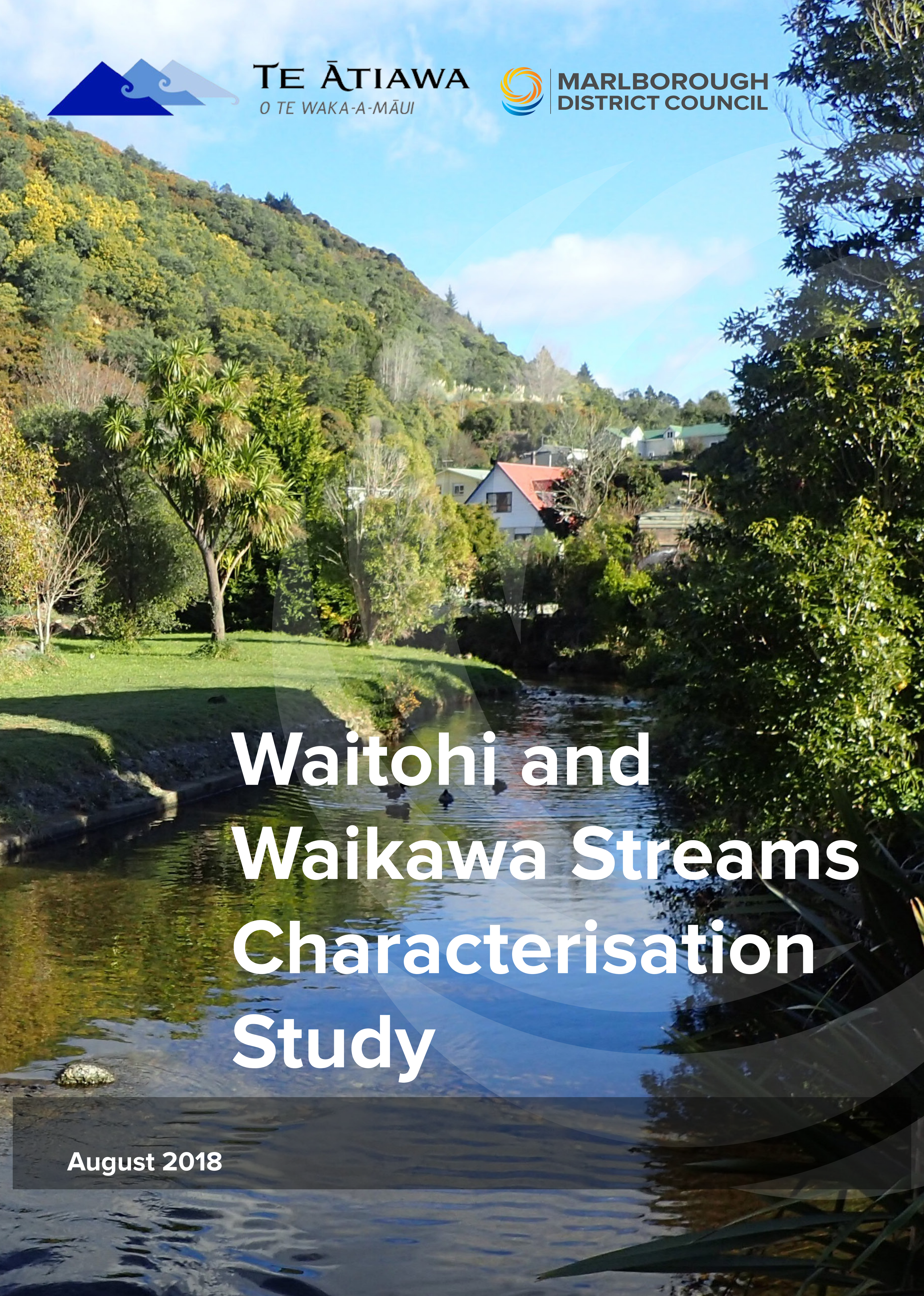

Te Ātiawa o Te Waka-a-Māui

Marlborough District Council

Waitohi and Waikawa Streams Characterisation Study

August 2018

Waitohi and Waikawa Streams Characterisation Study

A Report

Project funded by: Ministry for the Environment (MfE)

Project led by: Te Ātiawa Manawhenua Ki Te Tau Ihu Trust (Charitable Trust Registration no. 610596)

Project supported scientifically by: The Marlborough District Council

The Project Contract is appended

Report prepared by Te Ātiawa Rohe Management Office, Waikawa, Picton.

This report has two sections; Section 1, facilitated by Te Ātiawa Manawhenua Ki Te Tau Ihu Trust, which describes the history and cultural values associated with the Waitohi and Waikawa streams, and, Section 2, being a report by the Marlborough District Council that addresses Water Quality in the Waitohi and Waikawa catchments.

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Section 1: A report that describes the history and cultural values associated with the Waitohi and Waikawa streams

Section 2: A report by the Marlborough District Council that addresses Water Quality in the Waitohi and Waikawa catchments

Section 1: A report that describes the history and cultural values associated with the Waitohi and Waikawa streams

Section1 has three distinct parts; an *Overview* of the Waitohi and Waikawa Streams, Part A, which summarizes the background of the migration of Te Ātiawa from Taranaki to the rohe in which the Waitohi River and Waikawa Stream are located, and Part B, which offers the tikanga around the Waitohi River and Waikawa Stream. (Parts A and B have been taken, verbatim, from material provided by Te Ātiawa cultural advisors.)

Overview: The Waitohi and Waikawa Streams

The Waitohi and Waikawa Streams have a special place in the Rohe of Te Ātiawa and have had a close association with Waikawa Marae in Tōtaranui / Queen Charlotte Sound, where Te Ātiawa people are Tangata whenua. As kaitiaki of its Te Tau Ihu rohe, Te Ātiawa people want to ensure that the environment is sustainably managed. They carry a responsibility to protect and care for the environment for future generations.

Waitohi River – is of utmost cultural significance to Te Ātiawa. Before Europeans arrived, the iwi occupied the banks of the Waitohi. The waters of the Waitohi were considered sacred as it came from their maunga, Piripiri, at the head of the catchment. The waters were used for a variety of tikanga, one of which was the preparation of warriors for battle. Post European settlement, and the displacement of Te Ātiawa from Picton, the banks of the Waitohi were developed and its waters polluted by urban and industrial developments. Simply put, there has been no work done on the Waitohi River to indicate its overall health or mauri. The proposed work will provide Te Ātiawa with an assessment of the Waitohi River's current overall health and a tool for the future management/enhancement.

Waikawa Stream – once relocated to Waikawa, Te Ātiawa adopted the Waikawa Stream. It provided freshwater for tikanga, gardens, and other ceremonies. A makeshift marae/community facility was constructed close to its banks and eventually the Waikawa Marae (Arapaoa) was constructed on its banks. Many Te Ātiawa members would identify with the Waikawa Stream, as that is what they have grown up with. Yet, there has been no characterisation work undertaken on the Waikawa Stream, and development has been allowed on its banks unabated. The proposed work would assess the ecological health/state of the Waikawa Stream and provide a benchmark (for Te Ātiawa) to seek improvement/enhancement.

Part A: Te Ātiawa Migration to Te Tau Ihu

Demand for more land and resources and the conquest of Te Tau Ihu

As the numbers of Te Ātiawa increased in the lower North Island, so too did the demand for more land and resources. Inevitably, the Taranaki and Kawhia tribes turned their attention to the South Island. Te Ātiawa took up opportunities with the arrival of the early whalers and traders. They also took advantage of the opportunity to acquire land in Te Tau Ihu.

The conquest of Te Tau Ihu was a joint effort with the Kawhia tribes. Te Manutoheroa, Huriwhenua, Te Koihua, Whitikau and many others led the contingent for Te Ātiawa in a series of attacks. The main attack took place around 1829-1830. The Northern tribes fought battles against Ngāti Kuia, Rangitāne, Ngāti Apa and Tu-mata-kokiri, who were armed with traditional weapons. The local tribes never really stood a chance against the northern tribes who were well armed with muskets. Ngai Tahu did not escape the wrath of the northern tribes either. The Poutini people occupying the West Coast were subdued and those on the East Coast suffered great losses.

Waikato and Manipoto seek revenge, more Ngatiawa head South

In 1832, Waikato and Maniapoto finally executed their threat to seek payment for both the assistance given to the Kawhia tribes at the Battle of Motunui, and for their subsequent loss of chiefs. Attacks were made at Pukerangiora and Ngā Motu. As a result, most of the remaining Ngatiawa people, along with the Europeans who had helped them, decided to migrate South to join their relatives – many of whom were now widely distributed about the Cook Strait District and the Northern South Island. Te Heke Tamateuaua left Taranaki, with around two thousand men, women and children.

Te Ātiawa settlement of Te Tau Ihu was a gradual process. Land was first settled in 1832, and by 1840; Te Ātiawa occupied land from Totaranui (Queen Charlotte Sound) to Mohua (Golden Bay).

Protecting the tribal estate of Te Ātiawa

Many Te Ātiawa returned to Taranaki in 1848 and subsequent heke occurred after the mid1850s. In both cases the return was influenced by concern about the land in Taranaki and, in the latter, as a result of the actions of the Colonial Government. The Taranaki Land Wars, one of the major events of the Nineteenth Century, stemmed from the desire of Wiremu Kingi Te Rangitaake to protect the tribal estate of Te Ātiawa. In 1860, the first of the country's land wars involving the Crown began and Māori resistance at Parihaka continued through until the end of the century.

Systematic loss of asset base and ability to exercise rangatiratanga

By 1860 Te Ātiawa were more restricted in their movements, largely because huge land purchases had already taken place by this time. In the 1840s and 1850s reserves were established for Te Ātiawa to live on. These reserves were all that remained of their land. Apart from the fact that the reserves were inadequate, in many cases, the land was worthless. Through successive government legislation and policy, Te Ātiawa have been systematically stripped of their main asset base, and the ability to exercise rangatiratanga in accordance with Te Tiriti o Waitangi. (J Ritai, Taranaki Muru Raupatu Wai 143, in A Riwaka (July 2000).)

Part B: Tikanga around the Waitohi River and Waikawa Stream

TE WERANGA O WAITOHI AND TE MAUNGA PIRIPIRI (Researched & Compiled By Kaumātua Mike Taylor)

Te Weranga o Waitohi was the original name for Picton. Waitohi was a ritual (baptismal) or Tohi rite before warriors went into battle, the latter lined the bank of the sacred stream, where as they filed past, the Tohunga dipped the branch of the karamu bush into the stream, striking each warrior on the right shoulder. If a leaf fell off the branch, that warriors chances of returning from battle was quite good, however, if a branch broke then that warriors chance of returning was very remote. Hence:-

Waitohi Te Awa Tapu = The sacred stream which flows from the sacred mountain, Piripiri Te Maunga Tapu. Te Maunga Piripiri is the mountain to the south-east of Waitohi, One meaning of Piripiri is to embrace which could refer to the surrounding hills which embrace Waitohi, but in this case it refers to the scented moss which grows on the high ridges of the mountain. Piripiri was highly prized by the Māori women, who wore it in small kete around their necks, Piripiri gives off a fragrant scent. The following lullaby which refers to this moss, and also to the Taramea (Speargrass), out of which Kakarataramea, a sweet scented gum which was made from the leaves of the Taramea. These were heated to expel the gum and mixed with oil extracted from the Kereru.

Taku hei Piripiri Taku hei Mokimoki Taku hei Tawhiri
Taku hei Taramea

My little neck satchel of sweet scented moss My little neck satchel of fragrant fern
My little neck satchel of odoriferous gum
My sweet smelling neck locket of sharp pointed Taramea.[1]

On researching further on the above I found another use which some of the above were also used. As an anointing oil for deceased persons. Made up as follows:-

Mokimoki, a scented fern;
Tarata, a tree producing a strong smelling turpentine; Kopura, a fragrant moss[2]
Taramea, the root which was very aromatic[3]

Kati Taramea (receptacle for scent) made of Albatross bone used as receptacle for material charged with taramea scent, worn round the neck over hei-koko (ornament of tui skin, which was scented with piripiri.

Another version of the same lullaby has been recorded by Richard Taylor as follows:- Perfume made from the semitransparent gum of taramea is celebrated in Māori song and proverb, as in this nursery love song: "My necklace of scented moss; My necklace of fragrant fern; My necklace of odorous shrubs; My sweet smelling locket of taramea." It

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1 Marlborough Archives written on either goat or pig skin parchment.

2 Also known as Kopuru.

1 2 3 Taramea is commonly known as Spear Grass.

formed the basis of a compound affectionately termed “the grand Māori perfume.” As well it was “fixed” in various bird and vegetable fats and suspended around the neck in hei, or neck bands[4]. Many of the plants from which perfume was extracted were known as Piripiri.

There was an instance I remember, when Manaia MacDonald and myself were hunting on Piripiri, we stopped on the high ridge to have something to eat, we sat in between the large roots of the black birch tree which formed an armchair type design. When Manaia said to me what’s that perfume you’ve got on, I said, ‘I thought it was you.” However, it was the moss on which we sat. On returning home Manaia mentioned it to his wife, and she told us it was Piripiri, and how the Māori girls used to wear it in little kete around their necks. The moss was growing on the south facing (damp) side of the trees.

Past authors of Māori history, especially in connection with Waitohi have continually referred to Waitohi being named after Te Rauparaha’s sister Waitohi, dying here, however, she died on Mana Island, Kapiti coast, and this was not until 1839, as recorded in Wakefield’s dispatches back to England. Also Memorials are not made to people still living. As Captain William Steine visited the Waitohi on August 14 1832, when he reported that he found 200 Māori living there.[5][5] Those same authors also refer to Te Wera o Waitohi, which after extensive research the only near reference which these authors seem to have shortened (as many Māori names were shortened, especially in schools and Crown agencies) is Te Wera o Waitohi from Te Weranga o Waitohi, the latter is mentioned in the Waitohi Purchase Deed. None of the afore mentioned authors have written the history from a Māori perspective, it is to be hoped that sometime in the near future this can be done, to ensure that the history our tamariki and mokopuna are learning at school is correct. **Te Weranga o Waitohi refers to the sacred waters.**

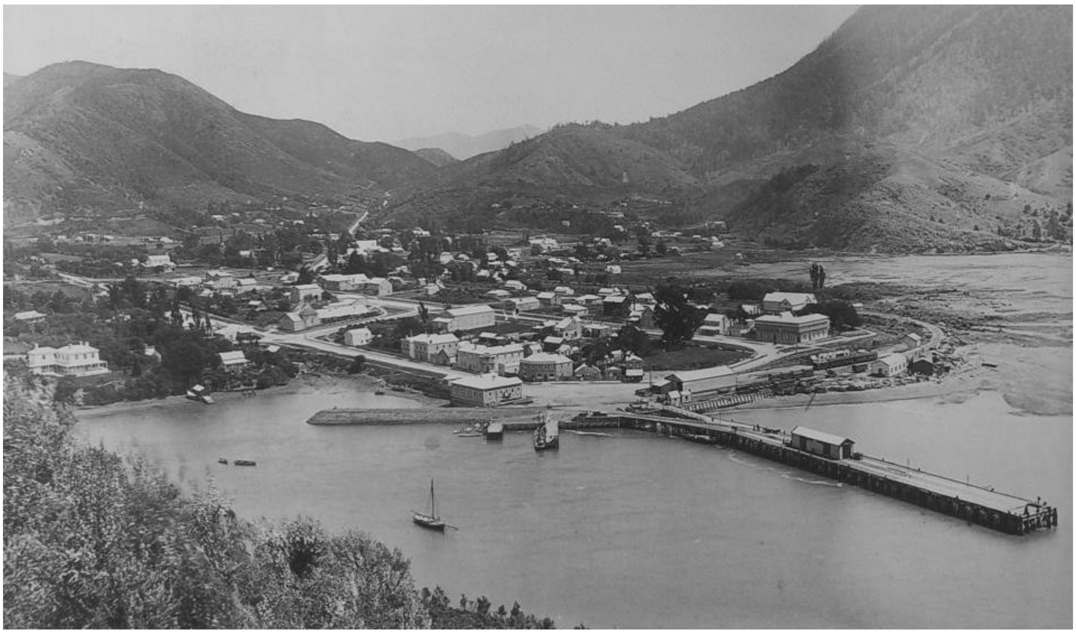
Also the Waitohi Valley which extends from Picton to Tua Marina.

[(related information) Over the past 70 years, the Waitohi Lagoon has been progressively filled in, totally changing the character of the lower Waitohi River, with the main reclamation, to enable the development of the rail yards, occurring in 1971. Ultimately, the lower reaches of the Waitohi River have been extensively culverted, with the seaward end discharging into the Picton Harbour, adjacent to the Interislander Ferry Terminal.

4 R. Taylor, Māori Race Notebooks GNZ MSS 297 Taylor Collection Auckland Public Library – Notebook 33.

5 Hobart Town Courier September 14 1832, Steine named Okiwa Bay in the Grove Arm, “Hornes Bay, and the Grove Arm “Queen Adelaide River

The Pictures below show these changes.]



Waitohi (Picton) and the Waitohi Lagoon – the delta of the Waitohi River, extreme right, circa 1895 - Photo: Historic Archive

Looking down on to the Picton ferry terminal. At left is the land reclaimed and in the middle of this area a transporter park will be made. The existing terminal, with the Aramoana departing, can be seen near the middle of the photograph. The No.2 terminal will be between that and the Waitohi Wharf alongside which are two ships

The Waitohi River and the Waitohi Lagoon have disappeared beneath fill and culverting. Photo: Nelson Photo News – No129: July 24, 1971

Currently, the Waitohi River runs to the sea beneath the rail yards, with its outlet approximately in the very centre of this image – Photo: Te Ātiawa Trust, circa 2014

Te Maunga Ko Tara o te Marama
Known as Mount Freeth, this mountain is situated to the west of Waitohi, which according to some is the mountain of the moon. It should also be noted here that the sun rises from the east and sets over Ko Tara o Te Marama, as does the moon.

Tokomaru - Mount Robinson, to the southeast of Picton, behind Piripiri, has a microwave disc on top.

Coming from Blenheim on reaching Tua Marina straight, the mountain directly in front of you is:-

Hine Koareare - Mount Strachan. History states that Hine Koareare is buried on the mountain, she was out gathering raupo roots with other women when a taua came through and she was killed.

Then on the opposite side of Waitohi Valley the highest point is Whitiao.

Other place names that are incorrectly written or shortened in Marlborough are:-

Okaramio	**Orakauhamu**
Onamalutu	**Ohinemahuta - daughter of Tane Mahuta god of Forests**
Ruapaka	**Otokoruapaka**

Waikawa Stream

Piripiri Te Hautapu is the mountain directly behind the Waikawa Marae, not to be confused with Piripiri Te Maunga above, [(related information) and it is from the water catchment dominated by this Maunga that Waikawa Stream rises].

In 1828, the Ngatiawa tribe (Te Ātiawa Iwi) took Tōtaranui (Queen Charlotte Sound) by conquest. Ropoama Te One, a paramount chief of the Ngatiawa, established himself at Waitohi and later negotiated the sale of the pa site which saw the tribe, albeit reluctantly, move to Waikawa [and (related information) all but perish from contaminated local water, arguably including Waikawa Stream. Fortunately, Ropoama Te One found a spring of fresh water which saved the people – see below.].

This stream also comes from a branch of Piripiri, the high point directly behind Waikawa Marae known as "Piripiri Te Hautapu."

Ropoama Te One, a rangitira of Te Ātiawa, was one of the signatories to the Treaty of Waitangi, and one of the main signatories to the Waitohi Purchase, by the New Zealand Company, in 1850.

Negotiations for the Waitohi pa site, as land for the future town of Picton, stretched from December 1848 through to the final deed of sale signed 4th March 1850. The establishment of the Town of Picton, formerly called Waitohi, was gazetted in October 1859.

The Waikawa Stream as is well known, was where our people eeled, and there used to be the native Trout, Koura, and down where it used to run into the sea, whitebait. However, the area was reclaimed over the top of our kaimoana beds.

[(related information) Lower Waikawa Stream has sufferd two major insults in the last 40 years: Firstly, the Marlborough Catchment Board and Regional Water Board undertook works straightening and containing of the lower stream, from what was formerly a wider braded shingle delta, with a view to enabling more land development in Waikawa. This very significant physical intervention totally changed all of the lower habitat /ecological characteristices, and has untimately created a higher velocity lower stream situation that offers a level of flood risk to developed land where the stream formerly meandered. Additionally, because of the changed gradient and velocity of the lower stream, considerably more bed material is being carried into Waikawa Bay, thus changing the benthic characteristics / habitat over an extensive area where Waikawa Stream discharges into the bay.]

[The second major insult to the lower area of Waikawa Stream and the significant remaining kaimoana beds that had evolved as a consequence of the stream's relationship with the intertidal zone and the wider bay over millenia, was the development of the Waikawa Marina. This development completely changed the character of this substantial area in the southwest of Waikawa Bay. Images that show these changes follow]

Early Waikawa Scene, showing Arapaoa House (two story building) at left. At extreme right of photo, shows how far the sea came up. Waitohi Stream delta, upper right. Photo: Mike Taylor Archive

Waikawa Bay looking towards Picton, taken from hill east of Waikawa. Waikawa Stream delta, centre right. Photo: Mike Taylor Archive

Waikawa Marina in the 1990's showing Waikawa School grounds and early development below Cemetery. Photo taken from top cemetery. Waikawa Stream runs from left to right in the centre of the image. Photo: Mike Taylor Archive

[(related information) After the latter the Māori people resident in Waitohi (Picton) moved to Waikawa, and it was soon after this that typhoid broke out amongst them. Māori oral history tells that Ropoama found a spring of fresh water and encouraged his people to use it, so ending the spread of disease. We do not have a date for this particular epidemic, as there were few written records of the Māori population at the time, and the Marlborough newspapers did not start publication until the 1860s.

Ropoama's well. The plaque. Image supplied by Picton Historical Society

Ropoama himself died in 1868, so we know the typhoid outbreak was before this time. However, an event does not have to be written down to have occurred, and it remained strong in the memories of the Kaumātua and was passed down to their children and grandchildren.

In 1978, when there was a strong Māori presence in Picton Historical Society and its President was Meteria (May) Horrey née Tonga Awhikau, the Society decided to mark this unscripted past event with a monument. At that time most people knew from their elders what had occurred, and the Society Minutes of 2 May 1978 record: "After a discussion in Committee it was decided that subject to the approval of the land owner and the Elders of Waikawa the Society would erect a plaque on or near the site of Ropoama's well in Waikawa where fresh water was discovered and broke the Typhoid epidemic that occurred when the Māoris shifted to Waikawa after the Waitohi purchase." This plaque cost the Society $257 that year, a considerable sum for a small voluntary organisation.

It is believed that the actual site of the spring was on the other side of Waikawa Road from where the plaque was placed. The monument remains as the only solid reminder of the episode.] (This story by Loreen Brehaut was first published in Picton in the Seaport Scene.)

Te Ātiawa Manawhenua Ki Te Tau Ihu Trust – 31 May 2018

Appendix

1 Contract for Services

2

3 Waitohi and Waikawa Streams Characterisation Study

4 Contract Reference number:

5 The Parties

6 ***Ministry for the Environment***	***7 Buyer)***
8 *Environment House, 23 Kate Sheppard Place, Thorndon, Wellington 6143* ***and***	
9 ***Te Ātiawa Manawhenua Ki Te Tau Ihu Trust*** *(Charitable Trust Registration no. 610596)*	***10 (Supplier)***
11 *72 Trafalgar Street, Nelson 7010*	

12 The Contract

13 Agreement

14 The Buyer appoints the Supplier to deliver the Services described in this Contract and the Supplier accepts that appointment. This Contract sets out the Parties' rights and obligations.

15 The documents forming this Contract are:

1. This page **Page 1**
2. Contract Details and Description of Services **Schedule 1**
3. Standard Terms and Conditions **Schedule 2**

   GMC Form 1 SERVICES | Schedule 2 (2nd Edition) available at: www.procurement.govt.nz
4. Any other attachments described at Schedule 1.

16 How to read this Contract

5. Together the above documents form the whole Contract.
6. Any Supplier terms and conditions do not apply.
7. Clause numbers refer to clauses in Schedule 2.
8. Words starting with capital letters have a special meaning. The special meaning is stated in the Definitions section at clause 17 (Schedule 2).

17 Acceptance

In signing this Contract each Party acknowledges that it has read and agrees to be bound by it.

For and on behalf of the **Buyer**: ____________________ (signature)		For and on behalf of the **Supplier**: ____________________ (signature)	
name:	Roger Bannister	**name:**	Archdeacon Harvey Ruru
position:	Manager	**position:**	Chairman
date:		**date:**	
		For and on behalf of the **Supplier**:	
		(signature)	
		name:	Richard Prosch
		position:	General Manager
		date:	

Schedule 1

18 Contract Details and Description of Services

Start Date	27 June 2017	**Reference Schedule 2 clause 1**
End Date	31 May 2018	**Reference Schedule 2 clause 1**

Contract Managers Reference Schedule 2 clause 4		**Buyer's Contract Manager**	**Supplier's Contract Manager**
	Name:	Jo Armstrong	Bruno Brosnan
	Title / position:	Senior Analyst	Rohe Manager
	Address:	Environment House, 23 Kate Sheppard Place, Thorndon, Wellington 6143	Beach Road, Waikawa Marina, Waikawa Picton
	Phone:	021 636 637	03 573 5170 021 621 439
	Fax:		
	Email:	Jo.armstrong@mfe.govt.nz	rm@teatiawatrust.co.nz

Addresses for Notices Reference Schedule 2 clause 14		**Buyer's address**	**Supplier's address**
	For the attention of:	Roger Bannister	Bruno Brosnan
	c.c. Contract Manager	Jo Armstrong	
	Delivery address:	Environment House, 23 Kate Sheppard Place, Thorndon, Wellington 6143	Beach Road, Waikawa Marina, Waikawa Picton
	Postal address:	PO Box 10362	PO Box 340, Picton 7250
	Fax:		

Supplier's Approved Sub-contractor Reference Schedule 2 clause 7		**Approved Sub-contractor**
	Name:	Marlborough District Council
	Address:	15 Seymour St, Blenheim
	Specialisation:	Environmental Science

Description of Services

Context

These Services are required to inform national implementation of the National Policy Statement on Freshwater Management resulting in improved freshwater management.

The Supplier will deliver a report detailing the significance and values associated with the Waitohi and Waikawa Streams (see Appendix 1 for further detail), a characterisation study of the waterways to determine the current state of water quality and instream ecology, and to investigate the potential for stream enhancement, and development of cultural indicators. It is anticipated that this work will provide information to support cultural monitoring and management of fresh waterways throughout New Zealand.

Currently there is little information available regarding the state of the Waitohi and Waikawa Streams outside the Marlborough District Council's State of the Environmental Monitoring programme's single site on the Waitohi Stream.

The Supplier will contract the Marlborough District Council (**the Council**) to undertake monitoring of the Waitohi and Waikawa Streams to determine their current "state" and provide a report to the trust on the waterways. The Supplier will comply with clause 7 (in particular clause 7.3 of Schedule 2 of this Contract) in respect of contracting the Council.

The Council Environmental Science Group has an in-depth knowledge of the water quality and instream ecological values of many waterways around Marlborough and has developed and undertaken several catchment characterisation studies over the last few years.

This project allows the Council to work with the Supplier to gather information on the state of the Waitohi and Waikawa Streams, encouraging partnerships with iwi to improve freshwater management and to ensure lessons learned are shared with iwi and other parties nationally.

Description of Services

The Supplier will undertake a characterisation study of Picton's Waitohi and Waikawa Streams to determine the current state of water quality and instream ecology, and to investigate the potential for enhancement. The output of the study will be a written report that:

- describes the history and cultural values associated with the Waitohi and Waikawa streams
- identifies the current state and pressures of the Streams
- identifies potential enhancement activities that iwi can undertake to support and improve the mauri of the streams
- identifies options for ongoing cultural monitoring
- shares the lessons nationally to support cultural monitoring and freshwater management

The Buyer will own the report for publication and teaching purposes but will allow the Supplier to use the report to direct and plan enhancement work and ongoing monitoring.

Methodology

The Supplier will contract the Council to monitor water quality at a total of 16 sites across the two waterways. Monitoring will be undertaken as follows:

- Each site will be monitored on a monthly basis over a six month period. Dissolved nutrients (DIN and DRP), turbidity, pH, *E.coli*, heavy metals (Cu, Zn, Pb, Cr, As) dissolved oxygen, temperature and conductivity will all be monitored at each site.
- In order to get a picture of the influence that stormwater runoff has on the water quality first flush sampling will occur during two rainfall events over the six-month sampling period.
- The first flush sampling will measure the same parameters as the monthly sampling with the addition of total nitrogen, total phosphorus, and total suspended solids, as well as hydrocarbons on one of the sampling rounds.
- Monitoring of the macroinvertebrates to determine long term water quality conditions will be carried out at three locations on two occasions over the monitoring period on both waterways.

- The distribution of fish species living in the Waitohi and Waikawa Streams will be investigated using electric fishing methods and spotlighting at night. The investigations will occur once in the winter and once in spring.

On completion of the field sampling an analysis of the field data will be undertaken and a report produced on the findings of the monitoring and analysis.

Deliverables

The Supplier will meet the Milestones and provide the Deliverables detailed in the table below by the stated due dates and to the Performance Standards described:

No.	Deliverable/Milestone	Performance Standards	Due date
1a	Scoping exercise to confirm that Marlborough District Council will undertake the stream characterisation work and to determine timing of monitoring activities. Copy to be provided to the Buyer with first quarterly report.	Schedule of monitoring and surveys complete.	30 June 2017
1b	Health and Safety Plan.	Health and safety plan complete (confirmed in quarterly report)	
2	Water quality and macroinvertebrate monitoring and fish survey.	Monitoring and surveys at least 75% complete	30 November 2017
3	Report detailing rohe history, stream characterisation ,and potential enhancement and ongoing cultural monitoring options for the streams provided to the Buyer	Report in PDF demonstrating a comprehensive account of the study (including methodology, results of stream characterisation and recommendations for potential stream enhancement and ongoing cultural monitoring).	31 May 2018

Supplier's Reporting Obligations Reference Schedule 2 clause 5	**Report to:**	**Type of report**	
	Contract Manager	Quarterly Progress Reports by email	30/9/17, 31/12/17, 31/3/18

CHARGES: The following section sets out the Charges. Charges are the total maximum amount payable by the Buyer to the Supplier for delivery of the Services. Charges include ***Fees***, and where agreed, ***Expenses*** and ***Daily Allowances.*** The Charges for this Contract are set out below.

Fees Reference Schedule 2 clause 3	**Fixed Fee** Fixed Milestone payments of the amounts set out in the Invoices section below up to a total maximum Fee of $**40,000.00** excluding GST.

Expenses **Reference Schedule 2 clause 3**	No Expenses are payable.

Invoices **Reference Schedule 2 Subject to clauses 3 and 11.7**	The Supplier must send the Buyer an invoice for the Charges at the following times: On the following dates subject to completion of the relevant Deliverables/Milestones for the Fees of that Deliverable / Milestone as set out in the table below:

No.	Deliverable/Milestone	Due date	Amount due (exc GST)
1	Scoping exercise to confirm that Marlborough District Council will undertake the stream characterisation work, and to determine timing of monitoring activities. Health and Safety Plan is complete.	30 June 2017	$10,000
2	Water quality and macroinvertebrate monitoring and fish survey	30 November 2017	$23,000
3	Report detailing rohe history, stream characterisation, and potential enhancement and ongoing cultural monitoring options for the streams.	31 May 2018	$7,000
		Total (exc GST)	***$40,000***

Tax invoices **Reference Schedule 2 clause 3**		**Buyer's address**
	For the attention of:	Accounts Payable
	Email:	accounts.payable@mfe.govt.nz
	CC Contract Manager:	Jo Armstrong Senior Analyst
		Supplier's Invoicing Details
	Supplier's GST Number:	061-478-787
	Email (for e-copy of Buyer's remittance advice):	office@teatiawatrust.co.nz

Insurance **Reference Schedule 2** **Clause 8.1**	**INSURANCE: (clause 8.1 Schedule 2)** It is the Supplier's responsibility to ensure its risks of doing business are adequately covered, whether by insurance or otherwise. The Buyer does not require any specific insurance under this Contract.
Changes to Schedule 2 and additional clause/s	**Schedule 2 of this Contract is amended as follows:** **Invoice requirements** The first sentence of clause 3.2 is replaced with the following: The Supplier must provide (via email to the Buyer's centralised Accounts Payable email address detailed in Schedule 1) valid tax invoices for all Charges on the dates or at the times specified in Schedule 1. Add the following new clause after clause 3.2: 3.2A If the Supplier's tax invoice does not contain the Buyer's contract reference, the Buyer will not process the invoice and will return the invoice to the Supplier. The Supplier shall reissue the invoice to the Buyer with the contract reference. Add the following new clause after clause 3.4: 3.4A If the Buyer disputes a tax invoice, the Supplier must provide a credit note for the original disputed Tax Invoice along with a replacement Tax Invoice for the undisputed amount if the Buyer requests one. **Subcontractor** Clause 7.5 is inserted as follows: 7.5 If the Buyer reasonably thinks that the Subcontractor has failed to deliver the aspect of the Services being subcontracted as required under this Contract and the failure cannot be remedied, the Buyer may, by Notice to the Supplier, require the Supplier to terminate that sub-contract immediately. **Intellectual Property Rights** Add the following new clause after clause 12.3: 12.3A The Buyer grants to the Supplier a perpetual, non-exclusive, worldwide and royalty-free licence to use, for the Purpose, all Intellectual Property Rights in the Report that are not owned by the Supplier. This licence includes the right to use, copy, modify and distribute the Report. **Email communications** Add the following clause after clause 14.4: 14.5 Despite any other clause in this Contract, both Parties agree to opt out of using electronic transactions. Contract Variations and Contract Notices cannot be legally effected by email communication. This clause 14.5 does not apply to the Supplier's provision of tax invoices to the Buyer in accordance with clause 3.2. **Definitions** Add the following new definitions to clause 17.1: **Purpose** To direct and plan enhancement work and ongoing monitoring with the overarching purpose of improving freshwater management and ensuring lessons learned are shared with iwi and other parties nationally. **Report** The report provided by the Supplier to the Buyer under this Contract detailing rohe history, stream characterisation, and potential enhancement and ongoing cultural monitoring options for Picton's Waitohi and Waikawa Streams to determine the current state of water quality and instream ecology, and to investigate the potential for enhancement.

Attachments **Reference 'Contract documents' described at Page 1**	Appendix 1 – the Waitohi and Waikawa Streams

Appendix 1

The Waitohi and Waikawa Streams

The Waitohi and Waikawa Streams have a special place in Te Ātiawa o Te Waka-a-Māui's Rohe and have had a close association with their marae in Totaranui / Queen Charlotte Sound. As kaitiaki of its Te Tau Ihu rohe Te Ātiawa want to ensure that the environment is sustainably managed and used and have a responsibility to care for the environment for future generations.

Waitohi River – is of utmost cultural significance to Te Ātiawa. Before Europeans arrived, the iwi occupied the banks of the Waitohi. The waters of the Waitohi were considered sacred as it came from their maunga Piripiri at the head of the catchment. The waters were used for a variety of tikanga, one of which was the preparation of warriors for battle. Post European settlement, and the displacement of Te Ātiawa from Picton, the banks of the Waitohi were developed and its waters polluted by urban and industrial developments. Simply put, there has been no work done on the Waitohi River to indicate its health or mauri. The proposed work will provide Te Ātiawa with an assessment of the Waitohi's current health and a tool for the future management/enhancement.

Waikawa Stream – once relocated to Waikawa, Te Ātiawa adopted the Waikawa stream. It provided freshwater for tikinga, gardens, and other ceremonies. A makeshift marae/community facility was constructed close to its banks and eventually the Waikawa Marae (arapaoa) was constructed on its banks. Many Te Ātiawa members would identify with the Waikawa stream as that is what they have grown up with. Yet there has been no characterisation work undertaken on the Waikawa Stream and development has been allowed on its banks unabated. The proposed work would assess the health/state of the Waikawa Stream and provide a benchmark (for Te Ātiawa) to seek improvement/enhancement.

Section 2: A report by the Marlborough District Council that addresses Water Quality in the Waitohi and Waikawa catchments

MARLBOROUGH DISTRICT COUNCIL

Only Marlborough

Water Quality in the Waitohi and Waikawa catchments

August 2018

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Introduction

The Marlborough District Council was contracted by Te Ātiawa o Te Waka-a-Māui to undertake monitoring of the Waitohi and Waikawa Streams to determine the current "state" of water quality. An interim report was provided in May 2018 to comply with the Ministry of the Environment funding requirements. Further sampling was carried out in June and July 2018. This report is a final document, combining the interim report, additional sampling results and analysis.

The Waitohi River and Waikawa Stream have relatively small catchments, which is typical of the Marlborough Sounds. The Waitohi catchment has an area of 1,818 ha and is larger than the neighbouring Waikawa catchment, which covers an area of 1,028 ha. Both catchments have a large proportion of native vegetation cover (about 90%, *Figure 1*). There are small areas of production forestry and extensively grazed pasture in both catchments. The influence of these on water quality cannot be assumed to be minor. In the lower parts of the catchments the native vegetation has been removed to make space for the two largest residential areas in the Queen Charlotte Sound/Totaranui, Picton and Waikawa. This urban development is likely the main anthropogenic influence on water quality.

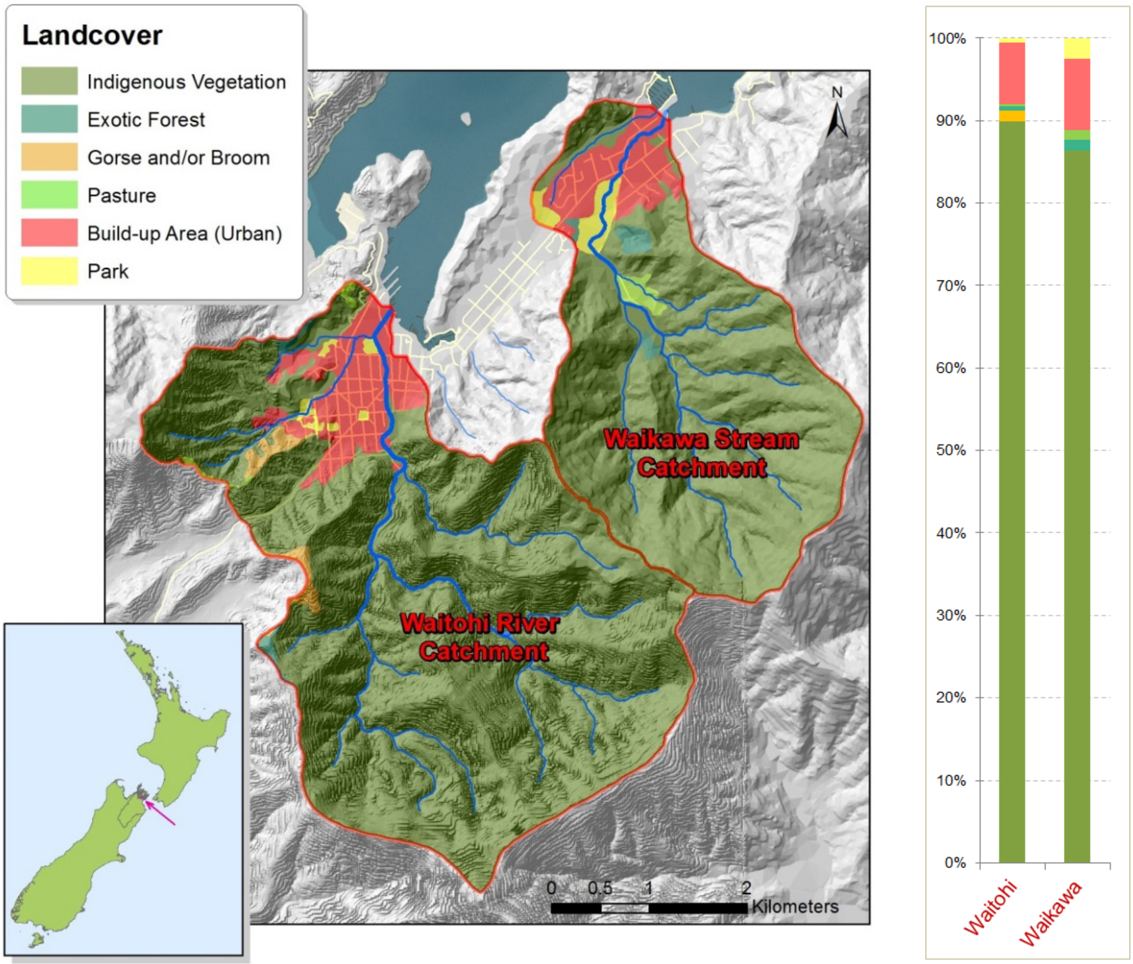


Figure 1: Land cover in the Waitohi and Waikawa catchments based on the New Zealand Land Cover Database 2012.

Urbanisation leads to the removal of vegetation and an increase of sealed surfaces, such as roofs, pathways and roads. As a result, rainfall cannot soak into the ground, but instead forms surface run-off, carrying with it contaminants that have accumulated on these surfaces. This run-off is collected in the stormwater system, which ultimately discharges into streams and coastal waters. Some of the main contaminants of concern in stormwater are heavy metals from vehicle wear and industrial areas. Additionally, damaged infrastructure and incorrectly connected sewerage pipes can cause contamination, which is noticeable as very high E. coli concentrations and elevated nutrient levels.

Water quality of the lower Waitohi River has been monitored as part of the council's State of the Environment (SoE) program since August 2007. This monitoring consists of monthly sampling at the State Highway One Bridge, approximately 800 meters upstream of the outflow into Picton Harbour. The water quality at this site is classified as "Fair", which is defined as conditions sometimes departing from the natural or desirable state. This slight degradation in water quality is caused by occasional exceedances of guidelines for Turbidity, Dissolved Reactive Phosphorus, Zinc and E. coli concentrations. The majority of these exceedances are associated with rainfall events. However, during low flow conditions in summer, pH and Water Temperatures also occasionally rise above guideline levels.

With the exception of a minor reduction in pH values, trend analysis of SoE data has shown very little change in water quality over the years.

The SoE program also includes annual monitoring of aquatic macroinvertebrates. Based on the results of this monitoring, the Waitohi River is classified as "good" in most years.

Although the State of the Environment results provides a good background and valuable long-term data, this report is primarily focused on the sampling that was carried out as part of the investigation in 2017 and 2018. The following sections present the methodology and results of this additional monitoring. Results and methodology for the State of the Environment monitoring are presented in other reports [4, 5].

Figure 2: Arial view of the lower parts of the two catchments. Picton can be seen in the foreground and the Waikawa catchment in the background.

Methodology

Because urban development is likely to have the greatest impact on water quality, the majority of monitoring sites were located in the lower urban areas. However, upstream sites representative of influences from areas covered in native vegetation were also included in the study. A total of 15 sites were sampled, ten in the Waitohi and five in the Waikawa catchment (*Figure 3*). Between October 2017 and March 2018 these sites were sampled once or twice per month; a total of eight times. Sampling was carried out four times during base flow, as this represents the water quality most of the time. However, surface runoff as a result of rainfall can significantly affect water quality, particularly in urban areas. Therefore, three sampling runs were carried out during relatively heavy rainfall, with one additional sampling run during light rain.

Water samples were stored chilled and in the dark immediately after collection and sent overnight to an independent and accredited laboratory (Hill Laboratories Christchurch) for analysis. Table 1 lists the parameters the samples were analysed for.

Parameter	Base Flow	Light Rain	(Heavy) Rain
Nitrite and Nitrate Nitrogen	✓	✓	✓
Total Ammonical Nitrogen	✓	✓	✓
Total Nitrogen	✓	✓	✓
Dissolved Reactive Phosphorus	✓	✓	✓
Total Phosphorus		✓	✓
E. coli	✓	✓	✓
pH	✓	✓	✓
Turbidity	✓	✓	✓
Total Suspended Solids		✓	✓
Dissolved and Total Arsenic		✓	✓
Dissolved and Total Cadmium		✓	✓
Dissolved and Total Copper		✓	✓
Dissolved and Total Zinc		✓	✓

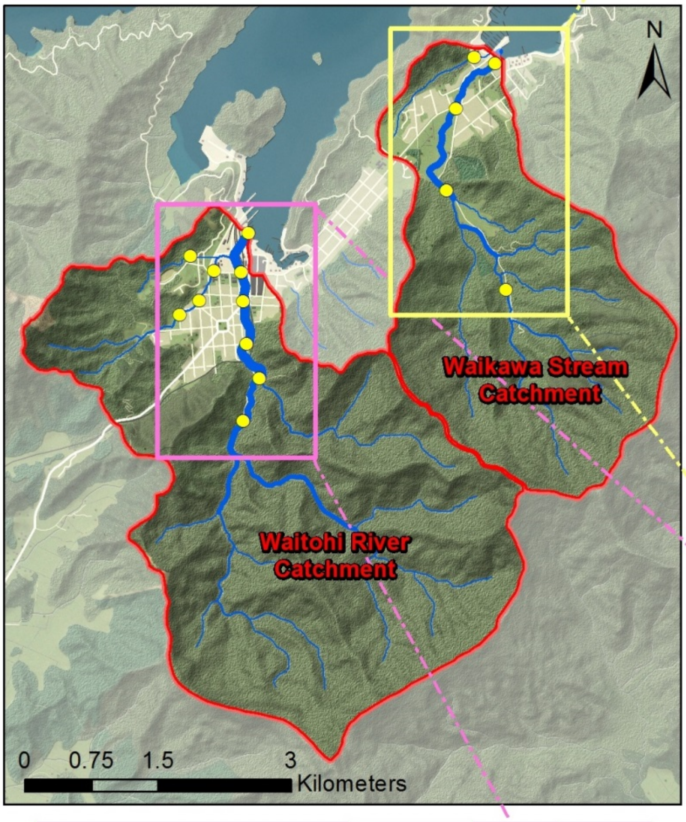
Table 1: Parameters monitored in samples taken during the investigation of water quality in the Waitohi and Waikawa catchment.

Due to tidal seawater inflow, some of the lower sites were not sampled as part of the run when tide levels were high.

In order to gain a better understanding of the ecological health of the streams, a habitat survey, macroinvertebrate sampling and a fish survey using an electric fishing machine were carried out. The habitat was assessed at more than 30 sites using the Rapid Habitat Assessment Protocol [2] on 4 - 6 July 2018. Macroinvertebrate Kicknet-samples were taken from riffle habitats at 7 sites on 6 July 2018. These samples were analysed by Stark Ltd. using coded abundance.

A fish survey was carried out at 4 sites on 2 November 2017 using an electric fishing machine. The survey was qualitative only, but results still provide sufficient information about the health of the stream ecosystem. In each catchment, sites representative of the upper, undisturbed catchment and sites within human influences were surveyed. The lower sites were located far enough upstream to exclude the influence of tidal saltwater inflows.

Site Name	Short Name	Easting	Northing
Waikawa Stream at Mouth	**Wk1**	1686984	5430855
Waikawa Stream at Waikawa Road	**Wk2**	1686536	5430343
Waikawa Stream at Two Pines	**Wk3**	1686436	5429419
Waikawa Stream at Timmermans	**Wk4**	1687100	54283004
Endeavour Stream at Boat Yard	**Ev1**	1686747	5430926



Site Name	Short Name	Easting	Northing
Waitohi River at Picton Harbour	**Wt1**	1684210	5428944
Waitohi River at Dublin St	**Wt2**	1684116	5428502
Waitohi River at SH1	**Wt3**	1684140	5428174
Waitohi River at Camping Ground	**Wt4**	1684163	5427677
Waitohi River at Garden Tce Ford	**Wt5**	1684324	5427303
Waitohi River at Treatment Plant	**Wt6**	1684141	5426821
Kent Street Drain at Dublin St	**Kt1**	1683810	5428514
Kent Street Drain at Durham St	**Kt2**	1683419	5428016
Kent Street Drain at Cornwall St	**Kt3**	1683640	5428181
Gravesend Drain at Cemetry Carpark	**Gs1**	1683544	5428681

Figure 3: Location of the sites in the Waitohi River and Waikawa catchments that were monitored as part of this project.

Results

The following sections present the results of the sampling carried out as part of this project. To improve readability the text will mainly refer to the sites using the short names shown on the maps accompanying the graphs.

Nitrogen

Nitrogen in waterways is generally divided into the dissolved forms of nitrogen and nitrogen that is bound to particles, mainly organic material. The most important dissolved form of nitrogen is Dissolved Inorganic Nitrogen (DIN), as it can be easily taken up by plants.

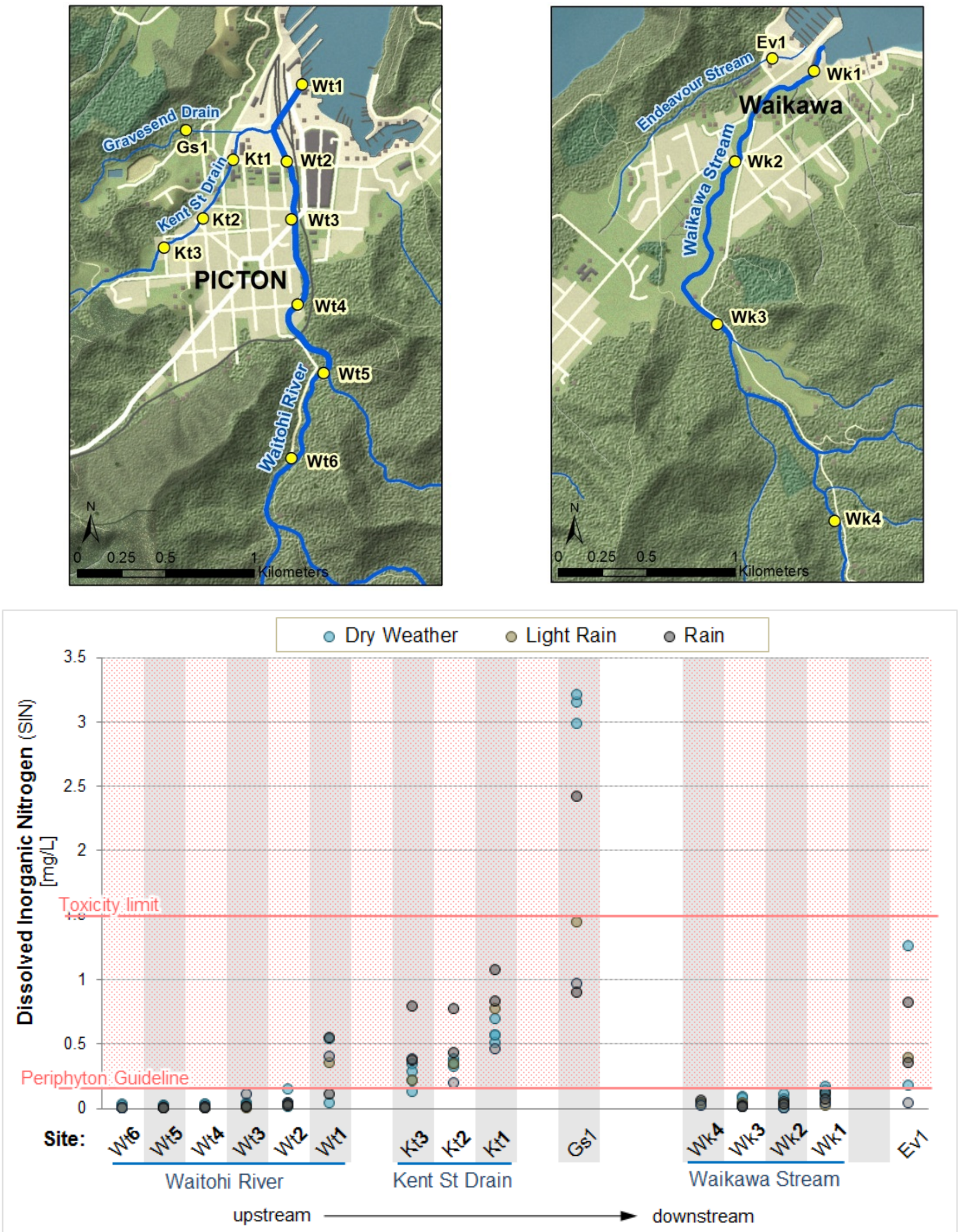


Figure 4: Dissolved Inorganic Nitrogen concentrations in the Waitohi and Waikawa catchments. Also shown are the 'Periphyton Guideline', which is indicative of the potential for excessive alga growth, and the 'Toxicity limit' for Nitrate Nitrogen based on the A-Band limit in the National Policy Statement for Freshwater Management. The colours of the dots represent different weather condition during sampling.

High concentrations of DIN can cause excessive algae growth on the stream bed. A thick cover of algae deteriorates the habitat for aquatic animals and limits the availability of food. Excessive algae growth also causes large dissolved oxygen fluctuations with low oxygen levels at night being the main stressor for aquatic life.

Figure 4 shows the DIN concentrations measured in the Waitohi River and Waikawa Stream and their tributaries. Values above the Periphyton Guideline during dry weather conditions indicate an increased likelihood for excess algae growth. In the main streams DIN concentrations are almost exclusively below the guideline, although levels increase in a downstream direction, coming very close to the guideline. In Kent St Drain, a downstream increase is also noticeable, but the changes are of greater magnitude. This is likely the result of less dilution, as a much greater proportion of Kent St Drain flows through urban areas. In fact, all tributaries have significantly higher DIN levels compared to the main streams. The highest DIN concentrations were measured in Gravesend Drain, which consistently had levels one or two orders of magnitude above those observed in Waitohi River and Waikawa Stream. DIN levels in Endeavour Stream showed a greater variability compared to the other sites. This means that nitrogen inputs into Endeavour Stream during base flow are more sporadic.

In most catchments elevated nitrogen concentrations during base flow are a result of diffuse sources, in particular nitrogen leaching from agricultural areas. However, in the Waitohi and Waikawa catchments, agriculture is unlikely to be a significant factor, especially as most of the pasture is located along the main streams, which have comparatively low DIN concentrations. High nitrogen concentrations as a result of urban development have been observed in other parts of the country [10]. They are likely a result of the much greater application of fertilisers in parks and private gardens combined with greater irrigation, which causes increased leaching through the soil. However, sewage contamination possibly contributes to high nutrient levels at some of the sites.

The very high DIN concentrations in Gravesend Drain, however, are likely to originate from a different source. Although, the stream flows past a cemetery, the gradient of the land causes most of the leachate from this area to reach surface water downstream of the sampling site. However, some influence from the cemetery cannot be ruled out. Nevertheless, it is more likely that activities further upstream are the source of nitrogen. Approximately 400 meters upstream of the sampling site (Gs1) is the location of the Picton sewage treatment plant and a closed landfill. Gravesend Drain flows next to the treatment ponds and closed landfill at a distance of approximately 20 meters (*Figure 5*). Any leachate escaping from these areas is therefore likely to surface in Gravesend Drain.

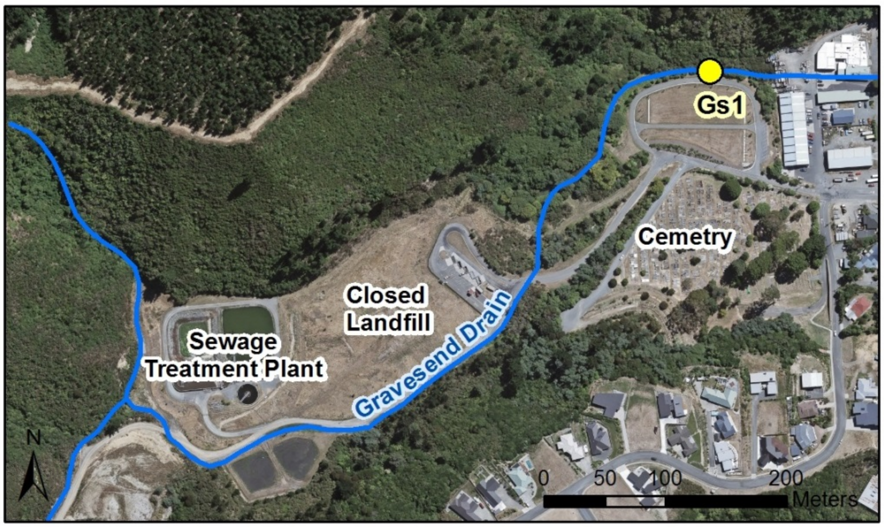


Figure 5: Arial photograph of the lower sub-catchment of Gravesend Drain.

During rainfall, additional sources of DIN can be introduced into waterways. This is the case for Kent St Drain, which shows higher DIN concentrations during rainfall. This is also effecting concentrations observed in the lowest Waitohi River site (Wt1) located downstream of the confluence with Kent St Drain (*Figure 4*, grey dots). The lower Waitohi site is also impacted by the high nitrogen concentration from Gravesend Drain, despite the fact that rainfall run-off has a diluting effect in Gravesend Drain. Rainfall dilution of DIN concentrations was also observed in Waikawa Stream.

DIN is comprised of Nitrate Nitrogen, Nitrite Nitrogen and Ammonical Nitrogen. In most waterways Nitrate Nitrogen is the major form of DIN as it is the most stable at natural oxygen levels. Dissolved nitrogen originating from organic contamination is comprised mainly of Nitrite Nitrogen and Ammonical Nitrogen. Bacteria naturally found in waterways quickly use the oxygen in the water column to convert these reduced forms of nitrogen into Nitrate. If oxygen levels in the water are very low however, Ammonical Nitrogen and Nitrite are not converted, instead Nitrate is reduced to these forms of Nitrogen. High levels of Nitrite and Ammonical Nitrogen are therefore an indication of significant contamination with organic material and/or a lack of dissolved oxygen in the water column.

In almost all streams monitored in the Waitohi and Waikawa catchments, Nitrate is the main form of DIN (*Figure 6*). The only exception is Gravesend Drain, which has high Nitrite and Ammonical Nitrogen concentrations. High Ammonical Nitrogen concentrations are toxic to aquatic life and concentrations in Gravesend Drain are above the 80% species protection limit in the National Policy Statement for Freshwater Management (NPS-FM).

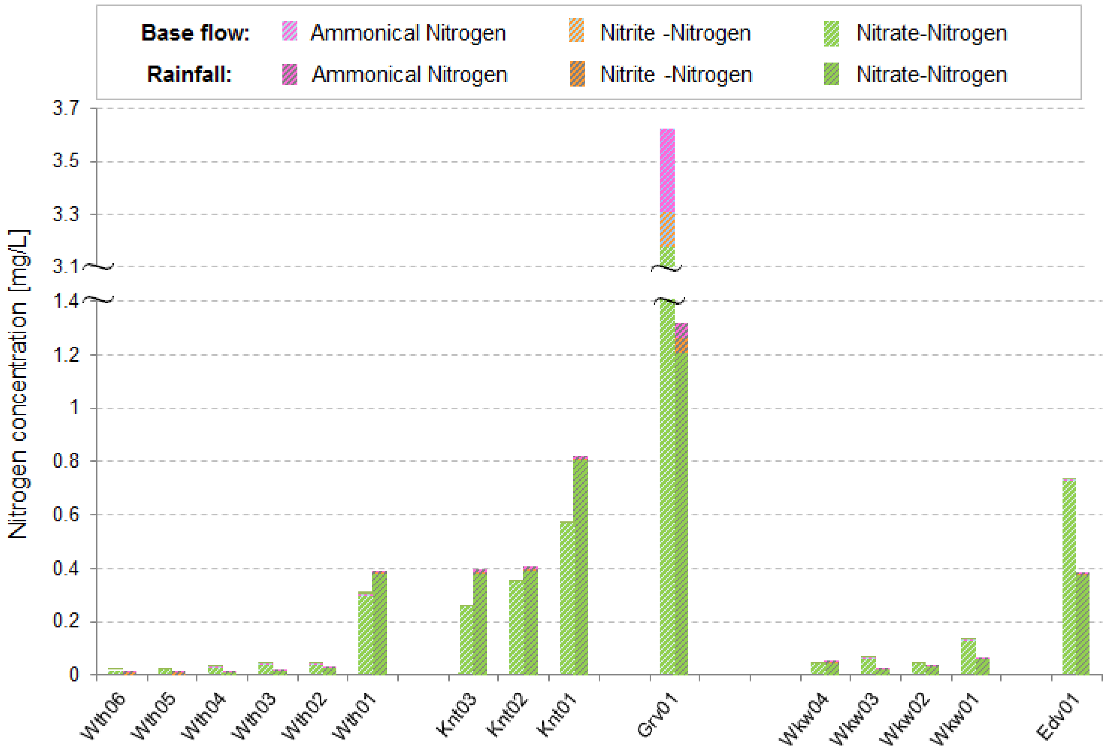


Figure 6: Forms of DIN in the streams of the Waitohi and Waikawa catchments based on median concentrations. Concentrations during base flow and rainfall are shown separately.

Very high Nitrate Nitrogen concentrations are also toxic to aquatic animals. The NPS-FM sets the limit for acute exposure that is unlikely to cause effects at a concentration of 1.5 mg/L. This limit is consistently exceeded in Gravesend Drain (*Figure 4* and *Figure 6*). The high Ammonical Nitrogen and Nitrate Nitrogen concentrations indicate that sensitive species are unlikely to survive in this waterway.

All other sites monitored had Nitrate and Ammonical Nitrogen concentration below the NPS-FM limits in all samples taken.

Samples collected during rainfall were also analysed for Total Nitrogen, which allows calculation of the amount of nitrogen that is bound in and to particulate material suspended in the water. Run-off during rainfall washes organic material off surfaces into streams, resulting in a greater amount of particulate nitrogen.

In the main stems of the Waitohi River and Waikawa Stream, almost all of the nitrogen was in the particulate form (*Figure 7*). In the tributaries, particulate nitrogen was often the dominant form, but compared to the main streams a larger proportion of Total Nitrogen was in the dissolved form. Gravesend Drain was again the exception, with a generally much smaller proportion of particulate nitrogen.

These results indicate that, except for Gravesend Drain, surface run-off is likely the most important source of nitrogen during rainfall.

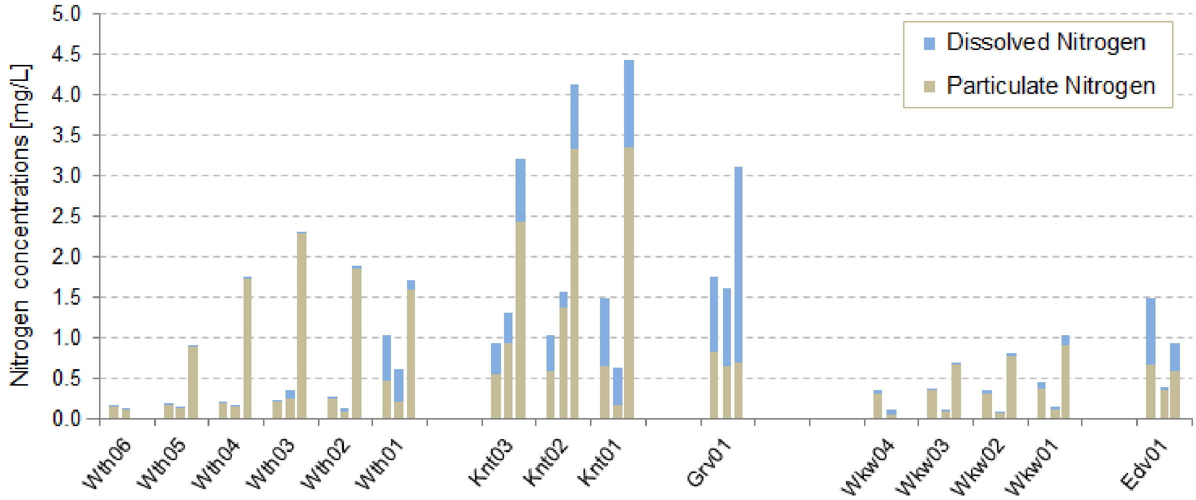


Figure 7: Dissolved and Particulate Nitrogen concentrations in samples taken during rainfall.

Particulate Nitrogen introduced into these streams during rainfall is unlikely to have an effect on the streams themselves. The relatively steep gradient of the land results in comparatively fast flows, which reduces the ability for particles to settle on the stream bed. Field observations indicate that fine sediment only appears to cover significant areas of the stream bed in the intertidal zone. Therefore, the impact of particulate nitrogen is mainly on the coastal environment, as the water flow is slowed and material settles onto the seabed. This results in increased nutrient availability to algae and smothering of the seabed.

Phosphorus

Like Nitrogen, phosphorus is a major nutrient for plant growth. High phosphorus concentrations in waterways can therefore contribute to excessive algae growth. Dissolved Reactive Phosphorus (DRP) represents the form of phosphorus most readily available to aquatic plants, such as algae.

Apart from one sample taken from the lower Kent St Drain (Kt1) with an unusually high value, DRP concentrations during dry weather conditions were consistently below the guideline level for algae (periphyton) growth (*Figure 8*). However, concentrations at the upper sites of both catchments (Wt6 and Wk4) were elevated, with values close to the guideline level. All samples from these sites had very similar DRP concentrations which points to a natural source of phosphorus, such as geological features in the catchment. Dry weather concentrations in Kent St Drain were of similar magnitude and variability as those observed in the upper catchments. The lower Waitohi River showed the greatest variability during base flow, likely due to anthropogenic sources.

In the Waikawa catchment DRP levels decrease in a downstream direction, with Endeavour Stream having dry weather DRP concentrations similar to those observed in the nearby lower Waikawa Stream. The measured concentration during dry weather conditions had a limited value range, suggesting predominantly natural sources for phosphorus in this catchment.

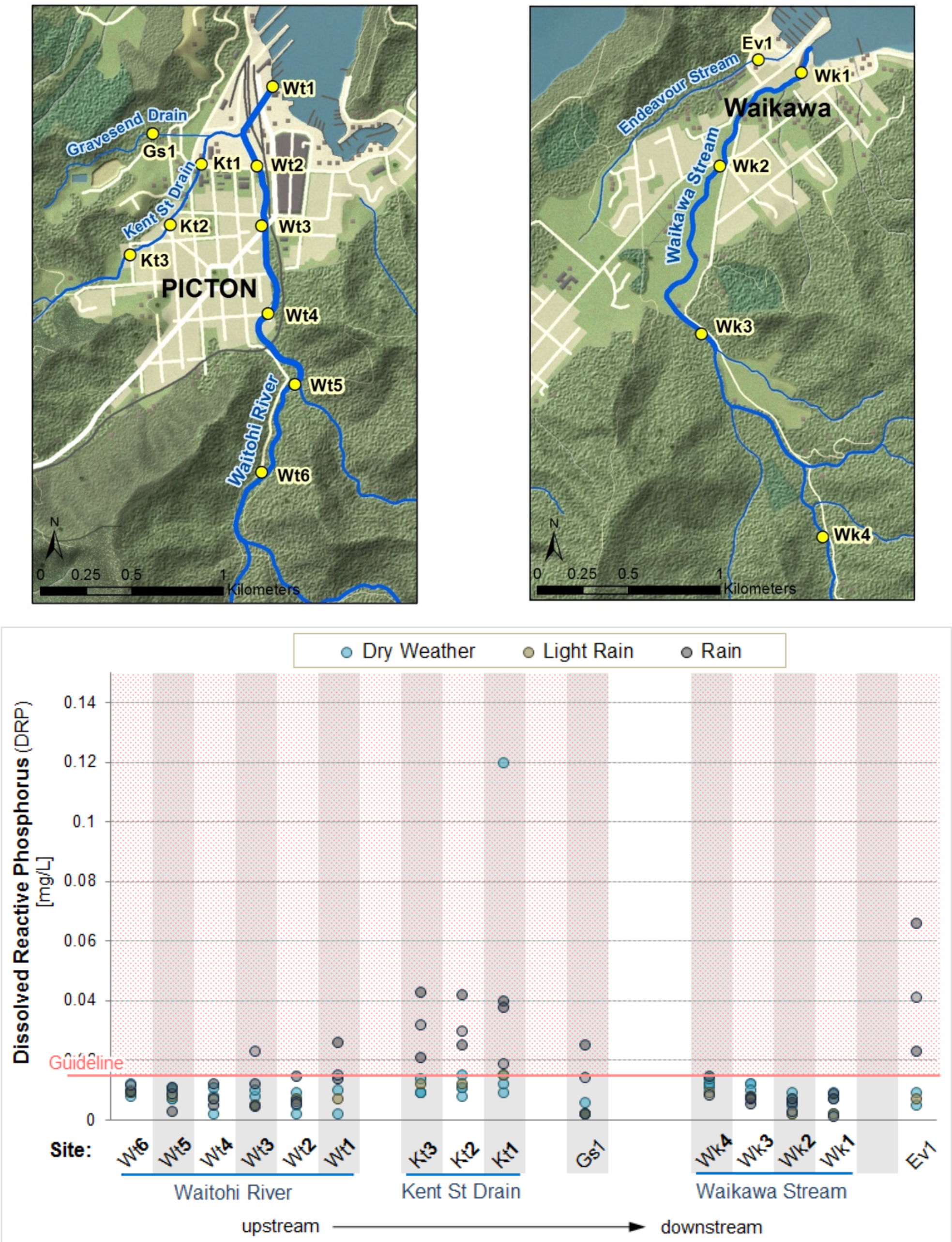


Figure 8: Dissolved Reactive Phosphorus (DRP) concentrations in Waitohi and Waikawa catchments. Also shown is the 'Periphyton Guideline', which is indicative of the potential for excessive alga growth.

Rainfall appears to have very little effect on DRP concentrations in the Waikawa Stream and the upper Waitohi River. In the tributaries, however, rainfall resulted in a noticeable increase in DRP levels, particularly for Endeavour Stream and Kent St Drain. The additional phosphorus is likely introduced bound to sediment that is washed into these waterways by surface run-off and then released into the water column. However, since these elevated DRP levels only occur for a relatively short period, the additional phosphorus is unlikely to result in a noticeable increase in algae growth in the streams. In fact, high phosphorus concentrations only occur in conjunction with fast flows that result in actual removal of algae cover through bed movement and abrasion.

As with nitrogen, rainfall samples were also analysed for the Total Phosphorus concentration, in order to determine the proportion of particulate phosphorus. The results show that the vast majority of the phosphorus was bound to particulate material. The total amount of phosphorus in the streams was significantly greater than the DRP concentrations alone would have suggested. Total phosphorus concentrations in the Waitohi River catchment were generally higher and more variable compared to the Waikawa catchment.

As was described for particulate nitrogen, the phosphorus bound in particulate matter is unlikely to significantly affect the streams upstream of the tidal zone, with the greatest impact to be expected on the seabed near the stream outflows.

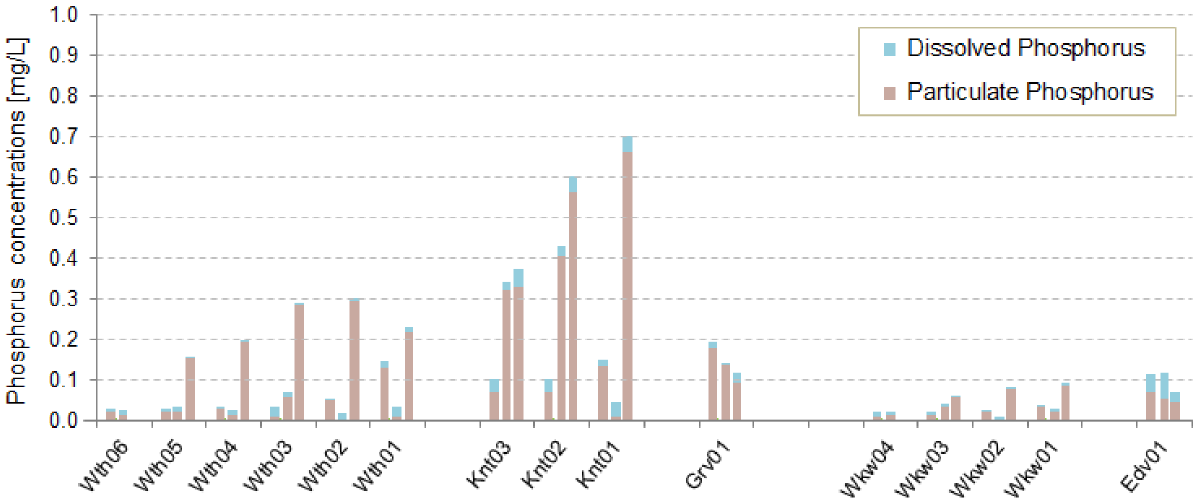


Figure 9: Dissolved and Particulate Phosphorus concentrations in samples taken during rainfall.

E. coli concentration

E. coli are bacteria that are used as an indicator for faecal contamination. High E. coli concentrations indicate a greater risk for recreational users of becoming sick when coming in contact with the water. Figure 10 shows the E. coli concentrations measured in the two catchments. The guideline value of 550 cfu/100mL is based on unsafe levels for swimmers as published in the Ministry for the Environment and Ministry of Health Guideline document [9].

During base flow (dry weather) E. coli concentrations in the Waitohi River catchment were more variable compared to the Waikawa catchment (*Figure 10*, blue dots). The lower Waikawa Stream (Wk1) was the only site in the Waikawa catchment that exceeded the guideline during dry weather.

In the Waitohi catchment, all sites monitored on Kent St Drain had at least one sample with E. coli concentrations above the guideline level. Kent St Drain had generally the highest E. coli concentrations in the study. E. coli levels in the Waitohi River itself reached their highest level at site Wt4 during base flow. This site is located near a campground that is the home to more than 30

Mallard ducks, which are the most likely source of faecal contamination (*Figure 11*). The sites located furthest upstream and downstream on Waitohi River had the lowest dry weather E. coli concentrations in this catchment.

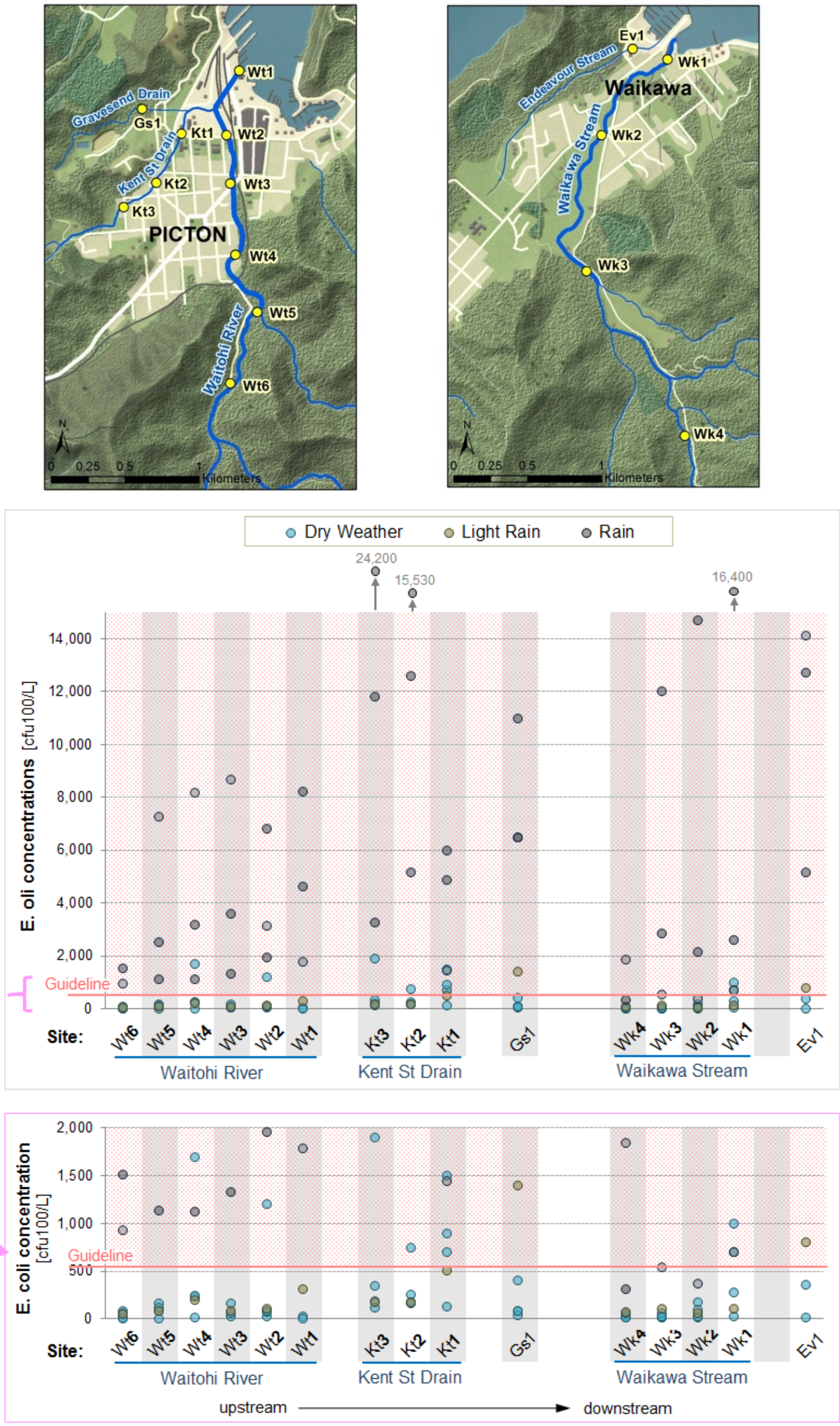


Figure 10: E. coli concentrations in Waitohi and Waikawa catchments.

During rainfall, E. coli concentrations varied considerably at most of the sites, but were lowest at the two most upstream sites (Wt6 and Wk4). Still, bacteria levels in some of the samples from the upstream sites were well above the guideline level. This is surprising, as the main sources of faecal contamination at these sites would be expected to be native and feral animals. At some of the other sites E. coli concentrations reached levels an order of magnitude higher than those observed at these upstream locations. In the Waitohi River, E. coli concentrations peaked at site Wt3, further downstream than during dry weather conditions. In the other waterways no apparent site-specific pattern for the E. coli concentrations could be observed during rainfall events.

Figure 11: Large number of Mallard Ducks at the Waitohi River at site Wt4.

In order to narrow down the sources of faecal contamination, several samples taken during heavy rainfall were analysed for genetic markers (*Figure 12*).

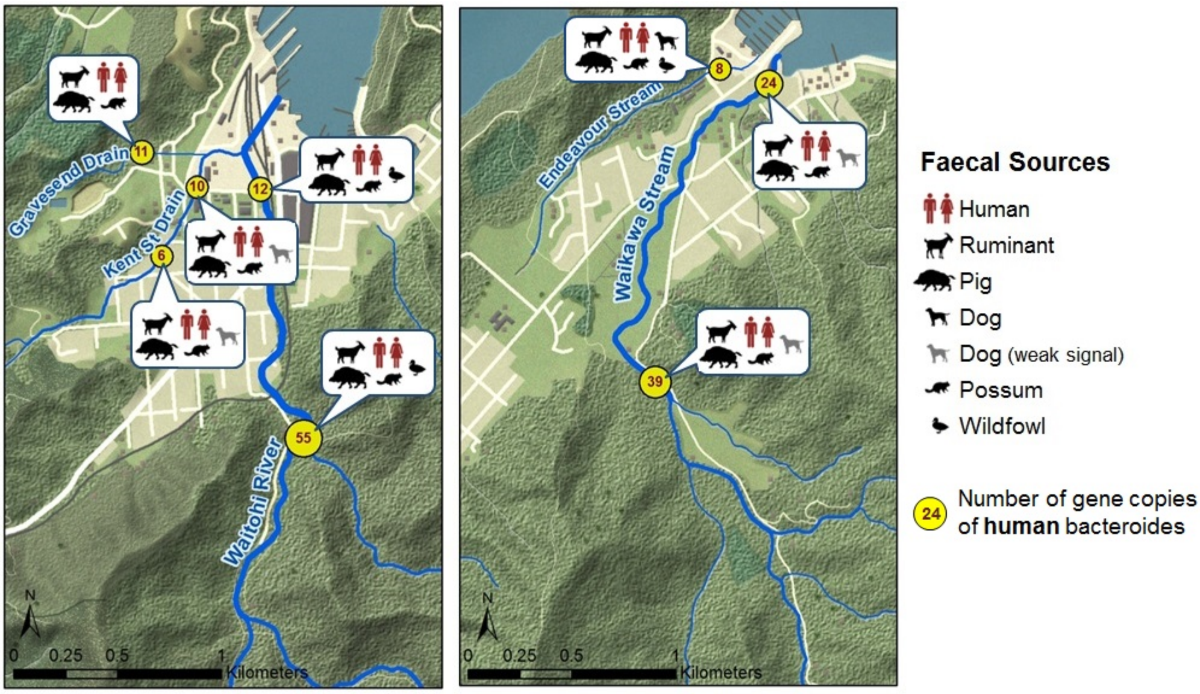


Figure 12: Genetic markers in samples taken during heavy rainfall.

All samples contained faecal material from possums as well as ruminants and pigs, which are likely feral animals living in the native bush. Surprisingly, all samples also had human sources. In order to quantify the human source input, the samples were also analysed for the number of gene copies from human bacteroides. The results showed that human sources were more predominant in the upper reaches. This indicates that during rainfall, private sewage treatment and disposal systems have a greater impact on water quality than the reticulated urban system.

Wildfowl, such as ducks were contributing to faecal contamination in the Waitohi River and Endeavour Stream, while dogs were a significant source in Endeavour Stream only.

Turbidity and Sediment

Turbidity is an indirect measure for water clarity. The higher the turbidity, the more reduced is the visibility under water. Water is generally turbid as a result of fine sediment that is suspended in the water column. When this fine sediment is deposited onto the stream bed it fills up important living spaces between pebbles and rock, resulting in the degradation of aquatic habitat. Additionally, when the eggs of aquatic insects and fish become covered in fine sediment, oxygen cannot reach these eggs and they die. Therefore, large amount of fine sediment cover on stream beds will result in the disappearance of more sensitive aquatic species.

Very high sediment loads can also have abrasive effects on the gills of fish, but values have to be exceptionally high for this to occur. The effect is most pronounced if high turbidity persists over long time periods and is not restricted to flood flows alone.

Sediment in the water affects the amenity value of water ways at significantly lower turbidity levels. The turbidity guideline of 5.6 NTU used in this document is taken from the ANZECC (2000) [1] guidelines based on recreational and amenity values.

During base flow (dry weather) the water at nearly all of the sites was relatively clear and turbidity was generally below the guideline level (*Figure 13*). The exception was the lower site of the Kent St Drain (Kt1). This site also had the highest amount of fine sediment deposited onto the stream bed, which is likely a result of the increased turbidity. During rainfall all sites along Kent St Drain generally had higher turbidity than other sites monitored as part of this study. It appears that a sediment source located between sites Kt2 and Kt1 is causing an increase in turbidity during base flow, while during rainfall, run-off from areas upstream of Kt3 is carrying large amounts of fine sediment into Kent St Drain.

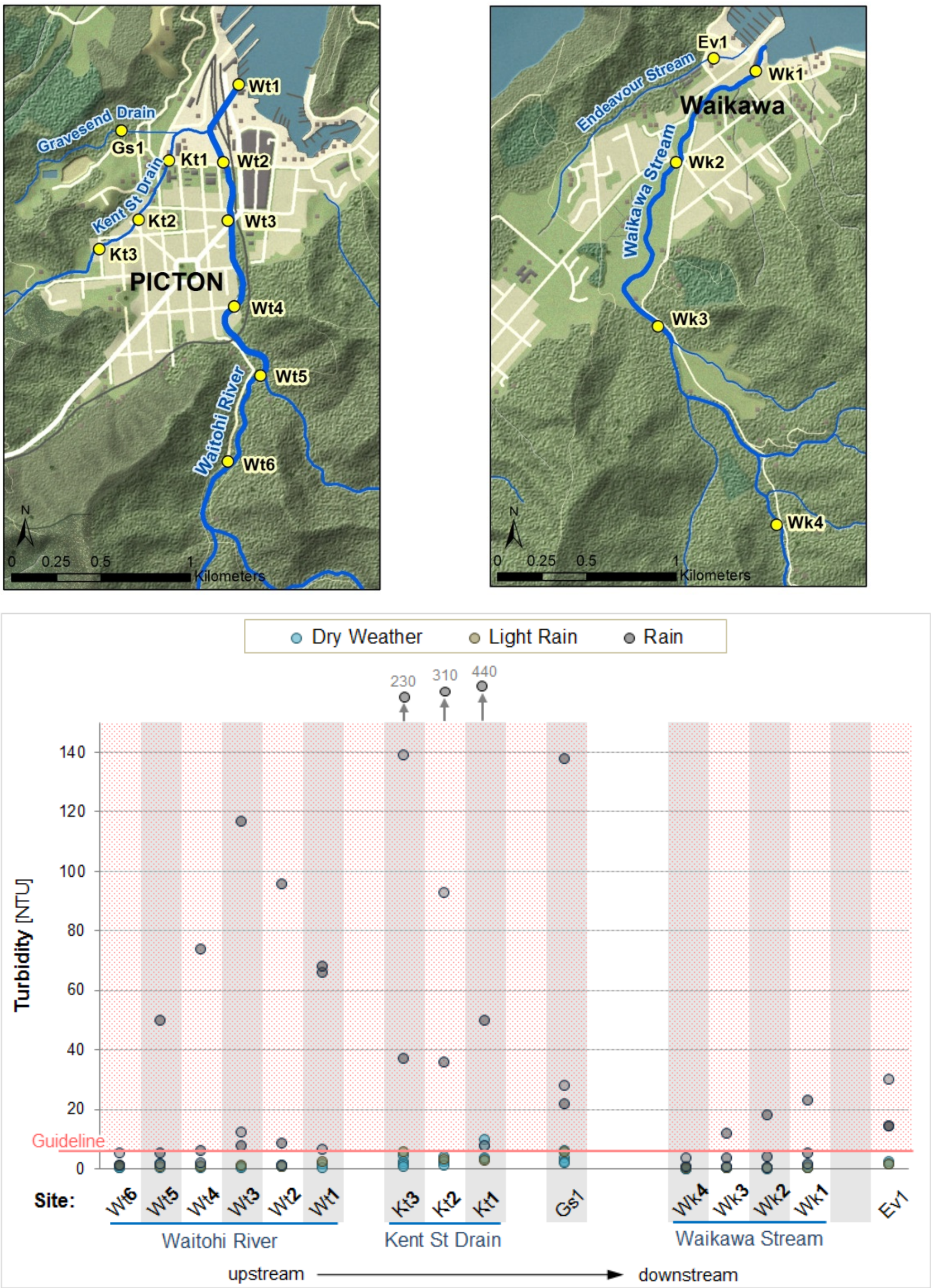


Figure 13: Turbidity in samples taken from the Waitohi and Waikawa catchments. The guideline is based on the Amenity trigger in the ANZECC (2000) document.

Of the tributaries, Endeavour Stream had the lowest turbidity during rainfall, but values were generally higher than in the main streams.

The most upstream sites of both catchments (Wt6 and Wk4) remained relatively clear during all rainfall events. The turbidity in Waikawa Stream reached values above the guideline during only one of the rainfall events. During this event, a consistent increase of turbidity in a downstream direction could be observed. This indicates that there is no single source of sediment in the catchment, but rather a cumulative effect of run-off from the whole catchment. In the Waitohi River, turbidity also increased downstream during the same event, but resulted in significantly greater measurement values. Generally during rainfall, the highest turbidity in the Waitohi River was observed at site Wt3.

Site Wt1, located furthest downstream is influenced by the sediment carried into the Waitohi River via Kent St Drain.

To gain a better understanding of sediment source characteristics, the actual concentration of sediment in rainfall samples was measured as Total Suspended Solid concentration. Plotting turbidity values versus the Total Suspended Solid concentration in the same sample indicates that the sources of suspended sediment in the main stems of Waitohi River and Waikawa Stream are very similar (*Figure 14*), probably resulting from erosion in the natural catchment. The sediments causing higher turbidity in the tributaries appear to be comparable to each other, but different from the sediment in Waitohi River and Waikawa Stream. This indicates that different sediment sources are the dominant cause for turbidity in the main streams compared to the tributaries.

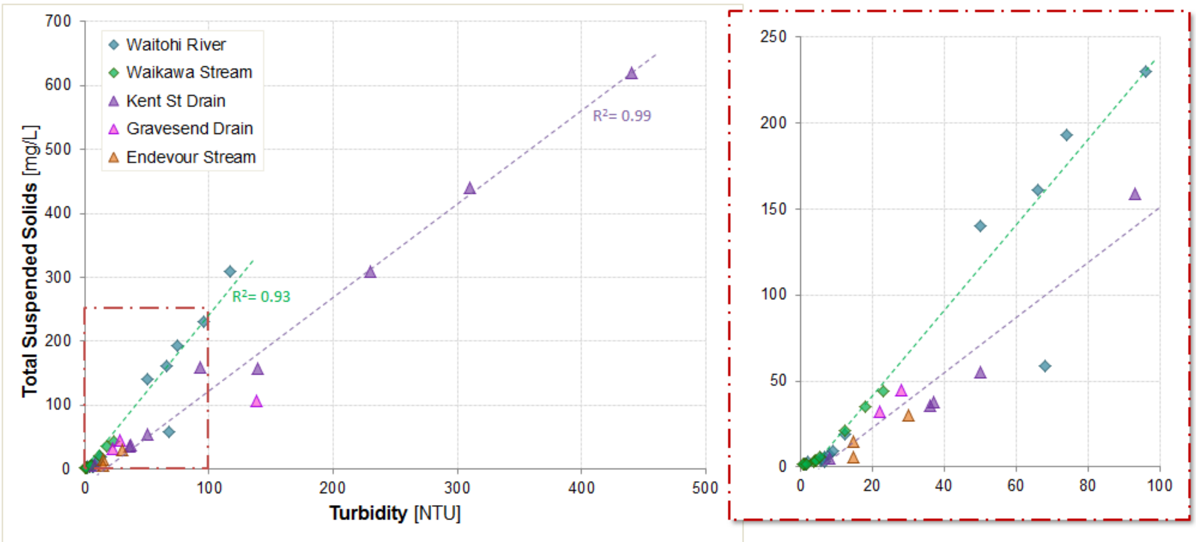


Figure 14: Correlation between Total Suspended Solid concentrations and Turbidity measurements in the Waitohi and Waikawa catchments.

PH

The pH value is a measure for the acidity or alkalinity of water. A pH value of 7 is neutral, while values below 7 indicate acidic water and values greater than 7 represent alkaline conditions. Deviation from natural pH values can impact on the growth, reproduction and survival of aquatic animals. Especially, rapid changes in pH can cause fish kills, effecting even relatively resistant species, such as eels. For example, the disposal of cement-mixture or lime into stormwater or directly into waterways can cause rapid changes in pH.

Many contamination sources, such as faecal material cause a drop in pH values, while photosynthetic activity of algae increases the pH.

During dry weather conditions, pH values were exclusively in the alkaline range for all sites monitored. The limited variability at some of the sites indicates that this is a natural phenomenon, likely linked to the local geology. Because pH values are so close to the upper guideline value of 7.8, relatively small increases will lead to exceedance of this guideline. However, despite significant algae cover at some of the lower sites, the pH values at these sites were only slightly greater than at upstream locations.

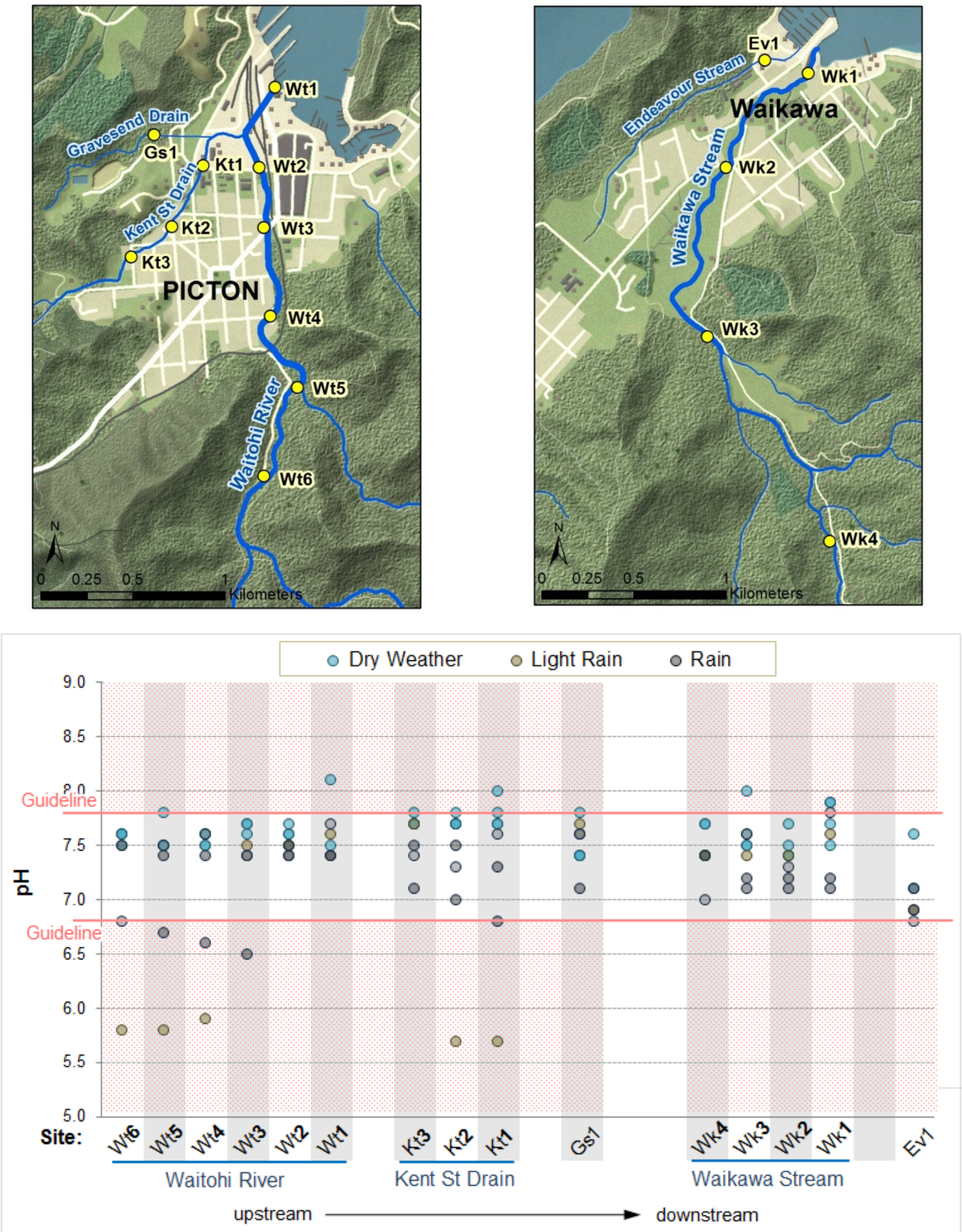


Figure 15: PH values in the Waitohi and Waikawa catchments.

Rainfall generally resulted in lower pH values. Surprisingly the lowest pH values were observed during light rainfall, causing the pH to reduce to values below 6 in the upper Waitohi River and the lower Kent St Drain. Despite very different catchment characteristics the low values in these two waterways were very similar. The cause for this is unclear.

With the exception of one rainfall run, pH values remained above the lower guideline of 6.8 during heavier rainfall. Interestingly, during that rainfall run, pH values were decreasing in a downstream direction in both the Waitohi River and Kent St Drain. In the Waitohi River pH values reached a minimum at site Wt3. The reverse pattern was observed for E. coli concentrations, which peaked at Wt3. It is therefore possible that faecal material washed into the stream from the surrounding land caused the decrease in pH values.

In Kent St Drain this pattern is reversed as the highest E. coli concentrations were observed in the most upstream sites, which also had the highest pH values. Therefore, faecal contamination is not the reason for the decreasing pH values in this waterway.

Heavy metals

High concentrations of heavy metals are toxic to aquatic life. Apart from effecting the survival of aquatic plants and animals, heavy metals can make them unsafe for human consumption.

There are a number of heavy metals that can be found in aquatic environments, but in urban areas, Copper and Zinc are the metals most often detected [6, 8]. The ANZECC (2000) guideline provides several triggers for different levels of protection. For most waterways the 95% species protection trigger is most appropriate, while the 80% species protection trigger is used for ecosystems that are highly disturbed by human activity.

The main sources of heavy metals in the urban environment are roofing iron, vehicle wear (eg; Copper from brake pads) and industrial areas. The metals find their way into stream via surface run-off from sealed surfaces during rainfall.

Samples taken from the Waitohi and Waikawa catchments were also analysed for Arsenic and Chromium as industrial activity can be the source for these metals, but both of these metals only occasionally exceeded the most stringent trigger for 99% Species protection.

Zinc and Copper, however, did reach levels well above all of the ANZECC (2000) trigger levels. Especially Copper concentrations exceeded the 95% Species protection trigger. However, these exceedances were limited to two waterways, Kent St Drain and Endeavour Stream. There are a number of small industrial yards located along the banks of the lower Kent St Drain, which are likely contributing to the high heavy metal concentrations in this waterway. Zinc concentrations are highest at the lower site of Kent St Drain (Kt1), located downstream of these industrial yards. Interestingly, Copper concentrations are already elevated further upstream, at sites Kt2 and Kt3, which are predominantly influence by residential areas. However, there is a construction yard located in the upper catchment which could be the source of some of the Copper in Kent St Drain.

Gravesend Drain had Copper concentrations similar to Kent St Drain, but had lower Zinc concentrations.

The majority of Copper and Zinc in the Waitohi River site Wt1 originates from Kent St Drain and Gravesend Drain, but additional inputs from the port area are also likely.

Endeavour Stream had the highest metal concentrations of all waterways monitored as part of this study with occasional values well above the most lenient ANZECC (2000) trigger levels for 80% species protection. Particularly Copper concentrations were high. It is unlikely that Copper from vehicle wear alone is causing these high levels. Although most of the stormwater entering this waterway originates from residential areas, surface run-off and leachate from the sports fields at Endeavour Park and from Port Marlborough Boatyards also enters the stream.

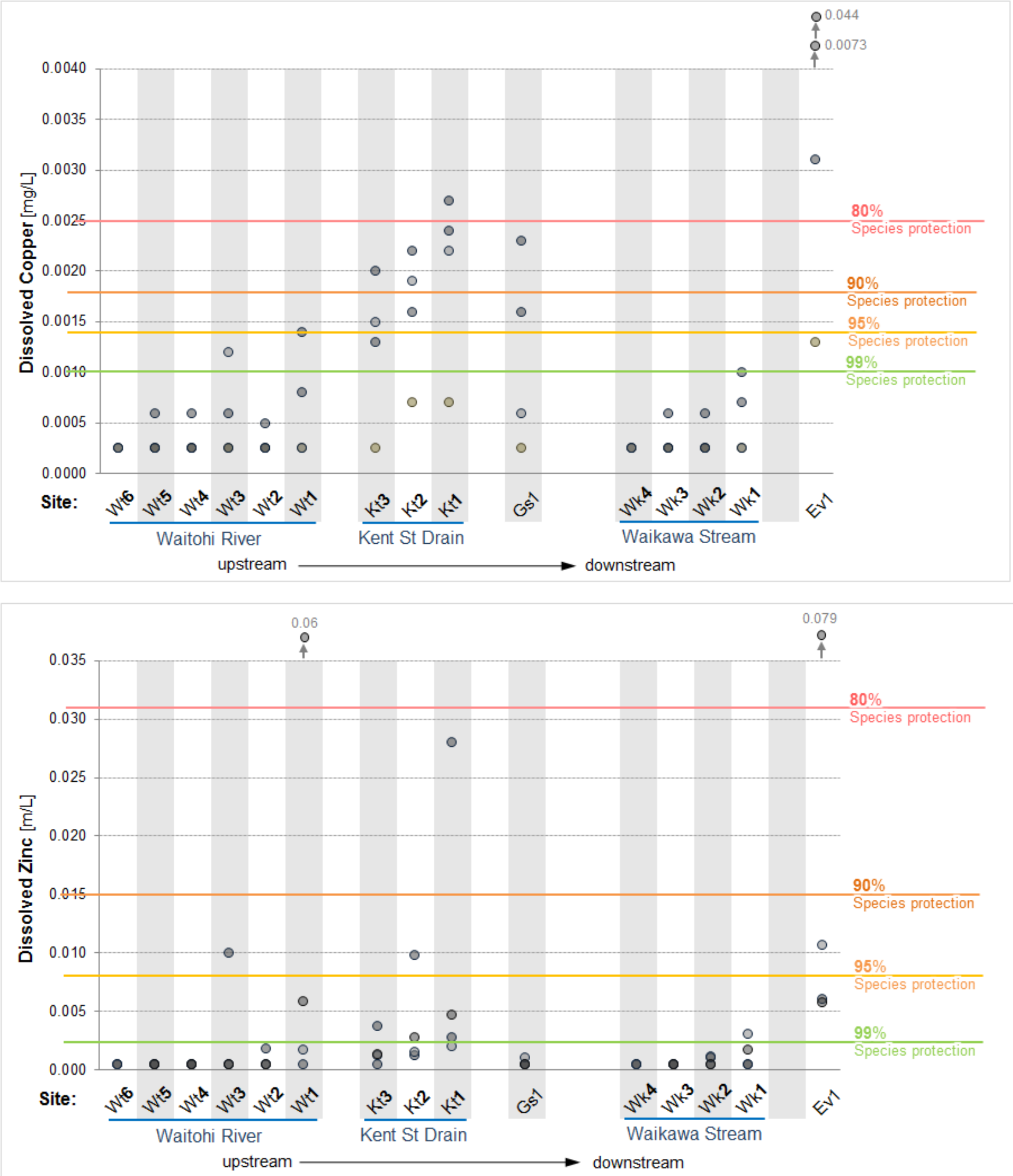


Figure 16: Dissolved Copper and Dissolved Zinc concentrations in the Waitohi and Waikawa catchments. Also shown are the ANZECC (2000) trigger levels.

Hydrocarbons

Hydrocarbons were not monitored as part of this study, but during sampling visits oily films could occasionally be seen on the surface of the lower Kent St Drain. During rainfall events, the most likely cause is rainfall run-off from the industrial yards located alongside the waterway. Oily films observed during dry weather conditions, however, are a sign of poorly managed spills or intentional disposal.

During heavy rainfall sampling in February 2018, significant amounts of diesel were being discharged from a boatyard into Endeavour Stream via a stormwater pipe. Oil and grit separators are in place at this yard, which should provide basic stormwater treatment; however, these systems need to be suitably sized and maintained to be effective.

Ecological Surveys

Fish and other animals living in streams need good water quality, but also good habitat in order to thrive. The dense native bush cover in the upper parts of both catchments provide naturally good habitat. In the lower reaches, however, the habitat quality is likely reduced as a result of human influences. Aquatic habitat quality can be measured and scored using the Rapid Habitat Assessment Protocol [3]. More than 30 sites were assessed using this method in July 2018. Sites were mostly located on the main stream channels and chosen at locations were changes in habitat quality were noticeable. The protocol does not provide qualitative categories, which means that habitat scores need to be interpreted as relative difference to the natural state (the scores of the most upstream sites).

The Habitat Scores for sites located within the native bush of the upper catchments were very similar for both the Waitohi River and Waikawa Stream. Between the main area of Picton and the most upstream site, small residential development resulted in slightly lower habitat scores, mainly as the result of riparian vegetation removal. Not surprisingly, the lowest scores were for sites within Picton where mowed grass on the river banks provides very little shading and modification of the river channel results in reduced habitat diversity (*Figure 17*).

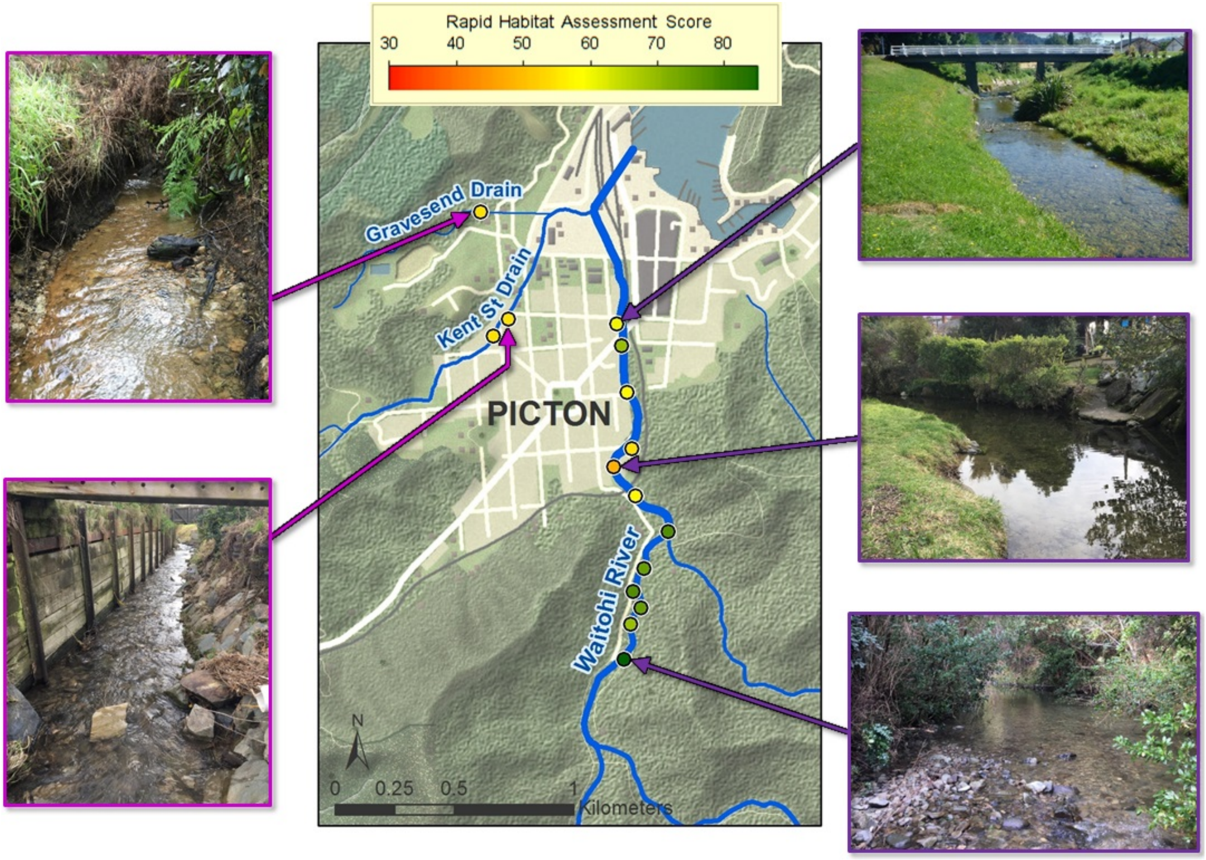


Figure 17: Habitat Scores for the sites in the lower Waitohi River catchment. The photos show examples of the different appearance of the waterways.

A similar pattern was observable in the Waikawa catchment, but unlike the Waitohi River, the stream flows through an area of agricultural land use with livestock access to the waterway. The lowest score along Waikawa Stream was recorded at a sheep farm (*Figure 18*). The low score was mainly the result of a lack of riparian vegetation and fish cover.

The lowest habitat score of all sites was recorded for the lower part of Endeavour Stream. Fine sediment covering the stream bed and eroding banks of mowed grass are the main reasons. Only 100 meters upstream, the habitat of Endeavour Stream is significantly better.

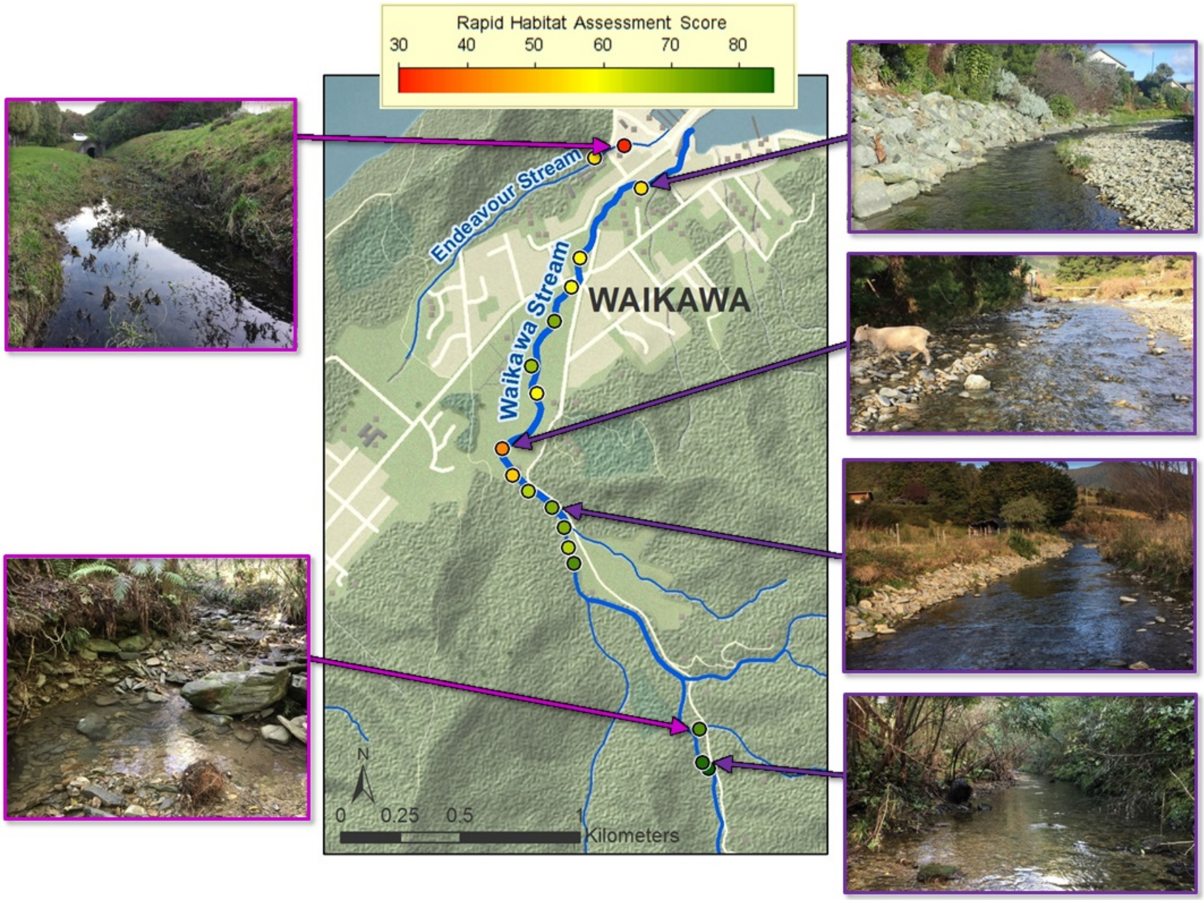


Figure 18: Habitat Scores for the sites in the lower Waikawa Stream catchment. The photos show examples of different stream appearances within the catchment.

The aquatic animals living in the waterways were also monitored. Macroinvertebrates are aquatic insects, crustaceans and worms that are large enough to be seen with the naked eye. They are a good indicator of stream health as sensitive species depend on good habitats and consistently good water quality to survive.

Macroinvertebrate data is commonly presented using the Macroinvertebrate Community Index (MCI), which provides a score based on the sensitivity and abundance of species found. Not surprisingly, the samples taken from the upper catchments have high MCI scores representative of excellent water quality (*Figure 19*). In the lower catchment of the main streams, water quality is categorised as good. The lowest MCI scores were observed in two of the tributaries; Gravesend Drain was categorized as fair, while Endeavour Stream had the lowest MCI score, putting it into the 'poor' category.

The Macroinvertebrate results appear to relate relatively well to the habitat scores. Only Gravesend Drain had a much lower MCI score compared to the habitat score, indicating that water quality is the main limiting factor for aquatic life.

Fish surveys were carried out in the main streams only. At the two upstream sites monitored (Wt5 and Wk3) a number of Redfin Bullies, Bluegill Bullies and Longfin Eels were found, but also a large Koaro in the Waitohi River (*Figure 19 & 18*). The lower Waikawa Stream at site Wk2 also had relatively abundant fish life, with Bluegill Bullies, Redfin Bullies, Longfin Eels and Inanga. The lower Waitohi River, however, had no fish life at all. After fishing a reach of approximately 100 meter length at site Wt2, no fish were caught.

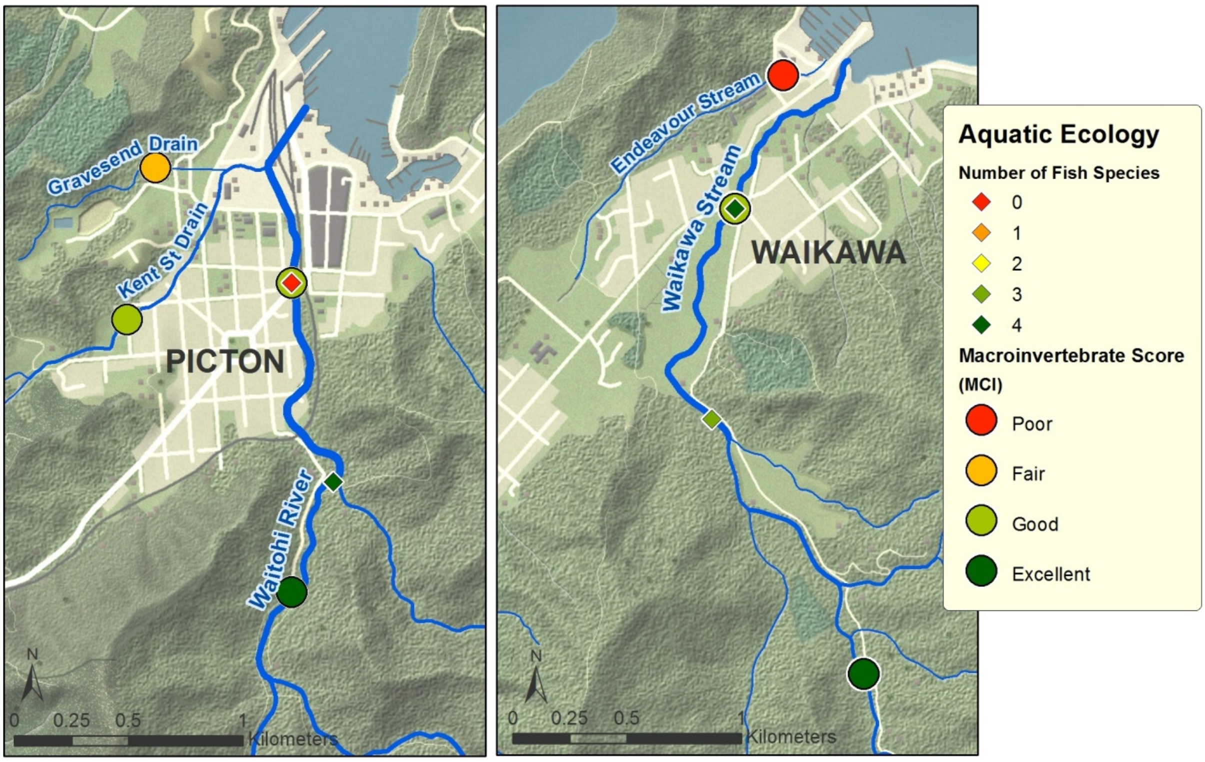


Figure 19: Number of fish species and Macroinvertebrate Score for the sites in the Waitohi River and Waikawa Stream catchment monitored as part of the study.

Figure 20: A Blugill Bully (Gobiomorphus hubbsi) [top] and a large Koaro (Galaxias brevipinnis) [bottom-left] caught in the mid Waitohi River; and a Redfin Bully (Gobiomorphus huttoni) [bottom-right] caught in the mid Waikawa Stream.

Summary and Discussion

The aim of this project was to determine the current water quality in the Waitohi River and Waikawa Stream, which flow into the Queen Charlotte Sound/Totaranui. Approximately 90% of both catchments are covered in native vegetation and human influences on water quality are almost exclusively confined to the lower areas near the coast. Sampling sites were concentrated in these lower parts of the catchments, but reference sites with minimal human impact were also sampled. Apart from several sites along the main stream channels, tributaries were also sampled. However, only tributaries with significant human influences were included in the program. In total, 15 sites (10 in the Waitohi and 5 in the Waikawa catchment) were sampled during dry weather conditions and rainfall. Dry weather conditions represent the water quality of the streams most of the time, but surface run-off during rainfall carries soil and contaminants into the water, significantly changing the water quality.

The samples were analysed for a number of parameters, including the major nutrient concentrations (nitrogen and phosphorus), turbidity and E. coli concentrations. Samples taken during rainfall were also analysed for sediment concentration (Total Suspended Solids) and heavy metals.

It is important to note that water quality is highly variable during rainfall events, depending on a number of factors, such as the distribution of rainfall across the catchment, the time since the previous rainfall event, rainfall duration and rainfall intensity. The highest concentration for a number of contaminants is usually observed during the so-called first-flush. This is the time, the first significant amount of run-off is reaching the water way. This initial run-off carries much of the contaminants, particularly from hard surfaces. However, water usually becomes more turbid well after the first-flush event. This turbidity is an indicator for sediment that is washed into stream as a result of erosion. This sediment represents another set of pollutants. Rainfall is generally not evenly distributed across a catchment. Therefore some sites or catchments can be more affected during the same event. Additionally, rain intensity varies and with the intensity the effect on water quality. It is important to keep in mind, that due to this variability, patterns observed during a single event are not necessarily representative and need to be interpreted with caution. Therefore, only general patterns observed during several sampling events will be discussed

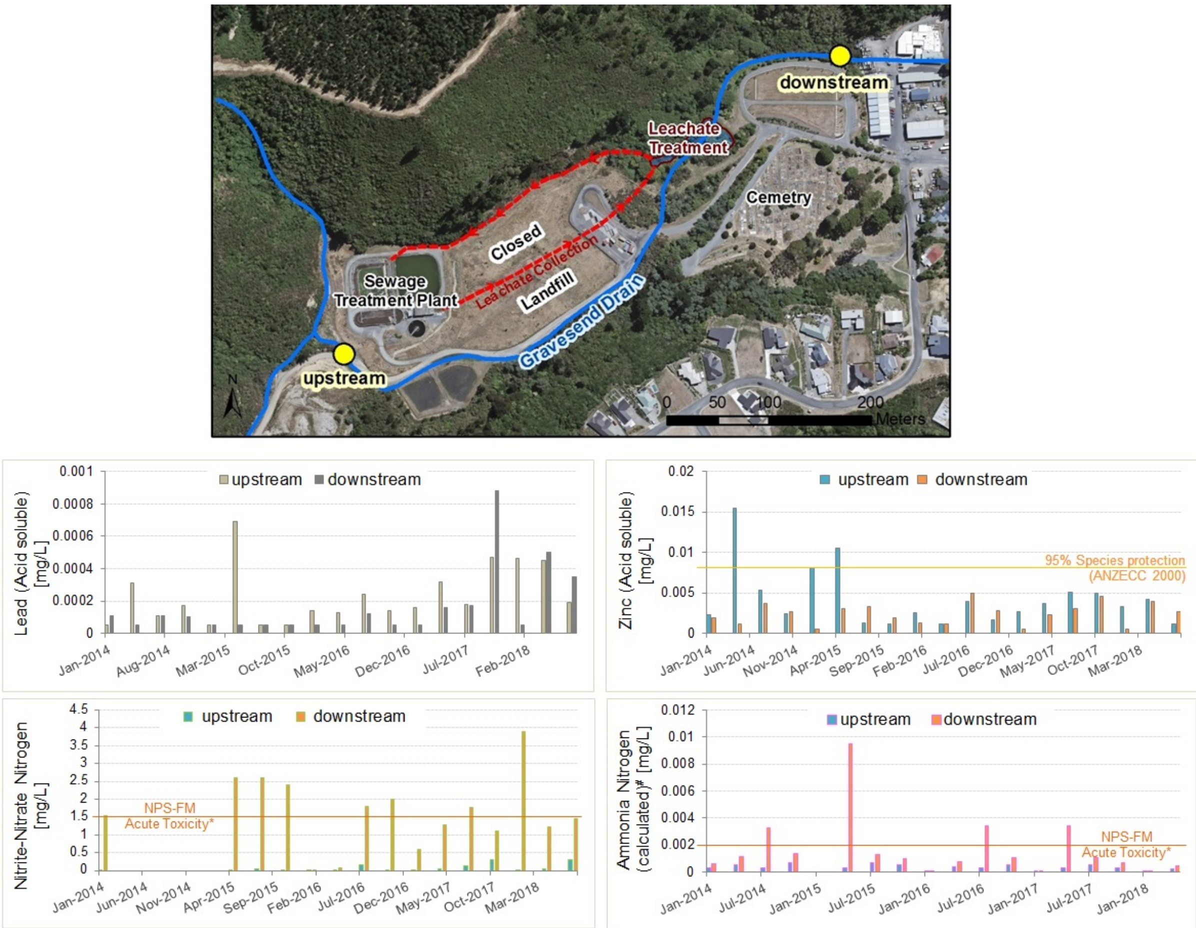
Dissolved nutrient concentrations in the main stream channel of Waikawa Stream were consistently below the guideline level for excessive algae growth. In Waitohi River dissolved nutrient concentrations occasionally exceeded the guidelines at the lowest site, which is located downstream of two tributaries influenced by urban development, Kent St Drain and Gravesend Drain. Dissolved Reactive Phosphorus concentrations appear to be naturally slightly elevated as a result of the catchment geology.

The nutrient concentrations in the tributaries sampled were generally higher than in the main stream channels of Waitohi River and Waikawa Stream. The tributary sub-catchments have a significantly smaller proportion of native vegetation cover. Therefore, dilution of contaminant inputs from urban areas with water from native bush is considerably smaller. This means contamination sources have a greater effect on the water quality in the tributaries.

A relatively small variability in Dissolved Inorganic Nitrogen concentrations in the tributaries during dry weather suggests that the nutrient discharge into these streams is constant rather than sporadic. This suggests leaching from fertiliser application and organic material storage in private gardens and parks as the main source of dissolved nitrogen during dry weather.

Dissolve Inorganic Nitrogen levels were highest in Gravesend Drain, with toxic concentrations of Nitrate and Ammonical Nitrogen. This toxicity is likely the reason that the macroinvertebrate score was much lower as could be expected based on the habitat assessment results. Gravesend Drain does not receive stormwater from residential development, but flows in close proximity to the Picton Sewage Treatment Plant and closed landfill. Nitrate and Ammonical Nitrogen are not the only contaminants effecting water quality and the closed landfill appears to be the most likely source. The Picton closed landfill was in operation from the 1960’s until 1996 and contains approximately 160,000 m^3 of refuse [12]. As all historic landfill, the Picton closed landfill has no liner underneath the refuse, but low permeability clay has been put on top to reduce the production of leachate. Underneath the landfill runs a concrete culvert that collects leachate from the refuse. Some of that leachate is pumped to the Sewage Treatment Plant for treatment. The remaining leachate is discharge into a separate two-pond treatment system which discharges into Gravesend Drain (*pers. comment, Stuart Donaldson*). Despite these efforts to treat leachate from the landfill, the results from this study and from resource consent monitoring (*Figure 21*) show that the water quality of Gravesend Drain is impacted.

Surprisingly, the resource consent monitoring shows that lead and Zinc concentrations are already elevated at the upstream site with occasional exceedances of the ANZECC (2000) 95% species protection trigger for Zinc. Lead concentrations do not exceed ANZECC (2000) trigger levels and the Zinc exceedances appear to be limited to the early years of monitoring. The only significant human activity upstream is a privately operated green-waste composting facility located South-West of the closed landfill.



* National Policy Statement for Freshwater Management (NPS-FM)- A-Band Annual 95th Percentile for Nitrate and Annual Maximum for Ammonical Nitrogen
\# Calculated from Total Ammonical Nitrogen concentrations and adjused to Water Temperature of 20ºC and pH 8 as required by NPS-FM

Figure 21: Sampling results from the resource consent monitoring of the Picton Closed Landfill.

Of the main plant nutrients, phosphorus binds more strongly to soil than nitrogen and is therefore less likely to leach. This explains the relatively low Dissolved Reactive Phosphorus concentrations observed during dry weather at all of the sites monitored during the study. During rainfall, Dissolved Reactive Phosphorus concentrations were often noticeably higher, particularly in the tributaries. The reason is phosphorus rich soil being washed into waterways during rainfall. Soils in urban areas, particularly parks and gardens, tend to be higher in nutrients. Additionally, the lack of riparian vegetation along streams and greater occurrence of bare soil leads to increased soil erosion. This also manifests in higher turbidity, particularly in the tributaries, compared to the reference sites located in the upper parts of the catchments. However, the results also show that different sources of fine sediment are causing increases in turbidity in the individual waterways. Correlation between turbidity and Total Suspended Solid concentrations show that the fine sediment in the main stream channels of Waitohi River and Waikawa Stream is similar, but is different from sediment found in the tributaries.

Although a single sampling run resulted in the highest turbidity values being observed in the Waitohi River, this is potentially a result of greater rainfall intensity in this catchment at the time, while rainfall might have been less in the Waikawa catchment. Putting this extreme event aside, turbidity in the Waitohi River is only slightly higher compared to that observed in Waikawa Stream.

During rainfall, the samples were also analysed for total nitrogen and total phosphorus concentrations. Not surprisingly, the results revealed that the vast majority of phosphorus was bound in particulate material. In the main stream channels most of the nitrogen was also in particulate form, while the tributaries in both catchments had generally a greater proportion of dissolved nitrogen.

Total Phosphorus concentrations during rainfall were noticeably higher in the Waitohi catchment compared to the Waikawa catchment. A similar pattern was observable for Total Nitrogen concentrations, but the difference between the catchments was less distinct. Particulate nitrogen and phosphorus primarily impact the lower stream sites and the seabed near the stream outflows and the results show that the nutrient input into Picton Harbour is greater than for the Waikawa Estuary.

E. coli are an indicator for faecal contamination. Concentrations were highest during rainfall. Results from the upstream samples suggest that native and feral animal can be a source of relatively high bacteria concentrations, but the sites influenced by residential development had significantly higher E. coli levels. The highest concentrations were observed in Kent St Drain, particularly the site located furthest upstream, at Cornwall Street Bridge. E. coli concentrations in this waterway were exceeding the guideline during dry weather conditions also. This indicates that stormwater/sewerage cross contamination is the likely reason as no noteworthy numbers of ducks or other wildfowl were observed in the area. Ducks did however have some impact on the water quality in the Waitohi River. E. coli concentrations during dry weather peaked at a site that is the home to more than 30 Mallard ducks. Surprisingly, during rainfall E. coli concentrations peaked at the site further downstream (Wt3). It is possible that another source is causing this rainfall peak.

In Waikawa Stream, E. coli concentrations steadily increased in a downstream direction, but during dry weather, exceeded the guideline at the site located furthest downstream only. Gravesend Drain and Endeavour Stream had E. coli concentrations above the guideline during rainfall only, but had higher values than the other sites during light rain.

Analysis of genetic markers in rainfall samples showed that ruminants, pigs and possums were a source of faecal contamination at all sites in both catchments. The most likely source are feral animals in the upper catchments. Surprisingly, human faecal contamination was also found at all sites. Further quantitative analysis of human contamination indicated that the impact of private sewage treatment is greater compared to the reticulated urban system. Unfortunately, private systems are often not maintained or regularly checked for damage. Unsuitably located or poorly designed sewage disposal areas can also cause discharge of human sewage into streams.

PH values appear to be naturally quite high in both catchments. Therefore, relatively small increases can result in pH values above the optimal range for aquatic animals. However, despite filamentous algae cover at a number of the sites during base flow, pH values were only occasionally elevated at the lower sites. Surprisingly, a small amount of rainfall resulted in very low pH values in the upper Waitohi River and Kent St Drain. It is unclear what was causing this phenomenon.

Of the heavy metals measured during rainfall, Copper and Zinc were of greatest concern, at some sites exceeding the 95% Species protection trigger during at least two of the three rainfall sampling runs. Generally, concentrations were greater in the tributaries with particularly high levels in Endeavour Stream. Of the tributaries monitored, Endeavour Stream has the smallest proportion of its catchment in native bush cover. Therefore influences from urban development are more prominent. Nevertheless, it is unlikely that residential development alone is causing the high heavy metal concentrations observed. The boatyards in the lower parts of the catchment are a more probable contamination source. Additionally, compliance monitoring of Endeavour Stream following the application of fertiliser at Endeavour Park revealed that during rainfall concentrations of nutrients increased significantly downstream of the park (unpublished data). Fertilisers, such as superphosphate, are known to contain impurities including Copper and Zinc [7] and it is possible that these metals are leached after fertilizer application.

Although high heavy metal concentrations only occur during a very short time period in the water (during flood flows) they have a legacy effect on the aquatic environment. A large proportion of these metals will be deposited together with sediment on the stream bed and in the coastal areas. Heavy metals in the sediment affect the aquatic fauna that makes their home on the stream or sea bed. Additionally, when this sediment becomes disturbed, some of the sediment and heavy metals will become re-suspended back into the water column.

Ecological monitoring included a habitat survey, macroinvertebrate sampling and a fish survey. Habitat assessments and Macroinvertebrate sampling are ideally carried out during low flows in summer when algae growth is most prolific, but relative differences in habitat and macroinvertebrate scores are still evident in the colder months.

Habitat and macroinvertebrate data revealed a similar pattern with higher scores in the upper catchment compared to the urban areas. The lower Endeavour Stream had the worst habitat and macroinvertebrate scores. Reasons include the smothering of the stream bed with fine sediment and a lack of tall riparian vegetation.

The fish survey was restricted to sites on the main stream channel. A healthy abundance of fish was found in the upper catchments and the lower Waikawa Stream. The lower Waitohi River at site Wt2, downstream of the State Highway One Bridge, however, was absolutely devoid of fish life. The results of the water quality sampling, habitat and Macroinvertebrate monitoring at this site, show that water quality and habitat are slightly degraded, but this does not explain the total lack of fish life. It is important to note that the fish survey and the macroinvertebrate sampling were carried out several months apart and it is possible that the MCI score might have been lower if a macroinvertebrate sample from site Wt2 was taken on the same day as the fish survey. Macroinvertebrate samples are taken annually at this site as part of the State of the Environment monitoring and MCI scores in some years have indicated fair water quality, but scores have never been low enough to explain the lack of fish observed at the site during this study. The most likely explanation is the illegal disposal of a substance, poisonous to fish either into a stormwater drain or the river itself. It only takes one such careless act to wipe out the entire fish population downstream. Unfortunately, it is impossible to determine what was discharged and when, unless it was witnessed and reported. However, no such reports have been received by council. Unfortunately, council was unable to carry out a follow-up survey to determine if fish numbers had recovered.

Recommendations

The following recommendations for the improvement of water quality in the Waitohi and Waikawa catchments are based on the results of the investigation.

- Promote good yard practices at industrial sites along Kent St Drain to reduce heavy metals in rainfall run-off and discharge of hydrocarbons. If possible investigate hot spots (areas that are the major sources of heavy metal during rainfall).
- Investigate stormwater/sewerage cross-connections effecting Kent St Drain, particularly the upper site (this will be done within the Marlborough District Council and has already been initiated).
- Require regular maintenance and checks of private sewage treatment and disposal systems.
- Educate residents that the discharge of liquids that are toxic to aquatic life into stormwater drains can have dramatic effects on aquatic ecosystems. Examples are the disposal of certain paints, concrete mixtures and the use of some pesticides and herbicides on driveways, roofs and pathways and along waterways.
- Investigate the sources of the very high Copper and Zinc concentration in Endeavour Stream and if possible eliminate or minimise these sources.
- Promote riparian planting in the lower reaches to reduce the smothering of stream bed habitat as a result of erosion and the excessive growth of algae on the stream bed

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Appendix

Water Sampling results

The following tables use the short site names. Refer to *Figure 3* for site coordinates.

Date	Site	Dissolved Inorganic Nitrogen	Nitrate-Nitrogen	Ammonical-Nitrogen	Dissolved Reactive Phosphorus	E.coli	Turbidity	pH
		mg/L	mg/L	mg/L	mg/L	cfu/100mL	NTU	
3 October 2017 (base flow)	Wkw1	0.169	0.163	0.005	0.007	24	1.27	7.5
	Wkw2	0.111	0.106	0.005	0.009	17	0.64	7.4
	Wkw3	0.09	0.085	0.005	0.012	16	0.62	7.5
	Wkw4	0.041	0.036	0.005	0.012	36	0.45	7.4
	Edv1	1.265	1.25	0.005	0.009	360	2.3	7.1
	Wth1	0.539	0.52	0.019	0.01	30	1.84	7.5
	Wth2	0.042	0.036	0.005	0.007	28	1.08	7.6
	Wth3	0.045	0.04	0.005	0.008	27	1.01	7.6
	Wth4	0.035	0.029	0.005	0.008	16	1	7.5
	Wth5	0.029	0.023	0.005	0.01	8	1.68	7.5
	Wth6	0.034	0.02	0.014	0.01	12	1.38	7.5
	Knt1	0.695	0.69	0.005	0.009	700	3.3	7.8
	Knt2	0.385	0.38	0.005	0.008	750	4	7.7
	Knt3	0.345	0.34	0.005	0.009	190	4.4	7.7
	Gvs1	2.99	2	0.79	0.002	80	6.4	7.4
24 October 2017 (base flow)	Wkw1	0.14	0.134	0.005	0.009	1000	0.89	7.7
	Wkw2	0.071	0.066	0.005	0.007	24	0.64	7.4
	Wkw3	0.084	0.069	0.014	0.012	22	0.45	7.5
	Wkw4	0.044	0.038	0.005	0.011	13	0.32	7.4
	Edv1	0.176	0.169	0.005	0.005	13	1.5	7.6
	Wth1	0.043	0.038	0.005	0.002	0	0.48	8.1
	Wth2	0.031	0.026	0.005	0.009	70	0.67	7.7
	Wth3	0.036	0.03	0.005	0.01	60	0.83	7.7
	Wth4	0.032	0.026	0.005	0.011	230	0.84	7.6
	Wth5	0.022	0.016	0.005	0.011	80	1.47	7.5
	Wth6	0.022	0.016	0.005	0.012	6	0.7	7.6
	Knt1	0.575	0.57	0.005	0.12	130	3.6	7.7
	Knt2	0.345	0.34	0.005	0.015	260	2.4	7.7
	Knt3	0.285	0.27	0.005	0.014	350	2.7	7.7
	Gvs1	3.15	2.4	0.55	0.002	40	3.6	7.4

Date	Site	Dissolved Inorganic Nitrogen	Nitrate-Nitrogen	Ammonical-Nitrogen	Dissolved Reactive Phosphorus	E.coli	Turbidity	pH
		mg/L	mg/L	mg/L	mg/L	cfu/100mL	NTU	
28 November 2017 (base flow)	Wkw1	0.103	0.098	0.005	0.002	700	0.51	7.9
	Wkw2	0.008	0.003	0.005	0.005	180	0.28	7.5
	Wkw3	0.034	0.027	0.005	0.01	60	0.42	7.6
	Wkw4	0.041	0.035	0.005	0.012	20	0.22	7.7
	Wth2	0.017	0.011	0.005	0.005	90	0.65	7.6
	Wth3	0.022	0.016	0.005	0.005	170	0.55	7.7
	Wth4	0.018	0.012	0.005	0.007	240	0.55	7.6
	Wth5	0.012	0.007	0.005	0.007	160	1.83	7.8
	Wth6	0.008	0.002	0.005	0.008	80	0.61	7.6
	Knt1	0.515	0.51	0.005	0.012	1500	7.7	8
	Knt2	0.325	0.32	0.005	0.011	180	2.3	7.7
	Knt3	0.215	0.2	0.005	0.009	120	1.79	7.7
	Gvs1	3.211	3.2	0.011	0.002	90	2.3	7.4
21 December 2017 (base flow)	Wkw1	0.119	0.112	0.005	0.002	280	0.61	7.9
	Wkw2	0.008	0.003	0.005	0.002	100	0.21	7.7
	Wkw3	0.011	0.006	0.005	0.008	30	0.59	8
	Wkw4	0.036	0.03	0.005	0.014	60	0.18	7.7
	Wth2	0.154	0.126	0.028	0.002	1200	1.37	7.5
	Wth4	0.006	0.001	0.005	0.002	1700	1.26	7.5
	Wth5	0.016	0.01	0.005	0.007	120	0.32	7.5
	Wth6	0.006	0.001	0.005	0.009	60	0.38	7.6
	Knt1	0.566	0.55	0.016	0.015	900	9.8	7.7
	Knt2	0.355	0.35	0.005	0.011	160	1.28	7.8
	Knt3	0.131	0.125	0.005	0.009	1900	1.04	7.8
	Gvs1	3.585	3.4	0.085	0.006	410	1.94	7.8

Date	Site	Dissolved Inorganic Nitrogen mg/L	Nitrate-Nitrogen mg/L	Ammonical-Nitrogen mg/L	Dissolved Reactive Phosphorus mg/L	E.coli cfu/100mL	Turbidity NTU	pH	Total Suspended Solids mg/L	Total Phosphorus mg/L	Total Nitrogen mg/L	Dissolved Copper mg/L	Dissolved Zinc mg/L	Dissolved Arsenic mg/L	Total Cadmium mg/L
27 March 2018 (light rainfall)	Wkw1	0.026	0.021	0.005	0.002	110	0.61	7.6		0.007	0.12	< 0.0005	< 0.0010		< 0.000053
	Wkw2	0.03	0.024	0.005	0.002	60	0.43	7.4		0.035	0.12	< 0.0005	< 0.0010		< 0.000053
	Wkw3	0.048	0.042	0.005	0.008	110	0.48	7.4		0.014	0.13	< 0.0005	< 0.0010		< 0.000053
	Wkw4	0.045	0.039	0.005	0.009	77	0.48	7.4		0.009	0.13	< 0.0005	< 0.0010		< 0.000053
	Edv1	0.395	0.39	0.005	0.007	800	1.63	6.9		0.021	0.61	0.0013	0.0061		< 0.000053
	Wth1	0.355	0.35	0.005	0.007	310	2.3	7.6		0.02	0.51	< 0.0010	< 0.002		< 0.00011
	Wth2	0.026	0.02	0.005	0.007	110	0.99	7.5		0.013	0.13	< 0.0005	< 0.0010		< 0.000053
	Wth3	0.006	0.001	0.005	0.005	90	1.11	7.5		0.009	0.13	< 0.0005	< 0.0010		< 0.000053
	Wth4	0.006	0.001	0.005	0.007	200	0.97	5.9		0.013	0.11	< 0.0005	< 0.0010		< 0.000053
	Wth5	0.006	0.001	0.005	0.008	90	1.05	5.8		0.016	< 0.11	< 0.0005	< 0.0010		< 0.000053
	Wth6	0.006	0.001	0.005	0.009	50	1.25	5.8		0.014	< 0.11	< 0.0005	< 0.0010		< 0.000053
	Knt1	0.775	0.76	0.005	0.015	510	3	5.7		0.025	0.95	0.0007	0.0028		< 0.000053
	Knt2	0.345	0.33	0.005	0.012	180	3.3	5.7		0.025	0.47	0.0007	0.0013		< 0.000053
	Knt3	0.215	0.21	0.005	0.012	180	5.7	7.7		0.024	0.36	< 0.0005	< 0.0010		< 0.000053
	Gvs1	1.445	1.33	0.035	0.002	1400	5.9	7.7		0.025	1.83	< 0.0005	< 0.0010		< 0.000053
5 January 2018 (heavy rainfall)	Wkw1	0.126	0.116	0.005	0.0087	16400	23	7.1	44	0.092	1.03	0.001	0.0031	< 0.0010	< 0.000053
	Wkw2	0.05	0.041	0.005	0.006	14700	18	7.1	35	0.081	0.81	0.0006	0.0012	< 0.0010	< 0.000053
	Wkw3	0.026	0.018	0.005	0.0056	12000	12.1	7.1	21	0.062	0.69	0.0006	< 0.0010	< 0.0010	< 0.000053
	Edv1	0.355	0.35	0.005	0.023	12700	14.4	6.9	15	0.069	0.93	0.0073	0.0107	< 0.0010	< 0.000053
	Wth1	0.111	0.104	0.005	0.0137	8200	66	7.4	161	0.23	1.69	0.0008	0.0017	0.001	< 0.000053
	Wth2	0.041	0.034	0.005	0.0062	6800	96	7.5	230	0.3	1.87	0.0005	< 0.0010	< 0.0010	< 0.000053
	Wth3	0.017	0.01	0.005	0.0045	3600	117	7.4	310	0.29	2.3	0.0006	< 0.0010	< 0.0010	< 0.000053
	Wth4	0.013	0.006	0.005	0.0048	3200	74	7.4	193	0.197	1.73	0.0006	< 0.0010	< 0.0010	< 0.000053
	Wth5	0.006	0.001	0.005	0.0028	2500	50	7.4	140	0.156	0.89	0.0006	< 0.0010	< 0.0010	< 0.000053
	Knt1	1.073	1.05	0.023	0.04	> 6000	440	7.3	620	0.7	4.4	0.0024	0.002	0.0014	0.000065
	Knt2	0.78	0.74	0.03	0.042	12600	310	7.5	440	0.6	4.1	0.0022	0.0015	0.0017	0.000055
	Knt3	0.792	0.76	0.022	0.043	11800	230	7.5	310	0.37	3.2	0.002	0.0013	0.0017	< 0.000053
	Gvs1	2.42	1.58	0.73	0.025	11000	22	7.6	32	0.116	3.1	0.0016	0.0011	< 0.0010	< 0.000053

Date	Site	Dissolved Inorganic Nitrogen mg/L	Nitrate-Nitrogen mg/L	Ammonical-Nitrogen mg/L	Dissolved Reactive Phosphorus mg/L	E.coli cfu/100mL	Turbidity NTU	pH	Total Suspended Solids mg/L	Total Phosphorus mg/L	Total Nitrogen mg/L	Dissolved Copper mg/L	Dissolved Zinc mg/L	Dissolved Arsenic mg/L	Total Cadmium mg/L
11 February 2018 (heavy rainfall)	Wkw1	0.046	0.04	0.005	0.0011	706	1.49	7.8	< 3	0.029	0.139	< 0.0005	< 0.0010	< 0.0010	< 0.000053
	Wkw2	0.006	0.001	0.005	0.003	369	0.53	7.3	< 3	0.006	0.063	< 0.0005	0.0011	< 0.0010	< 0.000053
	Wkw3	0.017	0.012	0.005	0.0075	545	0.72	7.6	< 3	0.039	0.105	< 0.0005	< 0.0010	< 0.0010	< 0.000053
	Wkw4	0.06	0.055	0.005	0.0146	318	0.82	7.4	< 3	0.02	0.103	< 0.0005	< 0.0010	< 0.0010	< 0.000053
	Edv1	0.048	0.041	0.005	0.041	14140	30	6.8	30	0.118	0.39	0.044	0.079	< 0.0010	0.000077
	Wth1	0.404	0.35	0.044	0.0151	1782	6.5	7.7	3	0.033	0.6	< 0.003	0.06	< 0.005	< 0.00027
	Wth2	0.03	0.025	0.005	0.0054	3130	1.17	7.4	< 3	0.016	0.119	< 0.0005	0.0018	< 0.0010	< 0.000053
	Wth3	0.117	0.11	0.005	0.023	8660	12.3	7.4	19	0.069	0.35	0.0012	0.01	< 0.0010	< 0.000053
	Wth4	0.019	0.013	0.005	0.0069	8160	1.94	7.6	3	0.024	0.155	< 0.0005	< 0.0010	< 0.0010	< 0.000053
	Wth5	0.008	0.003	0.005	0.0087	7270	1.61	7.5	< 3	0.03	0.128	< 0.0005	< 0.0010	< 0.0010	< 0.000053
	Wth6	0.006	0.001	0.005	0.0095	1515	1.32	7.5	< 3	0.025	0.106	< 0.0005	< 0.0010	< 0.0010	< 0.000053
	Knt1	0.465	0.45	0.005	0.019	1450	7.9	7.6	5	0.046	0.63	0.0022	0.028	0.001	< 0.000053
	Knt2	0.205	0.199	0.005	0.03	15530	93	7.3	159	0.43	1.56	0.0019	0.0098	0.0016	< 0.000053
	Knt3	0.385	0.37	0.005	0.032	24200	139	7.4	158	0.34	1.3	0.0015	0.0038	0.0018	< 0.000053
	Gvs1	0.975	0.96	0.005	0.0143	6490	28	7.6	45	0.14	1.61	0.0006	< 0.0010	< 0.0010	< 0.000053
26 February 2018 (heavy rainfall)	Wkw1	0.072	0.064	0.005	0.0072	2610	5.2	7.2	6	0.034	0.44	0.0007	0.0017	< 0.0010	< 0.000053
	Wkw2	0.032	0.024	0.005	0.0071	2140	4.2	7.2	4	0.025	0.34	< 0.0005	< 0.0010	< 0.0010	< 0.000053
	Wkw3	0.014	0.006	0.005	0.007	2850	3.9	7.2	4	0.021	0.35	< 0.0005	< 0.0010	< 0.0010	< 0.000053
	Wkw4	0.025	0.017	0.005	0.0082	1842	3.6	7	3	0.023	0.34	< 0.0005	< 0.0010	< 0.0010	< 0.000053
	Edv1	0.825	0.81	0.005	0.066	5170	14.5	7.1	6	0.112	1.49	0.0031	0.0058	0.0011	< 0.000053
	Wth1	0.555	0.54	0.005	0.026	4610	68	7.4	59	0.144	1.02	0.0014	0.0059	0.0015	< 0.000053
	Wth2	0.026	0.019	0.005	0.0145	1956	8.8	7.4	9	0.054	0.27	< 0.0005	< 0.0010	< 0.0010	< 0.000053
	Wth3	0.011	0.003	0.005	0.0122	1334	7.8	6.5	7	0.033	0.22	< 0.0005	< 0.0010	< 0.0010	< 0.000053
	Wth4	0.006	0.001	0.005	0.0122	1119	6.4	6.6	6	0.035	0.194	< 0.0005	< 0.0010	< 0.0010	< 0.000053
	Wth5	0.006	0.001	0.005	0.0108	1137	5.4	6.7	5	0.028	0.181	< 0.0005	< 0.0010	< 0.0010	< 0.000053
	Wth6	0.006	0.001	0.005	0.0116	933	5.5	6.8	4	0.031	0.154	< 0.0005	< 0.0010	< 0.0010	< 0.000053
	Knt1	0.831	0.8	0.021	0.038	4880	50	6.8	55	0.15	1.48	0.0027	0.0047	0.0016	< 0.000053
	Knt2	0.436	0.42	0.016	0.025	5170	36	7	36	0.1	1.02	0.0016	0.0028	0.0015	< 0.000053
	Knt3	0.375	0.36	0.015	0.021	3260	37	7.1	38	0.1	0.92	0.0013	0.0014	0.0012	< 0.000053
	Gvs1	0.902	0.78	0.082	0.0019	6490	138	7.1	107	0.192	1.73	0.0023	< 0.0010	< 0.0010	< 0.000053

Macroinvertebrate Scores

Site	MCI	Taxa Richness	SQMCI	EPTtaxa
Wkw4	136.4	35	7.6	62.9
Wkw2	113.3	29	5.0	58.6
Edv1	73.3	6	3.6	33.3
Wth6	121.5	27	6.9	55.6
Wth3	103.1	30	4.6	43.3
Knt2	107.4	19	6.3	42.1
Gvs1	93.3	6	3.8	50.0

Habitat Assessment Scores

Site	Northing	Easting	Date	Habitat Score
HA Waikawa Stm 01	5428320	1687103	43285	83.5
HA Waikawa Stm 02	5428343	1687078	43285	80
Unnamed Trib 01	5428484	1687065	43285	74.5
HA Waikawa Stm 03	5429177	1686539	43285	75
HA Waikawa Stm 04	5429244	1686515	43285	64.5
HA Waikawa Stm 05	5429328	1686498	43285	70.5
HA Waikawa at Wkw3	5429410	1686447	43285	70
HA Waikawa Stm 07	5429480	1686349	43285	65.5
HA Waikawa Stm 08	5429545	1686282	43285	52.5
HA Waikawa Stm 09	5429658	1686238	43285	45.5
HA Waikawa Stm 10	5429888	1686385	43285	58.5
HA Waikawa Stm 11	5430004	1686361	43285	66.5
HA Waikawa Stm 12	5430191	1686457	43285	70
HA Waikawa u/s Wkw2	5430334	1686530	43286	59.5
HA Waikawa d/s Wkw2	5430454	1686565	43286	58
HA Waikawa Stm 12	5430746	1686820	43286	56
HA Endeavour Stm 02	5430874	1686626	43287	56.5
HA Endeavour Stm at Edv1	5430926	1686750	43287	34.5

Site	Northing	Easting	Date	Habitat Score
Waitohi Rv at Wth6	5426802	1684163	43286	82.5
HA Waitohi Rv 02	5426948	1684192	43286	67.5
HA Waitohi Rv 03	5427018	1684235	43286	72.5
HA Waitohi Rv 04	5427086	1684200	43286	74
HA Waitohi Rv 05	5427181	1684246	43286	73.5
HA Waitohi Rv d/s Wth5	5427336	1684348	43286	76
HA Waitohi Rv 07	5427487	1684211	43286	57
HA Waitohi Rv 08	5427610	1684120	43286	50
HA Waitohi Rv 09	5427686	1684195	43286	55
HA Waitohi at Scottland St	5427922	1684177	43287	58
HA Waitohi u/s Wth3	5428116	1684154	43279	67
HA Waitohi d/s Wth3	5428208	1684132	43279	59.2
HA Kent St DN u/s Knt2	5428158	1683615	43287	56
HA Kent St DN d/s Knt2	5428229	1683678	43287	54.5
HA Gravesend Dn at Gvs1	5428679	1683562	43287	54.5