of the beaches adjacent to the Waikanae River mouth (Figure 4). This is because the Waikanae River does not have sufficient hydraulic gradient to move gravel all the way from the ranges to the river mouth (Tonkin & Taylor Ltd, 2018). It is likely that sea level rise will result in a further reduction of the energy gradient in the lower reaches of the river and estuary, reducing the sediment output to the coast (Tonkin & Taylor Ltd, 2018).

Figure 4 The Waikanae River has a predominantly gravel bed in the vicinity of Otaihanga Reserve (left), in contrast to the sand and mud substrate of the estuary and adjacent beach (right). Photos taken by EOS Ecology, May 2022.

The downstream transport of sediment in rivers is a natural process. However, changes to land use and land cover within river catchments can accelerate the rate of erosion and increase the quantity of sediment transported downstream. Although the Waikanae catchment still supports large areas of indigenous forest, there are also substantial areas of exotic forestry and farmland (Figure 5). These land uses have a higher potential to contribute fine sediment to the river, particularly during the harvesting phase of forestry operations. Further down the catchment, urban areas and their associated stormwater discharges also have high potential to contribute fine sediment and contaminants to the river.

Ongoing monitoring work at the Waikanae Estuary has identified a need to manage the nutrient and fine sediment sources entering the estuary from the catchment. It is well known that estuaries act as a sink for fine sediments that drain from developed catchments, and the Waikanae Estuary is an example of this, with soil and fine sediments originating from rural and urban land use areas accumulating in low energy areas within the estuary. Sedimentation rates have showed an increasing trend in the upper estuary since 2010, with an average sedimentation rate of 16.6 mm/year across ten years of monitoring, and a rolling mean of 7.7 mm/year for the past five years of monitoring (Stevens, 2020). The results of this ongoing sediment monitoring indicate that the upper estuary is at high risk of sediment related impacts, and that the rate of sedimentation is well above the natural state for this estuary (estimated at ~9 mm/year; Stevens, 2020). The mud content of the Waikanae Estuary sediments is also elevated, with the mud content of samples being greater than 25% for at least one survey at each of the three sampling sites during annual sampling since 2018, leading to a 'poor' condition rating for this characteristic (Roberts, 2021).

Broad scale habitat mapping of the Waikanae Estuary has been completed using a combination of field identification and analysis of aerial photography (Stevens & Robertson, 2015). This survey highlighted the risks facing the Waikanae Estuary, with the loss of seagrass, saltmarsh, and terrestrial margin habitat placing it at high risk, while the percentage of soft mud substrate and increases in sediment deposition rate suggest that the upper estuary is infilling rapidly. It is likely that this will have implications for habitat and biodiversity in the future and based on this information, the authors recommended more work to identify and manage the sources of fine sediment in the Waikanae catchment.

Figure 5 In the absence of vegetation cover, land is more vulnerable to erosion. Photo taken from Jim Cooke Memorial Park looking towards the Tararua Ranges with areas of exotic forestry, farmland, recently harvested exotic forest, and indigenous forest visible. Photo taken by EOS Ecology, May 2022.

2.3 Water Quantity & Water Takes

The Waikanae Water Treatment Plant (Waikanae WTP) is the only consented surface water abstraction in the Waikanae River catchment. Other smaller water takes in the catchment fall within the permitted activity rules of the Regional Freshwater Plan (Beca Ltd, 2012). The Waikanae WTP is located between the confluence of the Maungakōtukutuku Stream and the old State Highway 1 (Figure 1), utilising water from the steep slopes of the upper Waikanae catchment within the Tararua Ranges. Downstream of the Waikanae WTP weir, the river gradient decreases and the river meanders across an alluvial floodplain to the Waikanae estuary. The mean annual low flow (MALF) of the Waikanae River is 950 L/s at the Waikanae WTP, with a mean flow of 4,600 L/s and a median flow of 3,020 L/s (Watts, 2003). With a growing community and potential for increased water demand, the KCDC has further plans to secure water supply into the future, including a dam in the lower Maungakōtukutuku Stream valley which would store and release water to the catchment as required (KCDC, 2022b). Although preliminary investigations have been undertaken for such a dam, the Council anticipates that this will not be needed within the next 50 years.

The Waikanae WTP is operated by KCDC and provides water to Waikanae, Paraparaumu, and Raumati (KCDC, 2022b). The KCDC have a suite of resource consents to operate this water supply (WGN130103 [35973, 35974, & 35975]), including consents that authorise a surface water take from the Waikanae River, groundwater takes from the Waikanae borefield, and for recharge of the river with groundwater from the borefield. With these consents, the KCDC can take and use up to 30,700 m^3/day of water from the Waikanae River at the Waikanae WTP, at a maximum pumping rate of 463 L/s when the river is flowing at greater than 1,400 L/s, and 355 L/s when the river is flowing at less than 1,400 L/s. However, they must ensure that a minimum flow of 750 litres/second is maintained in the Waikanae River downstream of the Waikanae WTP unless the river naturally falls below this level. To ensure that this minimum flow is maintained, whilst still providing the community with water supply from the river, the KCDC operate a borefield, which provides groundwater from bores of 70–90 metre depth to recharge the river downstream of the treatment plant (KCDC, 2022b). Based on the projected population of the year 2060, it is anticipated that river recharge will be needed to maintain minimum flows for an average of 21 days per year, with these days typically falling during summer low flow conditions, rather than throughout the year (Beca Ltd, 2012). Since the groundwater recharge water has different physico-chemical characteristics to the river water, the environmental effects of this river recharge could not be accurately predicted prior to the activity commencing. As a result, the consent operates with an ongoing mitigation plan, which details the ecological and water quality monitoring that is used to monitor the actual effects of river recharge using groundwater from the borefield (Boffa Miskell Ltd, 2017). This plan provides a mechanism for addressing any potentially adverse effects that may develop for the surface water environment because of the groundwater recharge.

In terms of the potential effects of the river recharge, an increase in dissolved reactive phosphorus (DRP) in the river is likely because of higher concentrations of DRP in the groundwater, and this could lead to increases in periphyton/algal biomass downstream of the Waikanae WTP (Beca Ltd, 2012). A periphyton monitoring programme has been implemented to address this concern (Boffa Miskell Ltd, 2014). However, investigations in experimental channels showed that groundwater discharges had no significant effect on invertebrate community composition, with only subtle changes in the abundance of some taxa (Beca Ltd, 2012). There is also some uncertainty around whether the change to the chemical signature of the water could discourage migratory species from entering the river, and fish surveys have been initiated to monitor for this (Beca Ltd, 2012; Boffa Miskell Ltd, 2014).

2.4 Water Quality

Water quality in the Waikanae River is within the top 25 to 50% of water quality monitoring sites in New Zealand (LAWA, 2022), with nitrogen concentrations and water clarity typically falling within the highest attribute band (A Band) of the National Policy Statement for Freshwater Management 2020 (NPS-FM 2020), indicating that the observed concentrations should not be having an impact on species (Table 1). Two locations are sampled monthly for general water quality in the Waikanae River (Mangaone Walkway and Greenaway Road; Figure 1), while recreational water quality is assessed at Jim Cooke Park and State Highway 1, with the current swim status at these sites being displayed online (www.lawa.org.nz/explore-data/swimming/). Results from the monthly water quality monitoring sites show that while nitrate and *E. coli* concentrations tend to increase downstream in this catchment, values for DRP are higher for the upstream site at Mangaone Walkway (Table 1). Catchment geology is thought to be responsible for the naturally elevated concentrations of DRP at this monitoring site, since it is within an area dominated by indigenous forest cover (Perrie *et al.*, 2012).

Periphyton monitoring by GWRC shows that for Waikanae River at Greenaway Road, periphyton biomass also falls within the A band of the NPS-FM 2020, with chlorophyll *a* measuring at less than 50 mg/m^3 for this site (GWRC, 2021). Previous reports have also indicated that Waikanae River at Greenaway Road is 'excellent' quality in terms of periphyton cover and chlorophyll *a* concentration (Perrie *et al.*, 2012). Toxic cyanobacteria are known to be present in the Waikanae River and the Waikanae River was one of the locations linked with the first reports of freshwater cyanobacteria toxicity within New Zealand, where the deaths of several dogs were linked to the eating of benthic cyanobacterial mats (Hamill, 2001). Toxic cyanobacteria can be present in the river at any time but are often most abundant during hot dry weather. Even so, periphyton weighted composite cover and cyanobacteria cover are typically measured at between 0–20% for the monitoring site on the Waikanae River at Greenaway Road (GWRC, 2021).

Annual monitoring of macroalgae within the Waikanae Estuary is one part of a GWRC long term estuary monitoring programme (Stevens & Robertson, 2010). This map-based monitoring has found that most of the intertidal area has no macroalgae growth, and where macroalgal growth is found along the lower true left bank of the estuary, it consists of sparse growths of *Enteromorpha* on the boulders and nothing that would be considered nuisance levels of growth. There are typically accumulations of *Enteromorpha* near the flap gate at the outlet of Waimeha Lagoon. However, these were found to be nuisance levels during February 2012, when rotting macroalgae was causing anoxic sediment conditions and odours (Stevens & Robertson, 2012). Overall, the results of this annual monitoring indicate a decline in estuary quality since monitoring began in 2010 (Stevens & Robertson, 2013; 2014).

Table 1 Summary of water quality monitoring data for two sites on the Waikanae River, as recorded in the Land Air Water Aotearoa (LAWA) database (LAWA, 2022). These summary statistics represent 15 years of data for Greenaway Road (2006 to 2020) and 11 years of data for Mangaone Walkway (2006 to 2016). Refer to Figure 1 for the location of these water quality monitoring sites.

Location	Water Quality Measure	Units	NPS-FM 2020 Attribute Band (where applicable)	Median	Range
Waikanae River at Mangaone Walkway	Clarity	m	A	3.3	0.2–6.2
	pH	pH units		7.4	5.9–8.2
	E. coli	cfu/100 mL	Good	12	0.5–1,200
	Dissolved Inorganic Nitrogen (DIN)	mg/L		0.12	0.03–0.30
	Ammoniacal Nitrogen (NH4-N)	mg/L	A	0.005	0.003–0.060
	Nitrate Nitrogen (NO3-N)	mg/L	A	0.12	0.03–0.28
	Dissolved Reactive Phosphorus (DRP)	mg/L	C	0.013	0.006–0.020
Waikanae River at Greenaway Road	Clarity	m	A	3.5	0.1–9.9
	pH	pH units		7.3	6.2–9.2
	E. coli	cfu/100 mL	Fair	27	1–15,000
	Dissolved Inorganic Nitrogen (DIN)	mg/L		0.23	0.03–0.86
	Ammoniacal Nitrogen (NH4-N)	mg/L	A	0.005	0.003–0.100
	Nitrate Nitrogen (NO3-N)	mg/L	A	0.22	0.02–0.86
	Dissolved Reactive Phosphorus (DRP)	mg/L	B	0.008	0.002–0.043

Water quality generally declines downstream for the Waikanae River. The Mazengarb Stream is a major contributor to the decline in water quality in the lower reaches of the river as this tributary is influenced by urban and rural runoff, as well as discharge from the Paraparaumu Wastewater Treatment Plant (WWTP) and Paraparaumu landfill (Warr, 2002). This tributary enters the Waikanae mainstem downstream of both water quality monitoring sites described in Table 1. It is known to have high concentrations of nitrate and DRP, as well as faecal coliforms that exceed recreational guidelines. It often also fails to meet dissolved oxygen, turbidity, biochemical oxygen demand, and ammonia guidelines (Warr, 2002). While Mazengarb Stream is still a source of contaminants to the Waikanae River and estuary, a major upgrade of the WWTP during 2002 has reduced the impact of the WWPT on the water quality of the Waikanae River, with additional nutrient removal and disinfection of the wastewater included in the treatment process to improve the quality of the discharge (Cameron, 2016).

2.5 Fish Passage

Many of New Zealand's native fish species are migratory, meaning that they need to move both upstream and downstream within catchments to complete their life cycle. Most of the native fish species found in the Waikanae catchment are migratory, including longfin and shortfin eel, several kōkopu and bully species, and torrentfish. For these species, unimpeded passage upstream and downstream is crucial to their distribution in the catchment. Barriers to fish passage are known to limit fish migration, especially for species that have poorer swimming or climbing ability. The Fish Passage Assessment Tool (FPAT; NIWA, 2022), provides an online tool for recording the nature of instream structures and the likely impact of these structures on fish passage. The FPAT holds records for 154 structures in the Waikanae River catchment (as of May 2022), with the majority of these being culverts and bridges (Table 2). Aside from a natural waterfall barrier within the Muaupoko Stream, it is culverts and flap gates that pose the greatest risk to fish passage within the Waikanae catchment, with 15 culverts rated as having a high or very high risk to fish passage (Table 2). These higher risk culvert structures are distributed throughout much of the Waikanae catchment, including the Kapakapanui, Ngatiawa, lower Waikanae, and Rangiora subcatchments (Figure 6). There are also several weirs in the mainstem of the Waikanae River. The Waikanae WTP weir spans the 60-metre width of the river downstream of the water supply intake and has a height of 1 metre (NIWA, 2022). The FPAT records this structure as having a medium risk to fish passage, as it is fitted with some fish passage improvements, including a rock ramp and fish pass (NIWA, 2022). A stepped weir near the old State Highway 1 bridge also spans the width of the river at that location, being around 24 metres across and 0.9 metres height (NIWA, 2022). This weir has been assessed as posing a medium risk to fish passage and has weir baffles installed as a fish passage improvement (NIWA, 2022).

Table 2 Summary of fish passage assessments for the Waikanae catchment, as recorded in the Fish Passage Assessment Tool as of May 2022 (NIWA, 2022).

Structure type	Number of fish passage assessment tool records	Risk to fish passage	Subcatchments with high or very high-risk fish barriers present
Bridge	58	Very low risk = 28 Low risk = 30	None
Culvert	79	Very low risk = 2 Low risk = 31 Medium risk = 25 High risk = 7 Very high risk = 8 Not assessed = 5	Kapakapanui, Ngatiawa, Lower Waikanae, Rangiora
Flap gate	7	Medium risk = 1 High risk = 1 Very high risk = 4	Lower Waikanae
Weir	6	Medium risk = 2 Not assessed = 4	None
Ford	4	Very low risk = 1 Low risk = 3	None
Natural (waterfall)	1	High risk = 1	Lower Waikanae
Other (concrete waterfall)	1	Very high risk = 1	Lower Waikanae

Figure 6 *…figure over page…* Location of fish barriers within the Waikanae River catchment that are recorded as high or very high risk on the New Zealand Fish Passage Assessment Tool (FPAT) as of May 2022.

Waikanae River Catchment: Fish Passage Barriers

FISH PASSAGE BARRIER

- Natural
- Culvert
- Flap gate with culvert
- Other

RISK LEVEL

- Very high
- High

0 280 560 1,120 Meters

N

Layer source: waterways: REC; catchments: Greater Wellington Regional Council; fish passage barriers: NIWA's Fish Passage Assessment Tool.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

2.6 Climate Change

Climate change predictions for the Kāpiti Coast include increases in average annual air temperature, total rainfall, and the amount of rain that falls during extreme events (KCDC, 2022c). The area is also expected to see more drought conditions, stronger winds, and rising sea levels. These changes are expected to increase flood risks and coastal erosion as well as having an impact on biodiversity and vulnerable habitats such as the estuary margins.

The vulnerability of New Zealand's freshwater taonga species has been assessed using a Climate Change Vulnerability Assessment (CCVA), which identifies which species are most vulnerable based on their exposure to predicted changes in the environment and their sensitivity to changes based on known characteristics of the species (Egan *et al.,* 2020). This assessment indicates that longfin eel and lamprey have very high vulnerability to climate change. Shortfin eel, banded kōkopu, īnanga, and kōaro have high vulnerability to climate change. Giant kōkopu and kōura have moderate vulnerability and yellow eye mullet have low vulnerability to climate change. The Waikanae River supports populations of both longfin eel and lamprey, the two species considered to be at the greatest vulnerability to climate change. The catchment also supports populations of those species with high vulnerability to climate change (shortfin eel, banded kōkopu, īnanga, and kōaro). The reasons for longfin eel having very high vulnerability include their complex lifecycle, long migrations, use of environmental triggers, and the multiple threats that the species already faces (Egan *et al.,* 2020). For lamprey, their very high vulnerability is linked to the low larval dispersal, habitat specificity, reproduction complexity, exposure to other pressures and their dependence on other species as part of their lifecycle. The vulnerability of īnanga to climate change is also linked to the complexity of their lifecycle, with their specific requirements for spawning grasses and appropriate water levels being key factors in their vulnerability.

3 AQUATIC BIODIVERSITY VALUES OF THE WAIKANAE CATCHMENT

3.1 New Zealand Freshwater Fish Database

The New Zealand Freshwater Fish Database (NZFFD) holds records of 133 unique fish surveys within the Waikanae catchment, covering the period from 1958 to 2021 (Figure 7). Of the subcatchments identified in Figure 1, the lower Waikanae has received by far the most fish survey attention, followed by the Kapakapanui subcatchment, which includes the Waikanae headwaters and tributaries (Table 3). In contrast, all other subcatchments have been surveyed on less than ten occasions, with the Rangiora River subcatchment having no fish surveys recorded in the NZFFD. As expected, most of the survey effort has been focused on easily accessible reaches of the catchment, which are typically within more highly modified land use areas, while there is little information on the fish community within indigenous forest areas (Figure 2; Figure 7).

The NZFFD records the presence of 22 freshwater fish species and two invertebrate species within the Waikanae River catchment (Table 4). Note that the NZFFD only record large invertebrate species that are typically caught or observed during fishing surveys, such as kōura, kākahi, and freshwater shrimp. Of the 22 species recorded as present, seven have a conservation status of “Not Threatened”, and a further four of these species are “Introduced and Naturalised”. The Waikanae catchment also supports two fish species that are “Threatened – Nationally Vulnerable”, eight species that are “At Risk – Declining”, and one species that is “At Risk – Naturally Uncommon” according to the conservation classifications of Dunn *et al.* (2018; Table 4).

Although the survey effort has not been evenly distributed across the Waikanae catchment, the surveys recorded in the NZFFD indicate that longfin eel, kōaro, redfin bully, and brown trout are the most widespread fish species in the Waikanae catchment, being found in all surveyed subcatchments (Table 5). Shortjaw kōkopu, torrentfish, and kōura are also reasonably widely distributed, being recorded as present in three of the six subcatchments (lower Waikanae, Maungakotukutuku, and Kapakapanui). In contrast, giant kōkopu, brown mudfish, īnanga, giant bully, yelloweye mullet, common smelt, black flounder, rainbow trout, brook char, goldfish, and freshwater shrimp were only found in the lower Waikanae subcatchment. Of these species, yelloweye mullet, common smelt, and black founder are known to be typical of lower river/estuary locations, while the habitat preferences of giant kōkopu, brown mudfish, and giant bully make the slower flowing reaches and wetland areas of the lower Waikanae more suitable for these species. However, the swimming ability of īnanga may limit the upstream movement of this species, especially as there are known fish barriers present in the catchment, including substantial weirs on the mainstem (see Section 2.5).

The only NZFFD records of pest fish (goldfish) within the catchment are from recent (2020–2021) fyke net surveys within Mazengarb Stream, a tributary that enters the Waikanae River from the true left near the estuary. The absence of pest fish records for the catchment may reflect a lack of targeted survey effort for the catchment, rather than the absence of these species. However, the lower Waikanae River and tributaries were included in a boat electrofishing survey during winter 2006, with the purpose of providing an overview of invasive fish populations in the river (Hicks *et al*., 2006). There were no pest fish species recorded for the lower Waikanae River, or the Ratanui Lagoon (Mazengarb Stream catchment) during this survey. The researchers did observe shortfin eel, bullies, common smelt, flounder, and yelloweye mullet, but the only introduced species recorded was brown trout. The results of this survey are included in the NZFFD and are therefore represented in Table 5.

Figure 7 *…figure over page…* Location of fish surveys within the Waikanae River catchment, 1958–2021, based on records in the New Zealand Freshwater Fish Database (NZFFD).

Waikanae River Catchment: Recorded Fish Survey Locations

NZFFD SURVEY YEAR

- 1900–1969
- 1970–1979
- 1980–1989
- 1990–1999
- 2000–2009
- 2010–2019
- 2020–2021

- Catchment
- Subcatchments
- Waterways

0 0.5 1 2 Kilometers

N

Layer source: fish data: NZFFD; waterways: REC; catchments: Greater Wellington Regional Council.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Table 3 Freshwater fish survey effort by subcatchment for the Waikanae catchment (1958–2021) as recorded in the New Zealand Freshwater Fish Database. Refer to Figure 7 for information on the location of records within each subcatchment.

Subcatchment	Number of Surveys	Oldest Record	Most Recent Record
Lower Waikanae	104	1958	2021
Maungakotukutuku	7	1962	2002
Reikorangi	2	1990	2002
Rangiora	0	NA	NA
Ngatiawa	3	1964	2002
Kapakapanui	17	1979	2018

Table 4 Freshwater fish and invertebrate species recorded within the Waikanae catchment (1958–2021) as per the New Zealand Freshwater Fish Database. The conservation status (according to Dunn *et al*., 2018 for fish and Grainger *et al.,* 2018 for invertebrates) is also given. Within this report, fish and invertebrates are referred to by the underlined names presented in this table. *Native fish species that are non-migratory.

Type	Common & Māori Names	Scientific Name	Family	Conservation Status (Dunn *et al*., 2018; Grainger *et al*., 2018)
Native fish	Shortfin eel, tuna	*Anguilla australis*	Anguillidae	Not Threatened
	Longfin eel, tuna	*Anguilla dieffenbachii*	Anguillidae	At Risk – Declining
	Kōaro	*Galaxias brevipinnis*	Galaxiidae	At Risk – Declining
	Banded kōkopu	*Galaxias fasciatus*	Galaxiidae	Not Threatened
	Giant kōkopu	*Galaxias argenteus*	Galaxiidae	At Risk – Declining
	Īnanga, atutahi, atutai, karohi, karohe	*Galaxias maculatus*	Galaxiidae	At Risk – Declining
	Shortjaw kōkopu	*Galaxias postvectis*	Galaxiidae	Threatened – Nationally Vulnerable
	Dwarf galaxias*	*Galaxias divergens*	Galaxiidae	At Risk – Declining
	Brown mudfish*	*Neochanna apoda*	Galaxiidae	At Risk – Declining
	Common bully, toitoi	*Gobiomorphus cotidianus*	Eleotridae	Not Threatened
	Redfin bully, toitoi	*Gobiomorphus huttoni*	Eleotridae	Not Threatened
	Giant bully	*Gobiomorphus gobioides*	Eleotridae	At Risk – Naturally Uncommon
	Bluegill bully	*Gobiomorphus hubbsi*	Eleotridae	At Risk – Declining
	Torrentfish, panoko, panokonoko, panuku, papanoko	*Cheimarrichthys fosteri*	Mugiloididae	At Risk – Declining
	Lamprey, piharau	*Geotria australis*	Geotriidae	Threatened – Nationally Vulnerable
	Yelloweye mullet, kanae aua	*Aldrichetta forsteri*	Mugilidae	Not Threatened
	Common smelt, ngaore	*Retropinna retropinna*	Retropinnidae	Not Threatened
	Black flounder, pātiki mohoao	*Rhombosolea retiaria*	Pleuronectidae	Not Threatened
Introduced sports fish	Brown trout	*Salmo trutta*	Salmonidae	Introduced & Naturalised
	Rainbow trout	*Oncorhynchus mykiss*	Salmonidae	Introduced & Naturalised
	Brook char	*Salvelinus fontinalis*	Salmonidae	Introduced & Naturalised
Introduced pest fish	Goldfish	*Carassius auratus*	Cyprinidae	Introduced & Naturalised
Invertebrates	Freshwater crayfish, kōura	*Paranephrops planifrons*	Parastacidae	Not Threatened
	Freshwater shrimp	*Paratya curvirostris*	Atyidae	Not Threatened

Table 5 Freshwater fish and invertebrate species present by subcatchment for the Waikanae catchment (1958–2021) as recorded in the New Zealand Freshwater Fish Database (NZFFD). The conservation status (according to Dunn *et al*., 2018 for fish and Grainger *et al.,* 2018 for invertebrates) is also given in parenthesis in the first column. Refer to Figure 1 for subcatchment boundaries.

	Lower Waikanae	Maungakotukutuku	Reikorangi	Rangiora	Ngatiawa	Kapakapanui
Number of fish and invertebrate species recorded in the NZFFD	23	9	4	no surveys	4	12
Shortfin eel (not threatened)	✓					✓
Longfin eel (at risk – declining)	✓	✓	✓		✓	✓
Kōaro (at risk – declining)	✓	✓	✓		✓	✓
Banded kōkopu (not threatened)	✓	✓				
Giant kōkopu (at risk – declining)	✓					
Īnanga (at risk – declining)	✓					
Shortjaw kōkopu (threatened – nationally vulnerable)	✓	✓				✓
Dwarf galaxias (at risk – declining)		✓				✓
Brown mudfish (at risk – declining)	✓					
Common bully (not threatened)	✓					✓
Redfin bully (not threatened)	✓	✓	✓		✓	✓
Giant bully (at risk – naturally uncommon)	✓					
Bluegill bully (at risk – declining)	✓					✓
Torrentfish (at risk – declining)	✓	✓				✓
Lamprey (threatened – nationally vulnerable)	✓					✓
Yelloweye mullet (not threatened)	✓					
Common smelt (not threatened)	✓					
Black flounder (not threatened)	✓					
Brown trout (introduced & naturalised)	✓	✓	✓		✓	✓
Rainbow trout (introduced & naturalised)	✓					
Brook char (introduced & naturalised)	✓					
Goldfish (introduced & naturalised)	✓					
Kōura (not threatened)	✓	✓				✓
Freshwater shrimp (not threatened)	✓					


Shortfin eel (*Anguilla australis*)


Longfin eel (*Anguilla dieffenbachii*)


Kōaro (*Galaxias brevipinnis*)


Īnanga (*Galaxias maculatus*)


Common bully (*Gobiomorphus cotidianus*)


Redfin bully (*Gobiomorphus huttoni*)


Torrentfish (*Cheimarrichthys fosteri*)


Brown trout (*Salmo trutta*)

Figure 8 **Images of the most frequently encountered freshwater fish species within the Waikanae catchment according to records in the New Zealand Freshwater Fish Database (NZFFD; Crow, 2018).** All photos © EOS Ecology

3.2 Fish

Of the numerous reports on the ecological values of the Waikanae catchment, most are associated with large developments or discharges to the catchment. Much of the fish data from these reports is also represented in the NZFFD (Figure 7). The MacKays to Peka Peka Expressway (M2PP) project (State Highway 1) is one such example, where extensive ecological reporting has accompanied the resource consenting for this development.

As part of the ecological reporting for the M2PP project, ecological values were assessed for the Waikanae River in the vicinity of the proposed road alignment (Risi, 2012; Keesing, 2012). The survey work included freshwater fish and macroinvertebrate surveys and comprehensive habitat measurements. As part of this work, surveys were undertaken on the upper Mazengarb Stream, Otaihanga wetlands, the lower Muaupoko Stream, and the Waikanae mainstem, near the confluence with Muaupoko Stream. Because of the location of the expressway, all survey reaches were on the coastal plains, less than three kilometres from the Waikanae estuary and less than 7 metres above sea level. As part of this study, six fish species were found in the Waikanae River (longfin eel, shortfin eel, common bully, redfin bully, inanga, and black flounder), while five species were found in Muaupoko Stream (longfin eel, shortfin eel, common bully, inanga, and common smelt), and three species were found in Mazengarb Stream (longfin eel, shortfin eel, common bully).

The KCDC water supply project is another major source of ecological information for the Waikanae catchment. This project has resulted in sizeable investigations of fish and instream habitat in the mid reaches of the Waikanae River. An instream habitat assessment for the Waikanae River found that optimum habitat for several species (brown trout, longfin eel, torrentfish) occurs around mean flow, with the weighted useable area decreasing considerably as flows decline below Mean Annual Low Flow (MALF; Watts, 2003). This study observed that at MALF, the Waikanae River provides a relatively high proportion of habitat for young brown trout, longfin eel, torrentfish, and redfin bully, when compared with other New Zealand rivers, while for adult trout and food producing habitat, the Waikanae River is amongst the lower quartile of New Zealand rivers (Watts, 2003). However, because of the differences in habitat suitability between species, it is not possible to set a minimum flow that optimises habitat for all species present in the river (Watts, 2003).

The water takes and discharge associated with the Waikanae WTP and the recharge of the Waikanae River with groundwater (see Section 2.3 for further information) have the potential to alter the river ecosystem. Therefore, there is extensive monitoring associated with these activities. Recent monitoring has found that fish taxa are similar above and below the Waikanae WTP and recharge location, although fish abundance is greater downstream (Beca Ltd, 2018). Surveys during the summer of 2017–2018 recorded ten fish species at a site above the Waikanae WTP, and nine species below the Waikanae WTP. Twice as many fish were caught below the Waikanae WTP compared to the site above the WTP, with abundances of torrentfish, elvers, and redfin bully all substantially higher at the downstream site compared to the upstream site (Beca Ltd, 2018). The report found that commonly present and abundant taxa were found above and below the Waikanae WTP. Further analysis of the fish size classes showed that recruitment and movement past the Waikanae WTP is occurring (Beca Ltd, 2018). However, although the Waikanae WTP weir is passable, it may present some challenges for fish movement, resulting in the observed differences in abundance between upstream and downstream sites. With similar findings reported for the 2019 survey, the authors conclude that the fish communities are not showing a pattern of effect related to the river recharge (Millican, 2019).

The Mazengarb Stream is relatively well studied compared to other waterways in this catchment, as it is subject to several point source discharges, including the Otaihanga Landfill and the WWTP. Although the stream has poor water quality and is heavily influenced by stormwater inputs, as well as discharges from industrial areas, the WWTP and landfill, it is historically known to have supported banded kōkopu and common smelt, as well as longfin eel, shortfin eel, and common bully (Risi, 2012).

3.2.1 Longfin & Shortfin Eel

Records from the NZFFD provide an overview of the distribution of shortfin and longfin eel in the Waikanae catchment (Figure 9). Although there has been substantially more survey effort in the lower catchment, records show that longfin eel are well dispersed throughout the catchment, and have been found in all of the subcatchments where surveys have been undertaken (Table 5; Figure 9). Shortfin eel are less widespread, with most observations of this species being from the lower Waikanae subcatchment. Over all surveys recorded in the NZFFD for the Waikanae catchment, longfin eel was recorded in 41% of surveys, whereas shortfin eel was found in 19% of surveys (Table 6). However, where shortfin eel were recorded, they were often caught in very high abundances, with an average of 51 shortfin eel per record, but up to 363 individuals recorded for one survey using baited traps in the Mazengarb Stream.

Table 6 Summary of New Zealand Freshwater Fish Database records of shortfin and longfin eel in the Waikanae catchment (1958–2021). Refer to Figure 9 for information on the distribution of these records within the catchment.

Species	Total Number of Records	Number of Records (including fish count data)	Number of Individuals Recorded	Mean Fish Abundance (per record)	Range in Abundance (per record)
Shortfin eel (*Anguilla australis*)	25	15	760	51	1–363
Longfin eel (*Anguilla dieffenbachii*)	55	30	420	14	1–66

The first fisheries assessment research document for eel was published in 1994 and includes information about the fisheries for both the longfin eel (*Anguilla dieffenbachii*) and the shortfin eel (*A. australis*) within New Zealand (Jellyman, 1994). Nationally, the commercial fishery for eel became established in the 1960s and catch volumes peaked in the mid 1970s. At this time, shortfin eels were the dominant species caught commercially on a national scale, with an estimated two-thirds of the catch being shortfins. More recently, an analysis of catch per unit effort (CPUE) for the North Island commercial freshwater eel fishery covered a 28-year period from 1990 to 2018 and found that shortfin eels still consistently dominated the commercial catch, with up to 89% of total eel landings being shortfin (Beentjes, 2020). Over this period, the Manawatu Eel Statistical Area (ESA), which includes the Waikanae catchment has contributed 7% of the total North Island eel catch, with the median annual shortfin catch ranging between 40 and 300 kg per day and median annual longfin catch ranging from 20 to 200 kg per day, with no obvious trends over time (Beentjes, 2020). The North Island eel fishery became part of the Quota Management System (QMS) in 2005, with separate stocks established for longfin and shortfin eels. However, because the ESAs cover multiple river catchments, it is not possible to determine the magnitude of any commercial fishery in the Waikanae catchment. Likewise, the extent of recreational or customary harvest within the Waikanae catchment is not recorded.

Figure 9 *…figure over page…* Locations where longfin eel (*Anguilla dieffenbachii*) and shortfin eel (*Anguilla australis*) have been recorded in the New Zealand Freshwater Fish Database (NZFFD) for the Waikanae catchment.

Waikanae River Catchment: Recorded Locations ANGUILLIDAE

SURVEY LOCATION

- Longfin eel (*Anguilla dieffenbachii*)
- Shortfin eel (*Anguilla australis*)
- Unidentified eel (*Anguilla spp*)

- Catchment
- Subcatchments
- Waterways

0 0.5 1 2 Kilometers

N

Layer source: fish data: NZFFD; waterways: REC; catchments: Greater Wellington Regional Council.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

3.2.2 Īnanga

Records from the NZFFD provide an overview of the distribution of īnanga in the Waikanae catchment (Figure 10). This shows that īnanga are limited to the lower Waikanae subcatchment, although they appear to be well distributed within the lower river tributaries, including records from the Mazengarb Stream, Muaupoko Stream, and Waimeha Lagoon. Īnanga may be more widely distributed than records show, as several of the more upstream subcatchments have received very little survey attention (Figure 7). However, their more widespread occurrence in the lower river is not surprising, since īnanga are known to be limited to lower gradient rivers and streams because of their inability to climb falls or swim through swift rapids (McDowell, 1990).

Over all surveys recorded in the NZFFD for the Waikanae catchment, there are 25 records of īnanga, with an average abundance of 36 fish per record for those surveys where absolute abundance was included (Table 7). The NZFFD records for this catchment show that electrofishing surveys generally record substantially lower abundances of īnanga compared to Gee minnow and fyke net surveys, with electrofishing records typically observing less than ten īnanga per record, whereas a fyke net survey in the Mazengarb Stream caught 393 īnanga.

Īnanga spawning surveys (īnanga egg searches) were completed during 2016 at 24 sites in the Wellington Region, including the Waikanae River mainstem (Taylor & Marshall, 2016). Īnanga eggs were found in the Waikanae River, although the identified spawning area was small and egg numbers were low. It was suggested that more survey effort would be required to determine the extent of the main spawning area at this location. The location where the eggs were found was approximately 1.6 km upstream of the river mouth, and while both banks of the river were searched, eggs were found on the true right bank only. Taylor & Marshall (2016) identified several other locations that may provide suitable spawning habitat and recommended further surveys to investigate these. A previous survey of potential īnanga spawning habitat on the Waikanae River was focused a little further upstream, within and downstream of the Otaihanga Reserve, where suitable spawning habitat was identified on the true left bank, while the true right was deemed unsuitable because it was heavily shaded by pine trees and lacked suitable groundcover vegetation to support spawning (Taylor & Kelly, 2001). No īnanga eggs were observed during this survey, although the focus was on identifying suitable habitat, rather than conducting egg searches in this instance. Potential threats to spawning sites include public use of adjacent areas, including the riverside cycleway. If people or pets stray from the designated pathway, they may damage the riparian vegetation and reduce bank stability (Taylor & Marshall, 2016). The installation of interpretive signage near spawning areas is one way to raise awareness and improve public understanding of the importance of protecting īnanga spawning habitat.

Table 7 Summary of New Zealand Freshwater Fish Database records of īnanga in the Waikanae catchment (1961–2021). Refer to Figure 10 for information on the distribution of these records within the catchment.

Species	Total Number of Records	Number of Records (including fish count data)	Number of Individuals Recorded	Mean Fish Abundance (per record)	Range in Abundance (per record)
Īnanga (*Galaxias maculatus*)	25	17	617	36	1–393

3.2.3 Other Galaxiidae (Banded kōkopu, Giant kōkopu, Shortjaw kōkopu, Kōaro, Dwarf galaxias, & Brown mudfish)

Of the six other galaxiidae taxa recorded in the NZFFD for the Waikanae catchment, kōaro is the most widespread, being found in all surveyed subcatchments (Figure 10), while the non-diadromous dwarf galaxias has been recorded in the highest abundance (Table 8). The NZFFD survey records for the Waikanae catchment show that banded kōkopu, giant kōkopu, and shortjaw kōkopu are typically found in very low abundances where they are present (Table 8). In addition, the most recent NZFFD records of giant and shortjaw kōkopu are over 20 years old. However, there has been very little spotlighting effort recorded in the NZFFD for this catchment and this method is typically more effective at assessing the abundance of these species.

Natural and artificial barriers to fish migration have an influence on fish distribution in New Zealand waterways. Most of the known barriers to fish migration in the Waikanae catchment are artificial, including culverts and flap gates (Section 2.5). However, kōaro, shortjaw kōkopu, and banded kōkopu are very strong climbers, with the ability to migrate upstream past substantial waterfalls (McDowell, 1990). Their excellent climbing ability, compared to other native and introduced fish species, allows them to penetrate well inland to high gradient rivers and streams, where suitable habitat is more available (Figure 10). This may be especially relevant for kōaro, who are known to favour swiftly flowing forested streams of small to moderate size (McDowell, 1990). This may explain the relatively widespread distribution of kōaro in the Waikanae catchment (Figure 10).

Table 8 Summary of New Zealand Freshwater Fish Database records of other Galaxiidae in the Waikanae catchment (1958–2021). Refer to Figure 10 for information on the distribution of these records within the catchment.

Species	Total Number of Records	Number of Records (including fish count data)	Number of Individuals Recorded	Mean Fish Abundance (per record)	Range in Abundance (per record)
Kōaro (*Galaxias brevipinnis*)	23	12	147	12	1–45
Banded kōkopu (*Galaxias fasciatus*)	7	4	11	3	1–7
Giant kōkopu (*Galaxias argenteus*)	1	1	1	1	1 only
Shortjaw kōkopu (*Galaxias postvectis*)	8	4	5	1	1–2
Dwarf galaxias (*Galaxias divergens*)	7	4	197	49	1–183
Brown mudfish *(Neochanna apoda)*	2	1	5	5	5 only

Figure 10 *…figure over page…* Locations where Galaxiidae have been recorded in the New Zealand Freshwater Fish Database (NZFFD) for the Waikanae catchment.

Waikanae River Catchment: Recorded Locations GALAXIIDAE

SURVEY LOCATION

- Banded kōkopu (*Galaxias fasciatus*)
- Brown mudfish (*Neochanna apoda*)
- Dwarf galaxias (*Galaxias divergens*)
- Giant kōkopu (*Galaxias argenteus*)
- Īnanga (*Galaxias maculatus*)
- Kōaro (*Galaxias brevipinnis*)
- Shortjaw kōkopu (*Galaxias postvectis*)
- Unidentified galaxiid (*Galaxias spp*)

- Catchment
- Subcatchments
- Waterways

0 0.5 1 2 Kilometers

N

Map © EOS Ecology, 2022 / www.eosecology.co.nz

Layer source: fish data: NZFFD; waterways: REC; catchments: Greater Wellington Regional Council.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

3.2.4 Eleotridae (Bluegill bully, Common bully, Giant bully, & Redfin bully)

Of the four Eleotridae taxa recorded in the NZFFD for the Waikanae catchment, redfin bully is the most widespread, being found in all surveyed subcatchments (Figure 11), while bluegill bully, common bully, and giant bully are more commonly found in the lower Waikanae catchment. While low numbers of giant bully have been recorded in the NZFFD for the Waikanae catchment, there are much higher abundances of common bully, with one survey in the McGregor Street Drain reporting 254 common bully captured by hand netting during 2019 (Table 9).

Table 9 Summary of New Zealand Freshwater Fish Database records of Eleotridae in the Waikanae catchment (1958–2021). Refer to Figure 11 for information on the distribution of these records within the catchment.

Species	Total Number of Records	Number of Records (including fish count data)	Number of Individuals Recorded	Mean Fish Abundance (per record)	Range in Abundance (per record)
Bluegill bully (*Gobiomorphus hubbsi*)	8	3	42	14	2–20
Common bully (*Gobiomorphus cotidianus*)	23	14	322	23	1–254
Giant bully (*Gobiomorphus gobioides*)	5	3	13	4	1–8
Redfin bully (*Gobiomorphus huttoni*)	54	20	316	16	2–51

Figure 11 *…figure over page…* Locations where Eleotridae have been recorded in the New Zealand Freshwater Fish Database (NZFFD) for the Waikanae catchment.

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Waikanae River Catchment: Recorded Locations ELEOTRIDAE

SURVEY LOCATION

- Bluegill bully (*Gobiomorphus hubbsi*)
- Common bully (*Gobiomorphus cotidianus*)
- Giant bully (*Gobiomorphus gobioides*)
- Redfin bully (*Gobiomorphus huttoni*)
- Unidentified bully (*Gobiomorphus spp*)

- Catchment
- Subcatchments
- Waterways

0 0.5 1 2 Kilometers

N

Map © EOS Ecology, 2022 / www.eosecology.co.nz

Layer source: fish data: NZFFD; waterways: REC; catchments: Greater Wellington Regional Council.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

3.2.5 Other Native Fish

Outside of the Anguillidae, Galaxiidae, and Eleotridae families that have already been discussed, there are five other native fish species known to be present within the Waikanae catchment (Figure 12; Table 10). These include lamprey, which has been found in both the lower Waikanae mainstem as well as the headwaters. In the most recent lamprey observation, recorded by Massey University during 2002, there were ten individuals identified at a site in the Kapakapanui subcatchment (Figure 12). However, electric fishing and netting are known to be ineffective for the survey of juvenile and adult lamprey (Baker *et al.*, 2016), and as they are not often recorded during surveys, such survey data does not provide an accurate assessment of how common they are within a catchment. In contrast, torrentfish have been found relatively frequently during surveys in the lower and upper catchment and have been found in very high abundances at times (Table 10). The lower Waikanae also supports black flounder, common smelt, and yelloweye mullet, although black flounder are only recorded once in the NZFFD for the Waikanae catchment.

Table 10 Summary of New Zealand Freshwater Fish Database records of other native fish (Figure 12) in the Waikanae catchment (1958–2021). Refer to Figure 12 for information on the distribution of these records within the catchment.

Species	Total Number of Records	Number of Records (including fish count data)	Number of Individuals Recorded	Mean Fish Abundance (per record)	Range in Abundance (per record)
Lamprey (*Geotria australis*)	9	2	11	6	1–10
Torrentfish (*Cheimarrichthys fosteri*)	28	15	510	34	1–100
Black flounder (*Rhombosolea retiarii*)	1	1	1	1	1 only
Common smelt (*Retropinna retropinna*)	12	5	32	6	1–20
Yelloweye mullet (*Aldrichetta forsteri*)	3	0	0	NA	NA

Figure 12 *...figure over page...* Locations where other native fish have been recorded in the New Zealand Freshwater Fish Database (NZFFD) for the Waikanae catchment.

Waikanae River Catchment: Recorded Locations OTHER NATIVE FISH

SURVEY LOCATION

- Black flounder (*Rhombosolea retiaria*)
- Common smelt (*Retropinna retropinna*)
- Lamprey (*Geotria australis*)
- Torrentfish (*Cheimarrichthys fosteri*)
- Unidentified flounder (*Rhombosolea spp*)
- Yelloweye mullet (*Aldrichetta forsteri*)

Catchment
Subcatchments
Waterways

0 0.5 1 2 Kilometers

Layer source: fish data: NZFFD; waterways: REC; catchments: Greater Wellington Regional Council.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

3.2.6 Sports fish

Greater Wellington Regional Council identifies important trout fishery rivers and spawning waters in Schedule I of the Natural Resources Plan for the Wellington Region. The Waikanae River is identified in this schedule, as an important trout fishery river, while the Waikanae River and Maungakōtukutuku Stream are listed as important trout spawning waters (GWRC, 2019).

With its importance as a trout fishery, the Waikanae River has received substantial survey effort for sports fish. Kavermann (2019) reported on 20 years of sports fish monitoring data for the Waikanae River, with surveys completed by Fish and Game Wellington. This long-term monitoring programme was established to examine whether the river control works undertaken by the GWRC were having an adverse effect on trout populations over time. An approximately 3.7 km reach of the Waikanae River is included in this monitoring programme, with the targeted reaches being surveyed for brown and rainbow trout using drift diving techniques. The survey reaches are in the mainstem of the river, in the vicinity of Jim Cooke Park and the Waikanae WTP. Mean trout abundance per kilometre is typically below 20 for the Waikanae River and although higher values were recorded during the 2011 and 2013 surveys, abundances have been declining since that time. Kavermann (2019) indicates that spawning is occurring within the Waikanae River, with juvenile trout being observed in each of the survey reaches during the 2019 survey, and spawning redds (nests) observed within the upper Waikanae during 2018.

Much of the long-term Fish and Game trout survey data is recorded in the NZFFD (Table 11; Figure 13). The majority of the NZFFD records of sports fish in the catchment are for brown trout, with only a few incidental records of rainbow trout (during 2010) and brook char (during 2001) within the catchment. While the majority of these records are from the Waikanae mainstem (as part of the long-term monitoring programme), there are also observations of brown trout in the Maungakotukutuku, Ngatiawa, Reikorangi, and Kapakapanui subcatchments.

Table 11 Summary of New Zealand Freshwater Fish Database records for sports fish in the Waikanae catchment (1958–2021). Refer to Figure 13 for information on the distribution of these records within the catchment.

Species	Total Number of Records	Number of Records (including fish count data)	Number of Individuals Recorded	Mean Fish Abundance (per record)	Range in Abundance (per record)
Brown trout (*Salmo trutta*)	114	97	732	7.5	1–37
Rainbow trout (*Oncorhynchus mykiss*)	3	3	5	1.7	1–2
Brook char (*Salvelinus fontinalis*)	1	0	NA	NA	NA

3.2.7 Pest Fish

The only pest fish species recorded for the Waikanae River catchment in the NZFFD is goldfish (Table 5; Figure 13). The NZFFD records of this species are recent (2020–2021) and the distribution is restricted to the Mazengarb Stream and Waikanae Estuary, where between one and three individuals were recorded in fyke net surveys.

Figure 13 *...figure over page...* Locations where introduced fish have been recorded in the New Zealand Freshwater Fish Database (NZFFD) for the Waikanae catchment.

Waikanae River Catchment: Recorded Locations INTRODUCED FISH

SURVEY LOCATION

- Brook char (*Salvelinus fontinalis*)
- Brown trout (*Salmo trutta*)
- Goldfish (*Carassius auratus*)
- Rainbow trout (*Oncorhynchus mykiss*)
- Unidentified salmonid (*Salmo spp*)

- Catchment
- Subcatchments
- Waterways

0 0.5 1 2 Kilometers

N

Layer source: fish data: NZFFD; waterways: REC; catchments: Greater Wellington Regional Council.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

3.3 Invertebrates

3.3.1 State of the Environment Monitoring

Macroinvertebrate sampling is often a routine part of catchment State of the Environment (SOE) monitoring programmes. It is useful because the composition of macroinvertebrate communities provides an indication of instream conditions and water quality, since different species have varying tolerance to environmental stressors. As part of their SOE monitoring programme, GWRC undertakes annual macroinvertebrate monitoring at two sites within the Waikanae River catchment, namely the Waikanae River at Greenaway Road and Waikanae River at Mangaone Walkway, where water quality sampling is also undertaken (Land, Air, Water Aotearoa, 2022; Figure 1). The Macroinvertebrate Community Index (MCI; Stark, 1985), taxa richness, and the percentage of Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa are calculated for these sites to provide an indicator of their ecological health.

Values for MCI at the lower catchment monitoring site at Greenaway Road range between 105 and 129, with a mean of 114 (Table 12). With these values, this site fits within the B attribute band of the NPS-FM 2020 and can be interpreted as having a macroinvertebrate community that is indicative of mild organic pollution or nutrient enrichment, but largely composed of taxa sensitive to organic pollution/nutrient enrichment. This site is located within pastoral land use, between the Waikanae township and Waikanae Beach urban areas (Figure 1). In contrast, the upper Waikanae catchment ecological monitoring site is located at Mangaone Walkway (Figure 1), where the catchment is dominated by native vegetation. At this site, the MCI ranges between 130 and 145, with a mean of 138 (Table 12). This site fits within the A attribute band of the NPS-FM 2020, indicating that the site has a macroinvertebrate community indicative of pristine conditions with almost no organic pollution or nutrient enrichment. In keeping with the downstream decrease in MCI values, both taxa richness and the %EPT taxa also decreased between the monitoring site at Mangaone Walkway and Greenaway Road, although the decreases were not substantial and even at the downstream site, almost half the community was composed of relatively sensitive EPT taxa (Table 12).

Table 12 Summary of macroinvertebrate community indices for the two sites in the Waikanae River catchment monitored annually by Greater Wellington Regional Council since 2005. Five-year medians are presented for Macroinvertebrate Community Index (MCI), taxa richness, and % Ephemeroptera, Plecoptera, and Trichoptera (% EPT), using data presented on LAWA (2022). Refer to Figure 1 for information on where these sites are located.

Site location	5-year median MCI	5-year median taxa richness	5-year median % EPT	MCI Attribute band (NPS-FM, 2020)
Waikanae River at Greenaway Road	114	28	46	B
Waikanae River at Mangaone Walkway	137	29	60	A

3.3.2 Other Invertebrate Research & Investigations

In addition to annual SOE monitoring, there have been several investigations that have added to the knowledge of macroinvertebrate communities in the Waikanae catchment. Ecological investigations were undertaken within the lower Waikanae catchment to establish baseline conditions for waterways to be traversed by the MacKays to Peka Peka Expressway (Risi, 2012). Survey sites included the mainstem of the Waikanae River, Otaihanga wetlands, Muaupoko Stream, and Mazengarb Stream, where three replicate kick samples were collected for each site. The results of this survey indicated that the Waikanae River site had an MCI value of 115, putting it within the NPS-FM 2020 attribute band B. In contrast, the surveyed lower catchment tributary sites had much lower MCI values, with Muaupoko Stream (MCI = 88), Mazengarb Stream (MCI = 69), and Mazengarb Stream at the WWTP (MCI = 40), all falling within the NPS-FM 2020 attribute band D, which is below the national bottom line for this attribute unit. These macroinvertebrate results indicate that while the lower Waikanae mainstem retains a community that is indicative of only mild organic pollution, the lower river tributaries may be heavily impacted by severe organic pollution or nutrient enrichment.

As part of a scoping study for water supply options for the Kāpiti Coast, Suren *et al.* (2010) surveyed macroinvertebrates at sites on Maungakōtukutuku Stream and an unnamed tributary of the Waikanae River that they described as Kapakapanui Dam Stream. Each stream was sampled at two sites upstream of proposed water supply dams and at two sites downstream of these. For the Kapakapanui Dam Stream, the riparian land use at the four survey sites varied from open farmland to well shaded native forest, but the stream substrate was dominated by hard substrate at all sites (boulders, cobbles, and coarse gravels), and the macroinvertebrate community composition was consistent among the sites. The invertebrate community metrics for this stream indicated that it was in pristine condition, with an average of 80% EPT taxa, and with MCI (mean = 134) and QMCI scores (mean = 7.9) putting this waterway within the A attribute band of the NPS-FM 2020. The survey sites on the Maungakōtukutuku Stream had riparian margins dominated by native vegetation which provided shade to the waterway, and hard substrate including bedrock, boulders, cobbles, and small gravels. As for the Kapakapanui Dam Stream, the invertebrate community metrics for this stream indicated that it was also in pristine condition, with an average of 73% EPT taxa, and with MCI (mean = 130) and QMCI scores (mean = 7.6) putting this waterway within the A attribute band of the NPS-FM 2020.

Suren *et al.* (2010) also surveyed three sites in the Waikanae River, downstream of the confluences with the Kapakapanui Dam Stream and Maungakōtukutuku Stream, and below the Waikanae WTP. These sites were used to assess the potential effects of changes to flood frequency that would result from water supply dams in upstream parts of the catchment. Invertebrate community indices calculated for the Waikanae River sites indicated that they were not in as good condition as the Mangakōtukutuku and Kapakapanui tributaries, but with an average of 59% EPT taxa, and with MCI (mean = 126) and QMCI scores (mean = 6.8) putting this waterway within the A (QMCI) or B (MCI) attribute bands of the NPS-FM 2020, the mainstem of the river would still be considered to be only mildly impacted by organic pollution or nutrient enrichment. This survey found that although species abundances varied by location, the macroinvertebrate communities of the Maungakōtukutuku Stream, Kapakapanui Dam Stream, and the Waikanae mainstem were typically dominated by caddisflies, including *Helicopsyche*, *Olinga*, *Pycnocentrodes*, *Aoteapsyche*, *Costachorema*, *Psilochorema*, and *Beraeoptera*, as well as the mayflies *Deleatidium* and *Coloburiscus* (Figure 14).

Additional macroinvertebrate investigations in the Waikanae catchment have been related to the potential effects of the Waikanae WTP. Suren & Duncan (2011) reviewed available data from the Waikanae River to determine whether abstraction for the Waikanae WTP was influencing algal biomass and invertebrate communities in the river. They found that the water abstraction was not altering algal biomass, with no relationship found between flow and chlorophyll biomass. The changes in algal biomass that were observed between sites reflected differences in nutrient levels, land use, and channel shading, rather than changes in flow. They found that the river supported a diverse invertebrate community and although there were differences to the invertebrate community found above and below the Waikanae WTP, they found no relationship between the invertebrate community composition and the flow regime and concluded that the impacts of the abstraction on the ecological values of the Waikanae River are minor. This study showed that the changes to the invertebrate community downstream in the Waikanae River are consistent with changes to land use, with the upper catchment dominated by indigenous forest, while the lower catchment is dominated by pasture.

Overall, the invertebrate indices for the Waikanae River showed that it has high ecological values in comparison to other similar waterways in the region.

The resource consent for groundwater recharge of the Waikanae River downstream of the Waikanae WTP (see Section 2.3 for details) also incorporates a monitoring programme. Baseline monitoring data has been collected for three years, to fulfil the consent conditions for the river recharge, including water chemistry, algal cover, macroinvertebrate, and fish surveys (Boffa Miskell Ltd, 2014; Beca Ltd, 2016). This monitoring includes sampling at two control sites upstream of the Waikanae WTP, and three receiving environment sites downstream of the Waikanae WTP. The baseline data will be used to inform an ongoing monitoring programme and to develop relevant trigger levels for the ongoing management of the river recharge consent (Beca Ltd, 2017).

The Waikanae Estuary has been the focus of detailed habitat mapping and monitoring of estuary condition since 2010 (Robertson & Stevens, 2010; 2011; 2012; 2017). Baseline monitoring for the estuary has found a dominance of benthic macroinvertebrates with high mud tolerances or preferences (Robertson & Stevens, 2010; 2011; 2012; 2017). This, along with sediment quality results have indicated that the estuary is moderately enriched with nutrients and has excessive fine sediment /mud inputs but has low levels of toxicity. The estuary showed a decline in condition during a 2012 survey, compared to previous years, and this was attributed to increased fine sediment loads during that year, potentially related to forest harvesting within the catchment (Robertson & Stevens, 2012).

Helicopsyche caddisfly (MCI score = 10) *Olinga* caddisfly (MCI score = 9) *Pycnocentrodes* caddisfly (MCI score = 5)

Aoteapsyche caddisfly (MCI score = 4) *Costachorema* caddisfly (MCI score = 7) *Psilochorema* caddisfly (MCI score = 8)

Beraeoptera caddisfly (MCI score = 8) *Deleatidium* mayfly (MCI = 8) *Coloburiscus* mayfly (MCI = 9)

Figure 14 **Images of the most abundant EPT taxa in samples from Kapakapanui Dam Stream, Maungakōtukutuku Stream, and Waikanae River surveys by Suren *et al.* (2010). MCI scores for each taxon are provided in parentheses, as per Stark & Maxted (2007).**

3.3.3 Kōura

Kōura, or freshwater crayfish are known to be present in the Waikanae catchment but are recorded relatively infrequently in surveys. The NZFFD often includes records of kōura, as they are a large invertebrate and may be encountered during fish surveys. However, the NZFFD records only six observations of kōura in the Waikanae catchment, with these being in the Waikanae headwaters (2 records), Muaupoko Stream (2 records), Maungakōtukutuku Stream (1 record), and Mazengarb Stream (1 record). The available records do not suggest that kōura are especially widespread or abundant within the Waikanae catchment, although this appearance may be because of a lack of specific survey effort for this species. As part of a study to examine the habitat preferences of kōura in lower North Island streams, Brown (2009) surveyed three sites within the Waikanae catchment, including the mainstem and two unnamed tributaries and found kōura present at two of these sites, including the mainstem location (Figure 15). Survey sites were selected based on being representative of land use patterns in the lower North Island and accessibility for day and night surveys. This study found that riparian vegetation, the presence of predators, and instream habitat characteristics were important factors in determining the presence or absence of kōura at a given location.

3.3.4 Kākahi

Kākahi (*Echyridella menziesii*), or freshwater mussels have a conservation status of *at risk – declining* (Grainger *et al.*, 2018). Although they are an invertebrate species, kākahi are often recorded in the NZFFD because they are a large invertebrate that may be observed during fish surveys. The NZFFD currently holds no records of kākahi for the Waikanae catchment. However, kākahi have been observed in Muaupoko Stream as recently as 2021, and eDNA sampling of this stream by community members during June 2022 has detected the presence of kākahi in the Muaupoko Stream, within the lower Waikanae subcatchment (Wilderlab, 2022).

Figure 15 *…figure over page…* Locations of previous research and investigations for macroinvertebrates within the Waikanae catchment, including annual monitoring by Greater Wellington Regional Council (GWRC), one-off investigations as part of the MacKays to Peka Peka Expressway project (Risi, 2012), a research project on kōura habitat preferences (Brown, 2009), and invertebrate records that have been included in the New Zealand Freshwater Fish Database (NZFFD).

Waikanae River Catchment: Recorded Locations INVERTEBRATES

SURVEY LOCATIONS

Kōura
(*Presence/Absence*)

Present

Invertebrate
(*MCI attribute band (NPS-FM)*)

A
B
D

Catchment
Subcatchments
Waterways

0 0.5 1 2 Kilometers

N

Map © EOS Ecology, 2022 / www.eosecology.co.nz

Layer source: waterways: REC; catchments: Greater Wellington Regional Council; invertebrate data: GWRC, Risi (2012), Brown (2009), NZFFD.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

3.4 Birds

The bird fauna of the Waikanae Estuary has been well documented over many years, with ornithologists known to have visited the estuary as far back as the 1870s (Wodzicki *et al.,* 1978). Detailed records of the distribution and abundance of bird fauna within Waikanae Estuary was described by Wodzicki *et al.* (1978), who examined the changes in habitat and bird fauna over a 30-year period between the 1940s and 1970s. They recorded the presence of 79 bird species within the estuary during their second survey, undertaken between 1971 and 1974. In comparison, there were 61 bird species observed during their first survey, undertaken between 1941 and 1943. These authors identified the encroachment of housing on the estuary as the major threat facing the estuary at that time, with the expectation that this would alter the extent and diversity of bird habitat available within the estuary.

More than forty years after Wodzicki *et al.* (1978) completed their surveys, the Waikanae Estuary was part of a baseline coastal bird survey undertaken on behalf of GWRC to identify coastal habitats of significance for indigenous birds, for inclusion in their proposed Natural Resources Plan (McArthur *et al.*, 2019). This survey has confirmed that Waikanae Estuary supports banded dotterel, black shag, New Zealand dotterel, a breeding colony of pied shag, red-billed gull, variable oystercatcher, and white fronted tern. Because of the importance of the species that it supports, McArthur *et al.* (2019) recommended that Waikanae Estuary be included as a habitat of significance. The estuary is known to support 13 “Nationally Threatened” or “At Risk” bird species and is one of only three sites in the region to support a breeding population of North Island fernbird. It is also one of only six sites in the region to support a breeding population of NZ dotterels. As well as being an important stopover site for migrant bird species such as the South Island pied oystercatcher and the bar-tailed godwit, the location also provides breeding habitat for pied shags.

The New Zealand eBird database records 95 species that have been counted by observers at Waikanae estuary, which places the estuary in eleventh place in terms of number of species at bird hotspots for New Zealand (New Zealand eBird, 2022). The observations recorded for Waikanae Estuary extend as far back as 1987, although most have been recorded within the last decade, as the popularity of this online database has increased.

New Zealand dotterel/tūturiwhatu are an endemic New Zealand bird with a conservation status of “Recovering” (Robertson *et al.,* 2021). This species is present within the Waikanae Estuary Scientific Reserve (WESR) and were first observed to be nesting there during 2017 (Stapleton, 2022a). As a result of their conservation importance, the population and nesting performance of New Zealand dotterel is observed and documented by members of the Waikanae Estuary Care Group (WECG). Although the eggs from the first observed nesting seasons were infertile, and the nest was eventually abandoned, there was greater success the following season. Three eggs were laid during the 2018–2019 season, and a single chick survived to fledge. This success has continued for the three subsequent seasons, with two chicks fledging during 2019/2020, one chick in 2020/2021, and another one during the 2021/2022 season (Stapleton, 2022a).

The Waikanae Estuary Scientific Reserve also provides a roosting location for Caspian tern/taranui (Stapleton, 2022b). This is a native New Zealand species with a conservation status of “Nationally Vulnerable” (Robertson *et al.,* 2021). According to Stapleton (2022b), these birds are typically observed in small groups of one or two birds, although they have been observed in larger groups also. Some of the birds observed in WESR are banded, allowing the WECG to keep a record of sightings of individual birds, although un-banded birds are also recorded when these are observed.

Although the Waikanae Estuary is an obvious hotspot for birds, the river continues to provide important bird habitat further from the coast. Moylan & Hudson (2007) conducted five-minute bird counts at parks and reserves in the Wellington Region, to determine the abundance and distribution of native birds. They found that in general, greater numbers of birds were counted in larger reserves. However, their results showed that for the

Waikanae River reserve survey, bird abundance and diversity was greater than expected, given the size of the reserve, with 360 birds counted from 28 species. They made three visits to six survey locations within the 70 ha Waikanae River reserve, with the reserve having an estimated 29% of woody habitat. The Waikanae River reserve had the most diverse assemblage of birds in this study (28 species), and while most of the species found there are not unique to that location, the presence of that many species in one location was unusual. The authors suggested that this may be because of the broad habitat types represented along the river, including the estuary, as well as the proximity of the reserve to Kāpiti Island and the Tararua Ranges, providing a corridor for these species. The reserve also had the greatest number of native species (13 species) of the reserves in the study, with 39% of the birds counted being native birds. Native species recorded for the Waikanae River reserve included bellbird/korimako, fantail/pīwakawaka, grey warbler/riroriro, kereru/New Zealand pigeon, tūī, kingfisher/kotare, shining cuckoo/pīpīwharauroa, and silvereye/tauhou. All these species have a "Not Threatened" conservation status (Robertson *et al.,* 2021). However, a single hihi/stitchbird ("Nationally Vulnerable") was also counted, which is thought to have come from Kāpiti Island.

McArthur *et al.* (2015) have reported on annual bird surveys that have been undertaken in the mid to lower reaches of the Waikanae River since 2012, with an emphasis on collecting a census of bird species that are most likely to be impacted by flood protection and erosion mitigation activities that are undertaken in the river. They found that there were no riverbed-nesting shorebirds breeding on the dry gravel beaches of the Waikanae River and suggested that there is currently very little suitable habitat to support this. However, a total of 45 bird species were recorded during these surveys, including 27 native species and 18 introduced species and McArthur *et al.* (2015) includes comprehensive lists of these. They found that total species diversity, the proportion of native species, and the proportion of "Nationally Threatened" and "At Risk" species increased from around 2 km of the coast and peaked at the estuary. The Waikanae Estuary was identified as a site of value for indigenous birds because of its relatively high bird diversity, including resident and migrant bird species.

4 GAPS AND RECOMMENDATIONS

4.1 Gaps, Overlaps & Currency of Information

- The lower Waikanae subcatchment has been the subject of numerous biological surveys and investigations over many years and is the subject of many of the most recent surveys in the catchment (Figure 7). The focus on the lower Waikanae is largely because of the greater accessibility of this part of the catchment and the higher levels of human modification that the lower catchment has been subject to. The more accessible reaches of the Kapakapanui and Maugakotukutuku subcatchments have received some survey attention, while very little is known of the biological communities present in the Ngatiawa, Rangiora, and Reikorangi subcatchments (Figure 7; Figure 15). With much of these upper subcatchments still retaining indigenous forest cover, it is likely that the instream ecosystems in these areas are representative of the reference condition for this catchment. As such, surveys of these areas would provide a useful benchmark to show what a pristine ecosystem would look like for the Waikanae catchment.
- With its status as a scientific reserve, the Waikanae Estuary is a hotspot for ecological surveys and scientific monitoring and investigations. Consequently, there is substantial volume of information and ongoing monitoring of birds, sediments, nutrients, macroalgae, and habitat within the estuary. However, estuary fish have received very little survey attention.
- Point source impacts tend to be well investigated (e.g., Waikanae WTP and groundwater recharge), while the influence of land use changes and diffuse impacts are less well understood for this catchment (e.g., the sources of increased fine sediment in the catchment and the potential impacts of forestry).

4.2 Recommendations for Research & Survey Work to Fill Knowledge Gaps

- **Expanded fish survey work:** There has been little fish survey work within the indigenous forest areas of the catchment, with typically only the more accessible reaches having been surveyed. Consequently, relatively little is known about the biodiversity of the upper catchment. It would be useful to establish a catchment wide and estuary monitoring programme to establish a baseline with which to compare the benefits of restoration activities as well as to pinpoint which tributaries and activities are causing the greatest changes to biodiversity values in the catchment. eDNA surveys could be a way to expand the reach of fish surveys quickly and easily within the catchment and estuary to cover this gap in knowledge.
- **Environmental DNA (eDNA):** This method is potentially a practical and cost-effective way of gaining knowledge of fish and macroinvertebrate distributions within the Waikanae catchment and estuary. It is recommended that eDNA techniques are incorporated into research programmes within the Waikanae catchment and estuary. The information it can provide on the presence of fish species may be useful for narrowing down locations for further field surveys or identifying catchments where pest fish work may be necessary. Whilst eDNA is a relatively new and developing survey technique and further research and testing is needed to better understand its reliability, it is likely to be particularly beneficial to detect the presence of those species that are difficult to detect with traditional survey techniques (e.g., lamprey), as well as being simple to complete with little equipment required, which makes it useful for less accessible locations.

- **Establish several baseline freshwater macroinvertebrate survey sites to track benefits of restoration efforts:** Although macroinvertebrates are monitored annually at two sites in the catchment as part of the GWRC State of the Environment monitoring programme, there has been no widespread survey of macroinvertebrates in the catchment. The monitoring of macroinvertebrate communities over time can provide a useful measure of the condition of catchment waterways and enable the observation of trends over time. Targeted macroinvertebrate surveys and long-term monitoring would be justified in locations where restoration work is planned, to establish baseline values and provide indicators that may be used to measure the success of restoration activities over the longer term.
- **Īnanga spawning ground identification:** Previous surveys have identified a need to examine the extent of īnanga spawning grounds for the Waikanae River (Taylor & Marshall, 2016), as well as the need to document and restore potential īnanga spawning sites (Todd *et al.,* 2016). This information is essential to inform appropriate management of spawning areas, restoration of potential future spawning areas, and to support the creation of informational signage for the area.
- **Establish electronic references library for Waikanae biodiversity resources**: It is recommended that DOC establish an electronic references library to provide easy access to biodiversity references relevant to the Waikanae River catchment. There is a large collection of biodiversity reporting relevant to this catchment and it is essential that this body of information can be easily accessed and referred to as needed, particularly to avoid the duplication of effort and to ensure comparability with future survey work. Ongoing and future research and monitoring work could then be added to this resource as it becomes available.
- **Research into the sources of fine sediment within the catchment**: As discussed in Section 4.1, the influence of land use changes and diffuse impacts are not well researched for this catchment. For example, information on the sources of increased fine sediment in the catchment would help to target restoration efforts to address this impact.

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