Pongakawa Community Group

Workshop Agenda

Friday, 26 May 2017

Interim Chairman:	**Wilma Foster**
Members:	**Andre Hickson, Andy Bell, Bernie Hermann, Bev Nairn, Colin McCarthy, Darryl Jensen, Dennis Walker, Geoff Rice, Grant Rowe, Councillor Jane Nees, John Garwood, John Cameron, John Meikle, Julian Fitter, Kevin Marsh, Mike Maassen, Melv Anderson, Paul Van der Berg, Roku Mihinui, Te Awhi Manahi and Wilma Foster (Chair)**
BOPRC Staff:	**Pim de Monchy (Relationship Manager), Nicola Green (Senior Planner), Andrew Millar (Senior Planner), Kerry Gosling (Facilitator), Stephanie Macdonald/Janie Stevenson (Support Facilitators), Rochelle Carter (Scientist), Raoul Fernandes (Scientist).** **Nic Conland (Consultant – catchment modelling)**
Administrator:	**Lisa Baty**
Apologies:	
Venue:	**Pongakawa Hall, Old Coach Road, Pongakawa**
Time:	**9.00am – 2.30pm**

8.30am	**Join us for a cup of tea catch up**
9.00am	**Welcome** **Where we are now** **Purpose of today** **National and regional update** **Desired in-river state**
10.00am	**Morning tea** **Freshwater issues** **Use values**
12.30pm	**Lunch**
1.00pm	**Integrated catchment modelling** **Groundwater modelling**
2.00pm	**Next Steps**
2.30pm	**Close**

WORKSHOP PAPER

Bay of Plenty REGIONAL COUNCIL

To: **Pongakawa Waitahanui Freshwater Futures Community Group**

From: Nicola Green and Santiago Bermeo
Senior Planners (Water Policy)

Date: 15 May 2017

Subject: **Freshwater Futures Workshop 5 Overview**

1 Introduction

As outlined in previous workshops, we are working towards developing freshwater quality and quantity objectives, limits and methods to support key freshwater values[1] (see Figure 1).

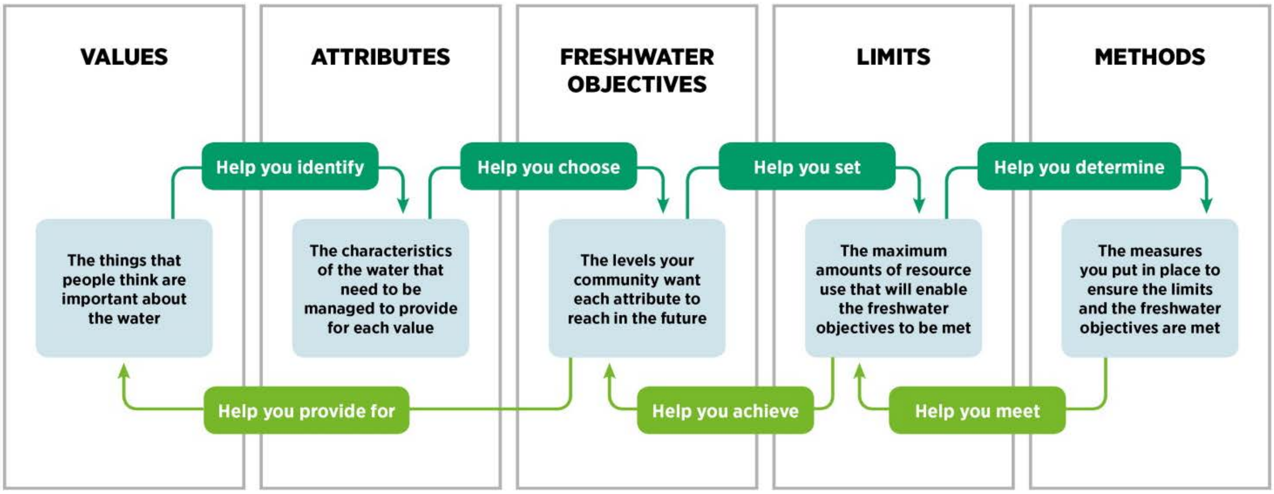


Figure 1: Main steps in the National Objectives Framework, National Policy Statement for Freshwater Management 2014 (NPSFM)

Table 1 summarises very briefly the work we have covered to date in community group workshops and general direction given by the group. Detail is provided within the notes for each workshop.

Table 1: Community Group workshop topics to date

Workshop	Topics	Direction given
1	Introduced the NPSFM process and group function. Discussed **freshwater values**.	
2	Presented **current state** water quality, quantity and ecology information for rivers, groundwater, Waihī estuary and wetlands.	
3	Discussed working draft **Regional Freshwater Value set, Freshwater Management Units** for surface water, and	General agreement that the draft Regional Freshwater Value Set is comprehensive – some additions and

[1] in accordance with the National Objectives Framework outlined in Figure 1 and set down by the National Policy Statement for Freshwater Management 2014

	freshwater values within these. Noted draft Freshwater Management Units for groundwater are yet to be determined, and will be based on hydrogeological units that will not necessarily match surface water boundaries.	modifications suggested which have largely been added. Agreed in principle that draft FMUs seemed appropriate, but sought the ability to revisit as we progress and understand implications more fully.
4	Discussed **acceptability of the state of "in-river" values** within each draft FMU - A first step towards objective setting.	Detailed input has been summarised and sent to the group.

In workshop 5, we will continue to progress towards setting freshwater objectives for water quality and quantity as outlined in Figure 2. In particular, we will seek your feedback on "desired in-river freshwater state" statements drafted by staff from workshop 4 notes and start to talk about use values and their freshwater quality and quantity needs. Catchment and groundwater modelling are key tools that will help us in assessing management options and how they achieve objectives, and we will spend some time talking with you about these as well. Table 2 outlines the content we will cover in the workshop.

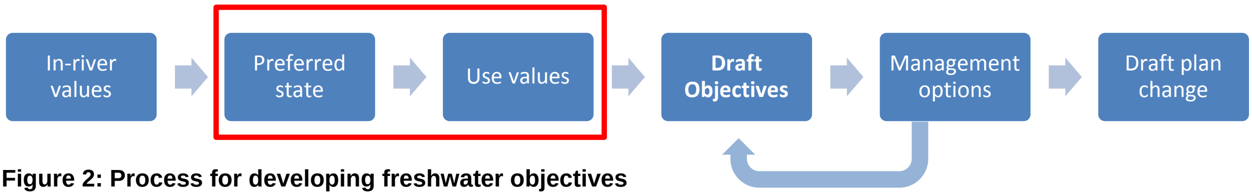


Figure 2: Process for developing freshwater objectives

Table 2: Community Group Workshop 5 topics

Topic	Content
National and regional update (see section 2 below)	**Purpose:** Note key changes of relevance to our work. Includes: • Resource Legislation Amendment Act • *Clean Water* consultation – proposed changes to the NPSFM • BOPRC Plans update • Recent relevant council decisions.
Desired in-river state (workshop paper attached)	**Purpose:** Seek feedback on *desired in-river state* statements developed from workshop 4 Community Group input. • Present preliminary science recommendations for attributes and bands. • Acknowledge gaps requiring further work, particularly the need to engage with iwi on sites of cultural significance **Feedback sought:** Have we got desired in-river state statements right?
Freshwater Issues (workshop paper attached)	**Purpose:** Summarise key freshwater quality and quantity resource management issues. **Feedback sought:** Discussion and agreement these are key issues we should be focussing on going forward.
Extractive use values (workshop paper attached)	**Purpose:** Understand current land use, allocation of water, discharges to water by industry per FMU and work progressing on economic value. • Present current land use **Feedback sought:** Discussion about this information and how it will be used. Is the land use map accurate?
Integrated catchment modelling (information sheets attached)	**Purpose:** Provide overview of integrated catchment modelling and groundwater modelling in progress. • Explain E-source model and groundwater modelling, input layers, what the model can/will do, outputs, data, limitations and uncertainties, and timeline.

	Feedback sought: • Level of comfort for the group on how model will work and contribute to process. • Feedback on accuracy of land use layer
Next steps	**Purpose:** Outline upcoming process of developing scenarios and management options **Feedback sought:** • What factors/criteria would you prefer to measure "success" of management options by? • Brainstorm of management options – which are you most interested in?

2 National and regional freshwater management updates

2.1 Resource Management Act changes

The Resource Legislation Amendment Act 2017, which makes numerous changes to the Resource Management Act 1991, became law on 18 April 2017. More information can be found on the Ministry for the Environment website. The changes of most relevance for freshwater management are:

- provision to enable stock exclusion regulations;
- provision for use of models (e.g. OVERSEER) in Plans;
- provision for collaborative planning processes as an alternative to the current Schedule 1 process for Plan Changes; and
- changes to s. 14(3)(b)(ii) to clarify that no resource consent is needed for stock drinking water, whether the stock is owned by an individual or a company (e.g. farming entity).
- provision for iwi participation agreements/Mana whakahono a rohe. Regional plans are to be prepared in accordance with these;

In the context of our current work in the Rangitāiki and Kaituna-Pongakawa-Waitahanui Water Management Areas (WMAs), we don't expect these changes will have significant implications. Iwi participation agreements may confirm or supersede existing participation arrangements, subject to when these can be finalised.

2.2 *Clean Water* consultation

The Ministry for the Environment consulted on the following proposals between February and April 2017:

- national targets for making large streams and lakes suitable for swimming (80% by 2030 and 90% by 2040);
- a number of proposed changes to the NPS-FM; and
- proposed stock exclusion regulations.

The document also opened for applications the $100m Freshwater Improvement Fund. BOPRC will be submitting an application to support the Kaituna River re-diversion programme.

BOPRC made a submission on the proposals, which is available on the Community Group online portal. BOPRC generally supported the proposals but made recommendations to:

- align the proposed swimmability targets more closely with NPS-FM implementation;
- reduce ambiguity/increase clarity;
- strengthen environmental considerations; and
- provide additional flexibility for regional management.

In advance of confirming final decisions, the Minister for the Environment requested that Regional Councils work with central government to develop draft plans by October 2017 for how the proposed 'swimmability' targets will be achieved. BOPRC is currently involved in this, noting that according to modelling and analysis by the Ministry for the Environment, 86% of the Bay of Plenty's large streams and lakes already meet the proposed swimming standards.

Final decisions on these national proposals are expected over the next couple of months, ahead of the General Election. We will need to take into account or give effect to any final decisions within the Rangitāiki and Kaituna-Pongakawa-Waitahanui WMAs. For example, we may need to consider how national targets for swimming in large rivers and lakes align with community expectations and favoured swimming locations, national stock exclusion requirements may be in place and this would effectively be a nationally applicable 'method', refer to Figure 1.

2.3 Regional Policy and Plan changes

Region—wide Water Quantity (Proposed Plan Change 9)

Proposed Plan Change 9 sets a number of region-wide policies and rules in relation to managing water quantity as outlined in previous workshops. It sets region-wide interim allocation limits that are in place until WMA specific Plan Changes supersede them. Further submissions will be received in May 2017, hearings are set for October/November 2017 and final decisions by March 2018.

In the context of the Rangitāiki and Kaituna-Pongakawa-Waitahanui WMA, there is opportunity to recommend more specific water quantity objectives, limits and methods that supersede the interim measures set by Plan Change 9. The policies and rules set by Plan Change 9 remain relevant other than where superseded by these WMA-specific changes.

Changes to Regional Policy Statement to recognise and provide for Te Ara Whanui/Pathways of the Rangitāiki River document (Proposed Change 3)

Nineteen submissions and six further submissions have been received on Proposed Change 3. Hearings are scheduled for 12 and 19 June 2017. Plan Change 12 provisions for Rangitāiki WMA will need to give effect Change 3. The Rangitāiki River Forum is a co-governance forum and decisions for Plan Change 12 relating to Rangitāiki WMA will go to the Forum for their advice/approval, although Council is the ultimate decision-maker. Te Maru o Kaituna are also preparing a river document, and a change to the Regional Policy Statement will follow that.

Lake Rotorua Nutrient Management (Proposed Plan Change 10)

Proposed Plan Change 10 introduces rules to limit the amount of nitrogen entering Lake Rotorua from land use in order to achieve lake water quality objective and limits set in the Regional Policy Statement and Regional Water and Land Plan (refer to Figure 1). The proposed rules set out how Nitrogen Discharge Allowances will be allocated to individual rural properties. Hearings on the Plan Change finished in early May 2017. Final decisions are expected in late June 2017.

There are no direct implications from Plan Change 10 for our work in the Rangitāiki and Kaituna-Pongakawa-Waitahanui WMAs, but Council is considering the learnings and outcomes as we work towards Plan Change 12. The objective for Lake Rotorua was set in 2001, a decade before the NPS-FM. The limit to support that objective was set in 2010 and the method the Plan Change is introducing now was determined in 2015, after significant engagement with Lake Rotorua stakeholders. A significant difference for Plan Change 12 is that we are considering objectives, limits and methods concurrently.

WORKSHOP PAPER

Bay of Plenty REGIONAL COUNCIL

To: **Pongakawa Waitahanui Freshwater Futures Community Group**

From: Michelle Lee
Planner (Water Policy)

Date: 12 May 2017

Subject: **Desired in-river state – Have we got it right?**

1 Purpose

The purpose of this paper is to confirm Council staff have correctly interpreted the ***desired in-river state*** from your comments on the acceptability of in-river values made in the previous workshop.

We would like your feedback on the bold-font statements in section 4 of this paper.

This is a first step towards drafting 'freshwater objectives' for draft freshwater management units (FMUs) under the National Objective Framework in the National Policy Statement for Freshwater Management.

This paper also presents a recap of steps to date (section 3) and links values to science attributes (ie. measures).

2 Introduction

At the 9 November 2016 workshop, the Pongakawa-Waitahanui Freshwater Futures Community Group detailed in-river values for the Waitahanui, Middle-upper Pongakawa and Lower Pongakawa draft Freshwater Management Units and for Waihī Estuary. We need to take these values and use values, and in due course establish freshwater objectives based on them.

Freshwater objectives are the intended environmental outcomes (particularly water quality and level/flow) for a water body that will provide for the values (e.g. swimming) the community considers important, taking into account aspirations and the existing state/condition among other things. Freshwater objectives need to be set for each FMU.

To date, the Community Group has considered the values and conditions *in* rivers and the estuary. In coming workshops, the Group will consider land and water use values, and modelling results for different land and water use scenarios, before finally determining freshwater objectives for water bodies.

3 The Steps to Date

3.1 Freshwater Values Set, Freshwater Management Units and the current state of freshwater

At workshop 1, Community Group members were introduced to a working draft regional freshwater values set and provided feedback on whether it captured all freshwater values.

At workshop 2, scientists presented the current scientifically monitored freshwater state of the Waitahanui River, Pongakawa River and tributaries which feed into Waihī Estuary, and also of the Waihī Estuary. This was summarised again briefly in *Workshop 4 briefing notes*.

In its third workshop, the Community Group considered freshwater values that apply to these areas and draft 'freshwater management units' (FMUs) (note these will be revisited as work progresses).

3.2 Community members' views on the acceptability of the state of in-river values

Building on this information, the Community Group expressed the current 'acceptability' of in-river values for the three draft FMUs and Waihī Estuary in the last (the fourth) workshop. A summary and analysis of the Groups' inputs were presented in *the notes for Workshop 4*.

For some freshwater values, the group expressed the need for more information and/or that the knowledge needs to come from other appropriate sources (e.g. from tangata whenua for wai tapu and cultural values). This is being progressed.

Staff have used workshop 4 outputs to draft the 'desired in-river state' for the FMUs (section 4). We now seek the Community Group's feedback and discussion on these in Workshop 5.

3.3 Preliminary recommendations for freshwater attributes

Attributes are the science-based measurable characteristics of a freshwater body which can be measured and managed to enable particular values to be provided for.

Council's scientists have assessed thirty[1] potential attributes that may be useful for this purpose and have provided preliminary recommendations (subject to external peer review). The nine compulsory attributes in the NPSFM and seven additional attributes are recommended along with state bands. Eleven of these attributes are for rivers (see Appendix One). Attributes will form an important part of 'freshwater objectives', and Council's freshwater monitoring plan.

Further work is required before attributes for groundwater and wetlands can be recommended. Similarly, attributes for measuring habitat and fish communities are the subject of further national research. Further additions to initial recommendations will be made as new research enables it.

Although scientists and national requirements outline some important attributes there are others too. Council staff acknowledge the importance of sediment affecting water bodies and outcomes for estuaries. Dissolved reactive phosphorus (DRP), dissolved inorganic nitrogen (DIN), total suspended sediment (TSS) and enterococci are key attributes that we consider important to include, but which no bands are currently developed for.

Enterococci is the preferred indicator bacteria for marine waters and will continue to be measured and used (in estuarine and marine waters) in line with national guidelines. This attribute was not included in the preliminary recommendations for freshwater as *E. coli* is the preferred indicator in freshwater. Significant research is currently underway (both regionally and nationally) on sediment, DIN and DRP attributes and additional attributes, or revised attributes, will be recommended once more information from the research is available.

Note that the surface water catchment model (which is explained in a separate workshop paper) will model *E. coli*, nitrate and nitrite, total and dissolved reactive phosphorous and total suspended sediment.

[1] *E.coli*, enterococci, nitrate-nitrogen (NO_3-N), ammoniacal-nitrogen (NH_4-N), trophic level index (TLI), dissolved inorganic nitrogen (DIN), total nitrogen (TN), total phosphorus (TP), dissolved oxygen (DO), acidity (pH), dissolved reactive phosphorus (DRP), temperature, clarity, turbidity, faecal coliforms, metals, total suspended solids (TSS), pesticides, conductivity/salinity, biological oxygen demand (BOD), deposited sediment, colour, algae (periphyton) cover, algae - chlorophyll, cyanobacteria – benthic, cyanobacteria – planktonic, macrophytes (submerged plant indicators, SPI), invertebrates, fish (biotic index), habitat (assessments).

4 Draft *desired in-river states* in FMUs and recommended freshwater attributes

This section presents the draft ‘desired in-river states’ interpreted from the last workshop inputs for your comments.

Key attributes/measures are added to indicate how these desired in-river states could be measured. In this section, the symbol “ **?** ” indicates measures that members have suggested, but it will require further research before they can be used as a freshwater attribute for limit setting. “ * ” indicates that the surface water catchment model will include this attribute.

4.1 Middle-upper Pongakawa

We have interpreted that the desired in-river states in middle-upper Pongakawa are that:

- **The water will continue to be good for swimming as it is now.**
  Key attribute: *E. coli* (currently[2] in band A)

- **The water will support healthy ecosystems and neutral or improving trends. In particular, further degradation from siltation/sedimentation, debris, summer slime rafts and nitrification will be prevented.**
  Key attributes: nitrate (currently in band B), ammonia (currently in band A), dissolved oxygen, periphyton, algae, benthic cyanobacteria, deposited sediment?, suspended sediment*, nitrate*, phosphorus*, temperature, pH, macrophyte, invertebrates

- **Water quality and flow will continue to provide for indigenous species, support fish habitat, mahinga kai (tuna, whitebait, watercress), fishing (fly fishing) and rongoa species, reduce decline in koura numbers and increase suitable riparian habitat.**
  Key attributes: water flow, *E. coli,* dissolved oxygen, temperature, algae (especially in summer), benthic cyanobacteria, macrophyte, invertebrates, suspended sediment*, deposited sediment?, fish?, habitat?

- **The water will remain free from slime rafts where they are absent now.**
  Key attributes: algae

- **The water flow and quality will not damage the cave drawing sites by the Pongakawa Stream.** Possible measures: water flow, deposited sediment? [preliminary info subject to tangata whenua knowledge input].

Community Group members shared important observations on specific sites within this draft FMU. These include:

- Swimming: Mangatoetoe stream SH2 Bridge.
- Natural form and character slime raft: Kaikokopu stream.

[2] It is intended this attribute will reflect the National Policy Statement for Freshwater Management 2014 and any subsequent amendments.

4.2 Lower Pongakawa

We have interpreted that the desired in-river states in lower Pongakawa are that:

- **The water will be swimmable at all swimming spots during November to March, other than immediately below a discharge point or after heavy rain or during summer low flows.** Key attribute: *E. coli* (currently[3] in band B)
- **The water will support healthy ecosystems and a steady neutral trend.** Key attributes: nitrate(toxicity, currently in band B), ammonia (toxicity, currently in band A), dissolved oxygen, periphyton, temperature, pH, algae, benthic cyanobacteria, macrophytes, invertebrates, phosphorous*
- **The water will continue to provide good habitats for eels and ducks, inanga, watercress, cockabullies, kokopu, and suitable for kahawai, mullet and flounder. In particular, siltation and sediment in the water will be managed and reduced to improve aquatic habitat and invertebrate conditions.** Key attributes: water flow, dissolved oxygen, temperature, invertebrates, suspended sediment*, deposited sediment?, metal?, pesticides?, fish?, habitat?
- **The water will support mahinga kai (eels, flounder, whitebait, ducks) that is safe to eat from rivers all year round.** Key attributes: *E. coli*, benthic cyanobacteria, macrophyte, invertebrates, metal?, pesticides?, faecal coliforms?, fish?, habitat?
- **The water will continue to be suitable for wai tapu such as full emersion baptising.** Key attributes: *E. coli*, suspended sediment* [requires further tangata whenua input]
- **The water will support good ecological health and high invertebrate diversity in wetlands.** Key measure: invertebrates, water level, wetland health?
- **The rivers will have no oily layers that deter people from swimming in it.** Key measure - unknown?
- **The water flow, depth, level of sediment and water quality will continue to support tauranga waka**. Possible measures: water flow, deposited sediment?

Community Group members shared observations on specific sites within this draft FMU. Most are not Council's regular monitoring sites, but these, along with other sites of significance, will be considered for future water quality and quantity modelling estimates. Identified locations include:

- Swimming locations: Pongakawa stream at the bridge on Old Coach Road (currently monitored), railway bridge, bridge below Braemar (Benner?) Road, Kaikokopu stream and Wharere river mouth.
- Mahinga kai: freshwater mussels below State Highway 2 where they used to be prolific. Whitebaiting and fishing at Wharere and Kaikokopu. Groundwater quality continues to be suitable for preparing customary food (such as rotten corn) [requires further tangata whenua input].
- Wai tapu: Wharere and Kaikokopu streams (siltation issue) [requires further tangata whenua input].
- Tauranga waka: the water flow and water quality at SH2 access, Cutwater Rd, Wharere Rd and lower Kaikokopu Stream.

[3] It is intended this attribute will reflect the National Policy Statement for Freshwater Management 2014 and any subsequent amendments.

From the information provided at the last workshop, we think the Community Group expects the following desired state in the Waihī Estuary:

- The water will be swimmable in the lower estuary (at the mouth) as well as upper estuary from November to June.
- The water will support ecosystem health.
- The water will continue to support pipi, flounder, oyster, kahawai, snapper and mullet, and safe eating and pleasant (less to no green algae) mahinga kai activities.
- The water flow and sediments level will maintain a navigable channel depth through control and reducing sediment, reducing sea water intrusion, while acknowledging that the channel changes all the time.

These estuary outcomes are noted particularly because freshwater objectives must support estuary values. However, only Freshwater quality and quantity objectives will be set in the plan change resulting from this NPSFM process.

4.3 Waitahanui

We have interpreted that the desired in-river states in Waitahanui are that:

- **The water will continue to be clean and clear with an attractive pumice bottom in the Waitahanui for swimming.** Key attributes and measurement: *E. coli* (below acceptable[4] for swimming at Ōtamarākau, currently on band B for wading), suspended sediment*
- **The water in Waitahanui will continue to be suitable for, and provide good ecosystem health for watercress, whitebait, trout and kahawai habitats as it has been for the last 40 years. There will be no further decline in species diversity, size and presence and continue to be attractive and provide for Oystercatchers.**
  Key attributes: nitrate (currently on band A), ammonia (currently on band A), dissolved oxygen, periphyton, pH, temperature, algae, benthic cyanobacteria, macrophyte, invertebrates, fish[?], habitat[?] suspended sediment*, deposited sediment[?]
- **The water flow and sediment level continues to provide for vessel passage as it has for the last 59 years**. Key measures: deposited sediment[?], water flow

5 Other desired in-river states

Community Group members also expressed desired actions/activities not directly related to freshwater quality and quantity. These included:

- Withdrawal of commercial eeling and commercial whitebaiting.
- Managing overharvesting of indigenous fish, so the fish stock (flounder, whitebait and native species) will not further reduce at the middle-upper Pongakawa, lower Pongakawa and Waihī Estuary.
- Reinstate and restore wetlands, possibly retiring wetland near Pukehina to allow the river to meander.
- Prepare land use for sea level rise.
- Notify the public when the river is not suitable for swimming.[5]
- Boat ramp availability and accessibility.

[4] It is intended this attribute will reflect the National Policy Statement for Freshwater Management 2014 and any subsequent amendments.

[5] There is already a process in place for this, and it already happens during the bathing season.

- Maintain access to:
  - the river through riparian margins at Waitahanui, lower Pongakawa
  - streams in middle-upper Pongakawa where they have been fenced off
  - Waitahanui stream where access is obstructed by blackberry bushes
  - streams in the middle-upper Pongakawa, where plants have been falling into the stream.

Appendix One Preliminary Attributes for rivers

These preliminary attributes are subject to expert review, and will be finalised after careful consideration of that review. There are some attributes (eg. sediment, DIN, DRP) where recommendations for 'bands' have not been made yet because significant research is currently underway (both regionally and nationally) and we want our recommendations to be informed by the best possible science information. Additional attributes, or revised attributes, will be recommended once more information from the research is available.

Attribute	Statistic	Band	Biophysical layer			Value(s) supported
			Volcanic Steep	Volcanic Gentle	Non-volcanic	
E.coli[6]	Annual median	A	≤ 260/100mL			Human Health for Recreation
		B	> 260 and ≤ 540/100mL			
		C	> 540 and ≤ 1000/100mL			
		D	>1000/100mL			
	95th percentile	A	≤ 260/100mL			
		B	> 260 and ≤ 540/100mL			
		>MAS	>540/100mL			
Nitrate-nitrogen	Annual median	A	≤1.0 mg/L			Ecosystem Health (toxicity)
		B	>1.0 and ≤ 2.4 mg/L			
		C	>2.4 and ≤ 6.9 mg/L			
		D	>6.9 mg/L			
	Annual 95th percentile	A	≤ 1.5 mg/L			
		B	>1.5 and ≤ 3.5 mg/L			
		C	>3.5 and ≤ 9.8 mg/L			
		D	> 9.8 mg/L			
Ammoniacal nitrogen	Annual median	A	≤0.03 mg/L			Ecosystem Health (toxicity)
		B	>0.03 and ≤ 0.24 mg/L			
		C	>0.24 and ≤ 1.3 mg/L			
		D	>1.3mg/L			
	Annual maximum	A	≤ 0.05 mg/L			
		B	>0.05 and ≤ 0.4 mg/L			
		C	>0.4 and ≤ 2.2 mg/L			
		D	> 2.2mg/L			
Dissolved oxygen	7-day summer mean minimum	A	≥ 8.0 mg/L			Ecosystem Health
		B	≥ 7.0 and < 8.0 mg/L			
		C	≥ 5.0 and < 7.0 mg/L			
		D	< 5.0 mg/L			
	1-day summer minimum	A	≥ 7.5 mg/L			
		B	≥ 5.0 and < 7.5 mg/L			
		C	≥ 4.0 and < 5.0mg/L			
		D	< 4.0 mg/L			
pH	95th summer percentile	A	≥ 6.5 and ≤ 8.0			Ecosystem Health
		B	> 6.5 and < 8.5			
		C	≥ 6.0 and ≤ 9.0			
		D	< 6.0 or >9.0			

[6] It is intended this attribute will reflect the National Policy Statement for Freshwater Management 2014 and any subsequent amendments.

Attribute	**Statistic**	**Band**	**Biophysical layer**			**Value(s) supported**
			Volcanic Steep	**Volcanic Gentle**	**Non-volcanic**	
Temperature	Summer Cox-Rutherford Index# for lowland areas	A	≤ 18.0ºC			Ecosystem Health
		B	≤ 20.0ºC			
		C	≤ 24.0ºC			
		D	> 24.0 ºC			
	Summer Cox-Rutherford Index for upland areas	A	≤ 19.0ºC			
		B	≤ 21.0ºC			
		C	≤ 25.0ºC			
		D	> 25.0 ºC			
Periphyton	Exceeded no more than 8% of samples (default class)	A	≤ 50 mg chl-a/m^2			Ecosystem Health
		B	> 50 and ≤ 120 mg chl-a/m^2			
		C	> 120 and ≤ 200 mg chl-a/m^2			
		D	> 200 mg chl-a/m^2			
	Exceeded no more than 17% of samples (productive class)	A	≤ 50 mg chl-a/m^2			
		B	> 50 and ≤ 120 mg chl-a/m^2			
		C	> 120 and ≤ 200 mg chl-a/m^2			
		D	> 200 mg chl-a/m^2			
Benthic cyanobacteria	80^{th} percentile	A	Cover < 20%.			Ecosystem Health and Human Health for Recreation
		B	N/A			
		C	Cover 20 – 50%			
		D	Cover > 50%, OR max dislodging and accumulating along river's edge			
Macrophytes - rivers	Annual monitoring	A	<50% channel cross-sectional area or volume OR channel water surface area			Ecosystem Health
		-	N/A			
		-	N/A			
		D	>50% channel cross-sectional area or volume OR channel water surface area			
Invertebrate communities	Annual monitoring: MCI scores	A	>120	>124	>115	Ecosystem Health
		B	110 - 120	106 - 124	100 - 115	
		C	100 - 110	88 – 106	87 – 100	
		D	<100	<88	<87	
	Annual monitoring: EPT richness	A	>12 EPT taxa	>11 EPT taxa	>9 EPT taxa	
		B	9 - 12 EPT taxa	7 – 11 EPT taxa	6 – 9 EPT taxa	
		C	6 – 9 EPT taxa	2 – 7 EPT taxa	3 – 6 EPT taxa	
		D	<6 EPT taxa	< 2 EPT taxa	<3 EPT taxa	
	Annual monitoring: BoP_IBI	A	>24	>47	>18	
		B	16 - 24	36 - 47	7 - 18	
		C	7 – 16	26 - 36	3 - 7	
		D	<7	<26	<3	

WORKSHOP PAPER

To: **Pongakawa Waitahanui Freshwater Futures Community Group**

From: Nicola Green
Senior Planner (Water Policy)

Date: 15 May 2017

Subject: **Issues in Kaituna-Pongakawa-Waitahanui Water Management Area**

1 Introduction

Science and community engagement reveals the key freshwater resource management issues listed below for the Kaituna-Pongakawa-Waitahanui Water Management Area (WMA). Work is progressing to assess our evidence base, uncertainties, and the scale and significance of these issues and their causes.

Estuary values will be a key driver for improving freshwater quality (reducing contaminants), because they are very sensitive to contaminant and flow inputs from freshwater bodies (more so than most freshwater values). Substantial reduction in nutrient and sediment may be needed in order to stabilise or improve estuary health, or even to prevent further decline. Objectives may need to seek improvement in water quality, which will require nitrogen, phosphorous, sediment (in some tributaries) and potentially microbial pathogen inputs from land use to be addressed.

2 Key issues

1. Ecological health, mahinga kai, cultural and recreational values are significantly degraded in Maketū and Waihī estuaries. Nutrient (nitrogen and, to a lesser extent, phosphorus), sediment, and faecal contaminants from the catchment, and modified freshwater flows are key stressors[1].
2. Nitrates are increasing at all monitored river and stream sites in the Kaituna, Pongakawa and Waitahanui catchments[2]. Current and potential land use change and intensification (and historic changes in the last few decades) pose a significant risk that nitrogen levels will continue to increase for some time, potentially affecting ecological health, amenity and recreation values in freshwater bodies.
3. There is increasing water demand for agricultural/horticultural and municipal uses in Kaituna catchment and Waihī Estuary catchment, and this has potential to cause adverse effects on ecological cultural and recreational values. Current allocation significantly exceeds interim region-wide water allocation limits in several sub-catchments (including Waithanui, Pongakwa and Wharere Stream) and in the Kaituna aquifer[3]. Flow records and, consequently allocation reporting, are being reviewed at present.
4. Soil phosphorous levels (using Olsen-P) under kiwifruit have increased significantly from 71 to 106 mg/kg between 1999/2000 and 2009 and the risk of runoff to water bodies is high, with potential effects on receiving environment ecological values. Olsen-P levels on dairying soils have also increased. Other soil quality issues include the increasing mineralisable N

[1] Donald, Rob (2016). Ecological Health of Waihi Estuary. Agenda Report to Bay of Plenty Regional Council's Regional Direction and Delivery Committee, 31 March 2016.

[2] Scholes, P. and Carter, R. (2015). Freshwater in the Bay of Plenty – Comparison against the National Objectives Framework. Bay of Plenty Regional Council, Environmental Publication 2015/04. ISSN: 11750-9372 (Print), 9471 (Online). April 2015.

[3] Kroon, Glenys (2016). Assessment of water availability and estimates of current allocation levels October 2016. Bay of Plenty Regional Council

concentrations in dairying soils with the mean now above the target band, increasing the risk of N leaching, and the high anaerobically mineralisable N on sheep and beef soils[4].

5. Community group members expressed significant concern about sediment affecting water quality and river substrate particularly in Waihī Estuary catchment. The majority of this sediment load is likely to be generated in high rainfall events for which there is currently limited data available.

6. Indigenous fish species are impacted by structural changes to/loss of habitat and obstacles to fish passage, and also by water quality, changes to flow regime and possibly harvesting

7. Monitoring results available for some recreation sites show E. coli concentrations do not meet the *current* minimum acceptable state for swimming (full immersion) stated in the NPS-FM (Pongakawa River at SH2, and Waitahanui River at SH2). Information is being reviewed in light of the proposed amendments in Clean Water 2017. Community group members in the WMAs and nationally are strongly voicing the expectation that all freshwater bodies should be safe to swim in. Some popular swimming spots are not monitored, and State of the Environment monitoring indicates that some of these sites may also not meet the current safe swimming standard. The lower reaches of the Kaituna River are an example of this[5].

8. Mahinga kai and natural character values are significantly impacted by water quality and waterbody modification (drainage schemes) in the lower Kaituna catchment and lower reaches of rivers draining to Waihī Estuary. Community groups show strong support for restoration of whitebait spawning areas and natural character while acknowledging the need for flood and drainage schemes. The safety of eating watercress gathered from the lower Kaituna and its tributaries, and the tributaries of Waihī Estuary, are likely to be an issue, but have not yet been fully evaluated.

9. Ecological health, measured using the Macro-invertebrate Community Index, is generally lower in streams/rivers draining pasture and urban areas, although most of the decline in condition is historic (ie indicators have stabilised). In some areas, particularly the upper Pongakawa, indicators show improving trends.

---

4 Carter, R., Suren, A., Fernandes, R., Bloor, M., Barber, J., and Dean, S. (2015). Kaituna-Pongakawa-Waitahanui Water Management Area: Current State and Gap Analysis. Bay of Plenty Regional Council Environmental Publication 2016/01. ISSN: 1175-9372(print),ISSN: 1179-9471 (online). March 2015.
http://www.boprc.govt.nz/media/99812/2010_22__soil_quality_in_the_bay_of_plenty_2010_update.pdf (Guinto/BOPRC, 2010)

5 Scholes, P and McKelvey, T (2015). Recreational Waters Surveillance Report 2014/2015. Bay of Plenty Regional Council Environmental Publication 2015/2016. ISSN: 1175 9372 (Print)
ISSN: 1179 9471 (Online)

WORKSHOP PAPER

To: **Pongakawa Waitahanui Freshwater Futures Community Group**

From: Santiago Bermeo
Senior Planner (Water Policy)

Date: 12 May 2017

Subject: **Extractive use values**

1 Introduction

The purpose of this paper is to summarise initial information on extractive freshwater use values collated by Council staff to date. In the last workshop, the Community Group concentrated on ‘in-river’ values, but ‘extractive/consumptive’ use values are a significant consideration as well. The information summarised in this paper is aimed at starting a discussion about those values.

Initial feedback from the Community Group is sought on the following information, in particular:

- the land use map;
- projected land use change; and
- other types of socio-economic information you consider would be helpful in our planning process.

The information summarised in this paper includes water allocation data, point-source discharge consent data, land use data and economic value of some industries.

The information contained in this paper was collated as part of a socio-economic baseline report being drafted in support of the planning process. A draft of the report, with more detail than this paper, will be made available on the Community Group internet portal. Once finalised, the report will include information on:

- tangata whenua connected to the WMA;
- social profile of WMA population and population growth estimates;
- water allocation and use data for the WMA, including discharges;
- land use data for the WMA, including projected land use change;
- information on Māori-owned land in the WMA; and
- economic value of land and water-dependent industries.

2 Water allocation consents and discharge consents

Figure 1 summarises surface water allocation (number of consents and rates allocated by draft Freshwater Management Unit and purpose) for the Kaituna-Pongakawa-Waitahanui Water Management Area.

Figure 2 summarises groundwater allocation (maximum yearly volumes allocated and number of consents by draft Freshwater Management Unit and purpose) for the Kaituna-Pongakawa-Waitahanui Water Management Area.

The location of surface and groundwater take consents in illustrated in Figure 3.

Figure 1 - Kaituna-Pongakawa-Waitahanui WMA: surface water take allocation and consents

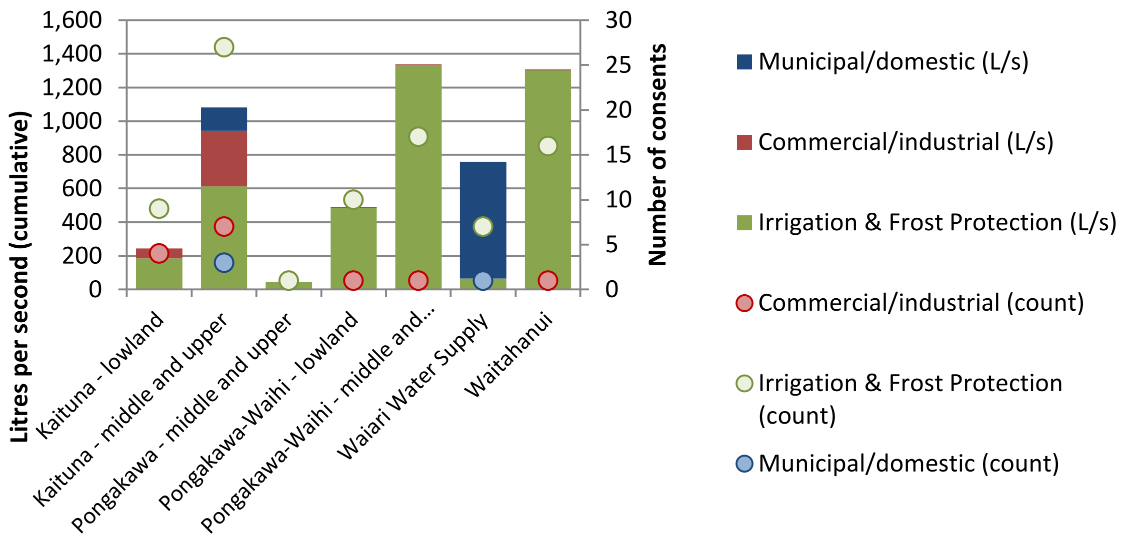


Figure 2 – Kaituna-Pongakawa-Waitahanui: groundwater take allocation and consents

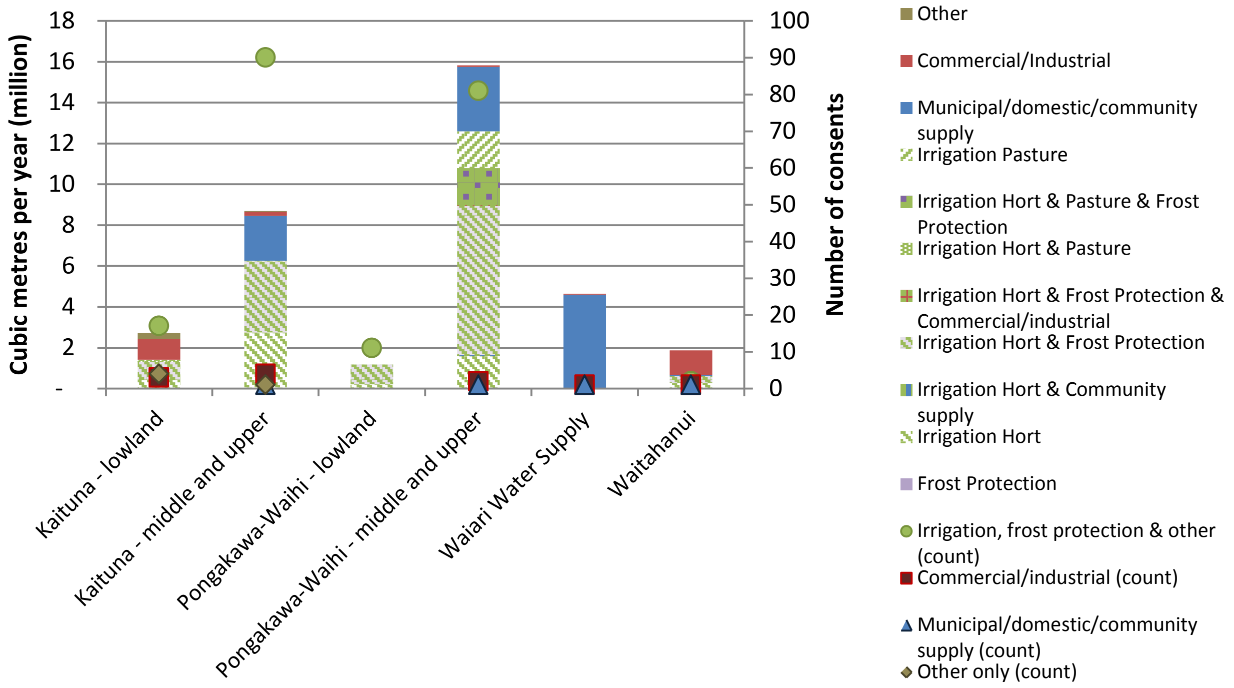


Figure 3 – Kaituna-Pongakawa-Waitahanui: surface and groundwater take consent locations

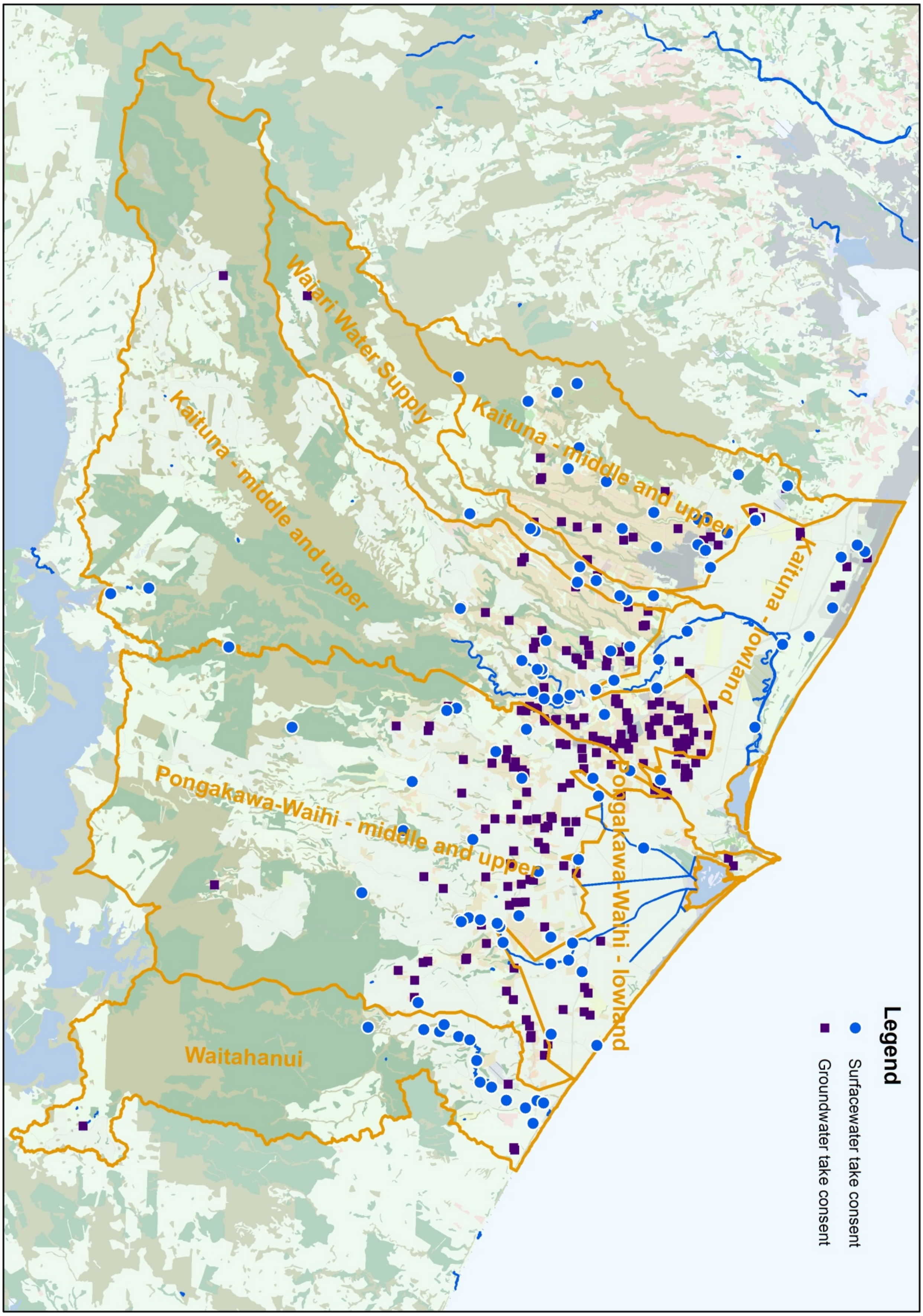


Figure 4A summarises point source discharge consents (number of consents by purpose and draft Freshwater Management Unit) for the Kaituna-Pongakawa-Waitahanui Water Management Area. Figure 4B illustrates the location of these discharge to water consents.

Figure 4A – Kaituna-Pongakawa-Waitahanui: discharge to water consents

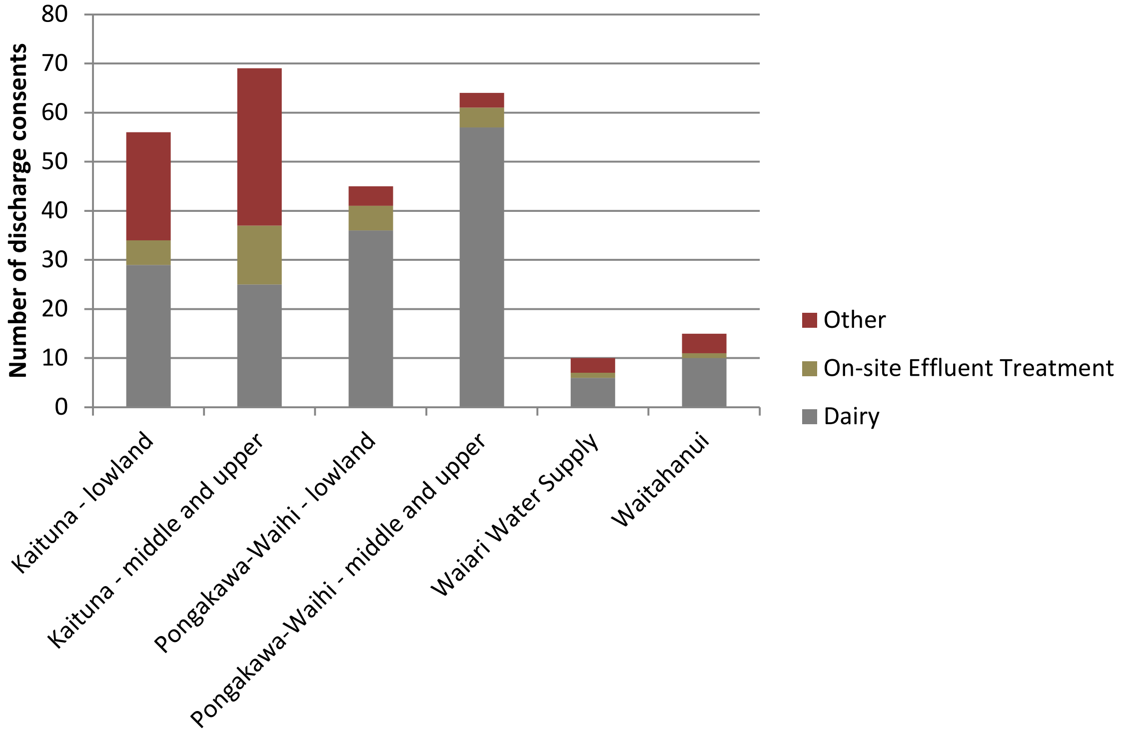
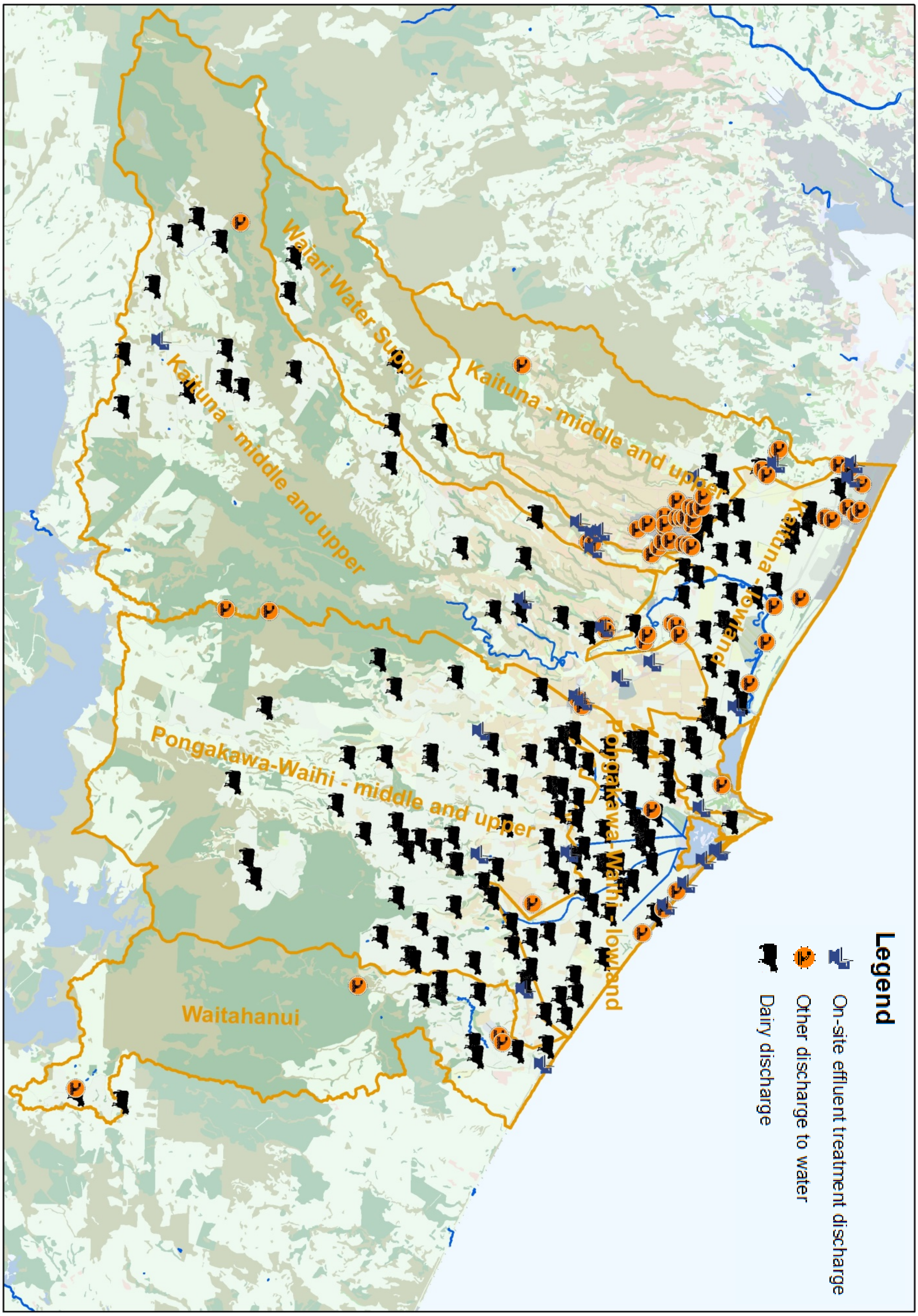


Figure 4B – Kaituna-Pongakawa-Waitahanui: discharge to water consent location



3 Land use data

Figures 5A and 5B show the distribution of land use in the WMA. A larger version of the map has been provided to Community Group members to confirm accuracy. This land use data will be a key input into the catchment modelling work which is supporting our planning process.

Figure 5A - Distribution of land use in the Kaituna-Pongakawa-Waitahanui WMA

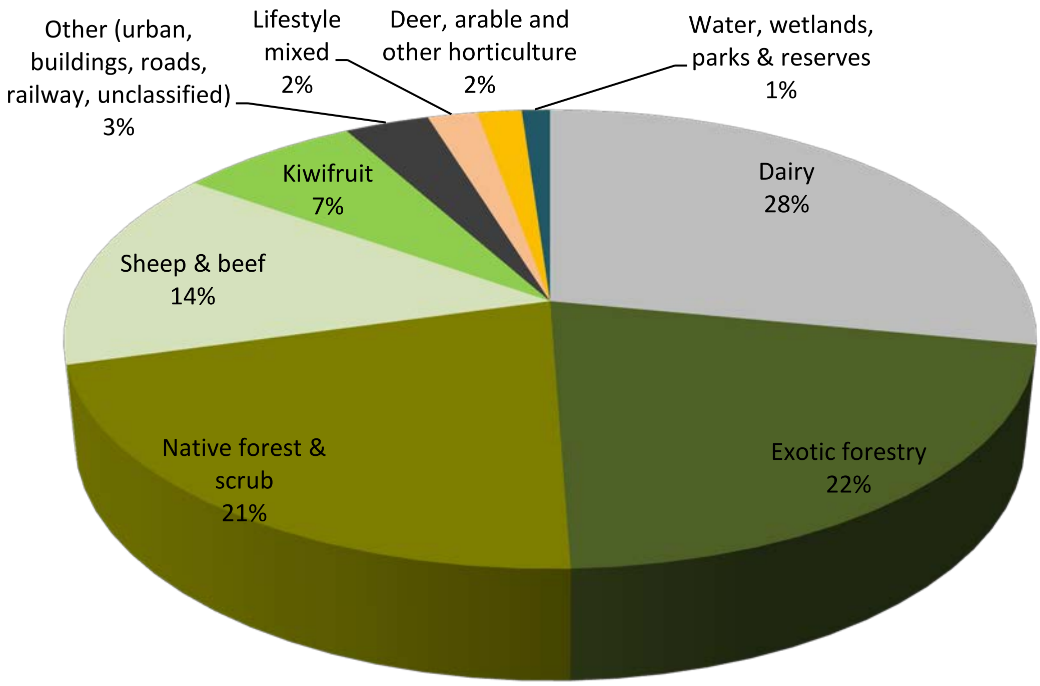


Figure 5B – Land use in the Kaituna-Pongakawa-Waitahanui WMA

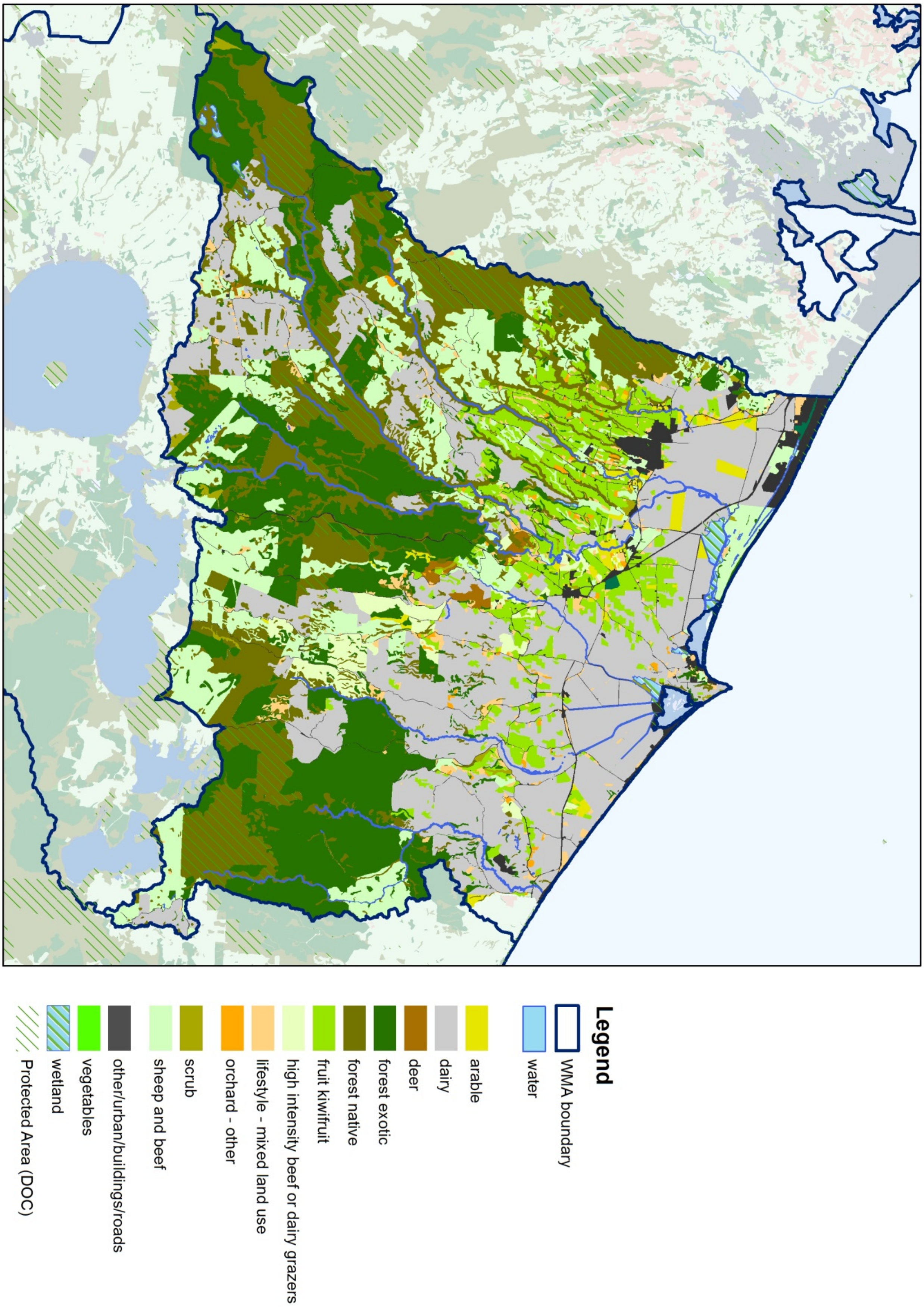
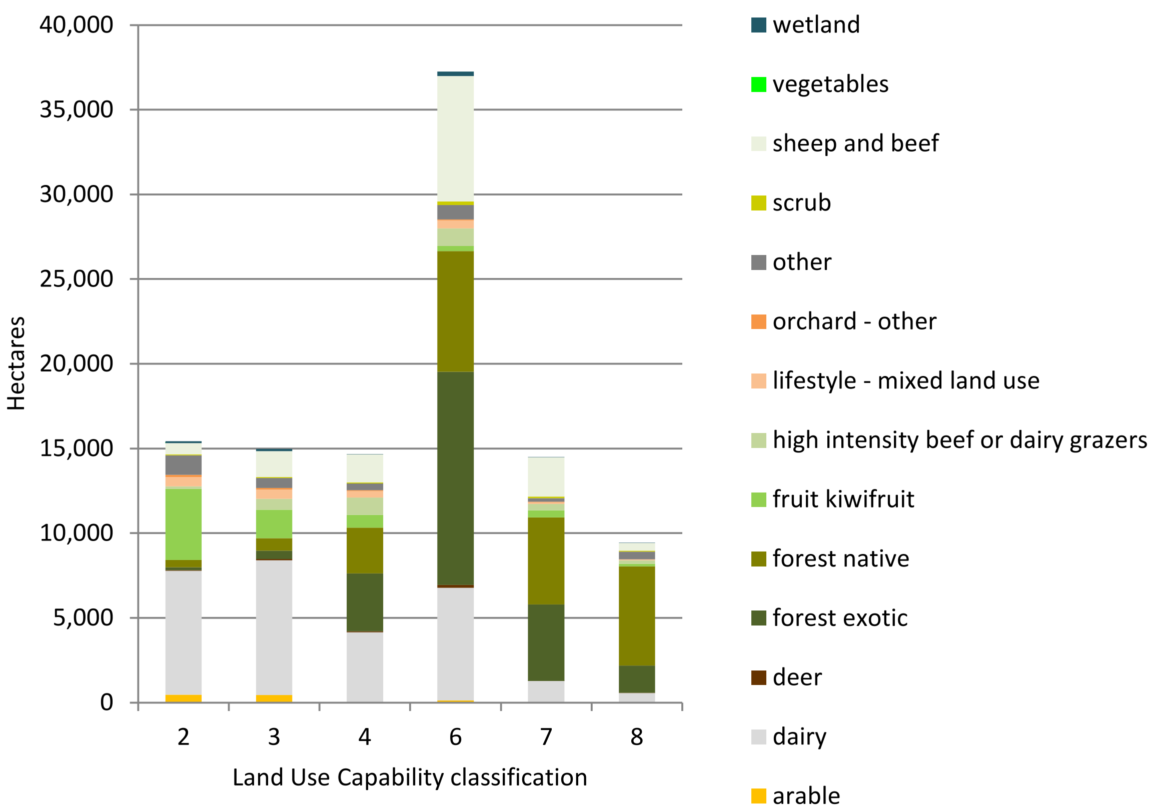


Figure 6 shows the distribution of these land uses by Land Use Capability class[1], where 1 is the highest capability and 8 is the lowest capability.

Figure 6 – Land use in the Kaituna-Pongakawa-Waitahahui WMA by Land Use Capability class



4 Estimated economic value

Figures 7A and 7B summarise the results of basic analysis on the economic value of the main land and water-based industries in the WMA. It is estimated that the five main industries shown generated an output of $430 million in 2012-13. Of this, $181 million was direct value-added, which in turn generated an indirect impact to the wider regional economy of nearly $100 million and an induced impact of $46.5 million. When considered together, the total economic impact of these industries to the Bay of Plenty region was $327 million, or about 3% of the regional GDP. Dairy farming generated the most overall economic value, followed by horticulture.[2]

[1] The Land Use Capability (LUC) rating indicates the ability of a piece of land to sustain agricultural production, where class 1 is the highest capability and class 8 is the lowest. The rating is based on an assessment of a piece of land's rock type, soil, slope, susceptibility to erosion, vegetation cover, climate and the effects of past land use. LUC is included in the New Zealand Land Resources Inventory, which is a national database of physical land resource information maintained by Landcare Research.

[2] **Output:** price multiplied by quantity of goods and services produced

Direct value-added: value of output not including value of inputs

Indirect impact: economic impact on other businesses (e.g. goods and services supplied) in the regional economy

Induced impact: flow-on effects from wages and incomes in the regional economy

In terms of employment, the five industries are estimated to have directly employed 1,691 people in 2012-13, while generating indirect and induced employment for a further 1,269 and 601 people respectively.

Figure 7A – Multiplier analysis: estimated economic impact of the main land and water-based industries in the Kaituna-Pongakawa-Waitahanui WMA in 2012-13

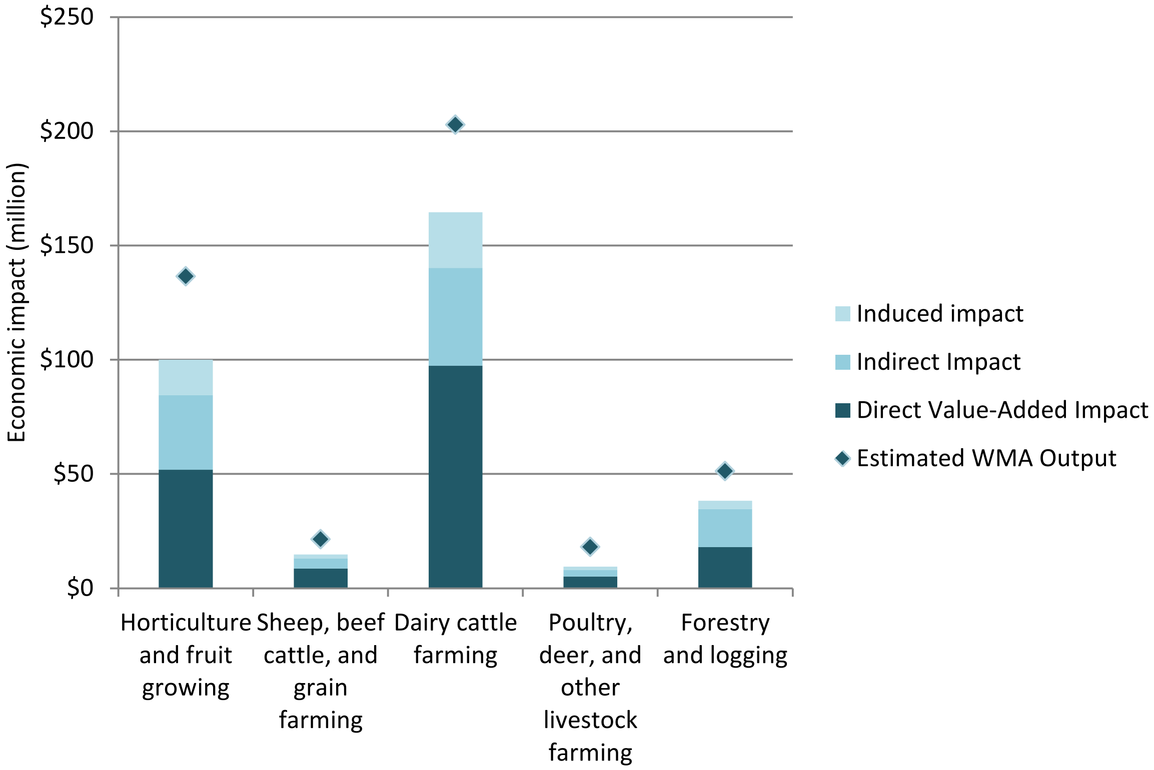
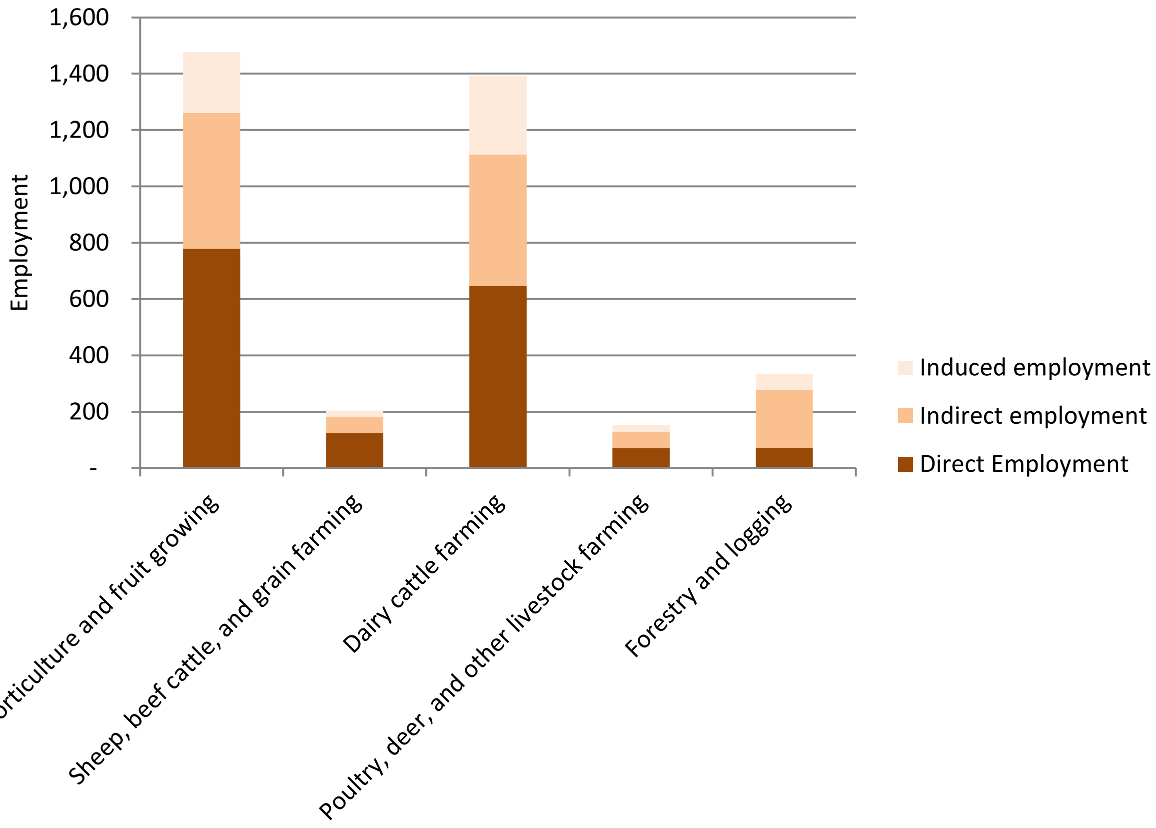


Figure 7B – Multiplier analysis: estimated employment generated by the main land and water-based industries in the Kaituna-Pongakawa-Waitahanui WMA in 2012-13



BOPRC staff have been seeking information on the economic value of other water-dependent industries in the WMA, such as tourism, and information on the economic value of in-stream uses (e.g. fishing, swimming, etc.). However, to date it has been difficult to source quantitative information on these values. BOPRC would welcome community group member feedback on possible ways to fill these gaps.

Integrated Catchment Modelling of the Kaituna-Pongakawa-Waitahanui and Rangitāiki Water Management Areas

Summary

The integrated catchment model being developed for Kaituna-Pongakawa-Waitahanui Water Management Area (WMA) and Rangitāiki WMA will provide a simplified representation of how water and certain contaminants move through the catchment.

The models help **estimate** the source and extent of water quality and quantity issues in a catchment. The model may be used to examine the likely effects of future land management, land and water use, and climate-change scenarios (potential futures). All models have limitations and uncertainties particularly where data is scarce, which will be reported alongside any outputs.

Integrated catchment modelling involves a combination of models working together. The eWater SOURCE model is the framework model. Other models that represent specific physical processes feed in to the eWater SOURCE model, including Agricultural Production Systems Simulator (APSIM), OVERSEER (on-farm scale nutrient budget model), SEDNET (constructs sediment and nutrient budgets) and Soil Moisture Balance models (to estimate how much water runs off the land and how much infiltrates into the ground).

The model will report daily values at specified locations across the catchment for Flow, Total Suspended Solids - Turbidity (sediment), NH4-H (Ammonia), NOx-N (Nitrate Nitrite Nitrogen), TN (Total Nitrogen), DRP – TP (Dissolved Reactive Phosphorus – Total Phosphorus), *E.coli* (bacteria).

1 Nature of the hydrological model and its purpose

Hydrological modelling plays an important role in freshwater management. Hydrological models are simplified, conceptual representations of a part of the hydrologic cycle (i.e., how water moves through a system). They are populated and run by specialists with experience in hydrology and modelling. Models are tools used to understand complex processes. They can be used to help inform policy and decision making for water resource sharing. Models help estimate the source and extent of water quality and quantity issues in a catchment.

A model may be used to identify 'hotspots' in a region. Once calibrated these models may be used to examine the likely effects of future land management, land use, and climate-change scenarios. The model can do this by representing rainfall runoff and nutrient generation from land and transport through surface water and groundwater systems. The model then generates predictions for stream flow and in-stream nutrient concentrations.

Integrated catchment modelling is a combination of models to utilise the best performance of different sub-models. It is important that the primary 'framework' model has the capacity to allow sub-models to work together effectively in an integrated way. Bay of Plenty Regional Council examined a range of nationally and internationally available computer based models against criteria to choose the most suitable solution. The scoring indicated that the eWater SOURCE model is the best choice for BOPRC's catchment management. BOPRC has engaged the services of specialist hydrological modellers experienced in the use of the eWater SOURCE software to populate and run the model.

BOPRC's goal is to have two functioning integrated surface catchment models; one model for the Kaituna- Pongakawa-Waitahanui Water Management Area and the other for the Rangitāiki WMA.

The two integrated surface catchment models operate with dependencies on other process based models (models that try to represent the physical processes observed in the real world) such as:

- Agricultural Production Systems Simulator (APSIM)
- OVERSEER - an on-farm scale nutrient budget model;
- SEDNET - defines a stream network as a series of links extending between stream junctions, and constructs sediment and nutrient budgets for each link; and
- Soil Moisture Balance models – estimates how much rainfall is lost through evaporation /evapotranspiration, how much runs off the land into surface waterbodies and how much infiltrates into the ground.

Together they are linked to the eWater SOURCE model which acts as an integrator of the results.

2 Parts of the model / sub models including the relationships between sub-models

The model framework operates at varying spatial (location) and temporal (time) scales depending on the requirements of each catchment. It can be used to consider effects at different locations and after different periods of time. The study area is divided into a catchment grid where the functions in the catchments are expected to have similar properties. The framework includes:

Framework components	**Inputs**
Gridded catchment climate data	National Institute of Water and Atmospheric Research (NIWA) climate computer
Rainfall runoff modelling	Soil Moisture Water Balance
Contaminant generation modelling (including Total Nitrogen and Phosphorus, Nitrate, Dissolved Reactive Phosphorus, Ammonia, Sediment and *E.Coli*)	'Baseflow' (groundwater-derived flow) and 'Quickflow' (direct runoff) export rates
River hydrology and hydrogeology	Council river flow gauging and catchment studies
Water allocation rules and consents (including irrigation demand and use)	Consent data
Surface water and groundwater interactions	MODFLOW groundwater model and technical studies on hydrology
Flow and constituent conservation and attenuation	Submodels such as SEDNET, APSIM, Soil Plant Atmosphere System Model (SPASMO)
Calibration	Council State of the Environment (SOE) data

The first step in any model build is the development of stream flow and the water balance between climate, rainfall runoff, groundwater storage to stream flows and groundwater levels. The following steps are required:

1. Climate generation and distribution.
2. Rainfall runoff modelling for naturalised (without any takes) flows.
3. Inclusion of water allocation (consented and permitted takes, water demand for irrigation including dam operations).
4. Flow calibration observed for current landuse (calibration is the process where the reliability or accuracy of the model is tested by assessing how well it is able to reproduce or match historically observed behaviour).

Each constituent in the generation framework needs to be balanced to the observed concentrations in groundwater and surface water, involving the following steps:

1. Mass distribution between 'quickflow' and 'baseflow'.
2. Load calculations at a sub-catchment scale.
3. Development of attenuation (reductions in contaminant concentration) functions.
4. Load calculations at a stream reach scale.

3 Outputs from the model – the contaminants considered

The model will report daily values at 'nodes' (specified locations) across the catchment for the following constituents:

- Flow
- Total Suspended Solids - Turbidity (sediment)
- NH4-H (Ammonia)
- NOx-N (Nitrate Nitrite Nitrogen)
- TN (Total Nitrogen)
- DRP – TP (Dissolved Reactive Phosphorus – Total Phosphorus)
- *E.coli* (bacteria)

Through reporting modules, the eWater SOURCE model can quickly present statistics /results for scenarios including flow (Mean Daily Flow, one in five year low flow), loads (mean annual loads in tons/year or tons/km's/year) and stream concentrations (median, 95 %ile, 5%ile). They can include summer and winter variation, lag times within land use, and groundwater attenuation.

4 Use of the model - scenarios and mitigation

The catchment models will generate and distribute flows, loads and concentrations from land use activities to both groundwater and surface water. The model will enable scenarios (different future states) to be run to estimate the consequences of land use changes and develop a solution framework by applying mitigations.

5 Limitations

Any model is the product of the data available to construct the model and complete the calibration. The level of confidence in the proposed models is higher in areas of the catchment where long term data has been collected. The further upstream from the data collection point, the lower the model confidence. The integrated catchment model will predict changes in conditions at a catchment scale well and make predications for changes at a sub-catchment scale, so it will be well suited to considering effects across the WMAs.

The land use inputs are from distributed actual farm data based on common factors such as soil and climate conditions, with assumptions for stocking rates and farm systems. Again, this means that the model will predict the consequences from land use change at a refined sub-catchment scale. However, predictions at a property scale are not possible unless the property was very large.

An advantage of the eWater SOURCE model framework is that new data can be easily added to improve the model resolution over time.

6 Uncertainty

The **model uncertainty** is determined by defined statistical assessments which look at the fit (how big the difference is) of the modelled data to the observed. This is an international method for determining model calibration performance.

To measure the **accuracy**, an assessment of the fit between the objective functions in the model can be made to determine if the 'best' solution was reached from the attribute selections by the modellers. The attribute fit can be tested statistically by multiple model runs with different attributes.

The last test is for the **model stability or precision** which is a sensitivity analysis on inputs to see how they individually affect the results. An input to the model is changed to determine what scale of effect it has on the model output predictions.

7 Future Work

At a later date, the eWater SOURCE models can be integrated with MODFLOW groundwater models (see separate Information sheet).

Groundwater Model for Kaituna-Pongakawa-Waitahanui Water Management Area

1 Background and Geology

The Bay of Plenty Regional Council (BOPRC) is responsible for the sustainable management of water allocated from groundwater and surface water systems in the Bay of Plenty area. To sustainably manage groundwater resources, the amount of water taken and used from the ground should not exceed the amount needed in the ground to:

- maintain groundwater levels;
- prevent the intrusion of saline water at the coast into the groundwater system; and,
- protect spring flows that contribute to the flow in rivers.

The interconnection between the groundwater system and rivers in the area means that rivers are likely to be sensitive to abstraction from groundwater during periods of low flow. Spring-flow to streams in the summer, when stream flows are typically lowest, is important to maintain the 'base flow' in streams. Improving the sustainable management of groundwater ensures the viability of on-going use of the freshwater resources and the benefits that are derived from that use.

Groundwater allocation is currently based on default values of recharge. Recharge is the proportion of rainfall that infiltrates in to the ground that replenishes the groundwater resource. Some rainfall is lost through evapotranspiration from plants. Some runs off the land into lake and rivers. The balance of the rainfall infiltrates into the ground and recharges the groundwater system. BOPRC is improving its estimates of groundwater recharge in the area. This will help to better inform choices in setting limits to sustainably manage freshwater resources. To achieve this, BOPRC is identifying the major groundwater systems and producing computer based numerical groundwater models to better understand them.

The Kaituna- Pongakawa-Waitahanui Water Management Area (WMA) is located between Tauranga and Matata, north of Rotorua (Figure 1). The geology in the area is dominated by volcanic activity. It can be classified into a series of ignimbrite deposits (pumice dominated flow from explosive volcanic eruption) and Tauranga Group sediments (described below).

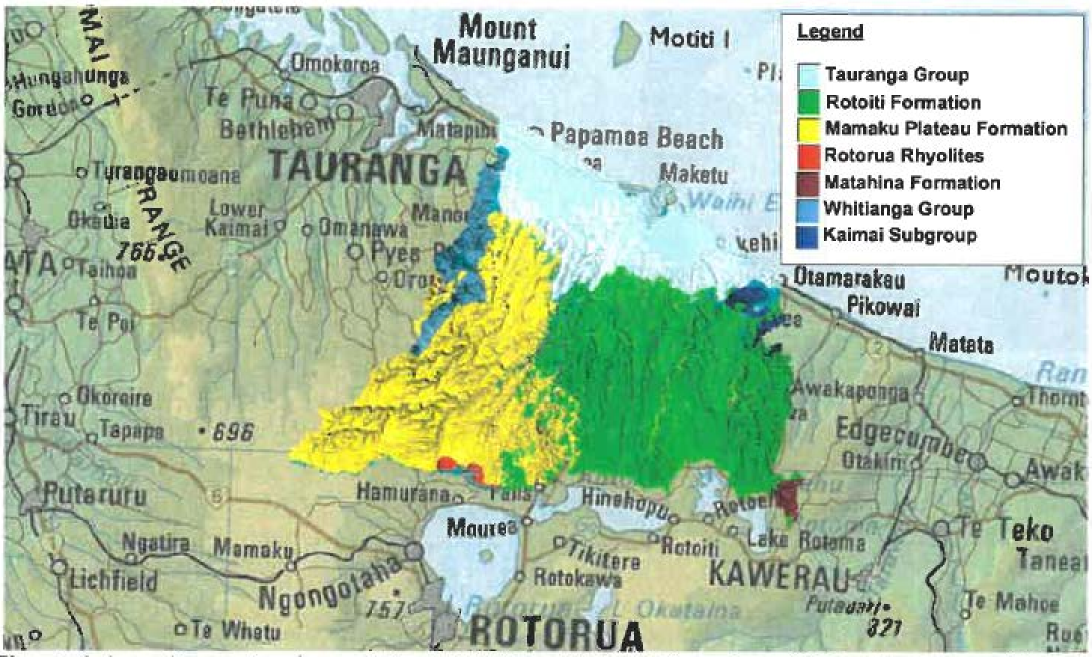


Figure 1. Location and surface geology of Kaituna-Maketū-Pongakawa Water Management Area

The volcanic deposits represent debris produced from the eruption of various volcanic centres along the Taupo Volcanic Zone between the Late Miocene (~11.63 years ago) to the Pleistocene (~3.6 million years ago) period. These deposits are made up of a poorly sorted mixture of volcanic ash and pumice and are not uniform in composition. They range from loose and unconsolidated to solidified ignimbrites with variable hydrogeological properties. Volcanic deposits which have been reworked through transportation by streams or rivers has produced the Tauranga Group sediments. These sediments are mainly composed of coarse sands and gravels. Pleistocene age mudstone is present along the coast and east of the WMA. Recent Holocene age (~11,700 years ago) silt and sand deposits form the topography of the low-lying coastal plains.

Streams and rivers form steeply incised gullies in the ignimbrite deposits. Surface water flow is characterised by significant contributions from groundwater. The hydrology of these water courses provides important information for characterising the nature and quantity of rainfall recharge to groundwater and groundwater-surface water interaction.

2 Groundwater Model

Groundwater models are computer models of groundwater flow systems, and are used by hydrogeologists. Groundwater models are used to simulate and predict aquifer conditions. A groundwater model is a simplification of the groundwater system. It is based on the information that is currently known about the system. The model development process involves a series of steps as illustrated in Figure 2 below.

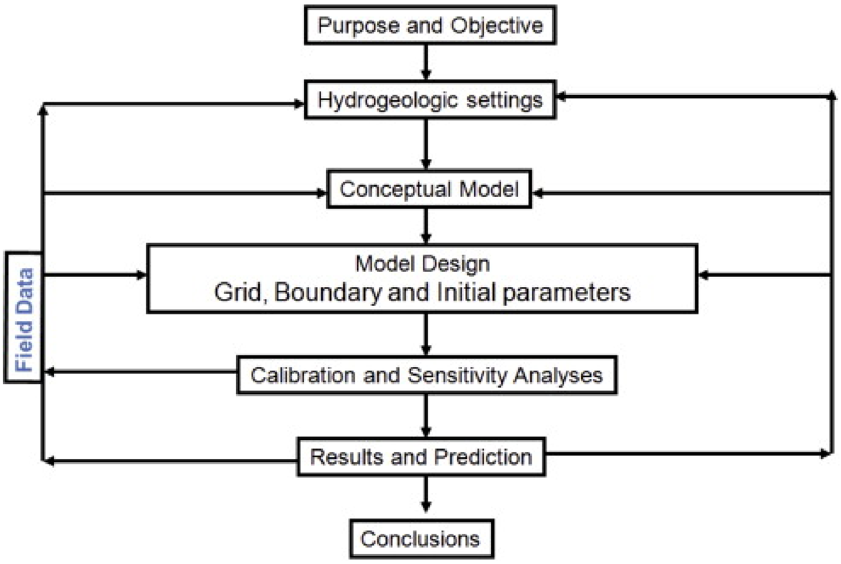


Figure 2. Groundwater Modelling Process

One of the initial steps is the conceptualisation of the hydrogeological system, i.e., identifying the system components, flow paths, hydro-stratigraphy (rock layers), hydraulic properties, boundary processes and geometry, and system stresses. The conceptual model is essentially a representation of the understanding of the underlying hydrogeology of the groundwater system and factors that may affect the groundwater system. An example of a conceptual model is presented in Figure 3 below. In Figure 4, the geological formations underlying the Kaituna-Pongakawa-Waitahanui WMA are shown.

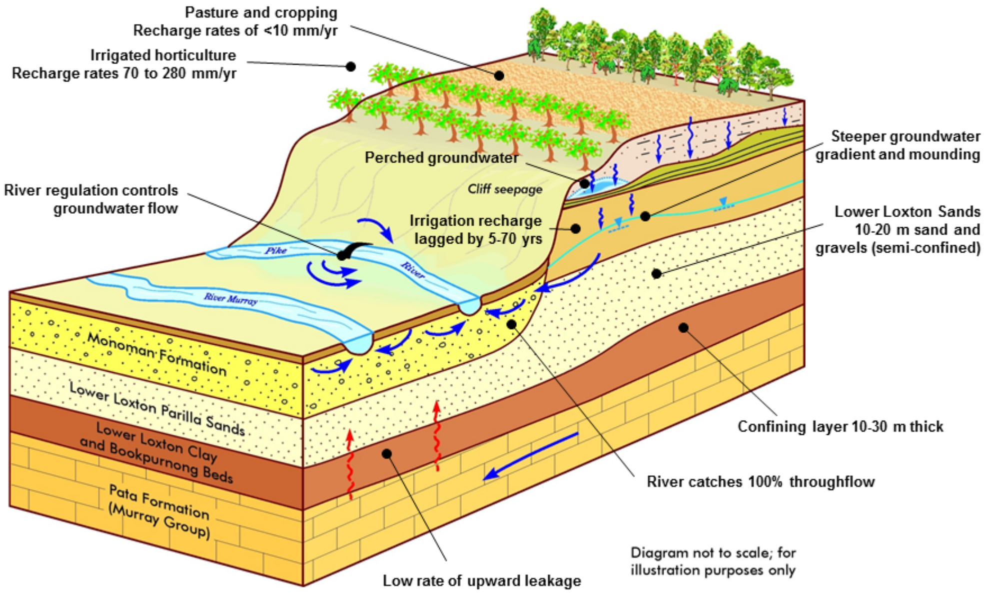


Figure 3. Example of a Conceptual Model

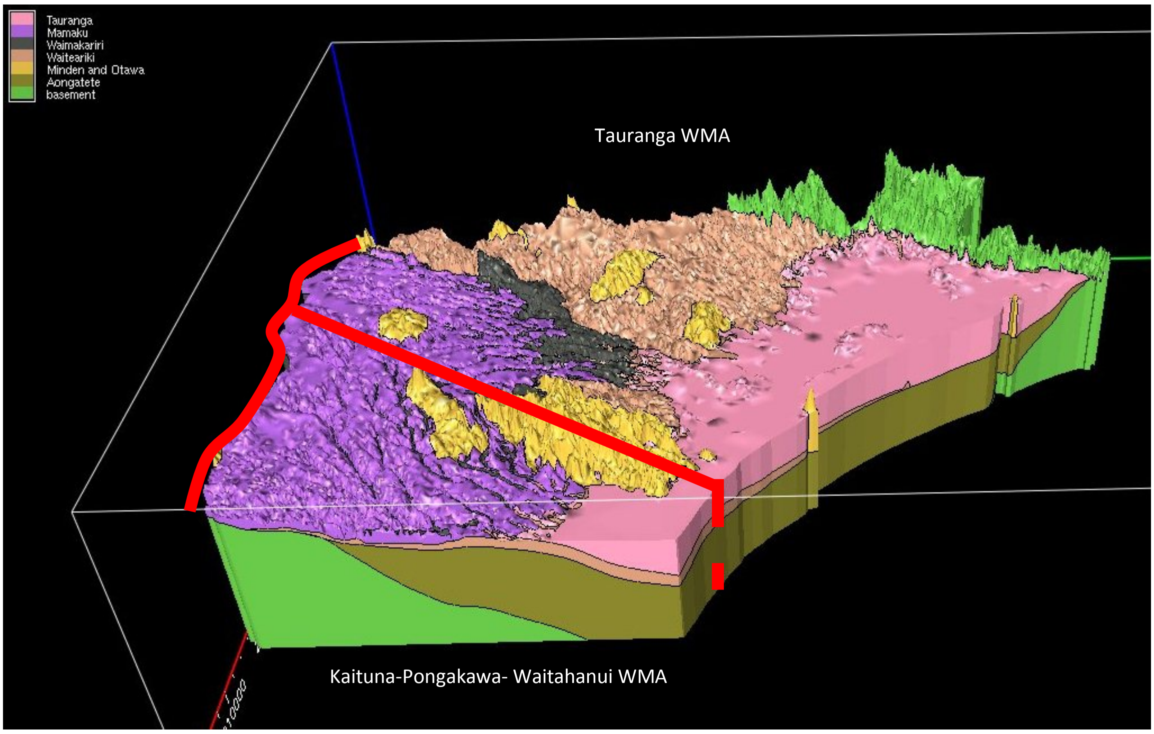


Figure 4: Groundwater systems extending beneath the Kaituna-Pongakawa-Waitahanui and Tauranga Water Management Areas. The red line indicates the WMA boundaries. Each colour represents a geological formation with groundwater systems. The lime green is basement rock (no groundwater).

Once the conceptual model of the system has been established, model design involves a series of decisions on how to best represent it in a computer modelling environment. A 3-dimensional groundwater modelling software platform called MODFLOW is being used for the Kaituna-

Pongakawa-Waitahanui WMAs. It is especially suited to sub regional scale groundwater modelling and has been in use for over 30 years. A model layer and grid structure has been designed and populated using the MODFLOW software.

Calibration is the process where the reliability or accuracy of the model is tested by assessing how well it is able to reproduce or match historically observed groundwater behaviour. Typically, calibration is used to refine or modify the key groundwater parameters in the model that control the flow and storage of water. The model is run many times in a trial-and-error approach until a satisfactory match to observations is attained. This process is used to reduce uncertainty and improve confidence in the model predictions. The Kaituna-Pongakawa-Waitahanui MODFLOW model has been calibrated using a number of criteria. These include the ability of the model to replicate estimated base-flow (from groundwater) in the major rivers that drain the catchment, and measured seasonal fluctuations in groundwater levels.

The model is used to simulate the hydrogeological environment within an acceptable accuracy. A number of assumptions have to be made in groundwater models. How well the model is able to predict observed data gives some indication of the level of uncertainty in model results. Once fully developed and calibrated it can be used to predict results of various groundwater management scenarios to address modelling objectives. The model can be used to consider changes to the rate of groundwater extraction and impacts on groundwater levels and flows. This helps to inform decisions on sustainable groundwater abstraction limits.