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Kaitiaki flow and management regime in the spring-fed Awahou Stream, Lake Rotorua

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Abstract

New Zealand environmental legislation and Treaty of Waitangi settlements recognise the value of water to Māori and enable their aspirations for a greater role in water management. However, consequent opportunities for iwi, such as the exercise of kaitiakitanga (guardianship), are hampered by barriers including a lack of established methods to transfer traditional Māori knowledge into policy and less than full Māori participation in water management decisions.

Kaitiaki flow is defined as stream flow that is consistent with tangata whenua values (e.g., amenity, environment and spirituality), identified by iwi-based assessment processes. This flow was determined within the unique cultural context of Ngāti Rangiwewehi, who are kaitiaki (guardians) of Awahou Stream and Taniwha Springs in the Lake Rotorua catchment, as part of a flow management regime designed for the co-managers (Ngāti Rangiwewehi and Rotorua Lakes Council) of the Taniwha Springs municipal water supply abstraction consent.

The regime, now part of the Taniwha Springs water supply consent application submitted to Bay of Plenty Regional Council, includes kaitiaki flow as a moving minimum mainstem flow that is 90% of daily mean naturalised flow in the Awahou Stream, permanent flow monitoring of Awahou Stream downstream of Taniwha Springs and a web-based information system.

Wide participation by Ngāti Rangiwewehi in the process to define the kaitaiki flow regime underlined the importance of kaitiakitanga and co-management roles to the iwi. The process showed how traditional Māori knowledge can be transferred into policy utilising methodologies that may provide a guideline to iwi engagement in other iwi/science water projects.

Keywords

Taniwha Springs; Awahou Stream; Lake Rotorua catchment; Ngāti Rangiwewehi; groundwater management; water management; Waitangi Tribunal; spring-fed streams.

Introduction

Water in New Zealand is fundamental to the natural environment, providing for lakes, rivers and aquifers that are highly prized and are part of our national identity. Furthermore, this resource has multiple economic uses, e.g., agricultural production, drinking water and power generation (White, 2001, 2011, 2018). In situ water uses are crucial to recreational activities and amenity (White *et al.*, 2001, 2016).

Water resources are inherently precious to Māori. In pre-contact times, large coastal swamps and wetlands provided food, e.g., Heretaunga had "abundant waterfowl, eels, freshwater crayfish, kokopu ..." (Waitangi Tribunal, 2012); they also provided for travel, e.g., swamps adjoining the Tarawera River were used by canoes to travel across the now-drained Rangitaiki Plains (Bay of Plenty Regional Council, 2015). Consequently, many sites of early Māori occupation were located very near to, or within, these wetlands, e.g., Ngāi Tahu settlements at Lake Waihora and Kaiapoi Pā (Evison, 2006; White, 1995).

Māori access to water resources has been affected by development of infrastructure and the creation of farmland from swamps. Access has also been impacted by land alienation due to confiscations, freeholding and deeds (e.g., Evison, 2006). Alienation has negatively affected Māori spiritual life. Water is used for ceremonies, such as christenings, and burial sites are commonly located on river banks (Waitangi Tribunal, 2012). For Māori, water has a life force ('mauri') and Māori describe the 'metaphysical' harm that comes to them when water is polluted or mixed.

Unsurprisingly, water resources have been an important part of Waitangi Tribunal claims. The Crown (i.e., central and regional government) has responded to these claims with policies and legislated Waitangi Tribunal settlements. For example, The National Policy Statement for Freshwater Management (NPS) (Ministry for the Environment, 2014a, 2014b, 2017) incorporated Māori involvement in water management with Te Mana o te Wai values that "must inform the setting of freshwater objectives and limits" and that link health (of the water body, the wider environment and the people) to policies (NPS Objective AA1).

Waitangi Tribunal settlements have resulted in co-management arrangements between iwi (see Glossary) and regional councils, e.g., the joint iwi-Crown Waikato River Authority (Waikato Regional Council, 2016). However, iwi face numerous barriers to exercising their kaitiakitanga (guardianship) and to engaging in water management, including a lack of established processes to transfer traditional Māori knowledge into laws under the Resource Management Act 1991, less than full Māori participation in water management decisions, and a lack of relevant capabilities in water science and water management (White, 2012; Tipa *et al.*, 2016).

Ngāti Rangiwewehi ('the iwi') based around Lake Rotorua, in the Bay of Plenty region, are kaitiaki of Awahou Stream and its associated spring complex including Taniwha Springs (also known as Pekehaua Puna) (Fig. 1). Stories of the taniwha who made his lair in Taniwha Spring are central to the iwi's traditions and identity: "The importance of this water Te Awahou is that it has a spirit which is embodied in the whole area in which it travels through the land … in essence it is the tikanga of the hapū of Ngāti Rangiwewehi." (Mohi, 2016).

Taniwha Springs are located in a reach of Awahou Stream that gains considerable flow, e.g., measured flows were 222 L/s and 1083 L/s at gauging sites MS1 and MS2 (Fig. 2), respectively, on 16 March 2018. This flow is sourced from springs (e.g., outflow from Taniwha Springs downstream of the water supply abstraction was 178 L/s on 16 March 2018; E. Gurden, pers. comm., 23 May 2019) and groundwater inflow through the Awahou Stream bed.

Taniwha Springs water is abstracted by Rotorua Lakes Council (RLC) and provided to residents, primarily in the Ngongotahā area; the iwi and RLC co-manage the Taniwha Springs water abstraction consent.

Renewal of the Taniwha Springs consent has led the iwi to consider implementation of a kaitiaki flow' in Awahou Stream and a flow

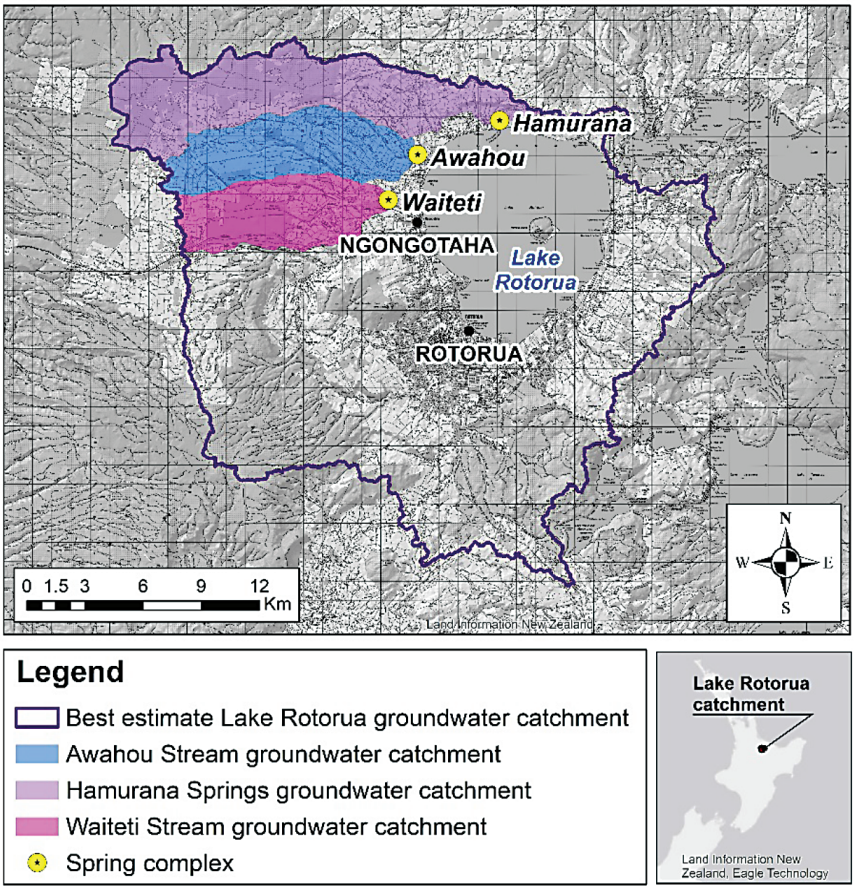

Figure 1 – Location of the Awahou springs complex, its catchment, and two adjacent spring complexes in the Lake Rotorua groundwater catchment (White *et al.*, 2014).

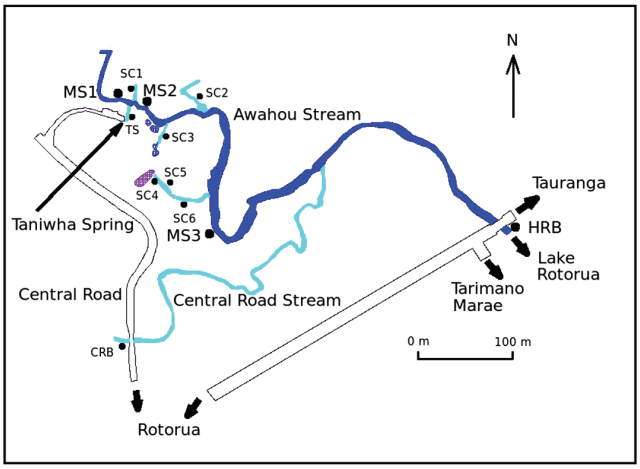

Figure 2 – The Awahou Stream area and springs complex. The Awahou Stream main stem (dark blue) is supplied with flow from numerous spring-fed tributary streams (teal). Streams (and flow measurement sites) include: Awahou Stream main stem (MS1, MS2, MS3) and Hamurana Road Bridge (HRB); Taniwha Stream (TS), Central Road Stream (CRB) and unnamed streams (SC1, SC2, SC3, SC4, SC5 and SC6).

management regime ('the regime') associated with the consent. For iwi, the kaitiaki flow and the regime address the decline in mauri, identified by Ngāti Rangiwewehi since the taking of land around Taniwha Springs in 1966 (Waitangi Tribunal, 1991), and consider iwi needs such as amenity, environment, food-bearing capacity, spiritual, sustainability and economic needs (see Tipa *et al.*, 2016). Economic needs are within the iwi's kaitiaki obligations as demonstrated by their plan for a water bottling venture at Hamurana Springs (New Zealand Herald, 2018; K. Hancock, pers. comm., 23 December 2019).

The Kaitiaki Flow Programme ('the Programme') aimed to identify the kaitiaki flow and the regime using Ngāti Rangiwewehi processes. This paper firstly summarises precursors to the Programme, i.e., the historical legal and legislative background that set the iwi cultural context for the Programme, including formation of the Taniwha Springs Joint Consent Project Team, the Iwi Management Plan (Mohi, 2012), and the Ka Tū Te Taniwha project (KTTT, 2014–2016; Lovett and White, 2016). The iwi-led process to define kaitiaki flow is then outlined in the context of three hui (meetings) between 2017 and 2019 (Bidois, 2019). Results from the Programme are described, i.e., the iwi-science engagement framework, the preferred Awahou Stream kaitiaki flow and the regime.

The Discussion summarises some benefits of the Programme in the context of iwi barriers to kaitiakitanga, iwi engagement in water management, and economic opportunities for the iwi. The Programme has provided some useful insights for other iwi-science projects. Therefore, the Discussion also considers the general application of the kaitiaki flow method and co-management arrangements.

Historical background to the Taniwha Springs Joint Consent Project Team

In 1966, land around Taniwha Springs was acquired by Rotorua County Council (subsequently renamed as Rotorua District Council, RDC, and now named Rotorua Lakes Council, RLC), under the Public Works Act 1928, to supply water to Ngongotahā (Waitangi Tribunal, 1991). This action triggered a significant grievance between the iwi and the Crown. Since then, decades of interaction between the iwi, the legal system and central government have led to the current Ngāti Rangiwewehi-RLC co-management agreement through the Taniwha Springs Joint Consent Project Team.

Waitangi Tribunal (1991)

Pekehaua Puna Trustees noted, in their claim to the Waitangi Tribunal (Wai 218/219), that they were "prejudicially affected by the actions of the Crown" by "acquiring title to the land surrounding our fresh water spring, commonly known as Taniwha Springs, by the use of the Public Works Act, without Tribal sanction and approval" and taking water from the spring "without Tribal sanction or approval (and without a water right)" (Waitangi Tribunal, 1991). This claim began a lengthy process by the iwi to reclaim kaitiakitanga over Taniwha Springs.

Environment Court

Sometime before 2001, RDC applied to Bay of Plenty Regional Council (BOPRC) for a consent to take water from Taniwha Springs at a maximum rate of 210 L/s to meet increased demand (Environment Court, 2008). In 2004, a consent was granted by BOPRC for a 25-year term at a maximum rate of 68 L/s. The decision was appealed by the iwi (wishing that the term should be reduced allowing time to investigate an alternative supply) and RDC (who sought to increase the rate).

An interim decision of the Environment Court (2008) allowed RDC to take water from the spring at a maximum rate of 210 L/s, requiring a minimum residual flow (29 L/s) in the side-creek that flows from Taniwha Springs to the main stem of Awahou Stream. The consent was given a term of 10 years.

Ngāti Rangiwewehi/RLC/BOPRC working group

This group was formed in 2011 and began to address the Wai 218/219 claim. In that same year, Ngāti Rangiwewehi met with other Rotorua iwi, the Minister of Treaty Settlements (Findlayson) and the RLC Mayor (Winters) regarding Treaty of Waitangi claims. An iwi-RLC co-management deed for Taniwha Springs governance came for the group "created on the foundation of goodwill and integrity and is a pledge of assurance that the parties will work collaboratively in partnership and in the spirit of commitment, trust and honour" (Tompkins Wake, 2016).

Ngāti Rangiwewehi Claims Settlement Act (2014)

This Act recognised the impact that taking of land under Public Works Act 1928 had on the iwi and offered an apology. The Crown "acknowledges that the taking of the land at Taniwha Springs and the subsequent abstraction of water had a severe impact on Ngāti Rangiwewehi and are strongly felt by Ngāti Rangiwewehi to be the greatest grievances they bear against the Crown" (s 9(11)); "The Crown regrets deeply the trauma and anguish this loss caused for Ngāti Rangiwewehi" (s 10(6)); and "The Crown hereby makes this apology to Ngāti Rangiwewehi, the people who descend from Tawakeheimoa and his son, Rangiwewehi." (s 10(1)).

Taniwha Springs Joint Consent Project Team

This Team has overseen multiple tasks such as completion of the new joint resource consent application for Taniwha Springs water use and plans for relocation of the Taniwha Springs pump house (Rotorua Lakes Council, 2017a and 2017b, respectively). The iwi (Te Rangikaheke Bidois, Gina Mohi and Toro Bidois) and RLC (Nico Claussen, Greg Manzano and Eric Cawte) formed the initial membership of the Team; they first met at Tarimano Marae, Awahou, in March 2017 and have had 18 meetings as at May 2019.

Iwi Management Plan and Ka Tū Te Taniwha project

The Iwi Management Plan originated from a series of wānanga at Tarimano Marae (Mohi, 2012, 2016). The plan identified, from a mātauranga Māori perspective, key concerns for waterways, including a lack of consideration given to Ngāti Rangiwewehi cultural values in water research and water management (Mohi, 2016).

The iwi's vision for the Awahou Stream spring complex was articulated through the Iwi Management Plan: "our awa and roto – strong, clear healthy and free"; "clean, safe drinking water"; "the life-supporting capacity and mauri maintained for future generations"; "traditional mahinga kai resources re-established and flourishing"; "traditional and culturally-acceptable practices of sustainable management, harvesting and monitoring of natural and physical resources … recognised by iwi and non-iwi alike" (Mohi, 2016).

KTTT described the hydrogeology and hydrology in Awahou Stream and its groundwater catchment, reinforced the prominence of the Awahou Stream spring complex in the traditional history of Taniwha Spring and underlined the importance of the springs to Ngāti Rangiwewehi culture (Lovett and White, 2016).

Method

Three hui were held: Hui 1 identified a Ngāti Rangiwewehi-based science engagement framework, Hui 2 explored iwi preferences for the kaitiaki flow and the regime, that led to the focus group recommending a regime to Hui 3, which identified the preferred regime. In addition, 23 ancillary focus group meetings were held with purposes including hui planning, hui de-briefing, processing of hui results and report writing. Mohi, Bidois (Ngāti Rangiwewehi) and White (GNS Science) were the members of the group; Bidois and Mohi took active leadership roles at the three Programme hui.

Hui 1: Ngāti Rangiwewehi framework of science engagement

Hui 1 set the scene for the iwi and whānau and introduced attendees to the aims of the Programme and to the research team (GNS Science and Ngāti Rangiwewehi). The hui was held on 5 October 2017 and was attended by approximately 30 iwi members, members of the wider Ngongotahā community and a representative of BOPRC.

Workshops within the hui aimed to understand the iwi's views on kaitiakitanga and pūtaiao. Kaitiakitanga-related questions were posed, e.g., "Why do we feel it is important for us to protect and care for our wai?", "How should we acknowledge the pūrākau and stories of our waterways (Pekehaua and Hinerua)?", and "Is cultural significance and history important when talking about water pollution and usage?" Pūtaiao-related questions were: "What regular scientific information do tāngata whenua need to know regarding their waterways and who can access these waters?", "What role do iwi have to ensure that water allocation doesn't impact negatively on the wai?", and "Is it important to use science to measure water quality and the impact of pollution on our waters?" The hui also discussed broad kaitiaki flow issues such as maintenance of existing flow variability, stream-flow monitoring, future water use by RLC and the iwi, and the importance of water quality.

Information from Hui 1 was collated into an iwi-science engagement framework that aimed to encapsulate the interaction between mātauranga Māori and western science. This framework allowed the definition of kaitiaki flow, the regime, and identified science information needs that were required for Hui 2.

Hui 2: iwi opinion, kaitiaki flow and the regime

Hui 2 was held at Parawai Marae, Ngongotahā, on 9 June 2018; approximately 40 people attended. The meeting began with discussion of the results from Hui 1 and four themes from iwi and science perspectives. These themes became elements of the kaitiaki flow and the regime, i.e., the location of streamflow, streamflow seasonality, streamflow rate and stream water quality (water quality is not a subject for this paper because the Taniwha Springs water supply consent is concerned with water quantity). Workshops in Hui 2 sought iwi opinions on each theme using visual media and hydrological data, with questionnaires that requested either a vote, i.e., 'yes' or 'no' answers to propositions, or a response to open-ended questions.

The location of streamflow in the Awahou Stream area was addressed with the question: "Shall the regime vary with location?" and presented Figure 3. This schematic was based on characterisation of springs and water flows in the Awahou Stream main stem, tributaries and springs in the complex by GNS Science and the National Institute of Water and Atmospheric Research (NIWA) (Fig. 2).

Flows were mostly measured with a FlowTracker Handheld Acoustic Doppler Velocimeter that records 2D or 3D currents and features an automatic discharge computation using international methods to ISO

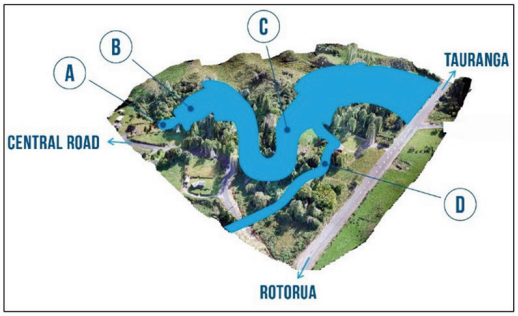

Figure 3 – Awahou Stream main-stem flow as presented to Hui 2; line thickness is proportional to measured flow. Labels represent features in Figure 2: A (MS1), B (MS2), C (MS3) and D (Central Road Stream).

standards. A StreamPro Acoustic Doppler Current Profiler (ADCP) was used to gauge flow at the Hamurana Road Bridge (HRB) site. The ADCP operates from a floating platform and measures discharge and velocity in streams 15-200 cm in depth. In addition, RLC recorded the instantaneous Taniwha Springs abstraction rate at minute intervals and the residual outflow from Taniwha Springs at ten-minute intervals.

Naturalised flow in the main stem (Q_{NMS}) at sites downstream of Taniwha Springs was calculated by adjusting gauged flow for RLC's water abstraction from Taniwha Spring:

$$Q_{NMS} = Q_{MS} + Q_{PP} * G_{SP} / G_S$$

Where Q_{MS} is main-stem gauged flow (L/s), Q_{PP} is mean abstraction rate (L/s) from Taniwha Springs by RLC during each main-stem gauging, G_S is the number of gauging verticals, and G_{SP} is the number of gauging verticals measured whilst Taniwha Springs was pumped, i.e., individual flow measurements that were potentially impacted by abstraction.

MS2 was the only site where this correction applied as Taniwha Springs was not pumped during other main-stem gauging measurements. Zero lag was assumed between pumping from Taniwha Springs and flow at MS2 because of the short travel time between the spring and MS2, i.e., the horizontal distance between the spring and MS2 is approximately 30 m and the median flow velocity at MS2 was 0.36 +/-0.04 m/s measured in three repeat gaugings (16 March 2018, 4 April 2018 and 6 April 2018). Flow at Central Road bridge (CRB) was calculated as the difference between gauged flows at MS3 and HRB.

The streamflow seasonality questionnaire considered time-variable stream flow with statistics of mean seasonal flow in Awahou Stream flows at HRB (Fig. 4) and the question: "Shall the regime vary with time?" Seasonal Awahou Stream flows were calculated from relatively recent flow gauging measurements at the HRB site (i.e., 30 gaugings between 7/10/2015 and 9/03/2018; E. Gurden, pers. comm., 16 March 2018). Awahou Stream is baseflow dominated, as shown by HRB flow statistics (i.e., mean 1654 L/s, median 1555 L/s and standard deviation 195 L/s), which is typical in spring-fed streams in the Lake Rotorua catchment (White *et al.*, 2007).

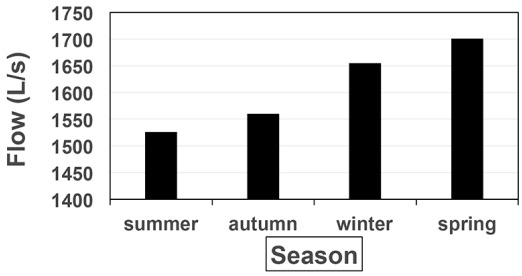

Figure 4 – Mean seasonal flow in Awahou Stream at HRB; December 2015 to October 2017.

Stream flow rate questionnaires elicited opinions on kaitiaki flow in the main stem of Awahou Stream. Images of stream level, a proxy for stream flow, were used to convey flow information to the hui because the

focus group indicated that iwi would prefer images, rather than graphs and tables, in their assement of flow scenarios.

Five stream flow scenarios at site MS2 were identified by the focus group for the hui, i.e., long-term mean flow (Q^{LT}_{MS2}) and four flows less than Q^{LT}_{MS2} (Flow 1 to Flow 4) (Table 1). Q^{LT}_{MS2} was calculated as:

$$Q^{LT}_{MS2} = Q^{LT}_{HRB} * Q^{G}_{MS2} / Q^{G}_{HRB} \quad (2)$$

Where:

Q^{LT}_{HRB} is mean long-term (1975–2012) flow of 1600 L/s at HRB, with a 95% confidence interval of 200 L/s (Rutherford and Palliser, 2014);

Q^{G}_{MS2} is gauged flow of 1083 L/s at MS2 on 16 March 2018;

Q^{G}_{HRB} is gauged flow of 1962 L/s at HRB on 19 March 2018.

Stream levels at MS2 were calculated relative to stream level at MS2 on 16 March 2018 (S^{G}_{MS2}), i.e.:

$$\Delta S_{MS2} = S_{MS2} - S^{G}_{MS2} \quad (3)$$

Where:

S_{MS2} is calculated stream level at MS2.

S_{MS2} was calculated from flow (Q_{MS2}) with a simple model that assumed a mean stream flow velocity from the MS2 gauging on 16 March 2018 (V_{MS2} = 0.173 m/s) and a cross-sectional area (A_{MS2}) calculated from the bed profile measured in the same gauging (Fig. 5), i.e:

Table 1 – Site MS2: stream flow scenarios and ΔS_{MS2}; numbers are rounded.

Hui 2 flow scenario		Q_{MS2} (L/s)	ΔS_{MS2} (m)
Now	Q^{LT}_{MS2}	880	-0.18
Flow 1	90% of Q^{LT}_{MS2}	790	-0.26
Flow 2	80% of Q^{LT}_{MS2}	700	-0.33
Flow 3	60% of Q^{LT}_{MS2}	530	-0.46
Flow 4	30% of Q^{LT}_{MS2}	260	-0.68

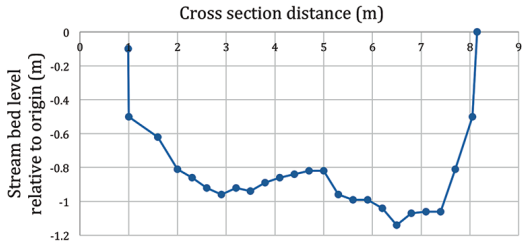

Figure 5 – MS2 stream bed profile as measured in the 16 March 2018 gauging.

$$S_{MS2} = 0.0008 * Q_{MS2} - 0.887$$
(best-fit line R^2 = 0.9994) (4)

$$Q_{MS2} = V_{MS2} * A_{MS2} \quad (5)$$

The questionnaires compared stream level "Now" (i.e., estimated stream bed position at a flow of Q^{LT}_{MS2}) with flow scenarios e.g., top right and top left, respectively; Fig. 6). The questionnaires represented an estimate of the water's edge (i.e., "The edge of the stream bank is shown in blue") and included the questions: "Do you see a difference between the two pictures?" and "What could this mean?" Responses to these questions generally identified the acceptability of scenarios. For example, comments that indicate an acceptable flow scenario include: "I wish I could keep this. Can live with this!" (Flow 1); comments that indicate an unacceptable flow scenario include: "Keep the now" (Flow 1) and "The difference is drastic which saddens me, so no." (Flow 4).

The text "Awahou Stream flow is less than now" headed Flow 1 and Flow 2 images and the text "Awahou Stream flow is much less than now" headed Flow 3 and Flow 4 images. Graphics represented the Awahou Stream groundwater catchment boundary (White *et al.*, 2014) and a schematic of present land use in the catchment, e.g., mixed forestry, sheep and dairy (bottom right and bottom left, respectively, Fig. 6).

Responses from Hui 2 were collated by the focus group. In some cases, individuals' opinions were clear, e.g., one response to

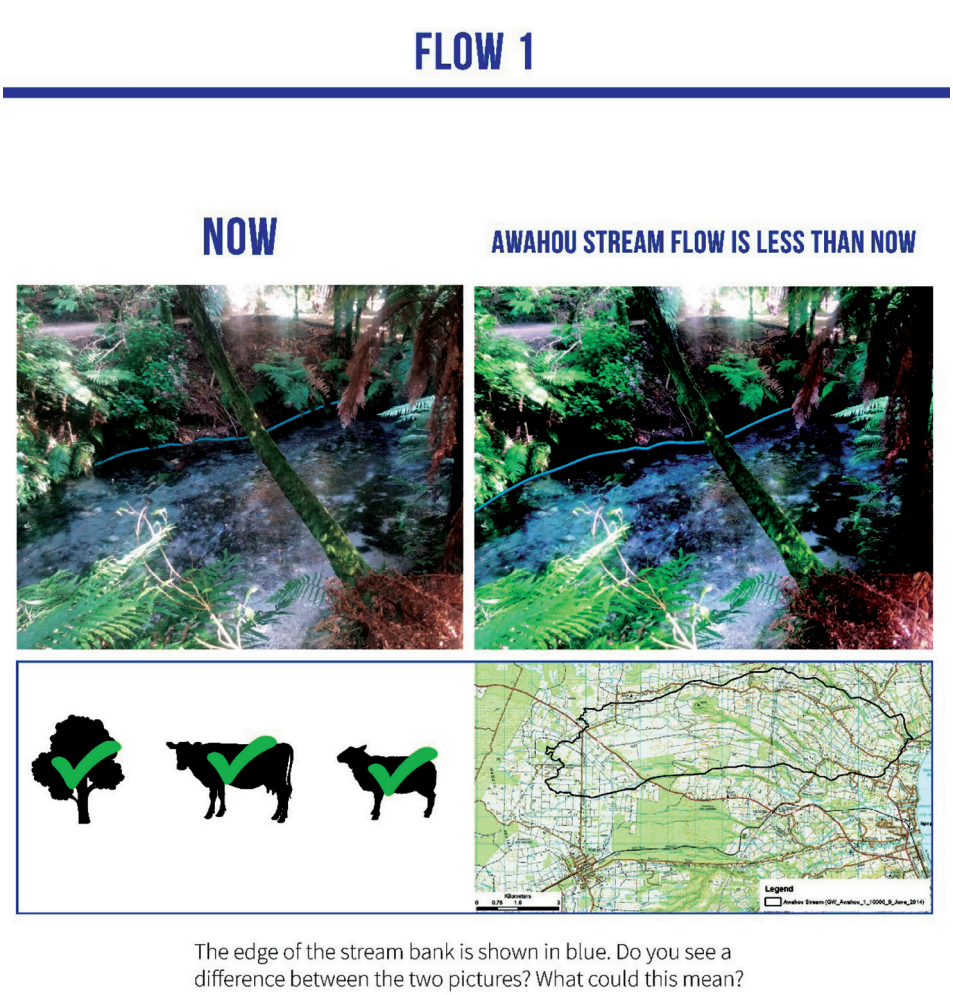

Figure 6 – Example of a Hui 2 questionnaire ("Flow 1") that explored opinions on stream level and stream flow showing the estimated stream bed position, in the vicinity of the MS2 gauging site, with two flow scenarios: "Now" and "Flow 1".

the question "Shall the regime vary with location?" was "This is a very important kaupapa. I fully support this Flow 1 so that it stays at a level for my moko [mokopuna]." In other cases, equivocal responses to questions required interpretation; e.g., a response to the same question was "No leave as it is", which was interpreted as meaning 'yes'. However, some responses to questions did not reveal the individual's opinion regarding kaitiaki flow options, e.g., "I only support community allocation if this council agrees to clean up the rest of our awa in the region!" was interpreted as 'unsure'. Hui attendees showed they were concerned that the present flow measurement practice (e.g., sporadic gaugings of Awahou Stream at HRB) was insufficient to meet their needs as kaitiaki; they also noted a preference for access to real-time flow data.

An analysis of these responses indicated broad agreement around kaitiaki flow and

captured a range of opinion on Awahou Stream management. The consensus was represented in the recommended kaitiaki flow and regime, identified by the focus group.

Hui 3: identification of the preferred kaitiaki flow

Hui 3 was held on 9 June 2019 at Tarimano Marae and approximately 30 people attended. This hui considered the focus group recommendations and identified a preferred kaitiaki flow and regime. The hui also discussed the potential contents of a Ngāti Rangiwewehi capability plan focussing on future iwi capabilities in water management.

Results

Iwi-science engagement framework

The KTTT project showed the great spiritual and cultural significance of Awahou Stream and Taniwha Springs for the Ngāti Rangiwewehi people.

The responses from Hui 1 led to definition of the Tikanga, Pūnaha and Mahi (TPM) framework defining the way the iwi interpret kaitiakitanga, mātauranga Māori and pūtaiao/western science in relation to stream flows (Bidois, 2019). This framework told the iwi that the interface between western and kaupapa Māori interventions, with the principle of "Ngā take Taiao", begins at the pūnaha level. The Programme reflected strongly how the iwi are integral to, and the facilitators of, the management and care of waterways and land in their rohe. TPM provided an acceptable method of engagement between mātauranga Māori and western science.

Definition of kaitiaki flow

Hui 2 attendees expressed some clear preferences for kaitiaki flow, strongly favouring maintenance of the natural characteristics of the flow system in the Awahou Stream area (Table 2). The Flow 1 scenario (90% of mean flow) was acceptable to a large majority of attendees (Table 3). In contrast, a slim majority found Flow 2 acceptable with the Flow 3 and Flow 4 scenarios not accepted by any attendees. This pattern of responses was consistent which tended to discount possible bias introduced by text headings on questionnaire images,

Table 2 – Stream character; Hui 2 responses. N is the number of responses from attendees.

Question	Response (%)			N
	Yes	No	Unsure	
Shall the regime vary with location?	81	6	13	16
Shall the regime vary with time?	85	0	15	13

Table 3 – Hui 2 flow scenarios and acceptability. N is the number of responses from attendees.

Hui 2 flow scenario		Scenario acceptability (%)			N
		Yes	No	Unsure	
Flow 1	90% of Q^{LT}_{MS2}	85	8	8	13
Flow 2	80% of Q^{LT}_{MS2}	54	38	8	18
Flow 3	60% of Q^{LT}_{MS2}	0	90	10	10
Flow 4	30% of Q^{LT}_{MS2}	0	87	13	15

i.e., the text "Awahou Stream flow is less than now" headed the Flow 1 and Flow 2 images, whereas the text "Awahou Stream flow is much less than now" headed the Flow 3 and Flow 4 images.

The preferred kaitiaki flow, agreed at Hui 3, was a moving minimum mainstem flow that is 90% of the daily-mean naturalised flow. The regime included a new, permanent, stage-recording measurement site to be located at MS2 (i.e., downstream of the Taniwha Springs confluence) with real-time flow monitoring data available through a website. Naturalised flow at this site will be calculated by summing the measured flow at MS2 and Taniwha Springs abstraction by RLC. Water use is allowed when stream flow at the site is greater than the kaitiaki flow; the website will generate digital warnings of the risk that near-future stream flow will decline below the kaitiaki flow.

The preferred kaitiaki flow and regime were agreed by the Taniwha Springs Joint Consent Project Team after an assessment of supply reliability. The regime was then incorporated into proposed conditions in the Taniwha Springs water supply replacement consent application which has been lodged with the Bay of Plenty Regional Council; Rotorua Lakes Council and the Pekehaua Puna Reserve Trust will be joint holders of this consent (C. Maginness, pers. comm., 27 April 2020).

Discussion

Benefits of the Programme

The Programme demonstrated the transfer of traditional Māori knowledge into policy. Extensive iwi participation in the Programme included numerous hui and focus-group meetings showing that "…the key to effective integration of Māori interests and values into freshwater management remains full iwi/hapū participation" (Tipa *et al.*, 2016). The wide iwi participation in the Programme was consistent with White's (2012) conclusion that Māori involvement in water management will increase in the future.

Education and exercises in Ngāti Rangiwewehi culture and science were completed for approximately 20 children from Te Kura o Te Koutu (Bidois, 2019). The children learnt the history and culture of the Awahou Stream area and investigated the hydrology of the site which included measuring water flow. The students used flow meters based on 'fidget spinner turbines', i.e., 3D laser-printed turbines, mounted onto fidget spinners, that were specially built for the field work, aiming at a fun activity that introduced water flow measurement to children.

The benefits to iwi were inter-generational as tamariki (Te Kōhanga Reo o Tarimano and Te Kura o Te Koutu) worked alongside kaumatua and scientists (Bidois, 2019; White *et al.*, 2018). This encouraged engagement and strengthened hapū connections to the Awahou area, showcased kaitiakitanga to the younger generations and will be an integral part of iwi succession planning (Bidois and White, 2019). A unit plan, written in te reo Māori and English, was completed for Te Kura o Te Koutu discussing ngā wai taheke, purea ine taheke and kaitiakitanga.

Capability development in water management, recognised by Ngāti Rangiwewehi, has been integral to the Programme (see also White, 2012 and Tipa *et al.*, 2016). Members of the focus group enhanced their expertise with much on-the-job training, e.g., for Mohi in the geology, groundwater resources, water chemistry, land use and water quality of the Awahou Catchment; Bidois and Mohi in the organisation of the iwi/science hui; and White in the iwi's tikanga. The iwi's capability plan has aims including: provision of an advisory role on the kaupapa within their rohe and tautoko other iwi (iwi whānui/iwi taketake) to meet the demands from organisations and interests outside of

Ngāti Rangiwewehi; kaitiakitanga; and he taonga tuku iho (Bidois and White, 2019).

Potentially, the Programme has provided future economic opportunities to the iwi. The economic use of Taniwha Springs for municipal supply by RLC, and other users, will be predicated on the minimum flow set by the kaitiaki flow regime. Ngāti Rangiwewehi aim to develop business opportunities using their new expertise, e.g., to assist other iwi with water management (Bidois and White, 2019).

General application of the kaitiaki flow method

The 'kaitiaki flow method' for iwi engagement, with the TPM framework, meets policy objectives of the NPS (Ministry for the Environment, 2017). The NPS recognises Māori involvement in water resources, i.e., "addressing tangata whenua values and interests" and "involvement of iwi and hapū in the overall management of fresh water" give effect to the Treaty of Waitangi (Preamble; Ministry for the Environment, 2017).

However, methods for Māori involvement in water resource management are not specified in the NPS. Rather, the NPS directs local authorities to take "reasonable steps" to involve iwi and hapū in the management of fresh water (Objective D1; Ministry for the Environment, 2017). Methods are typically prescribed at the regional level. For example, the Waikato Regional Plan (Implementation Method 2.3.4.23) includes methods for consultation with tangata whenua (Waikato Regional Council, 2020). Therefore, the Programme may provide a guideline to methods of iwi engagement that are generally suitable to other iwi-science water management projects. The exact nature of engagement is, of course, for each iwi to decide.

Co-management arrangements

The Kaitiaki Flow Programme has occurred at a unique time in the evolution of New Zealand's water resource management. Since 1991, when co-management was unheard of, Ngāti Rangiwewehi and the Crown have built relationships that allow the iwi and RLC to provide governance for the use of Taniwha Springs (Tompkins Wake, 2016). The authors doubt very much that the iwi's participation levels would have been achieved without this co-management arrangement.

The Programme provided contributions to the understanding of how co-management can work. Leadership (i.e., iwi and Crown agencies) should be completely "on board", for governance and science purposes, with the kaitiaki flow process, as was effected by meetings between focus group members and Ngāti Rangiwewehi leadership and by the establishment of the Taniwha Springs Joint Consent Project Team. The focus group was an important operational component of the Programme. Key characteristics of this group were its small size, membership (i.e., including iwi and science representatives), roles (e.g., planning hui and discussing details of the iwi-science interface) and the regularity of face-to-face meetings. Hui were essential for engagement with the wider iwi and the focus group.

Co-management arrangements, in the nature of legal documents (e.g., Tompkins Wake, 2016), are recommended in other iwi water management projects. Such documents define multiple issues associated with governance, e.g., they identify parties to the arrangement and the roles of these parties. However, these arrangements may not be necessary in all projects. In the present day, Crown agencies are now probably more open to co-management because national and regional policies are more receptive to the integration of iwi with water management. In the opinion of the authors, this new openness

could mean that Waitangi Tribunal claims and Crown settlements may not be a pre-requisite to new arrangements.

Conclusions

Awahou Stream, a baseflow-dominated stream and spring complex including Taniwha Springs, is located in the Lake Rotorua catchment. Ngāti Rangiwewehi are kaitiaki of Awahou Stream and have a co-management arrangement with Rotorua Lakes Council for the Taniwha Springs water supply that provides water to Ngongotahā; these partners aim to develop a new consent for abstracting water from the springs for the water supply.

A kaitiaki flow and flow management regime for the Awahou Stream and Taniwha Springs water supply forms part of the proposed consent and was established using Ngāti Rangiwewehi processes to meet their kaitiaki needs (e.g., amenity, environment and spirituality) for sustainable flows. An iwi-science engagement framework (based on Tikanga, Pūnaha and Mahi) defined how the iwi interpreted kaitiakitanga, mātauranga Māori and pūtaiao/western science in relation to Awahou Stream flow.

The framework guided hui that decided the kaitiaki flow and the regime after considering flow options. The regime includes a minimum flow in Awahou Stream, enhanced stream flow monitoring and a web-based information system that can be used by Ngāti Rangiwewehi to ensure that Awahou Stream flow, and Taniwha Springs water use, remain within kaitiaki flow limits.

The kaitiaki flow method was designed to address iwi barriers to the exercise of kaitiakitanga, and engagement, in water management by establishing processes to transfer traditional Māori knowledge into policies under the Resource Management Act. Other benefits of the method included: wide participation by Ngāti Rangiwewehi showing the importance of kaitiakitanga and co-management roles to the iwi; education, with training and exercises in Ngāti Rangiwewehi culture and science for children from Te Kura o Te Koutu; and iwi development through the iwi's capability plan. Furthermore, the method was shown as consistent with the iwi-engagement objectives of the NPS and with the 'objectives-method' approach of the NPS and regional policies. Therefore, the method may provide a guideline for iwi/science water projects under other iwi-Crown arrangements.

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References

Bay of Plenty Regional Council. 2015: Statutory Acknowledgments in the Bay of Plenty. 562p + 5 maps.

Bidois, L. 2019: Kaitiaki flows and baseflow-dominated stream systems. Prepared for Ngāti Rangiwewehi/GNS Science by the Rangiwewehi Charitable Trust. 26p.

Bidois, L.; White, P.A. 2019: Plan for Ngāti Rangiwewehi capability development in water resources assessment. Te Maru o Ngāti Rangiwewehi Iwi Authority. 7p.

Environment Court. 2008: Interim decision of the Environment Court. Appeal between Te Maro o Ngāti Rangiwewehi appellant and Rotorua District Council and Bay of Plenty Regional Council. Decision A095/2008.

Evison, H.C. 2006: The Ngai Tahu Deeds A window on New Zealand History. Canterbury University Press. ISBN 1-877257-39-7. 312p.

New Zealand Herald. 2018: Consent granted to take Hamurana Springs water for bottling. 9 October 2018. https://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=12138927 Accessed 26 December 2019.

Lovett, A.P.; White, P.A. 2016: Kā Tū Te Taniwha – Ka Ora Te Tangata: Scientific repository for the Awahou catchment. GNS Science Report 2016/13. 83 p.

Ministry for the Environment. 2014a: National Policy Statement for Freshwater Management 2014. Ministry for the Environment, Wellington 34p.

Ministry for the Environment. 2014b: A guide to the National Policy Statement for Freshwater Management 2014. Ministry for the Environment, Wellington. 96p.

Ministry for the Environment. 2017: National Policy Statement for Freshwater Management 2014 updated August 2017 to incorporate amendments from the National Policy Statement for Freshwater Amendment Order 2017. 47p.

Mohi, G. 2012: Ngāti Rangiwewehi Iwi Environmental Management Plan. Te Maru o Ngāti Rangiwewehi Iwi Authority. 78p.

Mohi, G. 2016: Bay of Plenty Regional Council Mātauranga Māori Project: Taniwha Springs, Rotorua case study. Te Maru o Ngāti Rangiwewehi Iwi Authority. Pouwhenua Consultants on behalf of the Ngāti Rangiwewehi Iwi Environmental Unit. 36p.

Rotorua Lakes Council. 2017a: Taniwha Springs Joint Consent Project Team minutes, 24/5/2017. RDC document #728757. 27p.

Rotorua Lakes Council. 2017b: Taniwha Springs Joint Consent Project Team minutes, 22/3/2017. RDC document #711619. 8p.

Rutherford, K.; Palliser, C. 2014: Lake Rotorua catchment boundaries Phase 2 water budget. NIWA Client Report No: HAM2014-045 for the Bay of Plenty Regional Council. 35p.

Tompkins Wake. 2016: Deed relating to Taniwha Springs/Pekehaua Puna Reserve, including Pekehaua Puna Reserve Trust – Rotorua Lakes Council Co-Management Agreement. 10p.

Tipa, G.; Harmsworth, G.R.; Williams, E.; Kitson, J.C. 2016: Integrating mātauranga Māori into freshwater management, planning and decision-making. In: Jellyman, P.G., Davie, T.J.A., Pearson C.P., Harding, J.S. (eds.) *Waters of New Zealand (2nd edition)*. New Zealand Hydrological Society Inc. and New Zealand Limnological Society Inc., Wellington. Pp 613-637.

Waikato Regional Council 2016: Proposed Waikato Regional Plan Change 1 – Waikato and Waipa river catchments. Waikato Regional Council Policy Series 2016/06 ISSN 2230-4339 (Print) ISSN 2230-4347 (Online). 120p.

Waikato Regional Council 2020. Waikato Regional Plan. https://www.waikatoregion.govt.nz/Council/Policy-and-plans/Rules-and-regulation/Regional-Plan/Waikato-Regional-Plan, accessed 10/4/2020.

Waitangi Tribunal. 1991: The Wai 218/219 claim of Pekehaua Puna Trustees. 20th June 1991.

Waitangi Tribunal. 2012: The interim report on the national fresh water and geothermal resources claim. WAI 2358. 296 p.

White, P.A. 1995: Image enhancement of photogrammetric measurements at the Kaiapohia Pa site, Canterbury. Archaeology in New Zealand 38(2): 119-131.

White, P.A. 2001: Groundwater resources in New Zealand. In: Rosen, M.R.; White, P.A. (eds.) *Groundwaters of New Zealand*. New Zealand Hydrological Society Inc., Wellington.

White, P.A. 2011: Economic drivers of land use and groundwater use by irrigators, Waimea Plains Nelson, New Zealand. *New Zealand Journal of Marine and Freshwater Research 45(3)*: 513-524.

White, P.A. 2012: The New Zealand Māori Council claim to the Waitangi Tribunal and water management in New Zealand. *New Zealand Science Review, 69(4)*: 82–85.

White, P.A. 2018: Efficiency measures for water management. J*ournal of Hydrology (NZ) 57(2)*: 95-105.

White, P.A.; Sharp, B.M.H.; Kerr, G.N. 2001: Economic valuation of the Waimea Plains groundwater system. *Journal of Hydrology (NZ) 40(1)*: 59-76.

White, P.A.; Zemansky, G.; Hong, T.; Kilgour, G.; Wall, M. 2007: Lake Rotorua groundwater and Lake Rotorua nutrients – phase 3 science programme technical report. GNS Client report 2007/220 to Environment Bay of Plenty. 402p.

White, P.A.; Tschritter, C.; Lovett, A.; Cusi, M. 2014: Lake Rotorua catchment boundary relevant to Bay of Plenty Regional Council's water and land management policies. GNS Science Consultancy Report 2014/111. 99 p.

White, P.A.; Tschritter, C.; Davidson, P. 2016: Groundwater-surface water interaction in a coastal aquifer system, lower Wairau Plain, Marlborough, New Zealand. *Journal of Hydrology (NZ) 55(1)*: 25-43.

White, P.A.; Bidois, L.; Mohi, G.; Tschritter, C. 2018: Kaitiaki flows: iwi-led science to identify spring-fed stream management regimes, Awahou Stream, Rotorua. Poster Presentation at the annual conference of the New Zealand Hydrological Society and the Meteorological Society of New Zealand, Christchurch, 4th – 6th November.

Glossary*

Awa: river.
Hapū: sub-tribe.
Hinerua: a female taniwha who resides at Te Kaikaitahuna, a river at Hamurana (Fig. 1).
He taonga tuku iho: succession planning.
Hui: meeting.
Iwi: tribe or tribes.
Iwi whānui: direct iwi relatives.
Iwi taketake: indigenous peoples around the world.
Kaitiaki: guardians.
Kaitiaki o Papatūānuku: custodians of Papatūānuku (the Earth/Earth mother, wife of Ranginui).
Kaitiakitanga: guardianship.
Kaumatua: tribal elders.
Kaupapa Māori: Māori principle or ideology.
Mātauranga Māori: Māori knowledge.
Mahi: work - projects and protocols.
Mahinga kai: locations where foods are sourced, e.g., gardens.
Mana whenua: people with customary authority over land.
Moko/mokopuna: grandchild/children.
Ngā take Taiao: environmental issues.
Ngā wai taheke: water flow.
Pekehaua: a male taniwha (guardian) who resides in Awahou Stream.
Pekehaua Puna: The spring where Pekehaua resides.
Pūnaha: system; policies and practices; the actions behind iwi responsibilities as tāngata whenua and kaitiaki.
Pūrākau: story.
Purea ine taheke: flow meter devices based on fidget spinners.
Pūtaiao: science.
Rohe: region; geographic area of mana whenua.
Roto: lake.
Tamariki: children.
Tāngata whenua: people of the land.
Taniwha: guardian.
Tautoko: support.
Te Kōhanga Reo o Tarimano: a Māori language early childhood centre located at Tarimano Marae, Rotorua.
Te Kura o Te Koutu: a Māori language medium school located at Te Koutu, Rotorua.
Te reo Māori: the Māori language.
Tikanga: procedure, protocol; the overarching positioning and rationale for the way Ngāti Rangiwewehi regard the environment as tāngata whenua and kaitiaki.
Wai: water.
Wānanga: conference.
Whānau: family.

* see also the Glossary of Tipa *et al.* (2016).

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