Greater Wellington
Te Pane Matua Taiao

COVER NOTE

Greater Wellington has undertaken this work as part of information gathering leading up to the Whaitua Kāpiti process. This is only part of the information base that the Whaitua Kāpiti Committee may draw from and is not considered to be definitive.

1 Greater Ōtaki water quality and ecology

This report details the current state of water quality and ecology for river and stream environments within the northern catchments of the Kāpiti Whaitua. It also examines the key pressures affecting water quality. Although this memo is primarily focused on the rivers and streams for which National Policy Statement for Freshwater Management 2020 (NPS-FM 2020) [1] attributes exist, it also summarises the known state and ecological condition of lakes, wetlands, groundwater, and estuaries. It is important to note that this memorandum does not describe the state of water quantity, water allocation or water levels.

It is intended that this report will be used by the Kāpiti Whaitua committee and community as a high-level introduction to the state of water quality and ecological condition in the Ōtaki River, Waitohu and Mangaone stream, and Lake Waiorongomai catchments that are collectively referred to as the greater Ōtaki assessment zone. This report predominantly uses scientific data sources and reports collected and / or commissioned by Greater Wellington Regional Council (GWRC), which has been captured by GWRC in a Kāpiti Whaitua database. It by no means represents an exhaustive account of the range of knowledge and data types that exist. For example, this report does not capture the knowledge held by local resource users and/or kaitiaki at the sub-catchment or site scale.

2 Greater Ōtaki Assessment zone

The Greater Ōtaki assessment zone encompasses the watercourses in the northern part of the Whaitua, which roughly overlap with the rohe of Ngā Hapū ō Ōtaki. It includes the large Ōtaki River catchment, the smaller Waitohu and Mangaone stream catchments and the Waiorongomai Lake/Stream catchment (Figure 1).

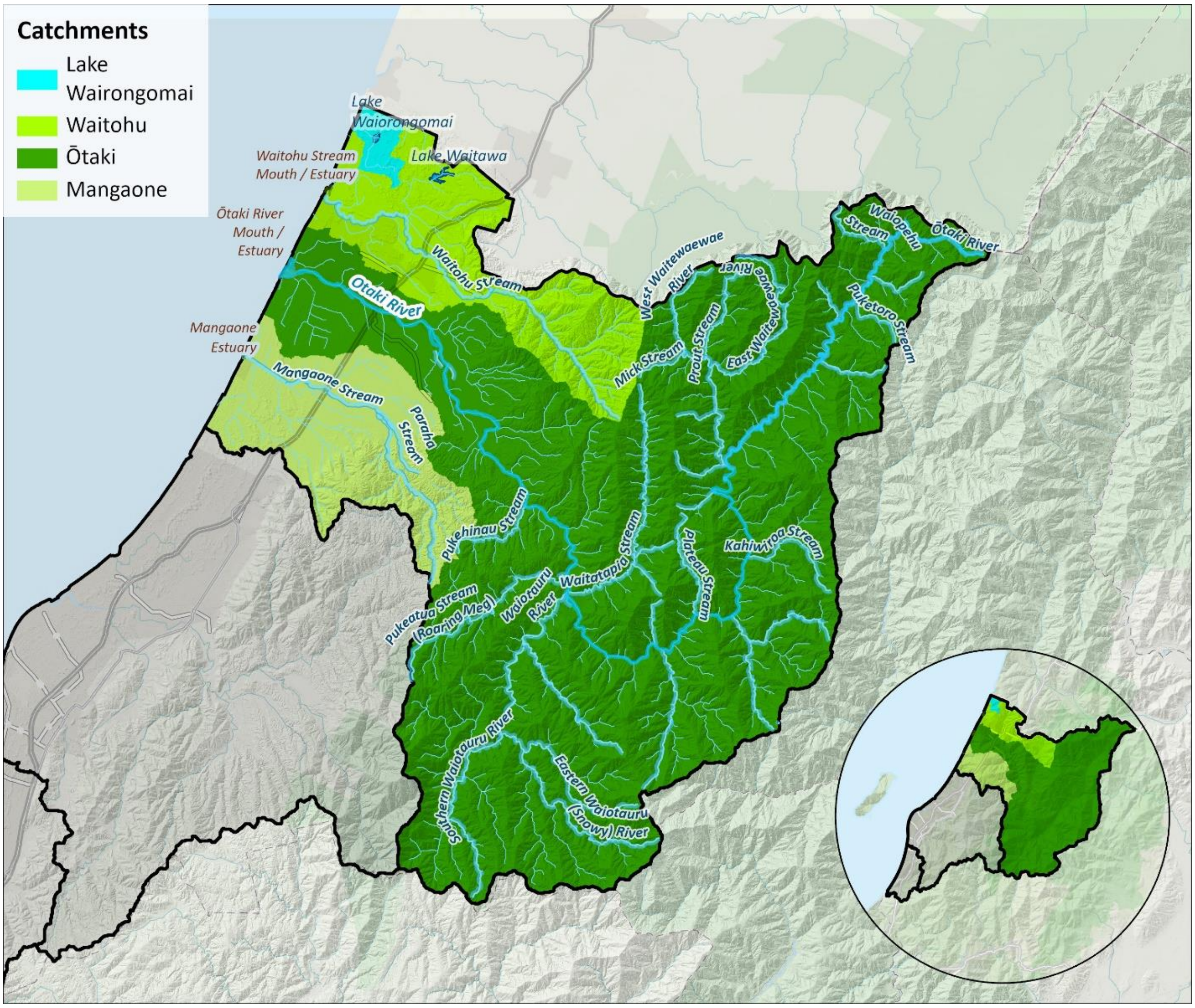

Figure 1: Map of the greater Ōtaki assessment zone.

All three river catchments originate in the Tararua Ranges, while the spring-fed streams that flow into Lake Waiorongomai are located on the coastal sand dune plains north of the Waitohu Stream. Over 80% of the large Ōtaki River catchment is in the Tararua Forest Park (in the conservation estate). Only the headwaters of the smaller Waitohu and Mangaone stream catchments are in the Tararua Forst Park.

The lower reaches of all three river and stream catchments and the entire Lake Waiorongomai catchment are on the Kāpiti coastal dune system, which is part of an extensive dunefield along the west coast of the North Island. The formation of the dunes, around 6,000 years ago, resulted in impeded water movement, giving rise to the once extensive network of wetlands and lakes that defined the Kāpiti Whaitua. Lake Waitawa (in the Waitohu catchment) and Waiorongomai are the two main dune lakes found in this assessment zone, wetlands in the area include Otepua-Paruāukua, Whakapawaewae and Ngatotara.

The Ōtaki, Waitohu and Mangaone watercourses have estuarine receiving environments where they meet the saline water of the Tasman Sea. Other than the Ōtaki Estuary, estuaries in this assessment zone are small, shallow, narrow, and tend to be completely blocked by sand and gravel build up just short of the sea. The Ōtaki Estuary is larger, dominated by freshwater flows instead of tidal flows and the mouth is almost always open.

Landcover in the Greater Ōtaki assessment zone is predominantly indigenous forest cover, the result of most of the large Ōtaki catchment being in the Tararua Forest Park. Over 69% of the assessment zone is in conservation estate. Landcover in the Tararua foothills and coastal sand dunes plains is primarily pastoral. Dairy (8%), sheep and / or beef (6%) and lifestyle properties (7%) are the primary land uses across this landcover. Urban and transport land uses make up 2% of the assessment zone and includes residential housing and commercial buildings, parks and playing fields and roads and footpaths. Ōtaki township and the smaller settlements of Ōtaki beach, Te Horo and Te Horo beach are the main urban areas in the assessment zone. According to the 2018 census the wider Ōtaki Region is home to ~9,000 people, with 3,489 and 1,818 located in Ōtaki and Ōtaki beach settlements, respectively.

State highway 1 and the main North Island rail line intersect all three catchments and are the main interior routes both north and south.

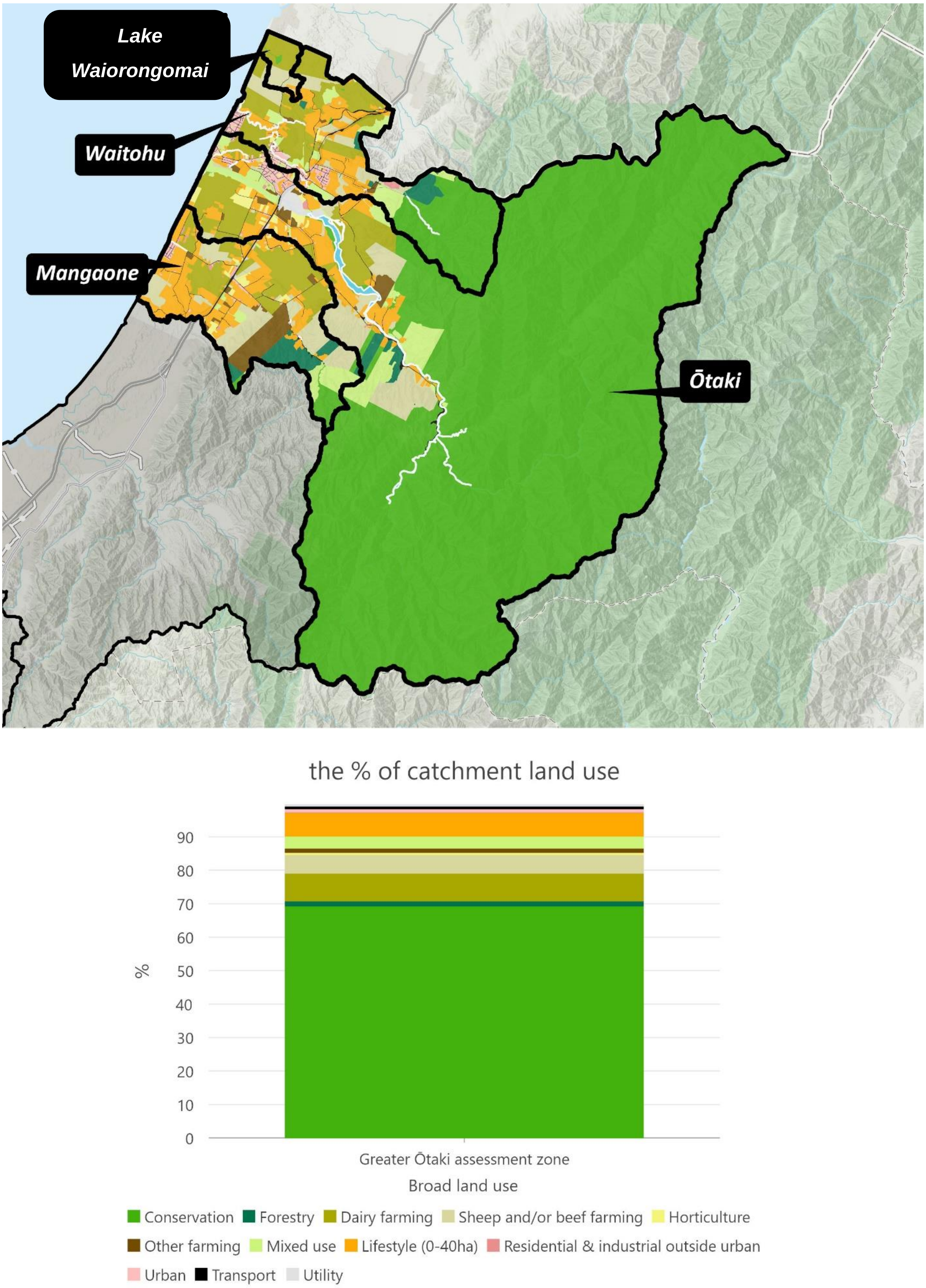

Figure 2: Greater Ōtaki landcover and land use

2.1 Waitohu Stream catchment

Catchment description

The Waitohu Stream catchment is the northernmost catchment of the greater Ōtaki catchment assessment zone and Kāpiti Whaitua and covers an area of 5,300 ha. The headwaters of the Waitohu Stream are in the foothills of the Tararua Forest Park. In the upper catchment there is a mixture of indigenous and plantation forest and low intensity sheep and/or beef farming. As the stream reaches the coastal sand dune plains, land use changes to predominantly dairy farming and lifestyle blocks, which continues all the way to the sea.

On its journey to the sea the Waitohu Stream is joined by two major tributary streams, the Ngā Totara and Mangapouri. The Ngā Totara Stream catchment is to the north of the Waitohu Stream mainstem and contains Lake Waitawa and several wetlands. Lake Waitawa is a shallow (~7m deep) and small (<16 ha) dune lake located on the northern boundary of the Waitohu catchment. The spring fed Mangapouri Stream flows through the township of Ōtaki before merging with Waitohu Stream near the coast.

The Waitohu Stream estuary is relatively small and shallow. Near the coast the channels' location varies widely as it meanders 500-800m over the beach, occasionally creating a shallow lagoon on the upper beach to the north of the estuary. The mouth can also block for short periods because of the build-up of sand and requires regular opening to control for flood risk.

Land use

Over half of the Waitohu Stream catchment is in pastoral land cover with the main land uses being dairy farming (24%), lifestyle blocks (16%) and sheep and/or beef farming (8%). Arable farming, horticulture, and market gardening make up 1% of the overall catchment land use.

Conservation land use, which is primarily indigenous forest located in the Tararua Forest Park, represents 32% of the catchment land use. Exotic forestry represents less than 4% of the catchment land use, while the urban environments of Ōtaki and Ōtaki beach make up 4%.

Ecological values

The Waitohu Stream and tributaries are recognised in Schedule F1 of the pNRP as a river with significant indigenous ecosystems. Sixteen indigenous fish species have been found in the catchment, including nine species listed as 'At Risk' or 'Nationally Vulnerable' (brown mudfish, longfin eel, giant kōkopu, shortjaw kōkopu, kōaro, inanga, redfin bully, torrent fish and lamprey), and the lower tidal reach has inanga spawning habitat.

The Waitohu Estuary is also recognised in the pNRP for providing seasonal or core habitat to indigenous migratory fish species and for providing important habitat for a variety of shorebirds, waders, and waterfowl, including the threatened or at-risk species: red-billed gull, variable oystercatcher, banded dotterel, pied stilt and caspian tern. The estuary also includes a relatively extensive salt march habitat, which has been lost from many smaller estuaries on the Kāpiti Coast. Human use and interest in the estuary is high and supported by active community restoration initiatives with pest and weed control and riparian planting of the estuary fringes and dune.

2.2 Ōtaki River catchment

The Ōtaki River is ~45kms long and its catchment, most of which is in the Tararua Forest Park, is the largest in the Kāpiti Coast (~36,000 ha). In the Tararua Forest Park the river is joined by three major tributaries, the Waitapia and Pukeatua streams and Waiotauru River. The catchments of these tributaries are covered in indigenous and regenerating indigenous forest. Logging occurred in the Ōtaki River catchment in the early 1900s, the remnants of which can still be seen today. The river takes it full shape at Ōtaki Forks before exiting the Forest Park and entering the Ōtaki Gorge.

The catchment narrows in the middle and lower reaches, confined between the Waitohu catchment to the north and Mangaone catchment to the south. Along its journey from the gorge to the sea the river becomes braided in places and is joined by several small spring fed streams, including Ngatoko and Rangiuru. Land in the lower Ōtaki catchment is extensively drained and there are large networks of drains across the rural landscape the extend into both the Mangaone and Waitohu catchments.

Drinking water for the Ōtaki and Ōtaki beach communities is from groundwater, with bores located at both Hautere near the Ōtaki River and Tasman and Rangiuru roads near Ōtaki township.

In the foothills of the Tararua Range, in the Ōtaki Gorge area, there is a mixture of sheep and/or beef and deer farming, exotic forestry, and lifestyle blocks. This transitions to predominantly dairy farming and lifestyle blocks with some urban, market gardening and sheep and/or beef in the lower reaches on the coastal dune plains. The river terminates at Ōtaki Beach and Estuary.

The lower reaches of the river are a flood risk in high flows to the nearby land and settlements; flood protection mitigations such as gravel extractions and channel straightening are required to manage this risk.

Land use

Eighty four percent of the Ōtaki River catchment is used for conservation, the majority of which is in the Tararua Forest Park. The remaining land use in the catchment is primarily farming and lifestyle blocks; 4% dairy farming, 3% sheep and/or beef farming and 3% lifestyle blocks. Exotic forestry and horticulture make up 0.5% and 0.5% of catchment land use, respectively. Urban landcover only represents 0.5% of the overall catchment land use.

Ecological values

The upper Ōtaki River (upstream of, and including, the confluence with the Pukeatua River) has been identified as an outstanding waterbody in the GWRC PNRP for the indigenous ecosystems it supports. Assessment criteria include high macroinvertebrate health, high indigenous fish diversity and abundant habitat for nationally threatened fish species. Only two other rivers in the Region meet the outstanding waterbody criteria. The rest of the Ōtaki River and its tributaries are also scheduled in the PRNP as supporting significant indigenous ecosystems, including inanga spawning habitat.

Ten indigenous fish species have been found in the Ōtaki River catchment, including seven species listed as ‘At Risk’ or ‘Nationally Vulnerable’ (longfin eel, giant kōkopu, shortjaw kōkopu, kōaro, inanga, redfin bully and torrent fish).

The Ōtaki River is identified as an important trout fishery, while its tributaries are also important trout spawning waters. Ōtaki Lake, is a recognised trout fishery and is particularly popular with children – 'take a kid' fishing days are a regular occurrence.

The river and estuarine environment provide significant habitats for indigenous birds; seven threatened or at-risk species are resident or regular visitors to this site: banded dotterel, pied stilt, black shag, pied shag, white-fronted tern, red-billed gull, and NZ pipit. The estuary and beach support the largest breeding populations of both banded dotterels and black-fronted dotterels on the west coast of the North Island south of the Manawatu River.

2.3 Mangaone Stream

The Mangaone stream originates in the foothills of the Tararua Forest Park and terminates at Mangaone estuary at Te Horo Beach and flows for ~12kms. The catchment covers ~4,900 ha and borders the Ōtaki catchment in the north and east, and the Te Kowhai and Waikanae catchments to the south and west, respectively.

In its lower reaches, the Mangaone Stream is slow flowing, dominated by macrophytes and has a soft sediment meaning the stream bed is covered by fine sediments, not gravels and cobbles. Several small spring fed tributaries flow in to the Mangaone Stream on its journey to the coast. There are also several wetlands in the catchment including the large Te Hapua wetland complex. Many of the wetland areas in the lower reaches of catchment have been historically drained for agriculture; an extensive network of drains exists along the coast between the Mangaone and Ōtaki catchments.

Land use

The Mangaone catchment is dominated by pastoral (~70%) landcover with beef and/or sheep (18%), dairy, deer farming (22%) and life-style blocks (27%) being the most common land uses. Dairy farming is spread across the lower parts of the catchment, while sheep and / or beef and some deer farming occurs on the lower foothills of the Tararua Range. Lifestyle blocks are predominantly spread across the lower catchment. Forestry, primarily on the foothills of the Tararua Range, represents 7% of the catchment land use. There is a small amount of urban cover at the Te Horo and Te Horo beach townships (~1%).

Ecological values

Nine indigenous fish species have been found in the Mangaone catchment, including five species listed as at risk or nationally vulnerable: longfin eel, shortjaw kōkopu, kōaro, inanga and redfin bully. The Mangaone estuarine area also provides inanga spawning habitat.

2.4 Lake Waiorongomai

The small (~390 ha) coastal Lake Waiorongamai catchment is located approximately 3 kms to the north of Ōtaki near the Wellington and Horizon regions border. Lake Waiorongomai itself is a small (6 ha) and shallow (~1 m deep) coastal dune lake, which discharges directly to the sea via the Waiorongomai Stream. The surrounding environment contains several wetlands and dune features.

The Waiorongamai catchment is almost entirely in pastoral landcover dominated by dairy (58%) and sheep and beef (33%) land use.

3 Drivers and indicators of ecosystem health & human health and data sources

The NPS-FM 2020 [1] contains a set of nationally consistent measures of water quality, such as *Escherichia coli* (*E. coli*) as a measure for pathogenic infection risk. These measures are called 'attributes' in the NPS-FM 2020 National Objectives Framework (NOF). In turn, the attributes have states ('attribute states') ranging from A to D & E. In most cases the boundary between C and D attribute states represents the nationally accepted bottom line.

Water quality and ecological condition (ecosystem health) have been primarily assessed against the NOF attributes states, which includes measures of ecological toxicants, nutrients, sediment, periphyton, macroinvertebrates and fish. Suitability for human contact has been assessed against the *E. coli* NOF attribute. Collectively the NOF attributes are a good holistic indicator of overall waterbody health. Additional attributes of water quality and ecological health (copper, zinc, and habitat) and human health (toxic algae), for which there are no NOF attributes have also been assessed. Table 1 outlines the attributes assessed and the source of the guideline they have been assessed against.

Ten-year trends were also assessed for most of the attributes following the methodology of McBride (2016) [2], which is the method used by Land Air Water Aotearoa (LAWA) https://www.lawa.org.nz/learn/factsheets/calculating-water-quality-trends-in-rivers-and-lakes/.

It is important to note the NOF attributes are restricted to lotic (rivers and streams) and lentic (lakes only) and do not include measures of groundwater, wetlands, or estuaries. In section 5, a summary of state, trends and pressures are provided for each of these environmental domains to provide a more complete understanding of the state of water quality across the Greater Ōtaki assessment zone.

Table 1: Attributes used to assess river ecosystem health and human health

Attributes class	Attributes assessed	Abbreviation	Trends	Attribute state framework source
Ecological toxicants	Copper	Cu	No	Copper and zinc attributes developed by Auckland Council [3] and applied in Te Awarua-o-Porirua Whaitua. These attributes are currently in the process of being adopted in GWRC NRP.
	Zinc	Zn	No	
	Total ammoniacal-nitrogen	NO_3-N	Yes	NPS-2020 NOF Attribute
	Nitrate-nitrogen	NH_4-N	Yes	NPS-2020 NOF Attribute
Dissolved oxygen	Dissolved oxygen	DO	No	NPS-2020 NOF Attribute
Sediment	Suspended sediment		Yes	NPS-2020 NOF Attribute
	Deposited sediment		No	NPS-2020 NOF Attribute
Nutrients for growth	Dissolved inorganic nitrogen	DIN	Yes, but as N Nitrite-Nitrate nitrogen	Nutrient criteria thresholds to achieve periphyton biomass NOF attribute states (Matherson et al. 2016) [4]
	Dissolved reactive phosphorus	DRP	Yes	NPS-2020 NOF Attribute
	Periphyton biomass		No	NPS-2020 NOF Attribute
Habitat	Habitat			Narrative assessment of stream rapid habitat assessment results (Clapcott et al, 2015) [5]
Ecology	Macroinvertebrates (Macroinvertebrate Community Index)	MCI	Yes	Wellington specific MCI grades developed by Clapcott and Goodwin (2014) [6] and developed into a NOF styled attribute state framework[1].
	Macroinvertebrates (Average Score Per Metric)	ASPM	No	NPS-2020 NOF Attribute
	Fish Index of Biotic Integrity	IBI	No	NPS-2020 NOF Attribute
Human Health	*N Escherichia coli*	*E. coli*	Yes	NPS-2020 NOF Attribute
	Benthic cyanobacteria	Toxic algae	No	Narrative assessment against the New Zealand guidelines for cyanobacteria in recreational fresh waters interim guidelines (MfE 2009) [7]

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[1] Wellington specific MCI attribute state framework is similar to the nationwide national objectives framework attribute but accounts for variability in factors such as climate, geology and topology.

3.1 Data sources

Current attribute state for the parameters in Table 1 were primarily assessed from data collected as part of GWRC's River Water Quality and Ecology (RWQE) monitoring programme (the RWQE sites are provided in Table 2 and their location in Figure 3) [8,9]. Additional data was also sourced from GWRC's Recreational Water Quality Monitoring programme [10] and Kapiti Coast District Council's (KCDC) stormwater monitoring programme, a requirement of their stormwater discharge n consent(s)[2] [11,12].

Attribute states for some of the parameters were also assessed at each River Environmental Classification (REC) reach (a reach is a section of river or stream between inflowing tributaries). These used empirical water quality and ecology models to address gaps for catchments where there is no monitoring site(s) and assess spatial variability in attribute states within and across catchments.

Table 2. Greater Wellington Regional Council River Water Quality and Ecology (RWQE) monitoring sites

Catchment	Site	Substrate (soft or hard bottomed)	Dominant land cover
Waitohu Stream	Mangapouri Stream at Bennetts Road	Soft	Urban
	Waitohu Stream at Forest Park*	Hard	Indigenous Forest
	Waitohu Stream at Norfolk Crescent	Soft	Pasture
Ōtaki River	Ōtaki River at Pukehinau	Hard	Indigenous Forest
	Ōtaki River at Mouth	Hard	Indigenous Forest
Mangaone Stream	Mangaone Stream at Sims Road Bridge	Soft	Pasture

* Historic monitoring stie. Monitoring at this site ended July 2016. No trend assessments were undertaken for this site.

It is important to note that monitoring at the Waitohu Stream at Forest Park site ceased in July 2016. The site has been included to provide a better spatial coverage of the state of streams in the Ōtaki assessment zone. Given there has been no monitoring data collected from this site in over 5 years trends have not been assessed.

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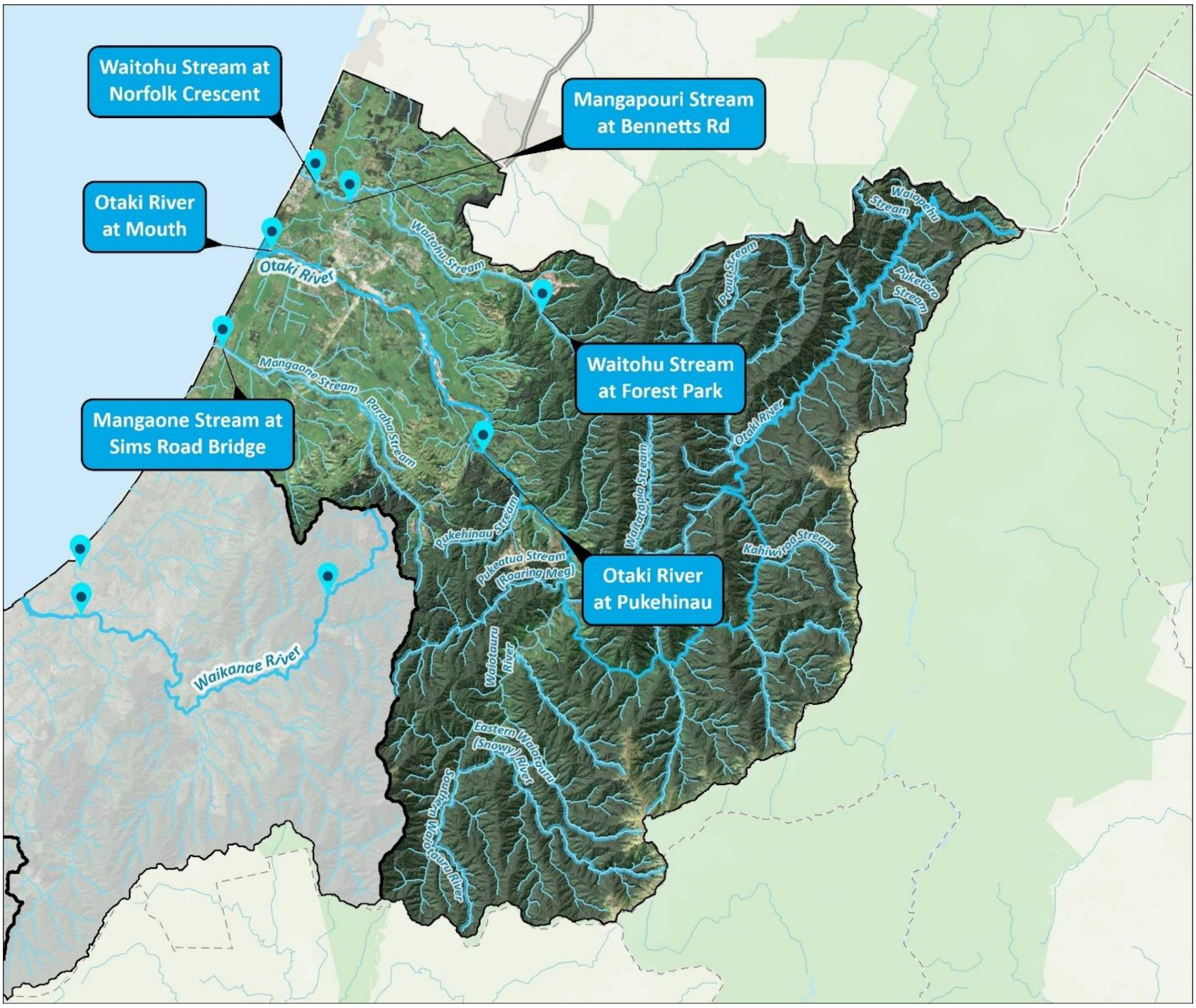
[2] Data from KCDCs stormwater discharge monitoring programme has been acquired and assessed from both their current 5-year global stormwater consent (granted in 2018) and their previous stormwater consent between 2006-2016.

Figure 3: Greater Ōtaki assessment zone monitoring sites



4 Current state, trends, and pressures

4.1 Ecological toxicants

Table 3: Ecological toxicants copper, zinc, nitrate-nitrogen, and total ammoniacal-nitrogen attribute states

Site	Ecological toxicants attribute states			
	Copper	**Zinc**	**Nitrate-nitrogen**	**Total ammoniacal-nitrogen**
Mangapouri S at Bennetts Rd	C	B	B↑↑	B↓↓
Waitohu S at Forest Park	*	*	A	A
Waitohu S at Norfolk Cres	*	*	A↑	A↓
Ōtaki R at Pukehinau	*	*	A↓↓	A[#]
Ōtaki R at Mouth	*	*	A↓↓	A[#]
Mangaone S at Sims Rd Br	*	*	B↓	B↓↓

* Attribute not monitored at this site. ↑↑ very likely improving trend. ↑ likely improving trend. – indeterminate trend. ↓ likely degrading trend. ↓↓ very likely degrading trend. [#] Could not be assessed due to number of censored values (values below laboratory detection limit). Blue, excellent (A state). Green, good (B state). Yellow, fair (C state). Red, poor (D state).

Copper and zinc

Copper and zinc at elevated concentrations in the water column can be toxic to aquatic fauna and flora. Exposure to copper and zinc can lead to adverse effects on survival, growth, reproduction as well as alterations of brain function, enzyme activity, blood chemistry, and metabolism [13].

Long-term copper and zinc monitoring data only exists for the Mangapouri Stream at Bennetts Road monitoring site. Greater Wellington Regional Council monitoring of copper and zinc has been limited to urban catchments where metal contaminants are predominantly generated.

Concentrations of copper and zinc at the Mangapouri Stream site were in the C and B state, respectively. At these concentrations chronic exposure to copper starts impacting regularly on the 20% most sensitive species, while zinc concentrations are impacting occasionally on the 5% most sensitive species.

Copper and zinc monitoring has also been undertaken by KCDC at three different Mangapouri Stream sites (Rahui Road, Anzac Road and Bennetts Road) as part of their stormwater discharge monitoring programme [12]. Monitoring between 2006 and 2016 indicates A state concentrations for both copper and zinc at the upstream Rahui Road control site (above Ōtaki township), but B and B/C state zinc at copper concentrations at the Anzac Road and Bennetts Road sites, respectively. The downstream of Ōtaki township results are generally consistent with GWRCs results. Note, the monitoring methods used (targeted wet and dry weather monitoring) by KCDC do not directly align with the requirements for the zinc and copper attribute frameworks being used for this assessment.

Zinc and copper can also accumulate in bed sediments, meaning that toxicity effects can build up over time. This is a concern in areas of sediment deposition such as estuaries, which can be biodiversity hot-spot and support rare and threatened habitat types. Monitoring undertaken of bed sediments in the Mangapouri Stream undertaken in 2010/11 by KCDC as part of their stormwater consent [12] showed that recoverable metal concentrations were all within ANZECC[3] (2000) guidelines, other than at the immediate location of a stormwater outlet, which exceeded the ISGC-Low trigger values [14]. This is consistent with an earlier investigation by Milne and Watts (2008) [15], who analysed bed sediments from three different Mangapouri stream sites in 2005, all of which were below the ANZECC guidelines [15].

Stormwater run-off is the main source of copper and zinc in urban areas. Copper accumulates on paved surfaces, such as car parks, and roads from vehicles (engine, tire, and break-pad wear) and building materials (roofing, treated wood and water pipes) and enters the stormwater system predominantly during rainfall [3,16]. The primary sources of zinc in urban streams are from unpainted galvanised roofs and vehicle tyre wear [16].

Copper and zinc are also indicators for other urban generated stormwater toxicants and contaminants such as polycyclic aromatic hydrocarbons, pesticides, persistent organic pollutants (such as DDT) and other metals (i.e., lead, nickel, cadmium, and chromium), all of which can be toxic to aquatic life.

Other than the Mangapouri stream, which receives large volumes of stormwater run-off from the Ōtaki township, copper and zinc concentrations are generally expected to be in low concentration (A state) throughout the mostly rural assessment zone.

Total ammoniacal-nitrogen and nitrate-nitrogen

Like zinc and copper, ammonia and nitrate can be toxic to aquatic life. Nitrate is toxic to invertebrates and fish in high concentrations, as it interferes with oxygen transport in the blood, and consequently, metabolic function [17]. In humans this effect is known as methemoglobinemia, and is often referred to as blue baby syndrome, due to the cyanosis (blue skin colouration) commonly observed in affected children [18]. Ammonia toxicity occurs when accumulations inside the body interfere with metabolic processes and increase body pH [17,19]. When exposed to extreme concentrations of ammonia, fish go into convulsions followed by coma, and death.

All monitoring sites were in the A attribute state for both nitrate and ammonia toxicity except for the Mangapouri and Mangaone, which were in the B state for both metals.

At A state concentrations (99% species protection level) any effects on ecosystem health are likely to be negligible. Ammonia and nitrate are expected to have occasional impacts on 5% of

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[3] Australian and New Zealand Environment and Conservation Council (ANZECC 2000) Interim Sediment Quality Guidelines (ISQG)

the most sensitive species at B state concentration (i.e., 95% species protection). All sites were above (better) the national bottom line, which is set at the 95% species protection level (the B/C attribute state boundary).

These data suggest that nitrate and ammonia concentrations across the greater Ōtaki zone are generally at low levels and will only be having minor effects on aquatic life. However, increasing total ammoniacal-nitrogen concentrations at the Mangapouri and Mangaone stream sites is of concern and indicates increased pressure is being placed on both streams. The reason for increasing concentrations at both Ōtaki River sites is unclear but may indicate a change in landcover/land use in the upper catchment above the Pukehinau monitoring site.

In urban areas, wastewater is the main source of nitrate and ammonia, generally from broken and/or cross connected (to stormwater) infrastructure. In rural areas wastewater from septic tanks, animal excrement and urine and application of inorganic fertilisers are generally the major sources.

4.2 Dissolved Oxygen

Dissolved oxygen (DO) is a vital component of water quality and at low levels can have significant impacts on aquatic organisms. The amount of oxygen fish and macroinvertebrates can absorb across the membranes of respiratory organs is heavily dependent on environmental oxygen conditions, reductions in external DO limits the supply of oxygen to body tissues [20]. Long-term exposure to low oxygen levels can hinder reproductive success, reduce growth rates, and decrease mobility [21]. Low oxygen levels become lethal when oxygen supply is no longer adequate to meet the energy demands essential for life functions [22].

The annual minimum DO saturations from monthly spot samples for the 2020-21 monitoring year were graded against the NPS-FM (2020) dissolved oxygen attribute 1-day minimum thresholds for each site. Dissolved oxygen can fluctuate dramatically between and within days. Therefore, the single monthly measurements of DO saturation presented in this report are not representative of the full 24-hour (diurnal) range of conditions and can only be used to identify when issues exist.

Table 4: Attribute states for dissolved oxygen

Site	Dissolved oxygen
Mangapouri Stream at Bennetts Road	D
Waitohu Stream at Forest Park[4]	A
Waitohu Stream at Norfolk Cres	B
Ōtaki River at Pukehinau	A
Ōtaki River at Mouth	A
Mangaone Stream at Sims Road Bridge	D

One-day minimum DO concentrations at the two Ōtaki River sites and the upstream Waitohu site were graded as excellent (A state). Although DO concentrations did not breach the 1-day minimum national bottom line, it does not necessarily mean that the thresholds were not breached at any point during this period. However, it is unlikely that there are low DO concentrations in the cobble dominated and fast flowing Ōtaki River, where large riffle sections (white water reaches) oxygenate the watercourse.

The Mangaone and Mangapouri Stream sites had a one-day minimum concentration that place them in the D attribute band and in exceedance of the national bottom line. At these concentrations there is significant stress on aquatic organisms and a high likelihood of local extinctions of oxygen sensitive macroinvertebrate and fish species.

Hypoxia (low in oxygen levels) is often caused by organic enrichment, such as nutrient and sediment inputs. Stream microbes consume oxygen as organic matter decays and therefore strip the water of oxygen. Slower moving low gradient streams are more susceptible to hypoxia, so too are those streams that experience warm water temperatures. The concentration of DO is inversely related to water temperature, less oxygen is able to dissolve in water at warmer temperatures.

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[4] Note the DO concentrations assessed for the Waitohu S at Forest Park monitoring stie are for the 2015-16 monitoring year (July 1 – June 30)

4.3 Sediment

Table 5: Attribute states for suspended and deposited sediment

Site	Sediment attribute states	
	Suspended sediment	**Deposited sediment**
Mangapouri Stream at Bennetts Road	D↑↑	*
Waitohu Stream at Forest Park	A	A
Waitohu Stream at Norfolk Cresent	D↑↑	D*
Ōtaki River at Pukehinau	A↑	A
Ōtaki River at Mouth	B↑↑	A
Mangaone Stream at Sims Road Bridge	B↑	*

* Attribute not assessed at this site (has naturally soft sediments). ↑↑ very likely improving trend. ↑ likely improving trend. - indeterminate trend. ↓ likely degrading trend. ↓↓ very likely degrading trend. Blue, excellent (A state). Green, good (B state). Yellow, fair (C state). Red, poor (D state).

Suspended sediment

At high concentrations, suspended sediments can have a range of direct and indirect negative ecological effects. Physical abrasion and reduced light penetration at high suspended sediment concentrations can reduce periphyton and macrophyte (algae, slime, and plants) abundance [23–25], thereby limiting food availability to macroinvertebrates [26]. This, combined with increased drift as macroinvertebrates are dislodged by sediment, can reduce macroinvertebrate abundance [26,27]. Fish can also be impacted by high suspended sediment concentrations by reduced recruitment of migrating juveniles, clogged gills, reduced feeding performance, and reduced food availability [26,28–30].

The NPS-FM 2020 defines numeric attribute states for suspended sediment to protect aquatic life (macroinvertebrates and fish). The attribute state thresholds are corrected for natural variability in catchment geology, climate, and topography. The suspended sediment (water clarity) attribute is assessed by measuring how far away (in metres) a black target (black disc) can be seen horizontally through the water. The further away the distance the disc can be seen at, the clearer the water.

Water clarity was variable across the greater Ōtaki assessment zone. Headwater forested sites (Ōtaki River at Pukehinau and Waitohu at Forest Park) were in the A state, the Ōtaki River at Mouth and Mangaone Stream sites were in the B state, while the lower Waitohu Stream and Mangapouri sites were both in the D state and below the national bottom line, indicating significant sediment inputs. Similarly, the national model developed by Whitehead et al. (2019) [31] estimated visual clarity to be in the A state in the Tararua Forest Park but in a poorer state in the Tararua foothills and coastal dune plains where most river/stream sections, except for the Otaki River, are in the D attribute state. Figure 4 shows those the modelled estimate states for river reaches across the assessment zone.

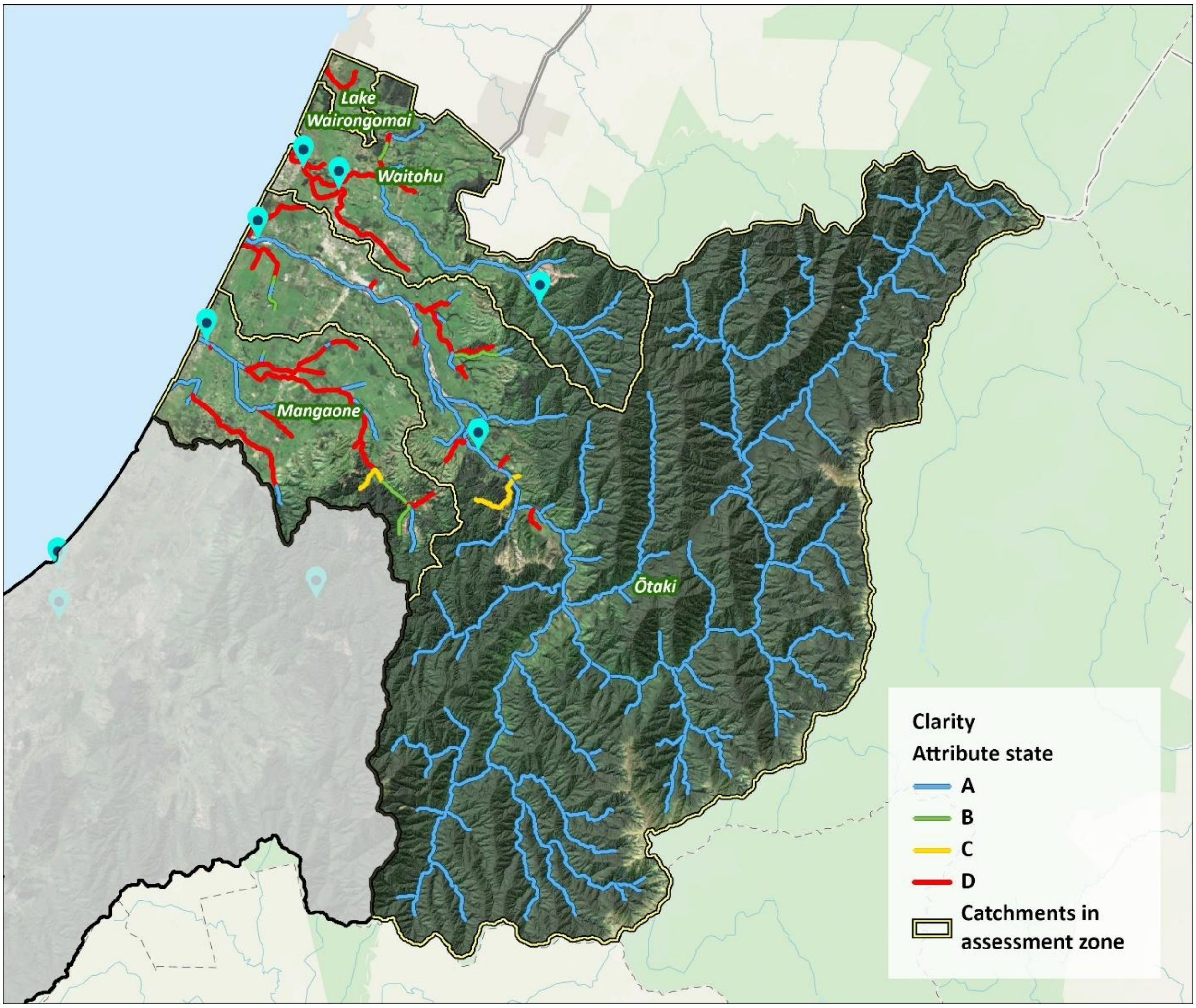

Figure 4: Predicted visual clarity NPS-FM attribute states for each stream reach using national scale model (Whitehead 2018).

At the D state suspended sediment concentrations are likely to be having a significant impact on instream biota. Ecological communities are expected to be considerably altered and sensitive fish and macroinvertebrate species may be lost or at high risk of being lost. In the B attribute state, a low to moderate impact is expected such as the abundance of some fish species may be reduced. Minimal impact is expected at A state, at these concentrations ecological communities are likely to be similar to those observed in natural reference conditions.

Improving water clarity trends were observed at all sites across the assessment zone. The improving trends are, in part, thought to be the result of sampling methodology and a shift from perspex black disc viewers, which would become cloudy and scratched over time, to glass disc viewers ~6 years ago. There was up to a c. 20% difference between the two viewers.

Deposited sediment

Deposited fine sediment also has a range of negative effects on stream ecosystems. Excessive fine sediment deposition reduces food and habitat availability to macroinvertebrates by smothering periphyton and macrophytes [26,32,33] and infilling the spaces between the gravels and cobble [26,34]. In addition, sediment deposition can affect benthic macroinvertebrates by reducing dissolved oxygen near the riverbed [35]. Deposited fine sediment can also be a source of nutrients to some periphyton species [36,37].

The effects of sediment deposition on macroinvertebrates can alter food availability to the fish species that prey upon them [38,39], which can affect fish growth rates and macroinvertebrate community structure9 [26,40]. Deposited sediment can also affect the reproductive performance of freshwater fish species. The availability of spawning habitat is a major determinant in the success or failure of fish populations, and large amounts of deposited sediment can have significant impacts on fish species that spawn in or on the bed of rivers and streams [34].

The deposited sediment attribute also corrects for natural variability in catchment geology, climate, and topography and excludes those rivers and streams dominated by soft sediment (e.g., silt and sand) using the river environmental classification (REC) system. Both the Mangapouri Stream at Bennetts and Mangaone at Simms Road monitoring sites are soft bottomed, Figure 5 shows those sites with naturally soft sediments sites.

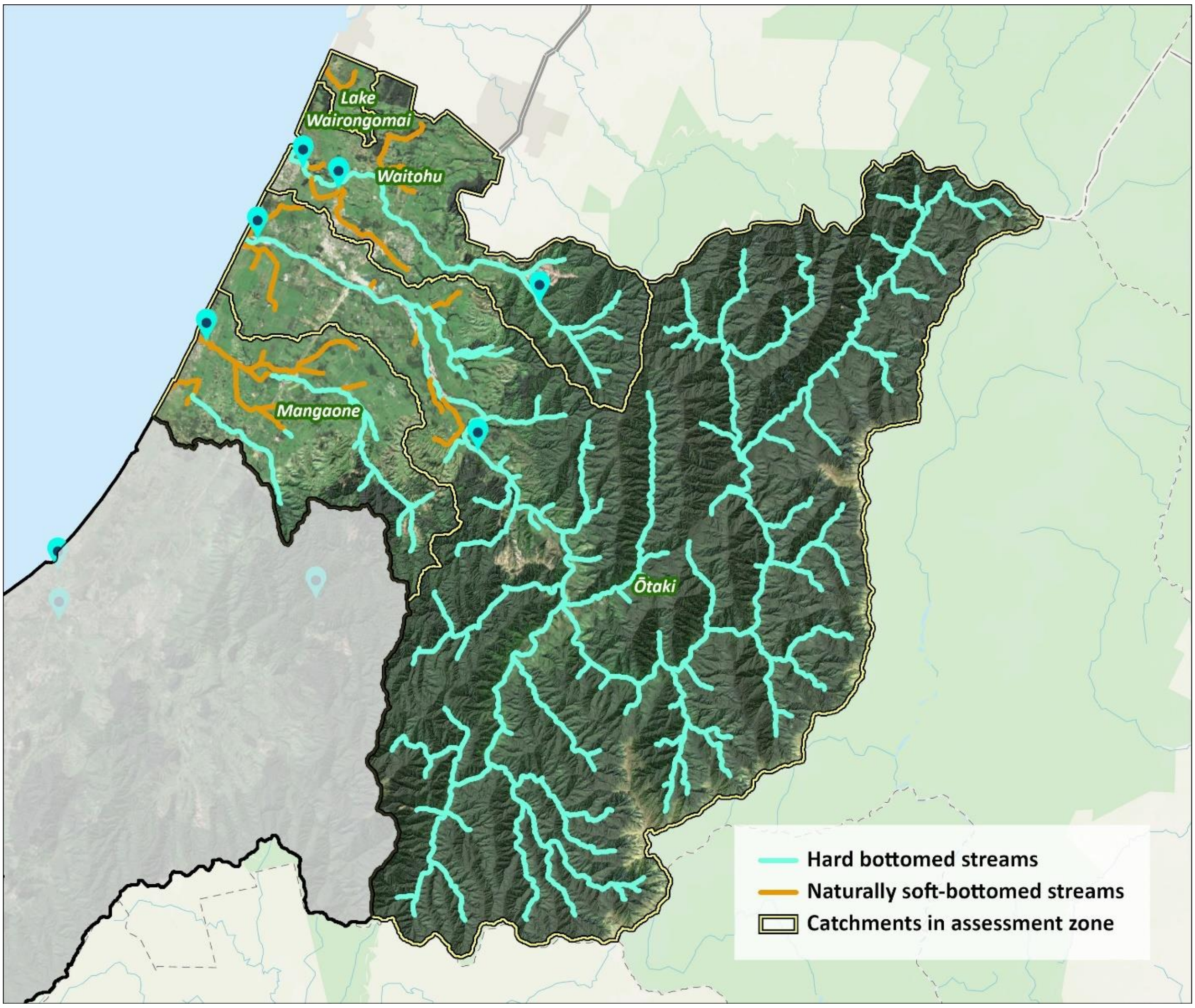

Figure 5: Map showing those streams that naturally have soft sediments

Deposited sediment concentrations were in the A state for all sites other than Waitohu at Norfolk Crescent, which was in the D state. At the D state deposited sediment concentrations ecological communities are likely to be significantly altered and sensitive fish and macroinvertebrate species are lost or at high risk of being lost.

Sediment can enter rivers and streams in many ways including instream scouring of the riverbed and banks, and erosion from the surrounding catchment from slips and exposed soil [41]. While these are all natural processes, anthropogenic influences can increase the rate of sediment delivery from these sources.

Removal of riparian vegetation can destabilise the streambank and increase bank erosion. The removal of streambank vegetation also reduces the ability to trap and attenuate (remove) mobilised sediment [41,42]. Change in landcover from forest to pasture, especially on steep land and highly erodible soils, can also destabilise the land and result in increased slips, hillslope erosion and exposed soils. The mechanical action of rain on exposed soils can cause further erosion and transport of sediments to waterway. Vegetation removal also results in increased peak river flows, meaning greater erosive power. Large construction projects, such as the building of motorways can also be a large source of sediments to small streams if not managed well.

At the property scale, activities such as stock access to streambank planting, livestock grazing practices, vegetation clearance and forest harvesting, access tracks maintenance and earthworks can have a large impact to increase sediment losses.

4.4 Nutrients for growth

Table 6: Attribute states for dissolved inorganic nitrogen, dissolved reactive phosphorus and periphyton biomass

Site	Nutrients for growth and periphyton attribute states		
	Dissolved Inorganic Nitrogen	**Dissolved Reactive Phosphorus**	**Periphyton Biomass**
Mangapouri S at Bennetts Rd	D	D↑	*
Waitohu S at Forest Park	A	B	A[#]
Waitohu S at Norfolk Cres	B↑	C-	*
Ōtaki R at Pukehinau	A↓↓	A↓↓	A[#]
Ōtaki R at Mouth	A↓↓	A↓↓	A
Mangaone S at Sims Rd Br	D	D ↑	*

* Attribute not monitored at this site. ↑↑ very likely improving trend. ↑ likely improving trend. - indeterminate trend. ↓ likely degrading trend. ↓↓ very likely degrading trend. [#] Biomass state inferred from annual biomass monitoring between 2009 and 2016. Blue, excellent (A state). Green, good (B state). Yellow, fair (C state). Red, poor (D state).

Nitrogen & phosphorus

Dissolved inorganic nitrogen (DIN) represents the components of nitrogen that are readily available for plant uptake. It is important to note total ammoniacal-nitrogen and nitrate are both components of DIN, but here the effect they have on plant growth, and indirectly higher order aquatic life (macroinvertebrates and fish) through plant growth, is being assessed and not the direct toxicity effects. As concentrations of DIN increase so too does the risk of nuisance periphyton growths and, to a lesser extent, nuisance macrophyte growths in spring-fed streams dominated by soft sediments [4,43].

Dissolved reactive phosphorus (DRP) is the readily available component of phosphorus for plant uptake, and, as with DIN, the higher the DRP concentration the greater the risk of nuisance periphyton and macrophyte growths, which can have wide ranging effects on macroinvertebrate and fish communities, stream hydrology (in the case of macrophytes clogging watercourses) and recreation.

Concentrations of both DIN and DRP at the Mangapouri and Mangaone stream monitoring sites were in the D attribute state. Both sites have naturally soft (sandy and muddy) stream beds and experience large nuisance macrophyte growths. Although nutrients are not considered to be limiting plant growth at these two sites, it is important to note that nutrient availability is just one of several factors that influence macrophyte growth. Light availability, flow conditions, sediment supply and rooting substrate (size of stones on the stream bed) also have a strong influence over macrophyte densities, invasive species dominance and growth rates. Furthermore, some macrophyte species extract nutrients from bed and bank sediments rather than the water column; these plants are less likely to be affected by instream DIN and DRP concentrations.

The Ōtaki River was in the A state for DIN and DRP at both the upstream and downstream monitoring sites meaning that no adverse effects attributable to DIN and/or DRP enrichment are expected, and ecological communities and ecosystem processes are likely to be similar to those of natural reference conditions. However, increasing trends is DIN and DRP at both Ōtaki River sites may be resulting in increased periphyton biomass. Blooms of toxic algae (*Microcoleus*) have become a regular occurrence in the lower Ōtaki River over the last decade.

The upper Waitohu Stream site had A state DIN and B State DRP concentrations, while the downstream Waitohu site had moderate levels of enrichment (B state for DIN and C state for DRP). At moderate levels of nutrient enrichment periphyton and / or plant growth is expected. Slightly elevated DRP concentrations at the upper Waitohu Stream site, which is in the Tararua Forest Park, appears to be the result of naturally high catchment phosphorus concentrations. This is not uncommon, fully forested rivers elsewhere in the greater Wellington Region, such as the Waikanae and Wainuiomata rivers, have elevated phosphorus concentrations.

Monitoring data from the Ōtaki assessment zone generally supports the national total nitrogen and phosphorus models, which indicate those stream reaches located in the Tararua Forest Park and at the foothills of the Tararua range tend to have low levels of nutrient enrichment, while those smaller and spring-fed streams located on the coastal sand dune plains tend to have higher levels of nutrient enrichment (Figure 6). Moreover, those areas with elevated nutrient concentrations tend to be associated with pastoral and urban land use.

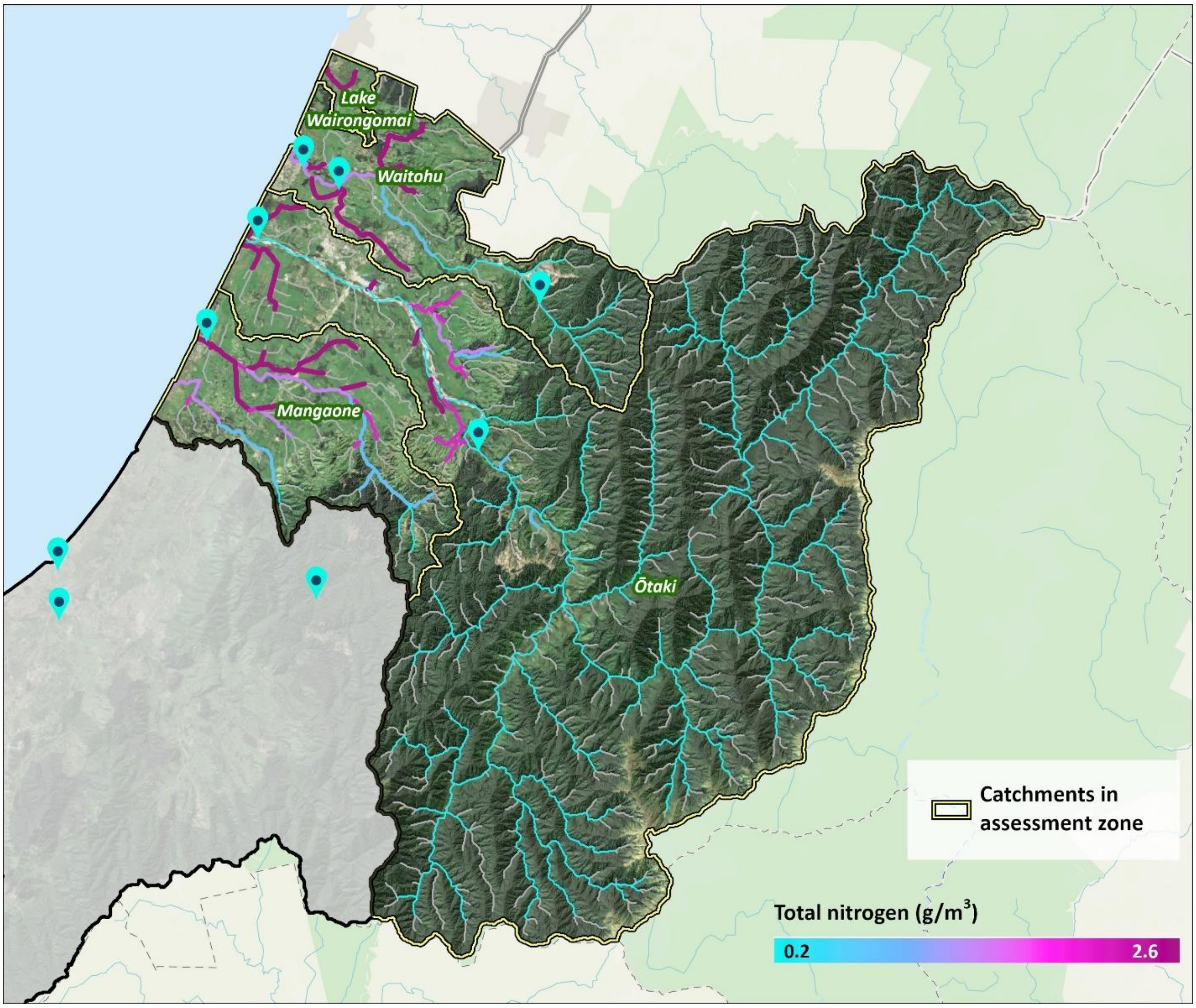

Figure 6: Modelled total nitrogen concentrations for each river reach in the greater Ōtaki assessment zone. g/m^3 = mg/L.

Elevated soil phosphorus concentrations are likely to be contributing to the high concentrations of DRP in the Ngārara Stream catchment. Soil quality monitoring undertaken across the Kāpiti Coast shows that Olsen P (a measure of phosphorus) concentrations are elevated across different land uses [44]. Any sediment from soil erosion and drain erosion in these areas is, therefore, likely to be carrying phosphorus and contributing to the nutrient enrichment of the surrounding water ways.

Sources of DIN, as with nitrate and ammonia, include wastewater inputs and nitrogen fertilisers applied to green spaces in urban areas. In rural areas waste from septic tanks and animals, application of inorganic fertilisers and animal urine are the major sources.

Periphyton

Periphyton (the algae, bacteria and fungi that make up the "slime" which grows on river and stream beds) are primary producers (acquire energy from the sun) and are an important foundation of many river and stream food webs. Periphyton also stabilise substrata and serve as habitat for many other organisms. However, an over-abundance of periphyton can reduce ecological habitat quality [4,43,45]. Large standing crops of periphyton can smother stream-bed substrate, thereby reducing the amount of suitable habitat available for fish and macroinvertebrates. High densities of periphyton can also cause large daily fluctuations in dissolved oxygen concentrations and pH, especially in slower flowing systems. Therefore, it is important to manage rivers and streams to reduce the risk of nuisance growths.

Periphyton at the Ōtaki River at Mouth monitoring site, the only current periphyton biomass monitoring site in the Ōtaki assessment zone, was in the A state reflecting generally low nutrient enrichment (DIN and DRP were both in the A state at the Ōtaki River at mouth monitoring site). Annual biomass monitoring between 2009-2016 and current monitoring of periphyton cover indicate biomass is also likely to be in the A state in the headwater predominantly forested Ōtaki River at Pukehinau and Waitohu Stream at Forest Park monitoring sites. The lower Mangapouri and Mangaone monitoring sites, located on coastal dune plains, have soft sediments, and are dominated by macrophyte plant communities. Macrophytes also dominate the lower Waitohu monitoring site, it is unclear whether this site is naturally soft bottom site or whether sediment had accumulated at the site in recent years because of catchment erosion.

Modelling estimates of stream reaches across the coastal sand dune plains showed that periphyton biomass is predominantly in the C and D state for these catchments (Figure 7)[5]. Nutrient enrichment and a lack of riparian cover/shade are likely to be the key drivers. Similarly, high nutrient concentrations and poor shading are likely to be the key driver of nuisance macrophyte growth in soft bottomed streams. Macrophytes are also abundant in the extensive network of drains that exist across the assessment zone.

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[5] It is important to note that the model outputs in Figure 7 assumes dual nutrient limitation is required to reduce periphyton biomass (i.e., both nitrogen and phosphorus must be low)

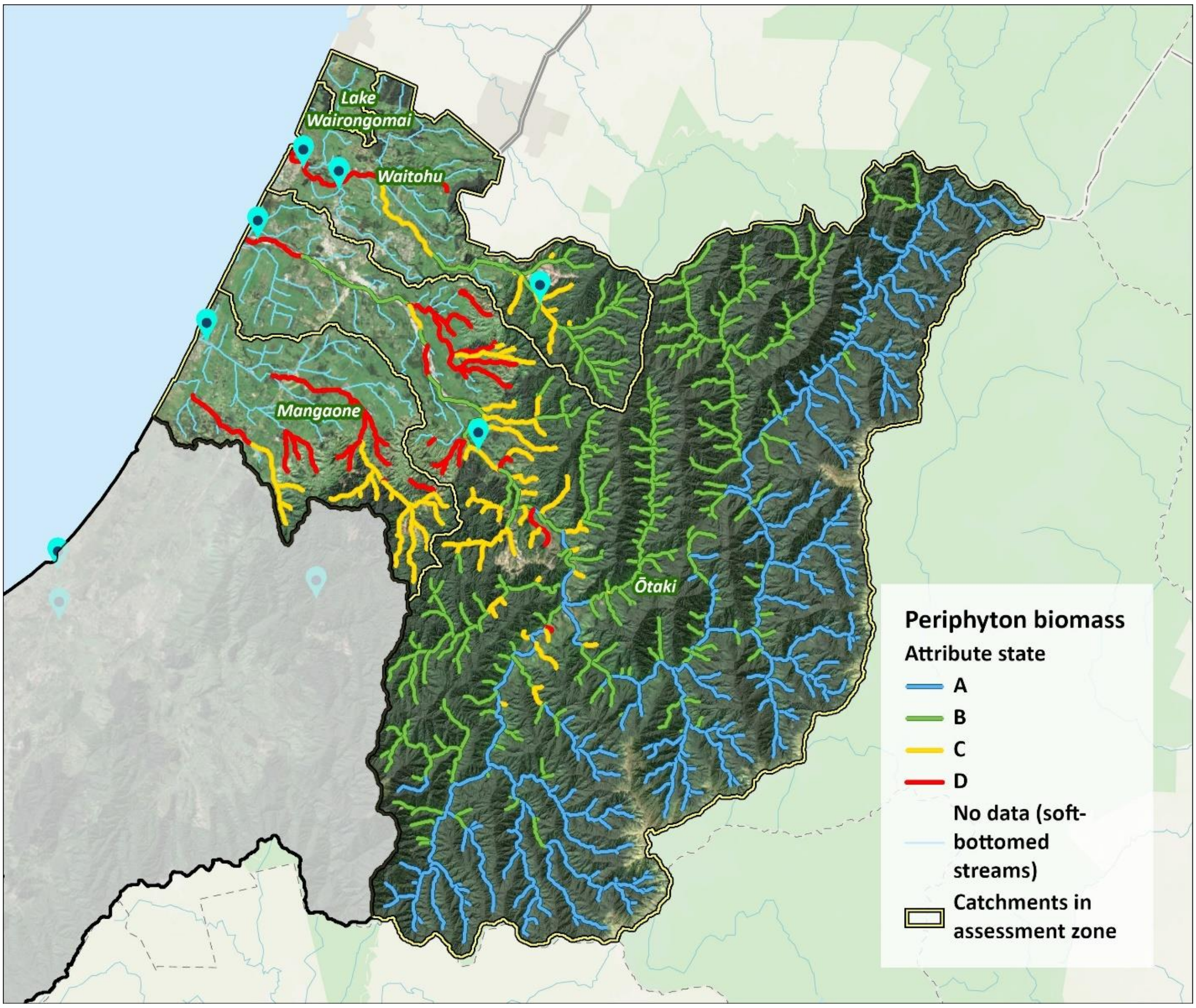

Figure 7: Periphyton biomass state estimates based on modelled phosphorus and nitrogen concentrations for each hard bottomed river and stream reach.

4.5 Stream morphology and habitat

Table 7: Habitat assessment scores

Site	Habitat
Mangapouri Stream at Bennetts Road	Good (59)
Waitohu Stream at Forest Park	Excellent (94)
Waitohu Stream at Norfolk Crescent	Fair (46.5)
Ōtaki River at Pukehinau	Excellent (86)
Ōtaki River at Mouth	Excellent (76)
Mangaone S at Sims Road Bridge	Fair (41)

Habitat scores are between 0 and 100. Blue = excellent (scores between 75 & 100). Green = good (scores between 50 & 74). Yellow = fair (scores between 25 - 49). Red = poor (scores between 0 -24).

There are several physical habitat parameters that influence ecosystem health besides plant growth and sedimentation. Factors such as shading, riparian zone composition and stream morphology all affect the structure of aquatic communities [5,46]. Ecological health is highest when there is a diversity of stream substrates (i.e., a mixture of sand, gravels, cobbles, boulders, woody debris, and leaf vegetation), flow (runs, riffles, pools, and backwaters) and riparian vegetation to stabilise stream banks, provide instream shade/cover and structure.

The habitat score for the Waitohu S at Forest Park Stream site was from the 2014/15 summer sampling season (the last assessment undertaken before monitoring was discontinued at this site). Habitat scores for the four other sites are an average of the 2018/19, 19/20 and 20/21 summer sampling assessments.

The results indicate that the two Ōtaki River sites and the Waitohu Stream at Forest Park monitoring site have excellent habitat suitable for a range of macroinvertebrate and fish species. In contrast, the Waitohu Stream at Norfolk Crescent and Mangaone Stream site have poor habitat and are unlikely to support diverse macroinvertebrate and fish communities.

4.6 Ecology

Table 8: Attribute states for macroinvertebrates and fish

Site	Ecological attribute states		
	Macroinvertebrates (QMCI & MCI)	**Macroinvertebrates (ASPM)**	**Fish IBI**
Mangapouri S at Bennetts Rd	D↑↑	D	NA
Waitohu S at Forest Park	A	A	NA
Waitohu S at Norfolk Cres	D↓↓	D	Na
Ōtaki R at Pukehinau	B↓	A	Na
Ōtaki R at Mouth	B↓	B	NA
Mangaone S at Sims Rd Br	D -	D	NA
Assessment zone state	NA	NA	

↑↑ very likely improving trend. ↑ likely improving trend. - indeterminate trend. ↓ likely degrading trend. ↓↓ very likely degrading trend. Blue, excellent (A state). Green, good (B state). Yellow, fair (C state). Red, poor (D state). NA = not applicable. [#] Grade(s) represent ≥75% of observed fish IBI results for the assessment unit. In this case over 75% of fish IBI results were in the A state.

Macroinvertebrate communities

The aquatic macroinvertebrate community is an important component of riverine ecosystems, and macroinvertebrate community health is a widely used indicator of ecosystem health. Sensitivity to habitat and water quality stressors differs between macroinvertebrate taxa, thus the composition of macroinvertebrate communities in a stream can provide valuable information about how the state and trends in water quality and habitat are influencing ecosystem health.

The macroinvertebrate community index (MCI) is an index of macroinvertebrate sensitivity to a wide range of environmental variables [47] and is used to measure community health [6]. The MCI responds to multiple stressors, including point source discharges, diffuse discharges, habitat degradation and water abstraction [48]; generally, the higher the MCI score the better the water and habitat quality. The MCI is used in the Greater Wellington Region Proposed Natural Resources Plan (NRP) to measure ecosystem condition according to river classes defined by Greenfield *et al.* (2015) [49]. The river class system uses a poor-fair-good-excellent grading system developed by Clapcott and Goodwin (2014) (adapted from the national grading system set out in Stark and Maxted (2007)) [6,47]. The NPS-FM 2020 also stipulates that if an MCI score falls below 90 (the D band threshold), or shows a declining trend, regional councils must identify the causes and develop a response plan.

Macroinvertebrate health was variable across the greater Ōtaki assessment zone. The predominantly headwater forested sites Ōtaki River at Pukehinau and Waitohu at Forest Park were in a generally good state, B and A state respectively. The lower Ōtaki River site (B state) was also in a generally good state. However, the smaller stream sites (Mangaone, lower Waitohu and Mangapouri) located in the coastal sand dune plains, were all in the D state and failed the national bottom line.

At D state macroinvertebrate communities consist only of the most tolerant taxa and indicates severe habitat alteration, organic pollution, and / or nutrient enrichment. Macroinvertebrate communities in the B state are largely composed of taxa sensitive to organic pollution, nutrient enrichment, and habitat alteration.

Fish communities

The fish Index of Biotic Integrity (IBI) is a combination of six metrics[6] developed specifically to assess the condition of New Zealand's fish fauna [50]. It considers the fact that many species exhibit diadromous life histories (i.e., migrate between the ocean and freshwater at some point in their lifecycle). The IBI compares the species found at a site with those expected to be at a site, while considering natural changes that occur with distance inland and elevation.

Fish IBI scores for the greater Whareroa assessment zone were taken from a Ministry for the Environment report titled *Fish index of biotic integrity in New Zealand rivers 1999-2018* (MfE 2019) [51]. In this MfE report, only electric fishing records lodged in the NZ freshwater fish database (maintained by NIWA) between 1999 and 2018 were used to derive fish IBI scores.

There were 26 fish records for the Ōtaki assessment zone, 20 were in the A state, 4 in the B state and 2 in the C state (Figure 8). At A state, fish communities are defined as having high integrity, and habitat and migratory access have minimal degradation.

Indigenous fish that have been found in this assessment zone include banded kōkopu, bluegill bully, brown mudfish, common bully, common smelt, crans's bully, dwarf galaxis, giant bully, giant kōkopu, inanga, kōaro, lamprey, longfin eel, redfin bully, torrent fish, shortjaw kōkopu and shortfin eel.

Monitoring undertaken as part of GWRCs RWQE programme across the Wellington Region indicates that fish condition and diversity is not always correlated with water quality, periphyton and macroinvertebrate indicators. Thus, Indigenous fish are not a good indicator over overall water quality state, nor is water quality a good indicator of fish communities.

The main stressors of native freshwater fish communities are:

- Competition and predation from non-native fish;
- Excess sediment, which can clog fish gills and smother habitat;
- Periphyton blooms, which in turn can decrease dissolved oxygen concentrations;

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[6] Total number of native species, number of native riffle-dwelling species, number of native benthic pool-dwelling species, number of native pelagic species, number of intolerant or sensitive native species, and proportion of non-native species.

- Toxicants such as metals, pesticides, and persistent organic pollutants (such as DDT); and
- Structures in waterways and changes to river flow that can block migration.

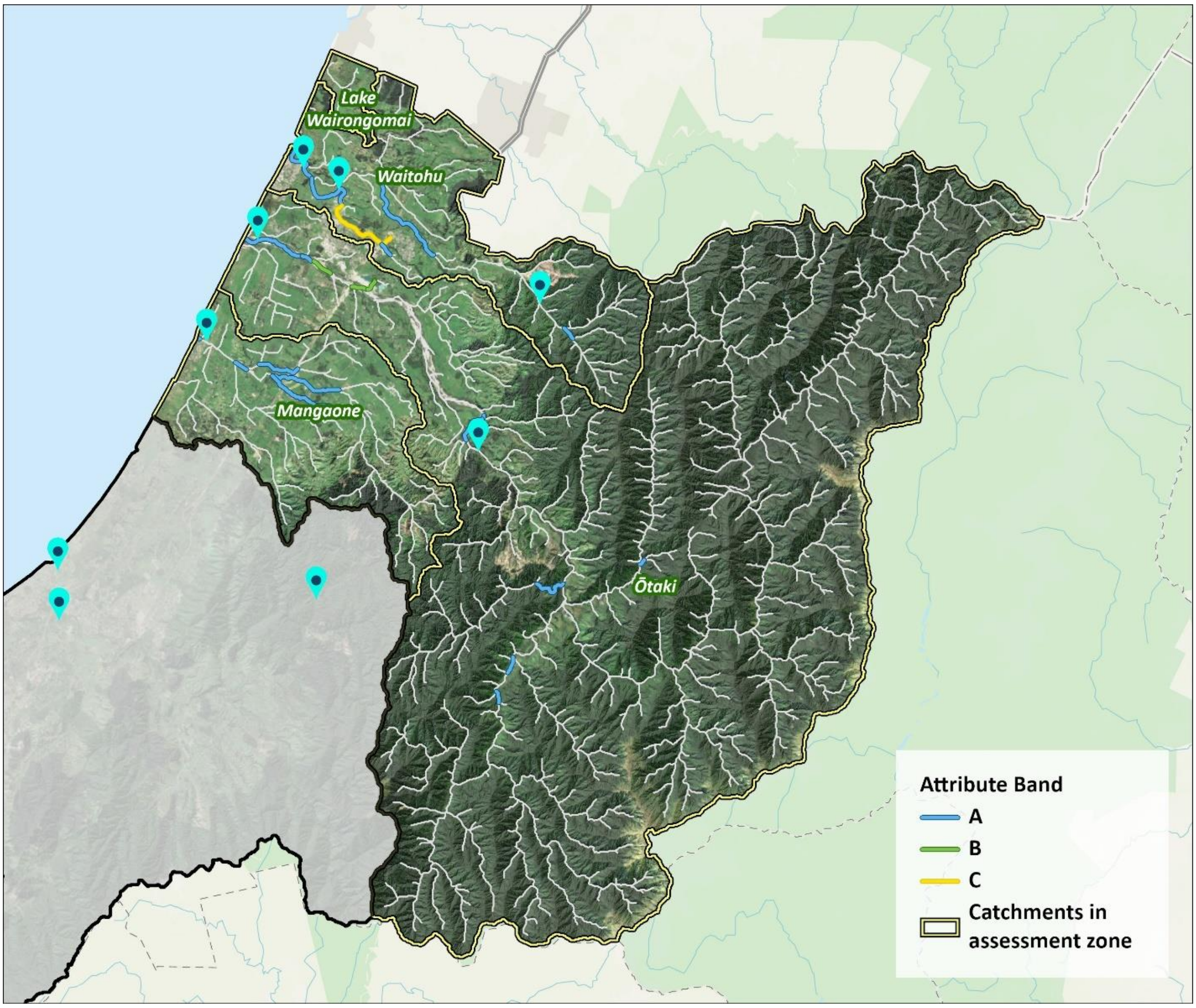

Figure 8: Fish IBI attribute states for stream reaches where electric fishing was undertaken between 1999 – 2018.

4.7 Human health

Table 9: E. coli attribute state of sites in the Greater Otaki assessment zone

Site	**Human attribute states**	
	E. coli	**Toxic algae**
Mangapouri S at Bennetts Rd	E↓↓	Not present
Waitohu S at Forest Park	A	Not present
Waitohu S at Norfolk Cres	E↓↓	Not present
Ōtaki R at Pukehinau	A*	Not present
Ōtaki R at Mouth	A↓	Occasional large blooms resulting in river closure
Mangaone S at Sims Rd Br	E↓↓	Not present

↑↑ very likely improving trend. ↑ likely improving trend. - indeterminate trend. ↓ likely degrading trend. ↓↓ very likely degrading trend. Blue, excellent (A state). Green, good (B state). Yellow, fair (C state). Red, poor (D state).

Escherichia coli (*E. coli*) is a bacterium that naturally occurs in the lower intestines of humans and warm-blooded animals; for that reason, its presence in freshwater is indicative of faecal contamination. Water contaminated by faecal material contains a range of pathogenic bacteria, viruses, and other micro-organisms (e.g., protozoa) that present a risk to the health of people conducting recreational activities where water is ingested, inhaled (as an aerosol), or comes into direct contact with sensitive areas (eyes, ears, open wounds). *E. coli* does not generally pose a significant risk to human health in and of itself. However, it is used as a Faecal Indicator Bacteria (FIB), meaning the level at which it is present can be used to quantify the risk of infection from faecal pathogens such as *Campylobacter, Salmonella, Giardia*, *Cryptosporidium* which are difficult or impractical to routinely measure directly in water. Consequently, *E. coli* is the primary attribute used in New Zealand to assess the microbiological health risks associated with primary contact with recreational freshwaters. Enterococci is the FIB bacteria used at beach (saltwater) sites, however the state of enterococci at beach/marine sites is outside the scope of this report, which focuses on freshwater environments and assessment against NOF attributes.

E. coli concentrations were in the A state at the two Ōtaki River sites and the Waitohu River at Forest Park site, meaning that there is a very low risk of infection and low levels of faecal contamination. In contrast, *E. coli* concentrations in the smaller stream located in the sand dune plains were all in the E state. There is high infection risk (the predicted average infection risk is >7%) at these concentrations and primary contact is not advised. The median and 95th percentile

E. coli concentrations used to derive the *E. coli* attribute state indicate that there are high concentrations in both wet and dry weather.

There are several different sources of *E. coli* in streams and rivers. The predominant source of faecal contamination in urban streams is wastewater from the exfiltration of private and municipal wastewater networks. Stormwater inflow and infiltration into the wastewater networks, which can result in wastewater overflows, is also a common source of faecal contamination to urban streams. Animal and avian excreta that can be washed from impervious surfaces (i.e., roads, footpaths, and parking lots) into the urban streams via the stormwater network during rainfall is another source of contamination. In rural areas, animal (cattle and sheep) and avian (e.g., Canada geese, black swans, and ducks) excreta as well as wastewater from septic tanks are the main sources.

In a 2019 investigation undertaken by GWRC of *E. coli* sources in the Waitohu Stream (including the Mangapouri Stream) catchment faecal source tracking indicated ducks were the major source. Ruminants (cow and sheep) were detected at low levels at most and human and dog detected at some sites (Figure 9) [52].

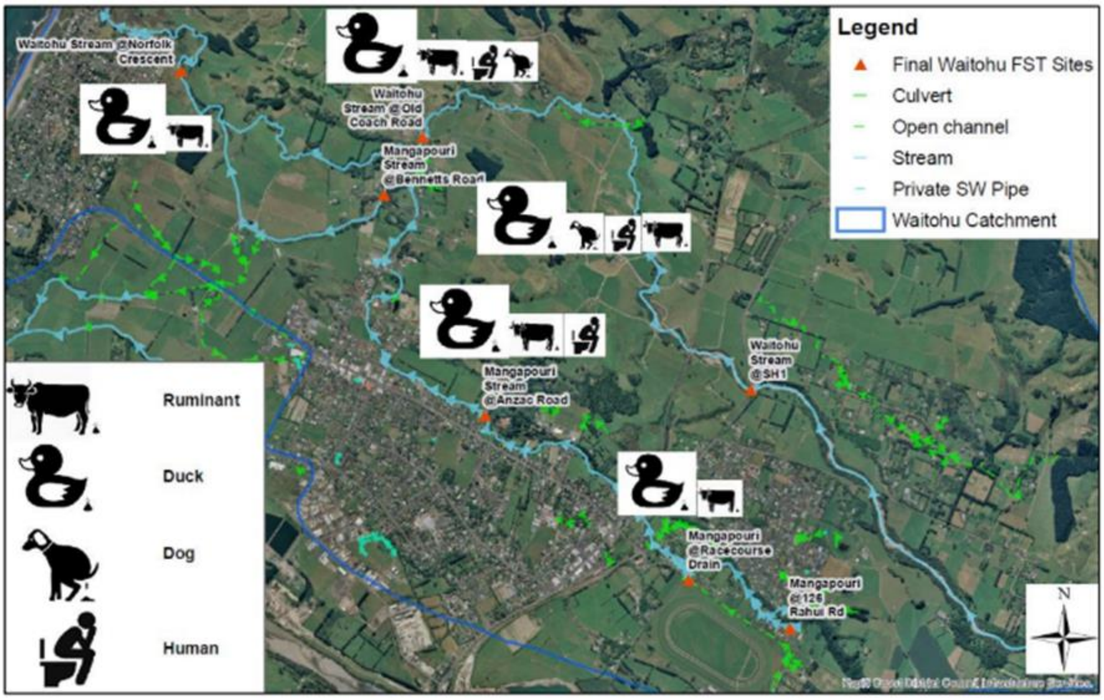

Figure 9: summary of 2019 faecal source tracking assessment undertaken by GWRC. Image courtesy of GWRC.

Microcoleus (toxic algae)

Microcoleus blooms (toxic algae) have been a common occurrence in the lower reaches of Ōtaki River over the last 5 years during the summer months. Since 2018 riverbed coverage of potentially toxic algae has exceeded the alert mode (amber) 20% coverage threshold on 11 occasions and the action mode (red) 50% coverage threshold on 1 occasion at the summer recreational water Ōtaki River at SH1 monitoring site. Although the lower Ōtaki River has only exceeded the action mode coverage threshold on one occasion, it has been regularly placed in the action mode because of mats (scums) of toxic algae that gave detached from the river gravels and cobbles and accumulated at the river's margins. Under the guidelines, detached mats trigger the action (red) mode because of the increased exposure risk. At the action mode, the public are advised against swimming and warning signs are erected [7].

Microcoleus grows as black/brown to green mats on the gravel and cobbles in the riverbed. Under certain conditions these mats can uplift, float downstream and ultimately accumulate at the river's edge where it is accessible to humans and especially dogs who are attracted to the deep musty odour they produce. Toxic algae can produce a suite of neurotoxins (anatoxins) which may result in serious illness or death if ingested [36,37]. Symptoms include nausea, shakes, cold fever, and diarrhoea.

Toxic algal blooms are not known to occur elsewhere in this assessment zone.

Heath and Greenfield (2016) investigated toxic algal blooms across the Wellington Region and found that they prefer low to moderate nutrient environments and bigger rivers with large substrate (i.e., cobbles) [37]. *Microcoleus* mats have been shown to extract phosphorus from fine sediment particles in the water column, while bacteria living in the mats have been shown to possess the ability to fix atmospheric nitrogen (convert nitrogen gas from the air to plant available forms) [36,53]. It is these processes that are believed to give toxic algae a competitive advantage over other periphyton during the warmer summer months. However, the drivers of toxic algae growth, and associated toxin production, are complex and not fully understood [36]. As a result, a suitable NOF attribute has not yet been developed.

4.8 Human drivers of degradation

The drivers of ecological degradation in the greater Ōtaki assessment zone waterways are primarily related to rural land-use. Towns in the assessment zone represent less than 0.5% of the assessment zone. This said, the effects of urban land use from the Ōtaki township are major driver of deteriorated water quality and ecology in the Mangapouri Stream.

Rural land use

Pastoral landcover represents over 70% of the landcover not in conservation estate in the greater Ōtaki assessment zone and is likely the main driver of degradation. Dairy (27%), Sheep and / or beef (18%) and lifestyle blocks (23%) are the main pastoral land uses. Horticulture and other farming contribute another 4 and 2% of the pastoral cover outside of the conservation estate, respectively. The primary mechanisms through which pastoral land use activity impacts on ecosystem health are:

- Hill slope erosion, which occurs when steep marginal land is in pasture and farmed rather than deep rooting forest that better hold the soils together. Erosion from hill sides can result in increased levels of sediment and sediment bound phosphorus in nearby waterways.
- Streambank erosion. Increased levels of streambank erosion can occur through riparian vegetation removal (riparian vegetation hold stream banks together and buffers them

from large rainfall events), stock (which can destabilise river margins) and increased flows. De-vegetated catchments can increase the rate of surface water run-off during rainfall, resulting in increased peak river flow, which have greater erosion potential. Like hill slope erosion, stream bank erosion can result in increased levels of instream suspended and deposited sediment and phosphorus levels.

- Elevated nutrients. Cattle urine and fertiliser are sources of nitrogen, which can leach into groundwater and nearby watercourses. Fertiliser, farm effluent and eroded soils are the main sources of phosphorus from pastoral land use. Elevated nutrient promotes periphyton (algal) growth, which in turn, can reduce macroinvertebrate and fish habitat, cause algal blooms, and reduce oxygen levels.
- Catchment drainage. Drainage of wetlands, to make way for farmland, can result in increased levels of organic matter and sediment entering streams. Increased organic matter can be a source of nitrogen and phosphorus and sediment, it can also have a high oxygen demand, which can cause streams to become oxygen depleted.
- Habitat modification. Riparian vegetation clearance, stock access, channel modification (channelisation and straightening) and increased sedimentation can significantly reduce stream habitat. For example, the provision of shade, from establish riparian vegetation, is important for the provision of shade (reduce stream temperatures), fish spawning habitat, stream bank stabilization (reduced erosion and thus deposited sediment) and the roots and branches of larger trees are important habitat structures for aquatic organisms.

The sources of faecal contamination in the rural areas of the assessment zone, like urban areas, are likely to be mixture of human wastewater from septic tank discharge which have connection with ground and/or surface waterbodies, livestock excrement discharged directly to stream or transported to stream via surface water run-off and wildfowl. Wildfowl were found to be the main source of faecal contamination in a recent investigation of the Waitohu/Mangapouri stream catchments.

Urban land use

The urban drivers of stream water quality and health degradation in this assessment zone, are runoff from impervious surface such as roads, industrial sites and roofs and contamination from faulty / leaky wastewater infrastructure. Rainwater ‘picks up’ sediment and metals, such as copper and zinc, which are then transported into stream networks via stormwater infrastructure. Excessive sedimentation has a range of negative effects in streams, and, at high concentrations, the metals commonly found in stormwater runoff are toxic to aquatic fauna. The input of these contaminants from stormwater can reduce the abundance of stream fauna and alter community structure. Wastewater inputs for leaky infrastructure can result in increased nutrient concentrations, which can promote periphyton and macrophyte growth, and elevated *E. coli* concentrations. Primary and secondary contact can be compromised as result of high algal biomass and high levels of pathogenic bacteria.

4.9 Conclusions

Macroinvertebrate community health is degraded in the lower reaches of both the Waitohu, Mangapouri and Mangaone streams, which drain catchments with a significant amount of pastoral land-cover. The poorest sites were those at the bottom of the catchment on the coastal sand dune plains, while the upper catchment Waitohu Stream and Ōtaki River sites were in good ecological condition.

Despite having poor water quality and generally poor macroinvertebrate health on the coastal plains, indigenous fish diversity remains high across the assessment zone. However, fish density/abundance and spawning habitat across the zone has likely decreased as result of habitat modification including stream straightening, riparian vegetation removal and change in flow regimes.

Faecal contamination is generally elevated in lower reaches of stream in the assessment zone and low in the forested upper reaches. The lower Waitohu Stream, Mangapouri and Mangaone were all not suitable for primary contact recreation due to elevated levels of the pathogen indicator bacteria *E. coli*. The sources of faecal contamination in this assessment zone are most likely a combination of livestock, wildfowl, and human waste from septic tanks. Faecal source tracking undertaken by KCDC and GWRC in the assessment zone indicates that wildfowl is a key *E. coli* source.

5 Lake's state, trends, and pressures in other aquatic systems

There are two main lakes in the Greater Ōtaki assessment zone, Lake Waitawa and Lake Waiorongamai.

Lakes Waitawa and Waiorongamai are both shallow small dune lakes located near the coast in the northern part of the Greater Ōtaki assessment zone. Lake Waitawa is in the Nga Totara Stream sub-catchment of the Waitohu Stream catchment. Lake Waiorongamai is in its own catchment and drains directly to the coast via the Waiorongamai Stream.

5.1 Lake Waitawa

Lake Waitawa water quality data

Lake Waitawa water quality was last monitored in 2014-15 for a 12-month period as part of GWRCs Lake Water Quality and Ecology monitoring programme [54], while the lake macrophytes were last assessed by NIWA in the 2016 summer [55]. Lake Waitawa ecological status was also comprehensively rereviewed in a recent technical report by the Cawthron institute prepared for GWRC [56].

Lake water quality and ecological condition has been assessed against the NOF lake attributes, which collectively provide a good overall assessment of lake heath.

State of lake Waitawa

Overall, Lake Waitawa, is in poor ecological condition. It exceeds the national bottom line for eight of the ten lake NOF attributes (Table 10) and has deteriorating trends. It is also at risk of undergoing a regime shift ('flipping') from a macrophyte to a phytoplankton/cyanobacteria dominated system.

Table 10: Lake Waitawa Water Quality and ecology as measured against the lake National Objective Framework attributes

Attributes	State
Total Nitrogen	D
Total phosphorus	D
Total Ammoniacal-nitrogen	C
Mid hypolimnetic dissolved oxygen	D
Lake bottom dissolved oxygen	D
Submerged plants (natives)	D
Submerged plants (Invasive)	D
Phytoplankton	C
Cyanobacteria	D
E. coli	B

Blue, excellent (A state). Green, good (B state). Yellow, fair (C state). Red, poor (D state).

Total nitrogen and phosphorus

At the D state for total nitrogen and total phosphorus the lake is considered nutrient rich and not limiting phytoplankton growth, including potentially toxic cyanobacterial blooms.

Runoff from the surrounding predominantly agricultural catchment (85% landcover) has been identified as the most likely source of nutrients to the lake. However, lake sediments that have built up over a long period of time also represent a significant internal nutrient source. Nutrients from the sediments at the bottom of the lake are released to the water column when the lake stratifies (generally during the warmer summer months), a process which results in the bottom of the lake becoming cooler and anoxic (without oxygen). The Forest Lakes camps oxidation ponds effluent discharge has also been an historic source of nutrients to the lake; however, the effluent is soon to be discharged to land. Groundwater nutrient inputs to the lake are expected to be low.

Phytoplankton and cyanobacteria

Phytoplankton concentrations were in the C state during the 2014/15 monitoring period, while cyanobacteria concentrations were in the D state. The high level of phytoplankton reflects the high nutrient levels measured in the lake. Cyanobacteria blooms were a common occurrence during the 2014/15 season and represent a high health risk to recreational users of the lake. Of the 12 different sampling occasions during the 2014/15 monitoring season, the Ministry for the Environment/Ministry of Health alert level framework 'action level' for potentially toxic cyanobacteria was exceeded ten times. However, production of the cyanotoxin microcystin (a hepatotoxin, affects the liver) only occurred during the summer months. The highest total microcystin concentration collected from the lake was over 180 times the recommended reactional activity threshold given in the Cyanobacterial Recreational Guidelines [7].

Reduction in both nutrient inputs into the lake and internal sediment nutrient loads (which can be released to the water column when the lake stratifies is without oxygen) are likely to be required to reduce the frequency and magnitude of cyanobacterial blooms. Fish populations may also be contributing to the high phytoplankton and cyanobacteria concentrations; juvenile perch, which are present in Lake Waitawa, are known to consume zooplankton. Without zooplankton there is reduced grazing pressure on phytoplankton communities.

Total ammoniacal-nitrogen and lake oxygen concentrations

At C state ammonia concentrations exceeded the national bottom line for protection of 95% of species. Samples collected from the bottom waters (hypolimnion) when the lake was stratified, had ammonia concentrations that were consistent with the D state and approaching acute toxicity levels.

Lake bottom dissolved oxygen concentrations were in the D state (i.e., with very low levels of oxygen) for those time of the years where the lake stratifies. Low lake-bottom dissolved oxygen concentrations create conditions conducive for the release of nutrients from sediments, including ammonia and dissolved reactive phosphorus, which in turn drive phytoplankton and cyanobacteria growth.

Submerged plants (macrophytes)

Both native and invasive submerged plants attributes were in the D state during the most recent plant survey (2016) [55]. No native macrophytes were observed except for some emergent raupō (bullrush), while several invasive macrophytes were present including hornwort, curly pondweed, and Egeria.

The 2016 survey showed a significant deterioration from a survey conducted in 2002, with shallower maximum vegetation depths indicating reduced light penetration for submerged plants and a reduction in native plants.

The changes in macrophyte dominance to exotic species and changes observed between 2002, 2007 and 2016 surveys as well as the frequency of phytoplankton/cyanobacteria blooms indicate the lake is at some risk of 'flipping' to a phytoplankton/cyanobacteria dominated state

E. coli and human health

At B state, *E. coli* concentrations are considered low and generally safe for swimming. However, the monitoring site assessed during 2014/15 was located on the opposite arm of the lake than the Forest Lakes campsite oxidation ponds effluent discharge. Therefore, the risk to recreational users was potentially underestimated.

The oxidation ponds effluent discharge is currently in the process of being shifted to land, which will result in the risk of infection from pathogens reducing further. The high abundance of waterfowl, including Canada geese and black swans, is likely to represent the biggest risk to primary contact, other than toxin producing cyanobacterial blooms.

Fish (NB. fish are not an NPS-FM 2020 lake attribute)

Fishing surveys dating back to 1953 indicate there has been a shift in the diversity and abundance of fish species from native to introduced [56]. In 1953 no introduced fish species were detected but from 2006, perch, rudd, tench and goldfish have all been consistently detected in the lake. More recently koi carp have also been detected at low levels. In contrast, a Galaxias sp. that was present in the lake in 1953 has not been detected in the lake in any fish survey since 2006. Native species still present in the lake include common bully, longfin eel and shortfin eel.

5.2 Lake Waiorongamai

There is a scarcity of data regarding the health of Lake Waiorongamai; however, the data that has been collected alongside the observational data, indicate the lake is in a similar state as Lake Waitawa. One-off water quality sampling indicates high levels of nutrient enrichment, while dissolved oxygen logger information indicates the lake bottom can become anoxic despite its shallow depths (~1m). Plant observation shows there is a high level of invasiveness.

Initial results from cores taken from the bottom of the lake as part of the Lakes 380 research programme indicate the lake has had high levels of algae for the last ~600 years. The increase in algae 600 years ago coincides with an increase in carbon levels from forest fires in the catchment.

6 Other domains state, trends, and pressures in other aquatic systems

6.1 Groundwater

Groundwater forms an integral part of the Greater Ōtaki Assessment zone's freshwater resources. It has a significant role in sustaining freshwater ecosystems in riverine and wetland habitats. The likes of the Mangapouri, Ngatoko and Rangiuru stream are all spring fed from upwelling groundwater. There is also significant use of the groundwater resources for domestic, municipal, industrial and irrigation water supplies. Bores located at Hautere, near the Ōtaki River, and Ōtaki at Tasman and Rangiuru roads supply both rural and urban communities with potable (drinking) water.

Balancing the conflict between the maintenance of environmental values associated with groundwater, including hydraulically connected surface waters, and the potentially social and economic benefits arising from water use presents a major resource challenge.

Groundwater zones and categories

Ground water across the Wellington Region is split into three classes reflecting the hydraulic connectivity with surface water [57]. Category A groundwater has direct connectivity with surface water, Category B has moderate connectivity to surface water and Category C has no direct connection to surface water. Aquifers with greater connection to surface water are more prone to stream depletion effects from groundwater abstraction and are also prone to contamination from overlying land use. Different allocation rules exist in the plan depending on the category of groundwater.

There are two distinct groundwater zones in the Greater Ōtaki assessment zone; Ōtaki, which has two sub-zones Waitohu and Ōtaki, and Te Horo [57]. The Te Horo and Waitohu sub zone (deeper than 40 m) are Category B groundwater, while the Ōtaki sub-zone and shallow Waitohu sub zone (shallower than 40 m) is category A groundwater (Figure 10).

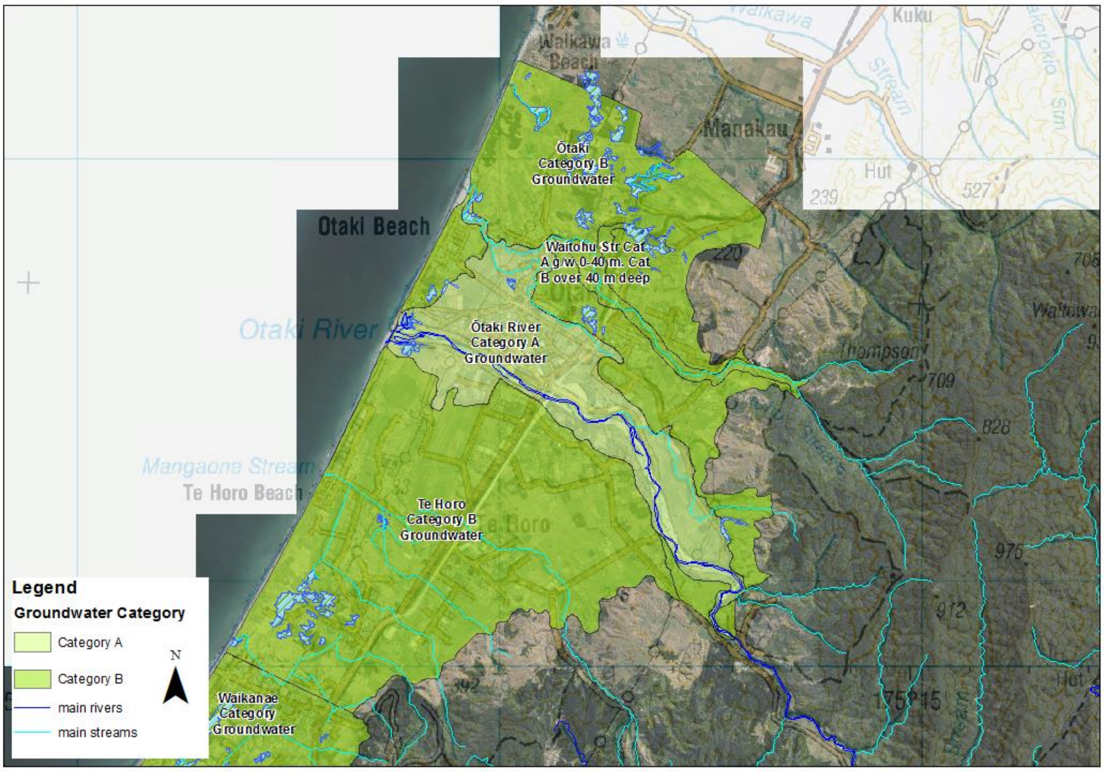

Figure 10: Groundwater zones in Greater Ōtaki assessment zone

Groundwater quality and trends

In the Greater Ōtaki assessment zone, there are 11 wells that are monitored quarterly for nitrate and E. coli and are assessed against human health and aquatic toxicity guidelines. The results presented below are from the last GWRC annual (2020/21) groundwater quality monitoring report https://www.gw.govt.nz/annual-monitoring-reports/2020-21/groundwater/index.html.

Human health: All sites were below the Drinking Water Standard New Zealand maximum acceptable values (MAV) of 11.3 mg/L for nitrate. Two sites (S25/5322 and S25/5256) were considered to have elevated nitrate concentrations (5.6 to 11.3 mg/L), while 9 sites were considered to have low concentrations (>5.6 mg/L) (Figure 11a). For drinking water supplies, *E. coli* counts should be below the MAV of <1 cfu/100mL (one colony forming zone). All sites were below the MAV and considered safe for drinking except for one (S25/5125) located in Category A groundwater in the Ōtaki sub-zone on the Hautere plains near the Ōtaki River (Figure 11b).

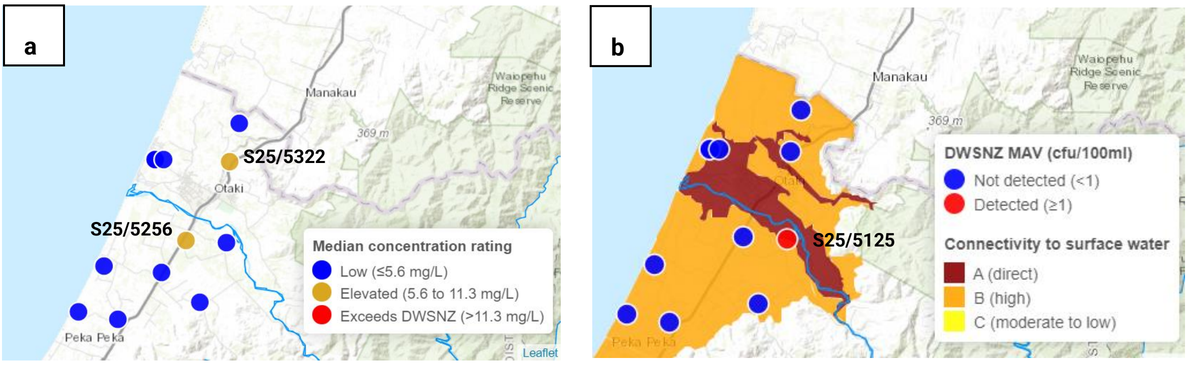

Figure 11: Nitrate-nitrogen (a) and *E. coli* (b) levels at Groundwater Quality State of the Environment Bores 2020/21

Aquatic life: Groundwater concentrations were assessed against the NPS-FM surface water nitrate national bottom line NPS-FM (2020). Five sites exceeded the national bottom line (>2.4 mg/L) for 95% protection of species (Figure 12). This included one Category A, two Category B, and two Category C sites. The highest median concentration of the 8.84 mg/L, which is almost four times higher than the national bottom line, was from a Category C well located in the Waitohu sub-zone. It is important to note that Category C groundwater has no direct connection with surface water, however groundwater in this category contributes to the overall baseflow and water quality to streams at catchment scale. The five sites that exceeded the NPS-FM national bottom line were spread across the Te Horo and Ōtaki zones, indicating widespread groundwater contamination.

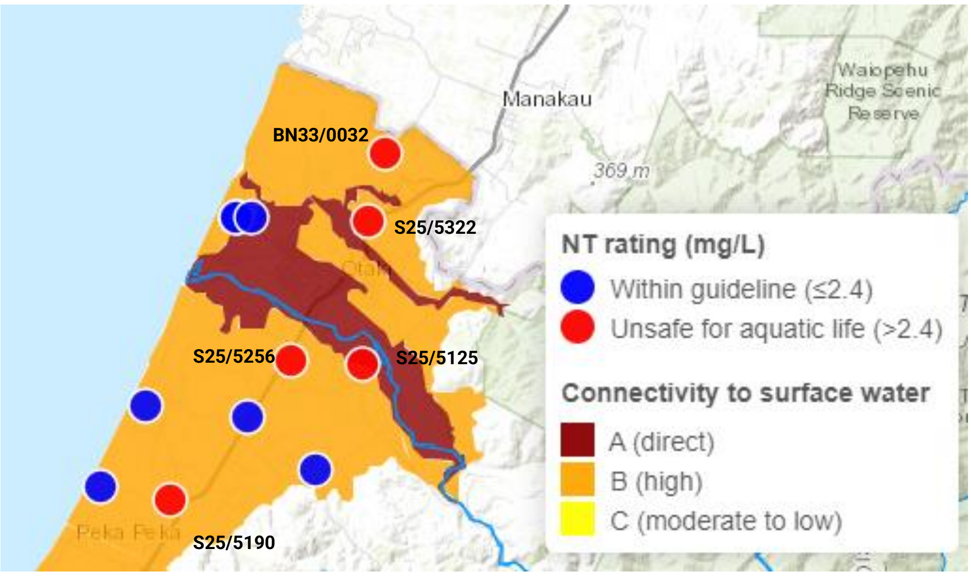

Figure 12: Groundwater quality SoE sites that exceed the national bottom line for NPS-FM (2020/21)

Groundwater trends

Groundwater nitrate trends for the greater Wellington Region were last assessed for the period 2003 to 2016. Of the 11 monitoring sites assessed in the greater Ōtaki assessment zone two sites had meaningful decreasing (improving) trends and there were no sites with increasing trends. The two wells with decreasing trends were located up gradient of the Te Hapua wetland (R25/5190) and on the Hautere plains (S25/5256).

Nitrate concentrations at the Hautere plains site (S25/5256) have decreased significantly at this location from ~15 mg/L in the early 1990s, to less than 8 mg/L in 2016. Prior to 1990 there was a lot of horticultural land use across the plains, however through the late 1980s and 1990s much of this was converted to lifestyle and dairy. The decrease in nitrate concentrations is likely to be reflective of this de-intensification of land use that occurred during this time.

Nitrate concentrations at the well near Te Hapua wetland (R25/5190) decreased from 10 mg/L to 4 mg/L. The relatively small capture zone for the well (100m radius) has mainly pasture as part of a lifestyle block and no changed in land use have been observed.

Decreasing concentrations of nitrate in all instances are most likely due to a reduction of nitrate contamination on the land, but this requires further investigation.

Pressures

Land use practices can influence groundwater quality especially in shallow and unconfined aquifers (Category A and B) where there is a greater hydraulic connectivity between the surface and unconfined aquifers. The main sources of nitrate to groundwater are likely to be from wastewater from septic tanks, animal excrement and urine, and application of inorganic fertilisers are generally the major sources in rural areas.

Stock exclusion, stock unit reduction, riparian planting and retirement are all mitigation in rural areas that can help reduce nitrate concentrations in groundwater.

6.2 Wetlands

Wetlands form a critical boundary between land and water. The RMA defines wetlands as "permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions". It is estimated that only 2.3% of the original wetland extent is estimated to remain in the Wellington region (Ausseil et al. 2003).

Across the Kāpiti Whaitua there are 49 wetlands that have been scheduled as significant (46) or outstanding (3) in the NRP, covering a combined 387ha.

Wetlands are important aquatic ecosystems, which have many environmental benefits. They act as natural water filters, absorbing nutrients and trapping sediment which would otherwise make it into our lakes, rivers, and streams. They slow the flow of water down from the land and slowly release it during dry periods, which is particularly important during periods of high or low rainfall. Wetland also support a diverse range of flora and fauna, including many rare and threatened species, which can only live in these environments

NPS-FM 2020 & wetlands

Under the NPS-FM 2020 GWRC must include a policy in its regional plan whereby "the loss of extent of natural inland wetlands is avoided, their values are protected, and their restoration is promoted". Natural wetlands in the NPS-FM have a narrower definition that that of wetlands in the RMA. It excludes constructed wetlands, geothermal wetlands, and those dominated by exotic pasture species (i.e., >50% coverage) so as not to capture productive farmland[7], Furthermore, each regional council must identify and map every natural wetland in its region that is greater than 0.05 ha (500m^2) as well as those naturally less than 0.05 ha that are known to contain threatened species by 2030.

To identify all natural inland wetlands GWRC have trialed the use of a computer-based model that uses machine learning to identify wetlands on the Kāpiti Coast [58]. The Model identified 10,458 wetland polygons (areas) >0.05ha, which represented ~3% of the mapped area. Further desktop refinement of the model outputs and ground truthing are ongoing to improve wetland delineation on the Kāpiti Coast. For example, many of the wetland polygons identified by the model belong to a single wetland system.

Wetland health and pressures

GWRC monitor a network of 150 wetland sites, roughly 30 in each of the five Whaitua, across the region over a 5-year period [59]. The 36 Kāpiti Coast wetlands, predominantly those already identified as Key Native Ecosystems (KNE) sites or as significant in the NRP, were monitored for the first time in either 2017/18 (30) or 2021 (6). Each surveyed wetland is assessed using the Wetland Condition Index (WCI) and Wetland Pressure Index (WPI). The WCI is a composite index that uses hydrologic integrity, physiochemical parameters, ecosystem intactness, browsing/predation/harvesting and dominance of native plants as indicators of wetland health. Fish and key indicator bird species monitoring was also undertaken at three of the regionally significant wetlands; Te Harakeke, Te Hapua Swamp Complex and O-Te-Pua/Paru ā uku. Indicator birds included bitten and spotless and marsh crake; these birds are particularly vulnerable to predation.

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[7] Note this definition is under review following a consultation period in 2021

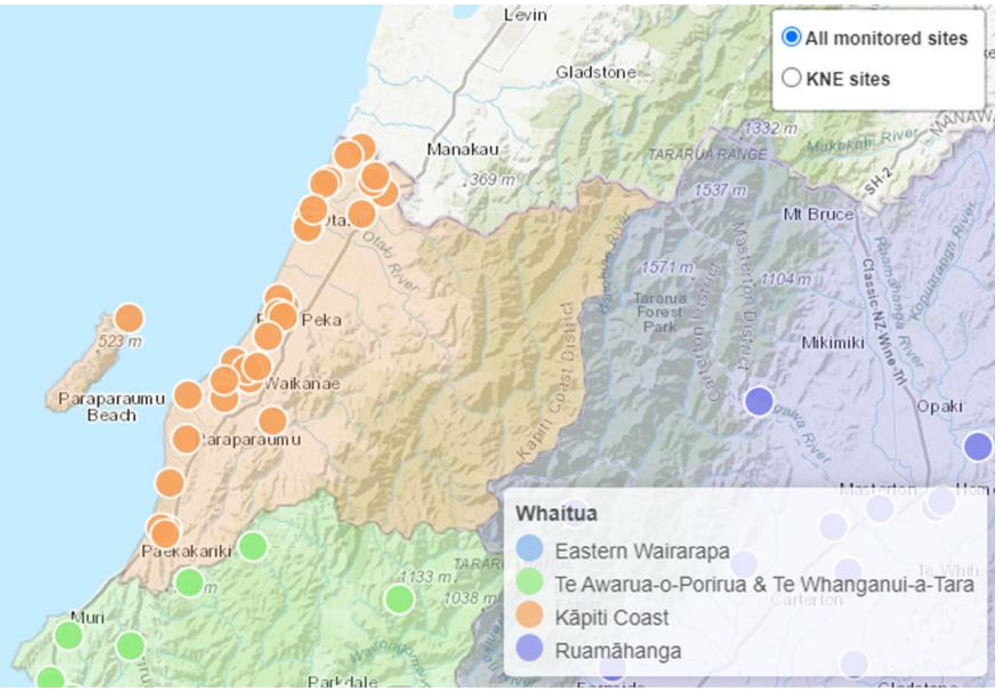

Figure 13: The 30 wetlands sampled as part of the GWRC wetland monitoring programme

Of the 36 wetlands monitored across the Whaitua, 12 of the wetlands were in the Ōtaki assessment zone. Three wetland types were identified: swamps[8], fens[9], marsh and salt marsh and consisted of eight dominant vegetation habitat types; herbfield, forest, shrubland, sedgeland, flaxland, grassland, fernland and reedland.

The wetlands assessed in the Ōtaki assessment zone were South Waikawa Beach Dune Lake, Ngatotara Lagoon, O te Pua, Haruatai Park Forest, Otaki River Mouth Lagoon & Rangiruru Wetland, Sims Wetland, Otaki River Mouth South, Waimanguru Lagoon (Forest Lake), Waitohu River Mouth Saltmarsh, Lake Kaitawa & Keelings Bush, Otaki Stewardship area wetland, Lake Waiorongomai Wetlands and Huritini Swamp.

The average condition of wetlands surveyed in the greater Ōtaki assessment zone was categorised as being in a good state by national standards [60,61]. All the condition indicators that make up the WCI had a good average state across in the assessment zone. However, some of the metrics in each condition indicator were in a moderate to poor state; these included loss in area of wetland, introduced predator impacts on wildlife, and native animal species decline.

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[8] Swamps are relatively high in nutrients, supplied by nutrients and often sediment via surface runoff and groundwater from surrounding land. The water table is usually above some of the ground surface, though due to large, seasonal fluctuations can periodically be much higher or lower.

[9] Fens have a predominantly peat substrate and fed by both rain and groundwater. The water table is typically just below the peat surface.

Table 11: Average wetland condition index and metric scores for wetlands assessed in the Ōtaki assessment zone.

Condition Indicator	Average condition (score out of 5)
Hydrological integrity	Good (3.3)
Physiochemical parameters	Good (3.5)
Ecosystem intactness	Good (3.4)
Browsing, predation & harvesting	Good (3.3)
Dominance of native plants	Good (3.1)
Wetland Condition Index	**Good (16.6)**

Condition score is out of 5; poor = 0 – 2, moderate = 2 – 3, good = 3 – 4, excellent = 4 – 5. Wetland condition score out of 25; 0 = poor condition, 25 = excellent condition.

Five fish (common bully, inanga, shortfin eel, longfin eel and brown mudfish) and two bird (spotless and marsh crake) species were identified in the three of the regionally significant wetlands where additional fish and key indicator bird monitoring was undertaken. The high abundance of crake at all three sites indicates low levels of predation.

The WPI was generally consistent across the vegetation types found across the assessment zone. Animal access and grazing was the pressure with the lowest score. The Wetland Pressure Index was generally higher (i.e., greater pressure) for Kāpiti Coast wetland than what it was for Ruamāhanga Whaitua wetlands. This is mostly likely be the result of the high degree of modification that has occurred on the Kāpiti lowlands through urban and rural development.

Table 12: Average wetland pressure index and metric scores for all wetlands assessed in the Ōtaki assessment zone.

Pressure Indicator	Average condition
Modifications to catchment hydrology	Poor (3.5)
Water quality decline in catchment	Poor (3.2)
Animal pest presence (excl. stock)	Poor (3.5)
Key undesirable species	Moderate (2.8)
% Catchment in introduced vegetation	Poor (3.7)
Wetland isolation	Moderate (2.5)
Grazing pressure	Good (1.4)
Wetland Pressure Index	Moderate **(19.4)**

Pressure score is out of 5; Excellent = 0 – 1, Good = 1 – 2, Moderate = 2 – 3, Poor = 3 – 5. Wetland Pressure score out of 35; 0 = no pressure (excellent), 25 = max pressure (poor).

In a report prepared for the KCDC by Boffa Miskell in 2012 [62] to assess the potential impacts on wetlands associated with the river Waikanae River recharge programme it was concluded that there was sufficient evidence to suggest that while the wetland ecosystems of the Kāpiti Coast are adapted to the current levels of change, they are highly vulnerable to any significant change to their hydrological regime. Drainage of wetlands for rural and urban development and water abstraction are the key drivers that have historically affected the hydrological integrity of wetlands.

6.3 Estuaries

An estuary is a partially enclosed body of water at the bottom of a catchment where saltwater (from the sea) and freshwater (from the land) meet and mix. In good ecological condition they are biodiversity hotspots supporting an enormous abundance and diversity of species including fish, shellfish, marine worms, reeds, seagrasses, mangroves, algae, and phytoplankton as well as visiting species such as birds which roost and feed, pelagic fish to spawn and use as nurseries, and freshwater fish to spawn and migrate through.

Estuaries are receiving environments for surface water contaminants, in particular sediment and nutrients, generated from upstream catchments. Thus, any decisions made to protect freshwater values upstream should also consider whether they will also protect the health and condition of the estuarine receiving environments.

In preparation for the Kāpiti Whaitua a review of estuary ecological condition and habitat vulnerability was commissioned by GWRC and undertaken by Salt Ecology [63]. The review assessed nine estuaries across the Whaitua and drew extensively on existing information but was also supplemented by synoptic surveys at each of the nine estuaries. The ‘overall condition’ section (below), summarises the condition of each individual estuary in the Ōtaki assessment zone and have been taken directly from Stevens & Forrest (2019) [63].

The estuaries assessed in the greater Ōtaki assessment zone included the Waitohu, Ōtaki and Mangaone.

All estuaries in the assessment zone, other than the Otaki Estuary, are classified as low flow and shallow estuaries, which occur where the stream outlet to the coast is restricted or blocked completely by a sand or gravel barrier just short of the ocean. Low flow shallow estuaries have little or no intertidal habitat or salt marsh. These estuaries have been heavily modified by past drainage and channelisation, with mouths periodically opened artificially to reduce flood risks.

The Otaki Estuary differs from the other estuaries in the assessment zone in that it has a moderate/high flow, which dominates over tidal flows and flushing is relatively extensive because the mouth is nearly always open.

6.3.1 Estuary condition and value ratings

Over the last decade approaches have been developed in NZ to assess estuaries susceptibility to specific pressures and evaluate the current state of the environment. These approaches are generally consistent with NPS-FM NOF attribute tables, in that there are four ‘bands’ (very good, good, moderate, and poor) for a suite of indicators, as well as combining multiple measures into integrated indices.

The New Zealand Estuary Trophic Index (ETI) is a measure of nutrient enrichment and is derived by from several metrics in the National Estuary Monitoring Protocols, while the ETI susceptibility rating is a measure of susceptibility to sediment and nutrient enrichment (i.e., future nutrient enrichment). In the Salt Ecology report, the ETI condition and susceptibility ratings as well as a range of additional metrics for seagrass, macroalgae, and sedimentation were used to assess the current condition of the estuaries in the Ōtaki assessment zone. These indicators and indices are presented in Table 13.

Table 13: Estuary condition ratings

	Waitohu	**Ōtaki**	**Mangaone**
Intertidal soft mud extent (%)	Very good	Moderate	Very good
Macro-algae	Very good	Very good	Very good
Seagrass (decrease from baseline)	Very good	Very good	Very good
Salt marsh (% of estuary)	Poor	Poor	Poor
Historic salt marsh (% remaining)	Poor	Poor	Poor
Densley vegetated 200m margin (%)	Good	Good	Poor
High Enrichment Conditions (ha, %)	Very good	Very good	Very good
Estuary Trophic Condition Rating			
NZ ETI susceptibility rating	Low	Low	Very High
NZ ETI score (Band)	**0.26 (B)**	**0.29 (B)**	**0.3 (B)**

Estuary ecosystem values, restoration potential and current pressures were also assessed and rated in the Salt ecology report and are summarised in Table 14. Ecosystem values were assessed in Stevens & Forrest (2019) by conflating rankings determined in two earlier reports; Todd et al. (2016) and Stevens (2013). Todd et al. (2016) assessed the ecological, economic, social, and cultural values, and the significance status and future management options of estuarine systems in the lower North Island. Stevens (2013) ranked estuaries as part of regional oil spill response planning for GWRC which provides an overall ranking using a simple additive scoring method.

Table 14: Estuary ecosystem value, restoration potential and pressures ratings

	Waitohu	**Ōtaki**	**Mangaone**
Ecosystem value	Moderate	Moderate	Low
Restoration potential	High	High	Moderate
Overall pressure	Moderate	Moderate	Moderate

Waitohu Estuary

Waitohu Estuary has moderate ecological value including relatively extensive salt marsh habitat which has been lost from many of the smaller estuaries on the Kāpiti Coast. It has low eutrophication susceptibility from nutrient inputs and showed no signs of excessive nutrient enrichment in January 2019.

Current pressures on the estuary are moderate and are predominantly a consequence of catchment influences (flow restrictions, flooding, poor water quality), although vehicle use, and managed mouth openings also cause ecological impacts.

Human use and interest in the estuary is high and supported by active community restoration initiatives with pest and weed control and riparian planting of the estuary fringes and dune. There is good potential for ongoing habitat restoration at this site.

Ōtaki Estuary

Ōtaki Estuary has moderate ecological value primarily bird and fish habitat, although the latter is constrained by flood control measures and tidal gates.

Estuarine biodiversity is relatively low due to the low diversity of substrate types and limited presence of salt marsh. It has low eutrophication susceptibility from nutrient inputs and showed no signs of excessive nutrient enrichment in January 2019.

Current pressures on the estuary are moderate and are predominantly a consequence of flood control measures, terrestrial weed invasion, and vehicle use. Human use and interest in the estuary is high and supported by active community restoration initiatives with pest and weed control and riparian planting of the northern estuary fringes. There is good potential for ongoing habitat restoration at this site.

Mangaone Estuary

Although Mangaone Estuary is included within the GWRC KNE Plan for the wider Ōtaki coast, its flood-prone nature and past modification, regular mouth closures (which cause water quality to be highly variable) and coarse sediment types mean estuarine biodiversity is relatively low. Despite these limitations, it supports limited salt marsh, provides bird and fish habitat, and has low eutrophication susceptibility from nutrient inputs. The estuary showed no signs of excessive nutrient enrichment in January 2019.

Current pressures on the estuary are moderate and predominantly arise from flood control measures, terrestrial weed invasion, and vehicle use.

Human use and interest in the estuary is moderate to high and supported by active community restoration initiatives with pest and weed control and riparian planting of the estuary fringes. There is good potential for ongoing habitat restoration at this site.

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