Waikanae River Catchment Nga Awa Sampling 2023/24

Ref:

PREPARED FOR: Department of Conservation

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Stantec

Revision Schedule

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1. Introduction

The Department of Conservation (DOC) has undertaken ecological monitoring in the Waikanae River catchment as part of its Nga Awa program since 2021. The Nga Awa program seeks to 'work together with our communities towards healthy thriving rivers from source to sea'. The program partners with community members, Ātiawa ki Whakarongotai Iwi and other Government Agencies, including Kapiti Coast District Council, and Greater Wellington Regional Council to form the Waikanae Ki Uta Ki Tai (WKUKT) project. The WKUKT project also partners with the Waikanae Jobs for Nature (WJ4N) restoration project. As part of this program DOC has engaged Stantec to carry out ecological monitoring in the upper reaches of the Waikanae River catchment. This report summarises the work undertaken by Stantec and DOC during the 2023/24 monitoring season. It is intended to be shared with landowners, without whom much of the knowledge gained from the three consecutive years of monitoring would not have been collected. The Department of Conservation, and all partners involved in monitoring under the WKUTKT project recognise the contributions from landowners in the catchment area who have granted access to monitoring staff to cross private land.

1.1 Context

The Waikanae River is a hard bottom (cobbles and gravel) river that flows into the Tasman Sea, approximately 50 kilometres north of Wellington City. It originates on the western slopes of the Tararua Ranges, with the upper catchment comprised primarily of regenerating native forest. The lower catchment is comprised of urban settlements and some small regional parks. It is a highly valued natural resource for the local community. There are four major tributaries to the Waikanae River; Maungakōtukutuku Stream, Reikorangi Stream, Rangiora River, and Ngatiawa River. Each of these tributaries signifies major subcatchments originating in the Tararua Ranges. The Muaūpoko Stream is another tributary to the Waikanae but begins much lower in the catchment. These subcatchments all converge and help form the overall Waikanae River Catchment.

1.2 Background on Monitoring to Date

DOC began physical monitoring during the 2020/21 summer season. This monitoring established baseline information gathering with a long-term purpose of informing an integrated monitoring approach to be developed collaboratively with WKUKT. This first survey included a comprehensive suite of methods that enabled reporting on components of ecological integrity in the Waikanae Catchment. This work was conducted by Aquanet, who subsequently produced a report detailing the results.

Following the survey by Aquanet, DOC commissioned a comprehensive review of aquatic biodiversity for the Waikanae Catchment. EOS Ecology were engaged to complete this review and produced a report[1]. The goal of this report was to identify and summarise the biodiversity values and describe the main pressures impacting biodiversity within the catchment. The report collated existing scientific information and monitoring data but did not include customary knowledge of the aquatic biodiversity of the Waikanae River. Information gaps in fish and macroinvertebrate distribution were identified in this report, particularly in the catchment headwaters.

The gaps EOS Ecology identified were followed by recommendations to expand fish and macroinvertebrate surveys to previously understudied areas, in particular the catchment headwaters. These recommendations led to DOC developing a monitoring plan for the 2022/23 summer season that targeted the upper reaches of the Waikanae Catchment within indigenous forest. Nine sites were surveyed using a comprehensive suite of methods that aligned with DOCs national freshwater monitoring protocols. This monitoring was also used to engage and provide upskilling opportunities for WJ4N partners. Following monitoring, DOC engaged the Cawthron Institute to complete an analysis and produce a report on the data collected.[2] This report suggested future monitoring could examine the upstream extent of migratory fish distributions to determine the extent of available migratory species habitat within the Waikanae Catchment.

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[1] Report is available on DOC website: waikanae-river-and-estuary-catchment-biodiversity-information-review.pdf (doc.govt.nz) (Dewson, 2022)
[2] Report available on DOC website: nga-awa-monitoring-programme-waikanae-catchment-reporting-2023.pdf (doc.govt.nz) (Eveleens & Kelly, 2023)

A monitoring plan for the 2023/24 summer season was developed based on information gathered from prior monitoring, and recommendations from Cawthron. The goal was to fill remaining information gaps to create a solid base to inform development of the integrated catchment plan. Two monitoring efforts were planned, one for the upper catchment, and one for the lower catchment. This monitoring was carried out between December 2023 and May 2024. This report describes the results of this monitoring.

1.3 Monitoring Scope 2023-24

The latest round of monitoring looked to complete the comprehensive data set started by Aquanet in 2021/22 in the lower catchment and examine the extent of fish distribution in the upper reaches of the catchment.

The 2021/22 monitoring completed by Aquanet did not include fish surveys due to time constraints. eDNA sampling did occur, however the technique used (passive sampling) differed to the standard eDNA sampling technique used by DOC for freshwater monitoring (six-replicate syringe sampling)[3]. The syringe sampling method is also the national standard method used in New Zealand, by regional councils, and other agencies. Field validations indicated that 6 replicates are capable of detecting approximately 90% of species in the area. It is important to keep sampling techniques consistent across monitoring sites to enable reliable comparison. Therefore, the 2023/24 monitoring plan aimed to revisit the six sites surveyed by Aquanet, complete fish surveys, and resample eDNA using the syringe sampling method. This will complete the comprehensive sampling at the lower catchment sites and bring the data in line with the comprehensive monitoring completed in the upper catchment in 2022/23.

Upper catchment monitoring involved eDNA sampling at new sites, further upstream in the catchment than any sites previously monitored as part of this project.

1.4 Monitoring Sites

A total of 9 sites were visited in the 2023/24 monitoring season. Table 1 below provides basic information on each site.

Table 1: Sites visited as part of the 2023/4 monitoring plan

Site Name	Distance Inland (KM)	Altitude (MASL)	Subcatchment
Muaūpoko 1 (M1)	8	51.8	Muaūpoko
Muaūpoko 2 (M2)	5.4	15	Muaūpoko
Muaūpoko 3 (M3)	3.1	4.5	Muaūpoko
Waikanae 1 (W1)	15.5	89	Waikanae
Ngatiawa 1 (N1)	13.6	79	Ngatiawa
WKN2_128	20.7	198	Waikanae
WKN2_498	17.4	295	Maungakōtukutuku
WKN3_167	18.6	237	Ngatiawa
WKN3_12	20.5	174	Waikanae
WKN3_56	20	160	Waikanae

[3] Information on eDNA sampling techniques found on Wilderlab website: wilderlab.co.nz/directions (Wilderlab, 2021)

1.4.1 Lower Catchment

Monitoring sites for the lower catchment monitoring were predetermined as they had been previously surveyed by Aquanet. Six sites were sampled in year 1, three were on the Muaūpoko Stream, and one on each of the Reikorangi, Ngatiawa, and Waikanae Rivers. Resampling of these sites occurred following the approval of landowners, who granted permissions for site access. The site in the Reikorangi subcatchment could not be resampled as landowner permission was not obtained. The other five sites were revisited. Figure 1 below shows the lower catchment monitoring sites.

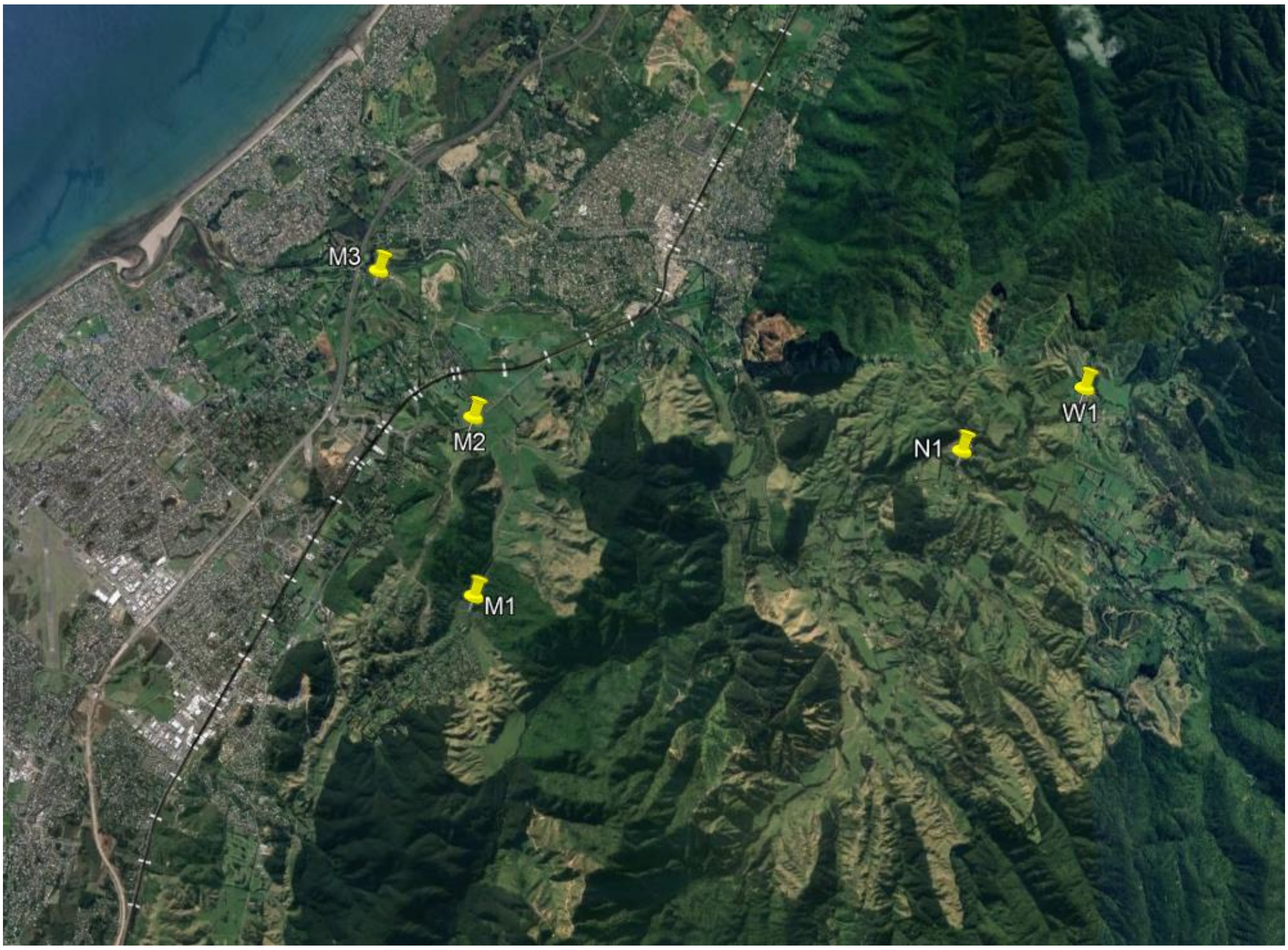

Figure 1: Locations of lower catchment monitoring sites.

The Waikanae and Ngatiawa river sites have large upstream catchments that predominantly consist of the indigenous forest cover of the Tararua Ranges. The Muaūpoko Stream has a much smaller catchment that is predominantly influenced by pasture and urban activities. Figures 2-6 below show a representative image from each of the surveyed sites.

Figure 2: Muaūpoko 1 (M1)

Figure 3: Muaūpoko 2 (M2)

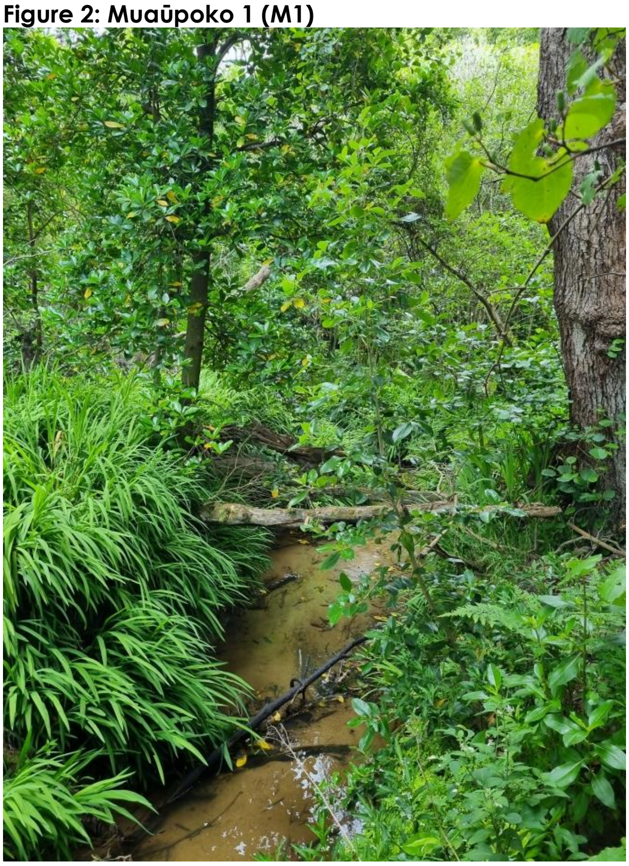

Figure 4: Muaūpoko 3 (M3)

Figure 5: Waikanae 1 (W1)

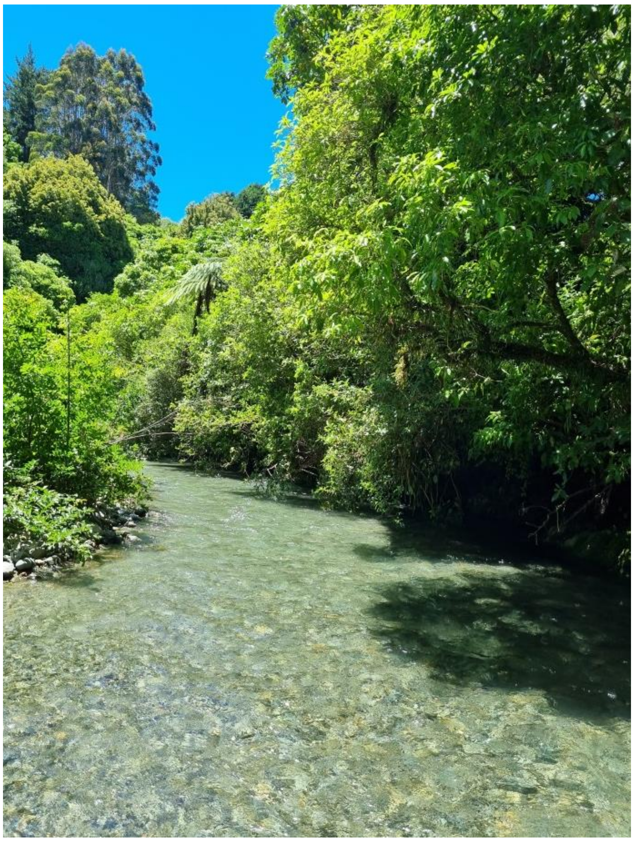
Figure 6: Ngatiawa 1 (N1)

1.4.2 Upper Catchment

Upper catchment sites had not be visited before. Sites were selected from a site list produced from the 2022/23 monitoring round. This list targeted permanent 1-3 order streams in the forested sections of the catchment. Stream orders are a measure of relative size of streams. The smallest are first order streams, which have no other tributaries. When two first order streams meet, it becomes a second order and so on. The Waikanae River is a fourth order river. Nine sites were selected from this list, 3 of each river strata. Of the 9 selected sites, five were surveyed. The surveyed sites were located on public or council land, landowner access was not confirmed for the remaining sites. Three sites were in the Waikanae subcatchment, and one site was in each of the Ngatiawa and Maungakōtukutuku subcatchments. These sites were all upstream of sites previously monitored. Figure 7 shows sites surveyed in the upper catchment.

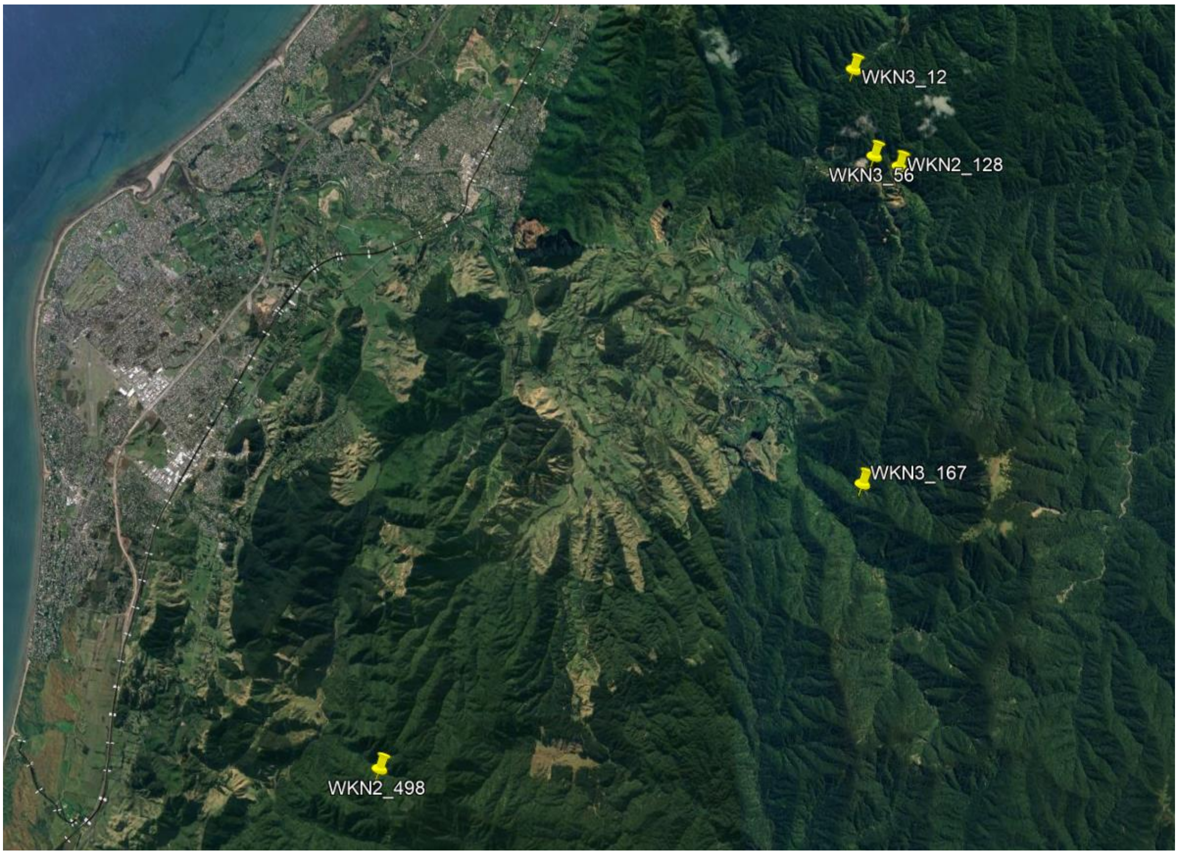

Figure 7: Locations of upper catchment monitoring sites.

All sites were constrained by dense indigenous forest, with the catchments existing within the foothills of the Tararua Ranges. Figures 8-12 below show a representative image of the sites visited.

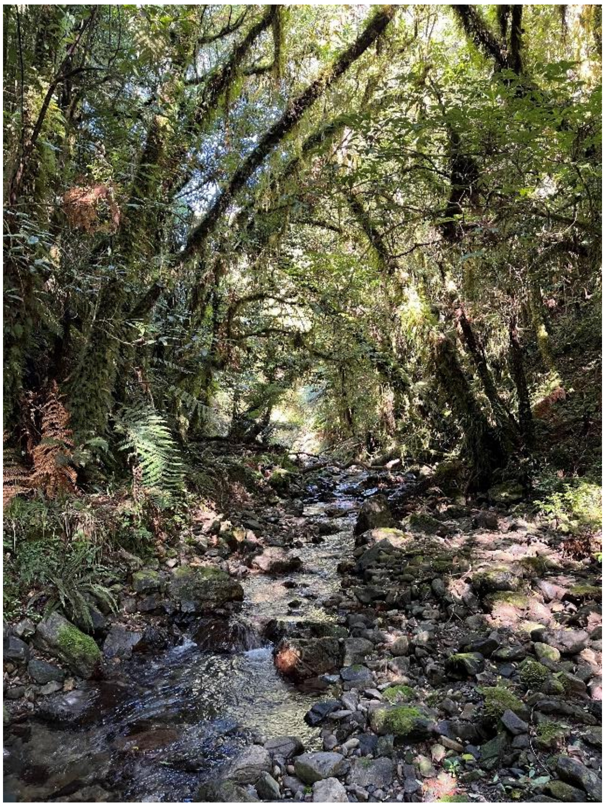
Figure 8: WKN2_128


Figure 9: WKN2_498


Figure 10: WKN3_12


Figure 11: WKN3_167

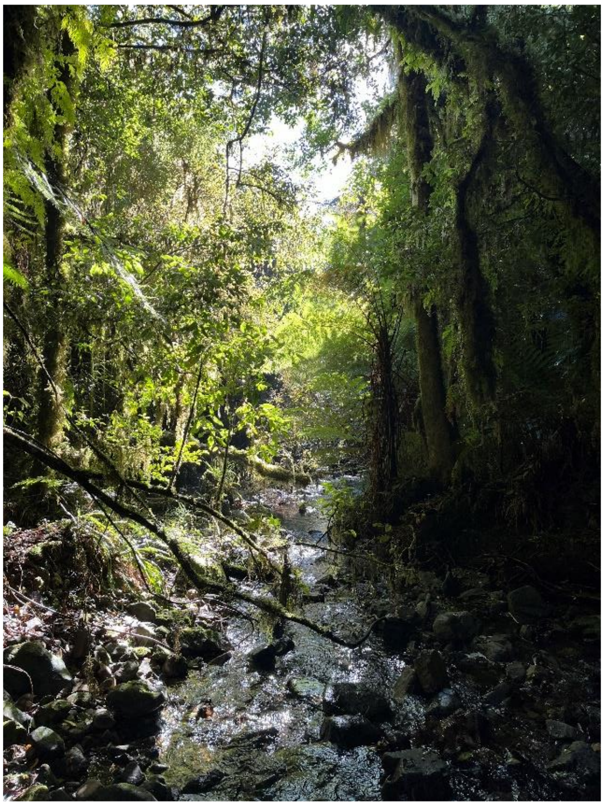

Figure 12: WKN3_56

2. Methododolgy

2.1 Site Selection

DOC produced sites lists for both lower and upper catchment monitoring using Halton Iterative Partitioning (HIP) to generate randomized sampling locations. HIP is a spatially balanced sampling design for environmental surveys. It generates an ordered list of randomized sample locations that are well spread across a study area.[4] Sites were selected from this list based on accessibility and feasibility.

2.2 Electric Fishing

The lower catchment monitoring involved electric fishing. Electric fishing is a commonly used technique to monitor freshwater fish in New Zealand. The technique typically involves two to three people, with one person wearing a backpack electric fishing machine and one or two people holding pole and or dip nets. Electric fishing machines omit an electrical pulse when activated, and temporarily stun fish. Stunned fish move with the flow of the stream or river into the pole net placed two to three metres downstream of the electric fisher. Fish are then transferred to a bucket to recover, before being measured, identified, and released downstream of electric fishing activities.

This survey work employed the Joy (et al) protocol. This protocol was designed specifically for New Zealand rivers, and is the standard protocol used for fish surveys across New Zealand. DOC commonly applies this method, and all electric

[4] See Robertson et al (2018) for more information on HIP: [Halton iterative partitioning : spatially balanced sampling via partitioning (mcdonalddatasciences.com)](mcdonalddatasciences.com) (Robertson, McDonald, Price, & Brown, 2018)

fishing in the Waikanae Catchment that has occurred as part of this project follows this protocol. A full description of the method can be found online.[5]

Fish data was combined to understand fish abundance, and species richness at each site. A Fish Index of Biotic Integrity (F-IBI)[6] was calculated using this data and compared to the National Policy Statement for Freshwater Management 2020 (NPS-FM) (2024). The NPSFM provides direction on how to manage freshwater under the Resource Management Act 1991[7]. For this report, it is used to provide comparative context to understand the health of the sites visited.

The F-IBI is one metric used to assess overall fish community. The F-IBI uses six attributes to assess the integrity of fish communities: number of native taxa (species) present, number of native benthic pool dwelling taxa, number of native benthic riffle-dwelling taxa, number of native pelagic pool-dwelling taxa, number of native intolerant taxa and proportion of native to non-native taxa. Low scores for the F-IBI indicate the absence (or lower diversity) of taxa that belong to these attributes, reflecting loss of biological integrity of the fish communities. This can be interpreted as the consequence of a lack of, or reduction in suitable habitat for those species, pollution reducing the number of pollution-intolerant taxa, or restrictions in fish passage preventing migratory species from reaching upper areas of a catchment.

2.3 eDNA

Environmental DNA (eDNA) is genetic material such as saliva, faeces, scales, skin, and gametes, that is shed by organisms as they interact with their environment. This material can be sampled using filtering techniques and laboratory analysis. Thousands of different fish, macroinvertebrate, mammal, plant, fungi, and bacteria species can be identified.

eDNA sampling was completed at each site in the lower and upper catchment in the 2023/2024 summer monitoring. The sampling technique used was the six-replicate syringe sampling method. This method involves pushing one litre of water through a filter using a syringe. This is completed six times (six different filters) at each site. This method has become the standard eDNA monitoring technique used across New Zealand.

Samples were sent to Wilderlab for comprehensive laboratory analysis.

Wilderlab has also developed a riverine taxon-independent community index (TICI) that assigns health indicator values to both identifiable and unidentifiable eDNA sequences. Sites can be evaluated for ecological health by averaging the indicator values of the DNA sequences present. Currently, fish and macroinvertebrate community surveys are the primary approaches to assessing ecological health. As described above, fish data is used to generate a fish IBI score, which indicates observed versus expected diversity in a given catchment. This score is useful to understand the potential occurrence of issues resulting from pollution and fish passage barriers. Macroinvertebrate samples are collected to produce a Macroinvertebrate Community Index (MCI). Taxa are assigned individual scores based on their susceptibility or tolerance to pollutants. MCI scores are used to categorise a habitats health. Both of these procedures are mandatory under the NPS-FM, despite their limitations and reliance on skilled individuals to conduct monitoring. A study conducted by Wilderlab showed strong correlation between MCI and TICI scores in previously studied systems (Wilkinson, et al., 2024). This correlation suggests TICI scores are a robust metric for assessing ecosystem health and have been used to provide commentary on the sites sampled.

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[5] Joy protocol for fish sampling in New Zealand: New_Zealand_Freshwater_Fish_Sampling_Protocols.pdf (niwa.co.nz) (Joy, David, & Lake, 2013)
[6] Information on F-IBI can be found online at Ministry for Environment: fish-index-of-biotic-integrity-in-new-zealand-rivers.pdf (environment.govt.nz). (Ministry for the Environment, 2023)
[7] Further information on the NPSFM can be found: National policy statement for freshwater management | Ministry for the Environment (Environment, Ministry for the, 2024)

3. Results

3.1 Lower Catchment

3.1.1 Electric Fishing

Electric fishing results are displayed in Table 2 below. Species richness (the number of different species caught at each site) ranged from 4 to 5. Sites M3 and W1 had the highest number of fish caught (133 and 130). F-IBI scores place all sites in attribute band A in the NPS-FM. Five at risk species were caught, all of which are also declining regionally, including kōaro and dwarf galaxiids.

Table 2 Fish species abundance and size ranges (mm) from electric fishing conducted in December 2023.

Species	Common name	Threat status[8]	Regional threat status[9]	Number and size range of fish (mm)				
				M1	M2	M3	W1	N1
Anguilla australis	Shortfin tuna/eel	Not Threatened	Not threatened	2 (90-110)	3 (90-400)	1	-	-
Anguilla dieffenbachii	Longfin tuna/eel	At Risk - Declining	Declining	3 (250-1100)	31 (100-750)	6	12 (100-800)	37 (100-400)
Galaxias sp.	Galaxiid sp.	N/A	N/A	-	-	-	5 (19-33)	-
Galaxias brevipinnis	Kōaro	At Risk - Declining	Declining	-	-	-	3 (55-105)	5 (53-130)
Galaxias divergens	Dwarf galaxias	At Risk - Declining	Declining	-	-	-	15	1 (35)
Galaxias maculatus	Inanga	At Risk - Declining	Declining	2 (82-83)	13	119	-	-
Gobiomorphus gobioides	Giant bully.	At Risk – Naturally Uncommon	Declining	-	1	-	-	-
Gobiomorphus huttoni	Redfin bully	Not Threatened	Declining	2 (57-85)	7	7	88 (35-100)	25 (42-100)
Salmo trutta	Brown trout	Introduced and Naturalised	Introduced and naturalised	-	-	-	22 (48-85)	-
Total abundance				8	57	133	130	68
Species richness				4	5	4	5	4
F-IBI score				34	38	34	44	44
NPS:FM (2020) Attribute Band				A	A	A	A	A
Regional IBI Category				A	A	A	A	A

[8] See the New Zealand Threat Classification System for further information. (New Zealand Threat Classification System, 2024). Fish Classifications are from (Dunn, et al., 2018)
[9] (Crisp, Perrie, & Morar, 2022)

3.1.2 eDNA

NIWA recently created a guide to interpreting eDNA results (Melchior & Baker, 2023). This guideline suggests considering sequence counts >100 in at least 2 out of 6 replicates as indicative of ‘true detection’. Counts that fall below this threshold should therefore be counted as ‘trace’ and ‘tentative’ records with further interpretation required. Table 3 below displays the eDNA results, with those marked with (t) as being trace results.

Trace results could be the result of false positives. False positive occur through contamination, environmental disturbances, and data analysis error. However, it could also be the result of a species being rare or in low abundance in the area, therefore having low detection limits. For the purpose of this report only species with “true detection” results were used to calculate F-IBI. It is considered likely, however, that those with trace results are present in the area but are in low abundance or further upstream.

Freshwater mussels, or kākahi, were also observed at Muaūpoko 3. Freshwater mussels were not recorded in the datasheets for this survey as focus was on fish surveys and eDNA. Field staff noted their presence, however, and took photographs. Photographs, and eDNA results confirm the species as *Echyridella menziesii*, categorized as At Risk – Declining in the NZ Threat Classification System. Their presence is of importance to note as they are a taonga species, and their distribution in the catchment may be of significance and warrant further investigation. Figures 13-17 below show kākahi, plus other freshwater species caught during these surveys.

Table 3: eDNA results, the number of replicates where eDNA is present, where (t) indicates a trace, or tentative result.

Species	Common name	Threat status	Regional threat status	M1	M2	M3[10]	W1	N1
Anguilla australis	Shortfin eel	Not Threatened	Not Threatened	3 (t)	2 (t)	2 (t)	6 (t)	1 (t)
Anguilla dieffenbachii	Longfin eel	At Risk - Declining	Declining	6	6	5	6	6
Cheimarrichthys fosteri	Torrent fish	At Risk - Declining	Declining	-	3 (t)	-	2	-
Galaxias argenteus	Giant kōkopu	At Risk - Declining	Declining	4	-	-	-	-
Galaxias brevipinnis	Kōaro	At Risk - Declining	Declining	-	-	-	6	6
Galaxias divergens	Dwarf galaxias	At Risk - Declining	Declining	-	-	-	6	6
Galaxias fasciatus	Banded kōkopu	Not Threatened	Stable	5	1 (t)	4 (t)	3	1 (t)
Galaxias maculatus	Inanga	At Risk - Declining	Declining	6	6	5	-	1 (t)
Geotria australis	Lamprey	Threatened – Nationally Vulnerable	Declining	-	-	-	5 (t)	-
Galaxias postvectis	Shortjaw kōkopu	Threatened – Nationally Vulnerable	Declining	-	-	-	1 (t)	1 (t)
Gobiomorphus cotidianus	Common bully	Not Threatened	Not Threatened	6	6	5	1 (t)	-
Gobiomorphus gobioides	Giant bully	At Risk - Naturally Uncommon	Declining	-	-	-	1 (t)	-
Gobiomorphus hubbsi	Bluegill bully	At Risk - Declining	Declining	-	-	-	-	3
Gobiomorphus huttoni	Redfin bully	Not Threatened	Declining	6	6	5	6	6
Salmo trutta	Brown trout	Introduced and Naturalised	Introduced and naturalised	-	-	-	6	4
TICI mean score				96.84	89.86	88.24	116.82	121.71
TICI rating				Average	Poor	Poor	Excellent	Pristine
Total number of fish taxa (including trace results)				7	7	6	12	10
F-IBI score (excluding trace results)				52	34	34	50	44
NPS:FM (2020) Attribute Band				A	A	A	A	A
Regional IBI Category				A	A	A	A	A

[10] Only 5 replicates were analysed for site M3 due to a broken syringe.

Figure 13: Kākahi

Figure 14: Redfin bully

Figure 15: Kōaro

Figure 16: Kōaro and redfin bullies

Figure 17: Two longfin tuna.

3.2 Upper Catchment

3.2.1 Fish Passage

Fish passage barriers include manmade structures such as culverts, fords, and weirs, as well as natural features a such as waterfalls. NIWA developed a citizen science app that is free to download. This application allows users to mark barriers to fish passage. No additional barriers to fish passage were observed enroute to eDNA monitoring locations. The online NIWA Fish Passage Assessment Tool maps all the barriers to fish passage that have been mapped across New Zealand.[11] A closer look at the Waikanae area reveals a significant number of barriers that may warrant further investigation.

3.2.2 eDNA

eDNA sampling in the upper catchment (Table 4) revealed longfin eels and kōaro are the most widespread in the catchment, in terms of how far inland they can penetrate. This is unsurprising given both are adept climbers and are known to scale large waterfalls. Site WKN3_56 had the highest diversity of species detected, including lamprey. This is also the only site where shortjaw kōkopu were detected (though only in trace amounts). TICI scores were in the pristine category at all sites, apart from WKN3_12, which was excellent. Sites WKN2_128 and WKN2_498 both scored in category B for F-IBI. Whereas the other three sites are in band A.

Like with lower catchment eDNA results, tentative results were not included in F-IBI calculations, but it is assumed that these species are present either in low abundance, or much further upstream of the sampling location.

Overall, fewer species were detected in the upper catchment. This is to be expected, and species that were detected in the upper catchment are known to be better swimmers and climbers than those not found. Fish habitat is readily available to those that can reach it in the upper catchment.

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[11] NIWA Fish Passage Assessment Tool: [Fish Passage Assessment Tool (niwa.co.nz)]

Table 4: eDNA results, the number of replicates where eDNA is present, where (t) indicates a trace, or tentative result.

Species	Common name	Threat status	Regional threat status	WKN2_128	WKN2_498 [12]	WKN3_167	WKN3_12	WKN3_56
Anguilla dieffenbachii	Longfin eel	At Risk - Declining	Declining	4	5	6	6	6
Cheimarrichthys fosteri	Torrent fish	At Risk - Declining	Declining	-	-	-	3 (t)	3
Galaxias brevipinnis	Kōaro	At Risk - Declining	Declining	6	5	6	6	6
Galaxias divergens	Dwarf galaxias	At Risk - Declining	Declining	-	-	2 (t)	-	-
Geotria australis	Lamprey	Threatened – Nationally Vulnerable	Declining	-	-	-	1 (t)	5
Galaxias postvectis	Shortjaw kōkopu	Threatened – Nationally Vulnerable	Declining	-	-	-	-	3 (t)
Gobiomorphus huttoni	Redfin bully	Not Threatened	Declining	-	-	5	6	6
Salmo trutta	Brown trout	Introduced and Naturalised	Introduced and naturalised	2 (t)	-	6	6	6
TICI mean score				128.56	127.38	131.08	117.76	124.05
TICI rating				Pristine	Pristine	Pristine	Excellent	Pristine
Total number of fish taxa (including trace results)				3	2	5	6	7
F-IBI score (excluding trace results)				28	28	36	36	44
NPS:FM (2020) Attribute Band				B	B	A	A	A
Regional IBI Category				B	B	A	A	A

4. Conclusions and Recommendations

Aquatic life metrics indicate there is healthy biodiversity at each site. Sites in the Muaūpoko subcatchment have lower TICI scores from eDNA in comparison to the other surveyed sites. This is most likely due to the greater urban influence and activities such as pasture grazing. A significant number of at risk and threatened native fish species were caught or detected across the catchment. Species diversity declines higher in the catchment. This is likely the result of barriers to fish passage, both man made and natural. Despite the decline in fish species diversity, ecosystem health improves higher in the catchment.

Three years of sampling in the Waikanae Catchment has created a comprehensive baseline dataset. Understanding of fish populations and distribution in the catchment has greatly improved since starting monitoring work. Further eDNA sampling at new sites will expand this knowledge, however, there is likely sufficient data to begin development of an integrated approach with WKUKT partners.

In preparation for development of future monitoring plans, a catchment wide analysis of the data already collected should be completed. To date, reporting and analysis has been completed at the end of the monitoring season, describing the

[12] Only 5 replicates were analysed for site WKN2_498 due to a broken syringe.

results of the surveys completed that year. Approximately 20 sites have been randomly selected and surveyed over the last three years. The data from all sites should be complied and analysed in a single report. An investigation into whether this data can be extrapolated through robust statistical analysis and applied at a catchment scale should be undertaken.

Compilation of all data presents an interesting opportunity to map fish distributions, habitat quality, and overall biodiversity across the catchment. This investigation may benefit from an analysis of fish passage barriers in relation to fish distribution. This will be informative in prioritizing barriers for remediation, and areas for restoration.

Future monitoring approaches could include targeting surveys to understand specific species distribution. Shortjaw kōkopu and lamprey are both species of significance in the catchment. Understanding their distribution will be significant in prioritizing areas for restoration and remediation. Survey approaches could include pheromone sampling (lamprey), electric fishing, or spotlighting. EOS Ecology noted a lack of spotlighting surveys in the catchment. Spotlighting is particularly effective for shortjaw and giant kōkopu and could help with understanding these species.

It is recommended that future sampling and monitoring plans are designed following analysis of all data, as described above, and after consultation with WKUKT partners.

5. References

Crisp, P., Perrie, A., & Morar, S. (2022). *Conservation status of indigenous freshwater fish in the Wellington region.* Greater Wellington Regional Council.

Dewson, Z. (2022). *Waikanae River Catchment & Estuary: Biodiversity Information Review, Summary of Pressures, and Recommendations.* EOS Ecology.

Dunn, N., Allibone, R., Closs, G., Crow, S., David, B., Goodman, J., . . . Rolfe, J. (2018). *Conservation status of New Zealand freshwater fishes, 2017.* Department of Conservation.

Environment, Ministry for the. (2024). *National policy statement for freshwater management.* Retrieved from Ministry for the Environment: https://environment.govt.nz/acts-and-regulations/national-policy-statements/national-policy-statement-freshwater-management/

Eveleens, R., & Kelly, L. (2023). *Nga Awa Monitoring Programme: Waikanae Catchment Reporting 2023.* Nelson: Cawthron Institute.

Joy, M., David, B., & Lake, M. (2013). *Environmental and Ecological Statistics*. Retrieved from NIWA: https://webstatic.niwa.co.nz/static/web/New_Zealand_Freshwater_Fish_Sampling_Protocols.pdf

Melchior, M., & Baker, C. (2023). *eDNA Guidelines and field protocols for lotic systems.* NIWA.

Ministry for the Environment. (2023). *Fish Index of Biotic Integrity:.* Retrieved from Ministry for the Environment: https://environment.govt.nz/acts-and-regulations/freshwater-implementation-guidance/nof/values-and-attributes/fish-index-of-biotic-integrity/

New Zealand Threat Classification System. (2024). *NZTCS*. Retrieved from New Zealand Threat Classification System.

Robertson, B., McDonald, T., Price, C., & Brown, J. (2018). Halton iterative partitioning : spatially balanced sampling via partitioning. *Environmental and Ecological Statistics*, 305-323.

Wilderlab. (2021). *Directions*. Retrieved from Wilderlab: https://www.wilderlab.co.nz/directions

Wilkinson, S., Gault, A., Welsh, S., Smith, J., David, B., Hicks, A., . . . Bunce, M. (2024). TICI: a taxon-independent community index for eDNA-based ecological health assessment. *PeerJ*.

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