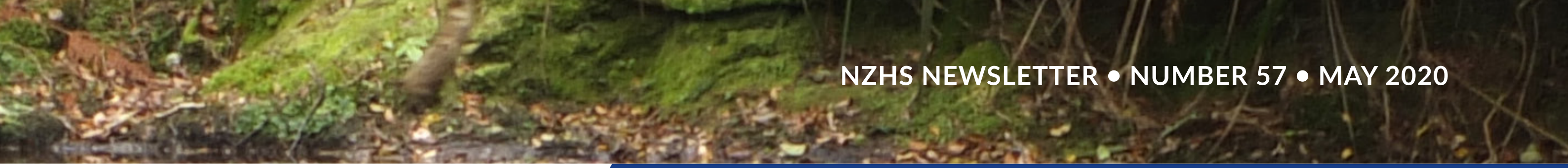
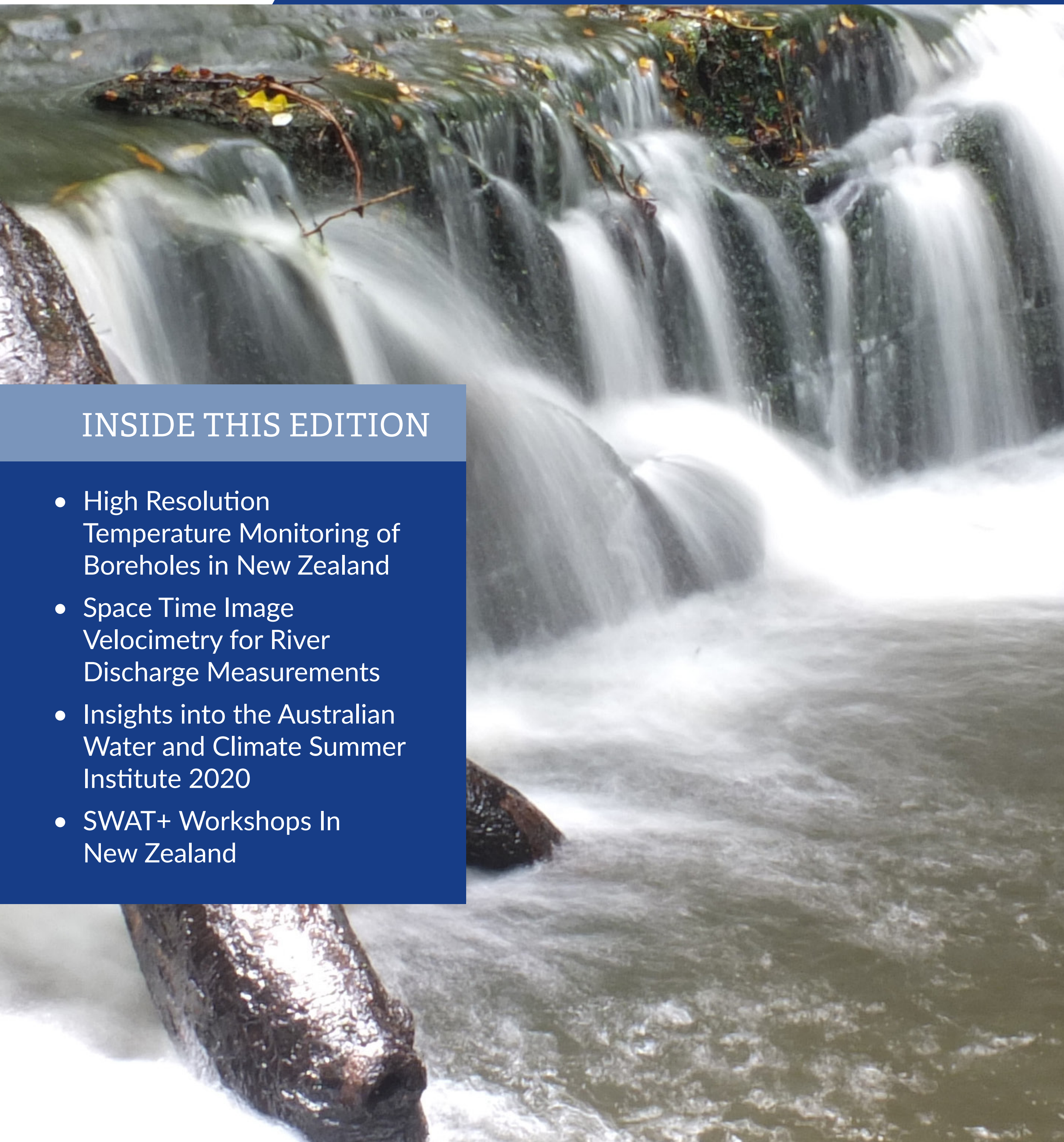


NZHS NEWSLETTER • NUMBER 57 • MAY 2020

NEW ZEALAND HYDROLOGICAL SOCIETY

CURRENT NEWSLETTER



INSIDE THIS EDITION

MESSAGE FROM THE EXECUTIVE

Thank you to all who contributed to the May edition of Current. Current again contains an interesting range of organisation updates and articles.

While recent news has been dominated by Covid-19 I would like to start by thanking the organising committee of the 2019 conference. It was great to see so many Society members at the NZHS *"Water: Above, Below, and Beyond"* conference held at the Energy Events Centre, Rotorua, 3 – 6 December 2019, and we experienced some great Bay of Plenty hospitality. Following the Executive elections at the Society's AGM we welcomed Conny Tschritter and Adam Martin to the Executive team. Raelene Mercer – Secretary, Richard Hawke - Editor and Sarah Mager were re-elected. Thanks to Abigail Lovett and David Leong, who left the Executive team, for their services to the Society over their past term.

In addition to celebrating all the presenters (of papers and posters) I would like to acknowledge Brioch Hemmings (on regional groundwater models as tools for informing management; an example of effective and efficient decision support modelling. Wairau valley NZ) – best overall oral; Hoa Pham (Does meterological drought have immediate effect on low flow in Northland Rivers) – best poster; Lisa Scott (Developing a triage tool for assessing discharges in community drinking water supply protection zones) – people's choice poster; Hamish Prince (Flooding in atmospheric rivers over the last 40 years) – people's choice oral.

Thanks to Tom Cochrane and MS Srinivasan for organising the SWAT+ (Soil & Water Assessment Tool) Workshops in Christchurch and Rotorua.

In March, just prior to the lockdown, our cunning technical folk managed to "sneak" in a Technical Workshop in beautiful Tauranga. At the workshop Marianne Watson was awarded her Achievement in Operational Hydrology award; congratulations. The presentations demonstrate innovative and exciting developments achieved and underway in the hydrological world.

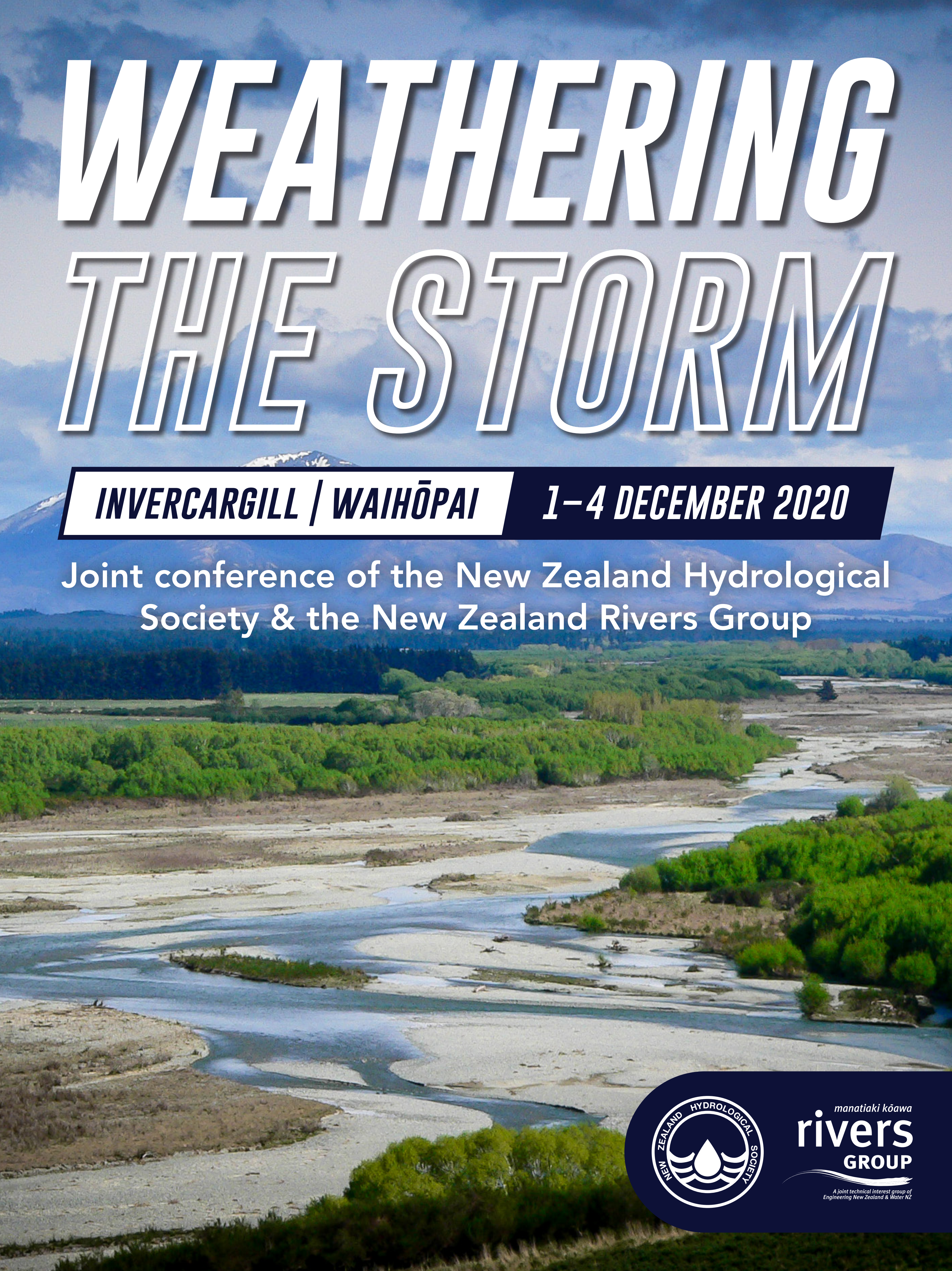
And, onto the Covid-19-affected world... I was pleased to see hydrologists recognised as among those undertaking "essential services" during Alert Level 3 and 4; thank you. As we shift into the new normal I trust you are all well and adapting. It is going to be challenging for a while. If you are like me then the immediate challenge is year-end and planning for the new financial year while agility adapting.

Looking forward, the Executive of the Society are supporting the Conference Organising Committee for the joint NZ Hydrological Society and Rivers Group conference to be held in Invercargill from 1 – 4 December 2020. Last year the organisers did well with their crystal ball in deciding the conference theme of *Weathering the Storm*. Invercargill is a superb venue for our conference and is another gateway to some of New Zealand's superb hydrological, nature and wildlife destinations. The Executive has budgeted for project grants to be available for students in this coming year – as we consider it important to be able to assist our students over this challenging period.

On the publications front, the second issue of the Journal for 2020 will be a special issue on Sediment Transport, which follows earlier special sediment transport-based issues. We also have planned a publication to celebrate the Society's 60th Anniversary (2021), which will be an update on the "Red Book" that was published for the Society's 50th. I would also like to encourage all those undertaking great work to consider publishing it in some form. As editor I look forward to seeing your manuscripts.

As we all face challenges (not just those due to Covid-19) don't forget to celebrate success and look after yourself and those around you.

Richard Hawke
Editor Journal of Hydrology



WEATHERING THE STORM

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Joint conference of the New Zealand Hydrological Society & the New Zealand Rivers Group

NEW ZEALAND HYDROLOGICAL SOCIETY

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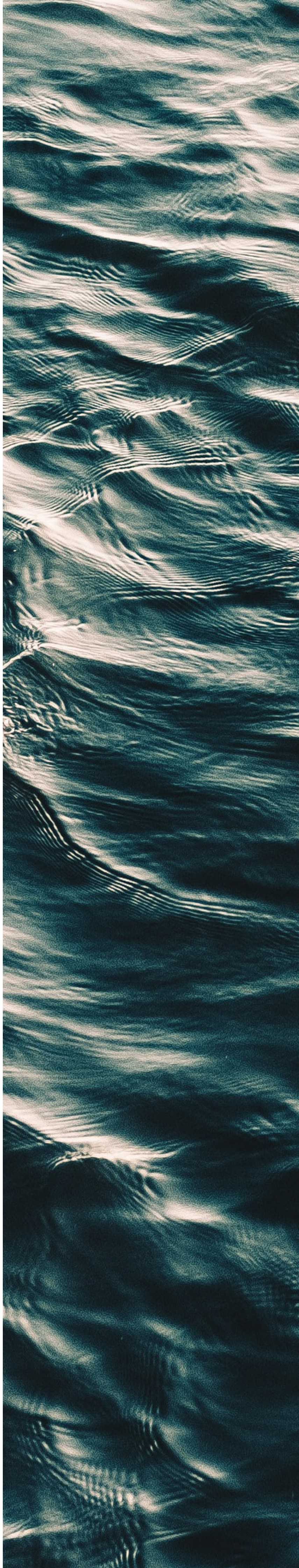


ARTICLE

Abigail Lovett, Earth & Environmental Science
Frederika Mourot, GNS Science

High Resolution Temperature Monitoring of Boreholes in New Zealand

Introduction

Fibre Optic Distributed Temperature Sensing (FODTS) technology allows for collection of temperature data at very high spatial and temporal resolutions in a range of environments. FODTS has previously been applied throughout New Zealand to better understand and monitor groundwater-surface water interaction in rivers, lakes, and streams (e.g., Moridnejad et al., 2019; Lovett et al., 2015; Moridnejad, 2015). Less frequently, FODTS has been implemented for temperature measurement in geothermal monitoring boreholes in New Zealand (e.g., Wairakei Power Station). A key benefit of FODTS is that the method enables downhole temperature monitoring with unprecedented temperature resolution (down to 0.01°C) and at a high spatial resolution (1 m) (Bense et al., 2016). Potential groundwater applications include site investigations of groundwater flow, in-well flow, and subsurface thermal property estimation.

The primary aim of this project was to explore the practical application of the FODTS method for better understanding groundwater and geothermal settings in New Zealand. The Waiwera geothermal-groundwater system (Waiwera aquifer) was selected as a test site due to its relatively easy access to deep boreholes and because temperature contrasts in the aquifer were likely to produce suitable results for an initial trial. The Waiwera aquifer is located approximately 40 km north of central Auckland (Figure 1), largely within the Waitemata Group Sandstone to a depth of approximately 400 m below ground level (BGL) (Kühn and Stöfen, 2005). The site is characterised by a small, low-temperature (*c*. 50°C) geothermal-groundwater system understood to be heated from convection via a primary fracture in the underlying greywacke basement (Auckland Council, 1986, 1991, 1999; Kühn and Stöfen, 2005).

In this article, the FODTS deployment method for borehole measurement and initial results are briefly presented. The intention is to inform the hydrological community of the FODTS method and its potential applicability for borehole investigations in the New Zealand setting. Limitations of the technique and potential options for further application in New Zealand are also discussed briefly.

Method

A steel weight was fixed to the end of the 500 m-long armoured fibre optic cable. The cable was gradually lowered down the monitoring boreholes to a maximum depth of 387 m and 105 m BGL in borehole #1 and borehole #3, respectively (Figures 1 and 2, Table 1). Unfortunately, measurements from borehole #2 were unable to be obtained as the casing was blocked at 10 m BGL. Borehole #1 was cased from c. 1.5 m above ground level to 115 m BGL and the remainder of the borehole was ‘open’ within fractured Waitemata Sandstone. Casing details were unknown for borehole #3. The static water level for both boreholes #1 and #3 was artesian (i.e., above ground level) during deployment. The Sensornet Oryx DTS system was set to record temperature measurements at 1-metre (spatial) and 1-minute (temporal) intervals. Temperature calibration of the DTS system was via ice bath and ambient air temperature cable reference sections. A more detailed description of the FODTS deployment methods and technical specifications to the cable and unit are presented in Moridnejad (2015).

Figure 1: *Location of the boreholes investigated for FODTS measurements at Waiwera (January 2020).*

Investigations were carried out on 21/01/2020 (borehole #1) and 22/01/2020 (borehole #3). Water was abstracted from borehole #1 at an approximate rate of 1 L/s from 18:25 h to 18:50 h. The pumping rate was considerably lower than intended due to bore head construction limitations and the type of pump that could be used (i.e., surface pump). A pump was unable to be installed for borehole #3 due to the narrow casing diameter (*c.* 40 mm) but water was naturally flowing during the test due to artesian pressure. Manual measurements of groundwater temperature were collected during the tests at the end of the discharge pipe for borehole #1 and directly at the ground surface for borehole #3 by handheld thermometer.

Table 1: *Summary of borehole locations and construction details for the FODTS field trial.*

Borehole ID	Bore location (NZTM 2000)	Bore depth (m BGL)	Casing depth (m BGL)	FODTS cable length (m) down borehole
#1	1752803 m E / 5954236 m N	387	115	387
#2	1752815 m E / 5953970 m N	400	8	-
#3*	1752819 m E / 5954220 m N	c. 107+	unknown	105

**No details of borehole #3 were available from the Auckland Council environmental database. Therefore the total depth of the borehole and the depth of the casing are both unknown.*

Figure 2: *Deployment of FODTS method at Waiwera (January 2020) showing FODTS equipment in the back of a field vehicle during deployment and monitoring of borehole temperatures.*

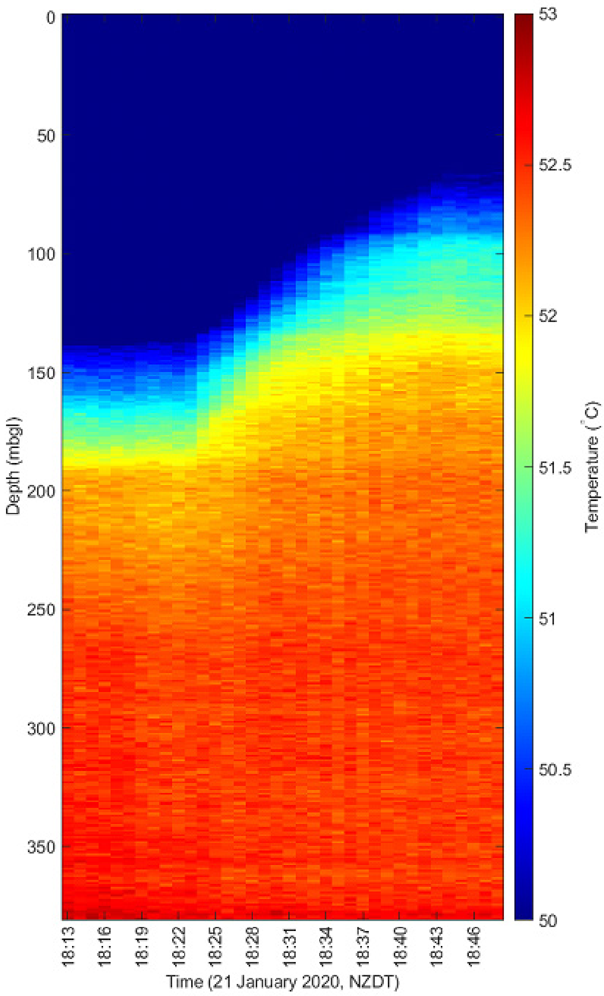
Results and Interpretation

Borehole temperature was plotted against cable length (metres BGL) and time for borehole #1 (Figure 3) and borehole #3 (Figure 4). The measured temperatures in borehole #1 were undertaken in two distinct phases. Phase one was under static conditions (18:13 – 18:25 h; no pumping or flow from the borehole) and phase two was under pumping conditions (18:25 – 18:50 h). For borehole #3 the temperature plot does not have distinct phases as no pumping was undertaken, although artesian flow occurred throughout measurement. Measurements in borehole #3 were collected during an incoming tide and it is likely that artesian flow increased slightly over time due to increased tidal load on the aquifer.

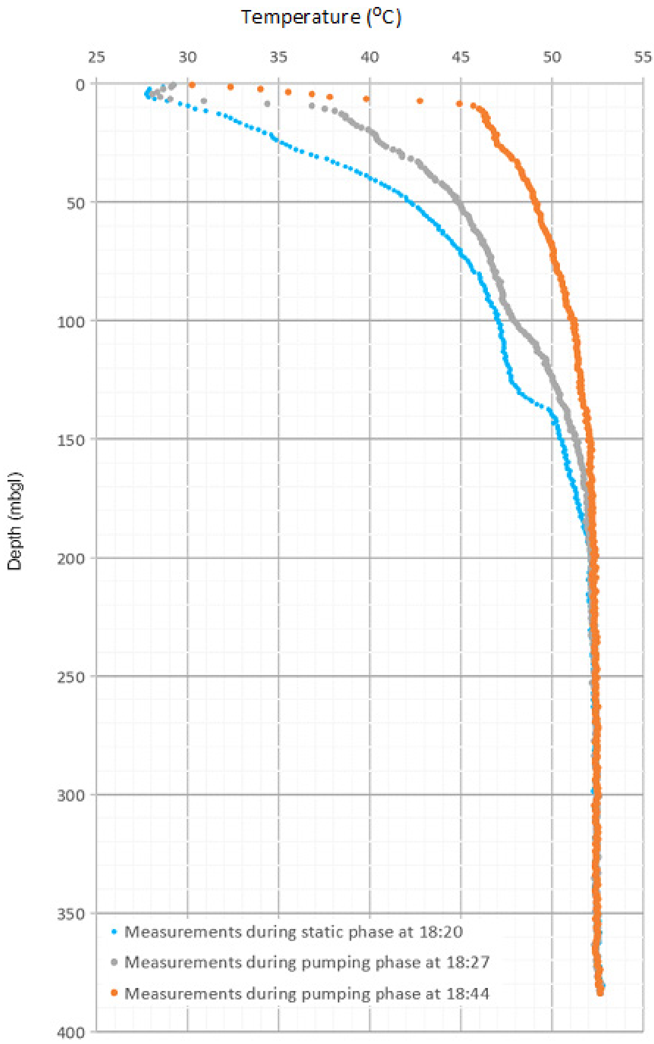
For borehole #1, the temperature plot during the static phase can be separated into three distinct depth sections based on temperature characteristics (Figure 3, Table 2). For the upper bore section (1–140 m BGL) the temperature was consistently less than 50°C. In the cased section, it is likely that conduction is taking place between the surrounding aquifer and the bore water via the casing. Relatively cooler groundwater inflows are probably occuring at depths of c. 110–130 m BGL. In the intermediate bore section (140–190 m BGL), groundwater temperature increased with depth from approximately 50°C to 52°C. In the lower bore section (190–387 m BGL) temperatures were relatively homogenous (i.e., consistently between 52°C and 53°C), with the highest temperature below 350 m BGL. During the pumping phase, warmer water was gradually drawn from the open section, which resulted in a slight increase in water temperature in the cased section. The bore temperature profile from the pumping phase did not reveal preferential higher temperature flow zones in the open section of the borehole. The temperature signature in the lower bore section (i.e., 190–387 m BGL) was similar under static and pumping phases, suggesting relatively homogenous temperature inflows of water in the open section below 250 m.

Table 2: *Summary of temperatures observed in borehole #1 per depth section and test periods, and interpretation.*

Depth section (m BGL)	Period	Temperature (°C)	Inferred interpretation of measured temperature
Upper 1 – 140	Static	< 50	Primarily controlled by surrounding groundwater temperature (conduction and thermal heat transfer); 130 – 140 m zone of warming
	Pumping	50 – 51.5	Increased from deeper warmer groundwater inputs
Intermediate 140 – 190	Static	50 – 52	Slightly increasing with depth
	Pumping	51.5 – 52.3	Increased from deeper warmer groundwater inputs
Lower 190 – 387	Static	52 – 53.0	Relatively constant, warmest groundwater inputs likely located within this section of the borehole, no preferential flow pathways / fractures were observed
	Pumping	52.3 – 53.0	



(a)



(b)

Figure 3: *Profiles of temperature and depth for borehole #1 during the Waiwera FODTS trial; (a) Matlab profile over time; (b) temperature and depth at static; early pumping (18:27 h); and late pumping (18:44 h) time steps.*

For borehole #3, groundwater temperature increased with depth from approximately 42°C near ground level to approximately 50°C at 105 m BGL (Figure 4). Manual temperature measurements at the surface increased from 42°C to 45.1°C from 16:50 h to 17:50 h. Borehole #3 FODTS measurements are consistent with those recorded for borehole #1 at similar depths, which was expected given the proximity of the boreholes (c. 22 m, Figure 1). During temperature measurements on borehole #3, the artesian flow from the bore increased. It is interpreted that temperature rise over time within the bore and the surface flow was due to an increased flow to the open hole section of the borehole due to the incoming tide exerting greater pressure on the aquifer system.

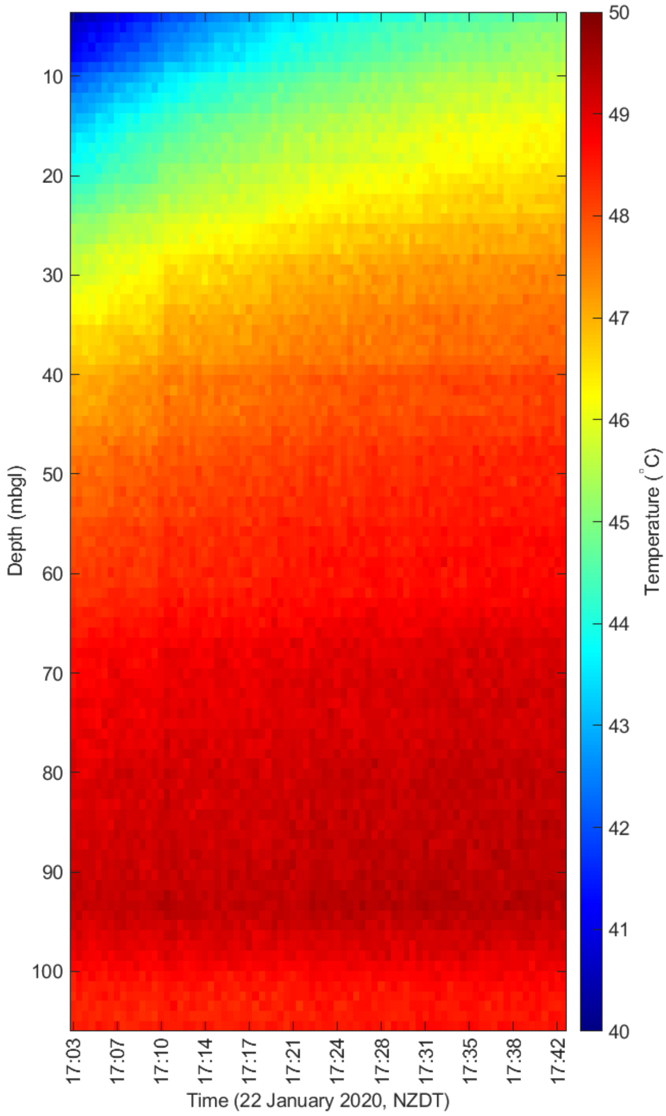


Figure 4: *Profile of temperature with depth over time for borehole #3 during the Waiwera FODTS trial.*

Based on FODTS measurements and previous knowledge of the Waiwera aquifer the following interpretations can be made:

- It is likely that groundwater temperature increases with depth from ground level to approximately 190 m BGL. A more homogenous, warmer temperature zone is observed below this depth (e.g., 52–53°C).
- Inflow from a slightly cooler aquifer layer around 110–130 m BGL probably reduces the thermal efficiency of the bore. Therefore, greater thermal efficiency could be obtained if casing was extended to at least 140 m BGL; ideally to 190 m BGL.
- Although the geology is fractured sandstone, there does not appear to be preferential heat transfer pathways in the open section of borehole #1. Pumping for a longer duration and at a higher rate, that is more representative of the actual capacity of the borehole, may return more informative results than the study obtained.
- Previous temperature measurements of the Waiwera aquifer have been undertaken, including deployment of temperature loggers down boreholes (e.g., 20 m resolution down to 200 m BGL). In comparison with these measurements, FODTS measurements were collected with a very short deployment timeframe and returned results with a considerably higher spatial resolution.
- Tidal pressure was observed to be influencing artesian flow from the aquifer system from boreholes that do not have suitable headworks (e.g., pressure valve on headworks).

Limitations associated with this trial include the accuracy of temperature calibration (e.g., reference sections in the ice bath and ambient air temperature), the relatively small pumping volume that was abstracted (i.e., limiting flow into the open section of borehole), and limited processing of the dataset. It is unknown whether FODTS was unable to determine discrete zones of water inflows in the open section of the bore due to the 1 m spatial resolution being too coarse, or whether the temperatures at greatest depth are relatively homogenous due to inflows of the same temperature or due to mixing processes in the borehole.

Application of FODTS in New Zealand Groundwater Setting

A recent review by Bense et al. (2016) indicated that FODTS methods have significant advantages in obtaining higher resolution data when compared to discrete point temperature measurements, particularly in deep wells. Results obtained from the FOTDS deployment in the Waiwera aquifer support this finding, particularly when compared to previous temperature profiling of the groundwater system. Therefore, deployment of FODTS using the method described in this article would allow for improved characterisation of deep boreholes throughout New Zealand under static or pumping conditions (e.g., to identify stratification of aquifer systems). Further, FODTS could provide for rapid measurement of aquifer temperature in low-temperature geothermal systems during drilling and bore development. In addition, Bense et al. (2016) highlighted the potential for further method developments (such as mechanical cooling or heating of the cable to infer groundwater flow velocities) in conjunction with other emerging hydro-geophysical tools such as distributed acoustic sensing. Further research into FODTS methods using heated and/or cooled cables could provide greater insights into the hydrogeological conditions in New Zealand. This research would be most beneficial to develop the method for measurement of hydraulic properties of aquifers, which could be achieved though FODTS measurement and development of a heat transfer model under a pumping scenario.

Conclusion

This relatively new application of FODTS for borehole temperature measurement in the New Zealand context was successful in obtaining high resolution temperature data of the Waiwera aquifer. Field deployment of equipment and measurement of groundwater temperature up to 53°C and to depths greater than 380 m BGL were undertaken. The method shows potential for successful investigations at higher temperatures and greater depths to be undertaken in a range of hydrogeological environments. The data collected provides an insight into temperature characteristics of the Waiwera aquifer at the highest resolution to date. Increased thermal efficiency is likely to be obtained if borehole casing was extended below 140 m BGL. Additional FODTS investigations could be undertaken to better define the hydraulic and thermal properties of the aquifer system. For example, FODTS measurement during a 24-hour aquifer test would enhance the characterisation of the system in terms of bore groundwater inflows and boundary limits, and could potentially be used to inform resource use and management decisions.

Acknowledgements

The successful trial of FODTS deployment at Waiwera would not have been possible without collaboration from the following organisations: Waiwera Properties Ltd who provided access to the borehole and covered costs for the pumping contractor; GNS Science who provided FODTS equipment, fieldwork staff, and Matlab processing; and local landowners for providing access to their property and boreholes. This field trial was made possible by the following people, who provided in-kind contributions of time to the project: Abigail Lovett (E&E Science), Frederika Mourot (GNS Science), and Rogier Westerhoff (GNS Science). The New Zealand Hydrological Society is acknowledged for providing a project grant which contributed to field trip disbursement costs. The authors also thank Stewart Cameron (GNS Science) and Kolt Johnson (Auckland Council) for their reviews. The authors welcome comments and feedback on this article and should address any correspondence to Abigail abigail@eescience.co.nz or Frederika f.mourot@gns.cri.nz.

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ARTICLE

Michael McDonald, Environment Southland
Regan Diggelmann, Taranaki Regional Council
Nicholas Holwerda, Auckland Council

Space Time Image Velocimetry for River Discharge Measurements

Introduction

Image velocimetry is an alternative method to float gaugings, currently still a standard Japanese method. There are two common forms of image velocimetry - Large Scale Particle Image Velocimetry (LSPIV) for two-dimensional velocity and Space Time Image Velocimetry (STIV) for one-dimensional velocity.

Developed in Japan by Professor Yano with PIV in 1983 and further developed by Professor Fujita with LSPIV in 1995, image velocimetry uses video of either objects on the surface or texture moving in the direction of stream flow. To relate surface velocity to the mean velocity a coefficient (alpha) is used. Alpha is either measured by conventional gaugings or estimated based on site conditions and is typically 0.85 for normal flow conditions and towards 1 for extreme conditions such as floods.

The advance of image velocimetry in New Zealand began with Mark Randall (Department of Natural Resources Mines and Energy, Queensland Government) presenting his experiences in using STIV methods in Australia during the New Zealand Hydrological Society Technical Workshop held in Blenheim in 2019. With the use of a drone, Mark was able to gauge the stream during the technical workshop regatta with the software package KU-STIV (Kobe University Space Time Image Velocimetry). As a result of the interest in Mark's presentation there was a dedicated training event hosted by the New Zealand Hydrological Society in Wellington in mid-2019. The training event in Wellington was reported on in the November 2019 edition of E-Current.

Following on from the Wellington workshop, there was the opportunity to attend a training course held in Cairns Australia in late 2019. This course was held for Queensland hydrologists to learn about the software. The New Zealand Hydrological Society were offered three grants to assist with travel for those who had been using image velocimetry techniques since the Wellington workshop.

Nicholas Holwerda (Auckland Council), Regan Diggelmann (Taranaki Regional Council), and Michael McDonald (Environment Southland) were all successful in applying.

Queensland Workshop

The first day in Cairns covered the history of image velocimetry techniques. There were presentations from Professor Fujita on the development of image velocimetry and the future automation of measurement processing.

The next two days were spent learning the software on fixed camera gaugings and drone videos while also looking at the beta version of KuSTIV1. Thursday morning was spent processing more video with the afternoon providing feedback on what would be useful in the new version of the software that Professor Fujita was developing.

Friday was a tour around two sites that had been in the presentations. The first stop was Saltwater Creek where James Cook University have built a site automating the processing of gaugings. This site was running a low voltage computer to process the results onsite. From here the group travelled to another hydrology site with a quick stop in Babinda. The site, Bucklands, is located next to a sugar cane farm and is a standard Queensland hydrology shed on a concrete base. These sites are hurricane proof! There are two cameras at this site: a standard IP camera and a FLIR (Full Long Range Infra Red) camera.

From Bucklands the group travelled down to Ettal Bay, a local beach, in the hope of spotting a cassowary. Lucky enough, there was one walking on the beach. No luck spotting a crocodile, however, on the way back to Cairns.

Methods

Video of the rivers can either be captured directly above by a drone or at an oblique angle from the stream bank via a fixed or mobile camera. Video captured needs to be calibrated to relate real world distance to pixel distance, both in scale and distance. This is completed in the software. Known reference points are surveyed using RTK GPS or Total Station methods. These points are called ground control points visible in the image. The image is then orthorectified in the software to then run the velocity techniques on the corrected image. In Figure 1 the image on the left side is the footage captured at an oblique angle. The image on the right is the orthorectified image with search lines drawn. Figure 1 is from the New Zealand Hydrological Society Technical Workshop annual gauging regatta in March 2020 and is discussed in the results.

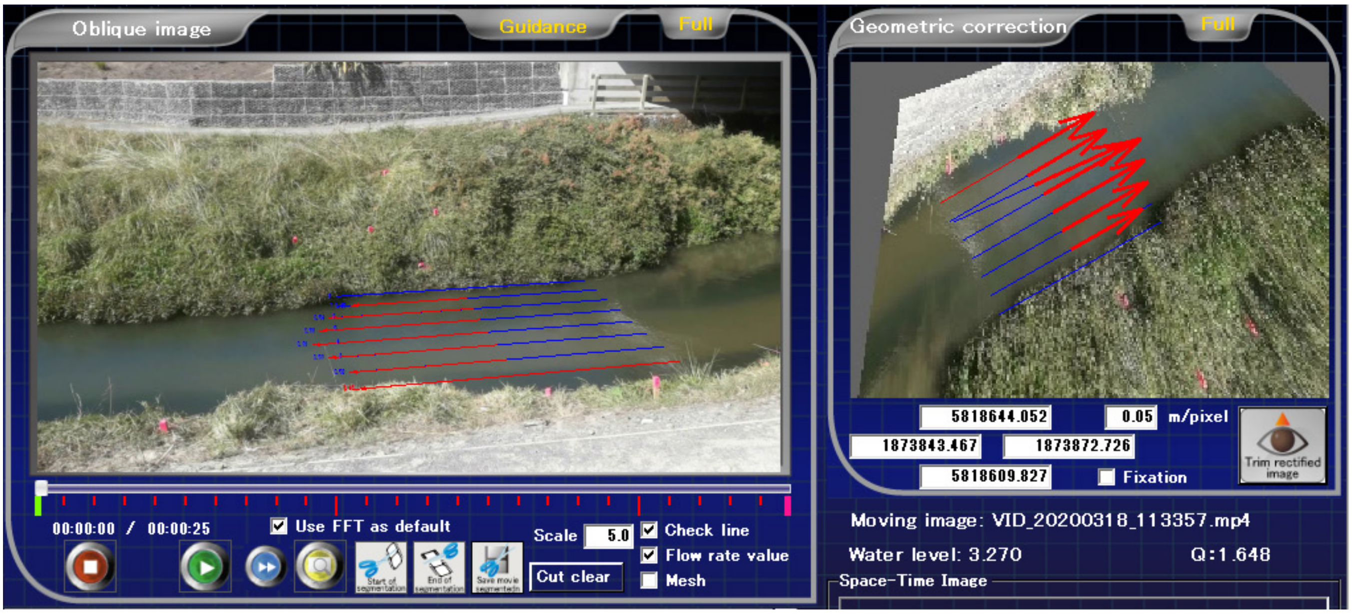


Figure 1: *Gauging regatta Tauranga*

Putting into practice all that has been learnt, there are now a number of camera deployments in New Zealand. Michael McDonald has a docking station for a smartphone to capture video and a smartphone in a waterproof box that can be remotely controlled. Regan Diggelmann was fortunate enough to have a number of cameras already installed for public interest. It is just a matter of optimising them for the ideal view to work well with image velocimetry. Nicholas Holwerda has a number of portable trail cameras, including one that is able to be remotely controlled, as well as an IP camera setup. All three have been collecting results from these setups.

Results

Environment Southland – Michael McDonald

The results from the New Zealand Hydrological Society Technical Workshop gauging regatta 2020 (Figure 2) are shown below. Over the course of the day, 38 gaugings were collected with a range of conventional methods from current meters through to dilution gaugings. Twenty-seven videos were captured using the remote smartphone and processed with the STIV method in KU-STIV. The mean result was 0.41% lower using STIV than the gauged average for the day.

Southland has also collected a number of STIV results over a range of flows from 2 m^3/s to 250 m^3/s. At mean flow and above, STIV is working well with all of the results within 5% of rated flow at our main site on the Makarewa River. There are some site-specific challenges below mean flow with the results differing from rated flow by more than 5%. It is notable that by having a site setup for STIV we were able to capture the second highest recorded flow event at this site. The STIV result was within 5% of the gauged flow during this event.

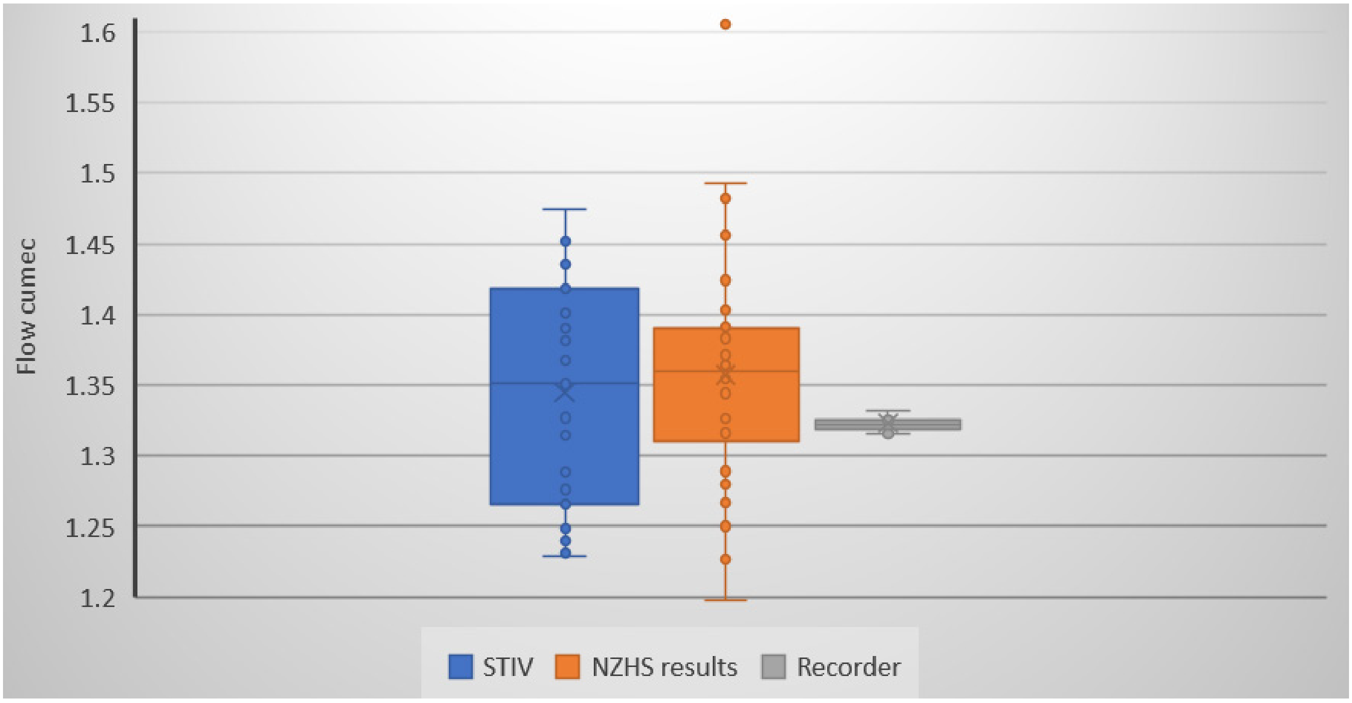


***Figure 2:** Gauging regatta Tauranga results*

Taranaki Regional Council – Regan Digglemann

Taranaki Regional Council's site on the Waiwhakaiho River captured 19 fixed camera and drone videos that were processed using KU-STIV software.

The highest gauging on record for this site was at a stage of 1715 mm with a calculated discharge of 34.568 m^3/s. KU-STIV was able to determine a discharge at a stage of 2410 mm with a calculated discharge of 100.602 m^3/s, 4.6% off the current extrapolated rating curve (Figure 3).

A comparison gauging was conducted between M9 and KU-STIV. The discharges were less than 1% different.

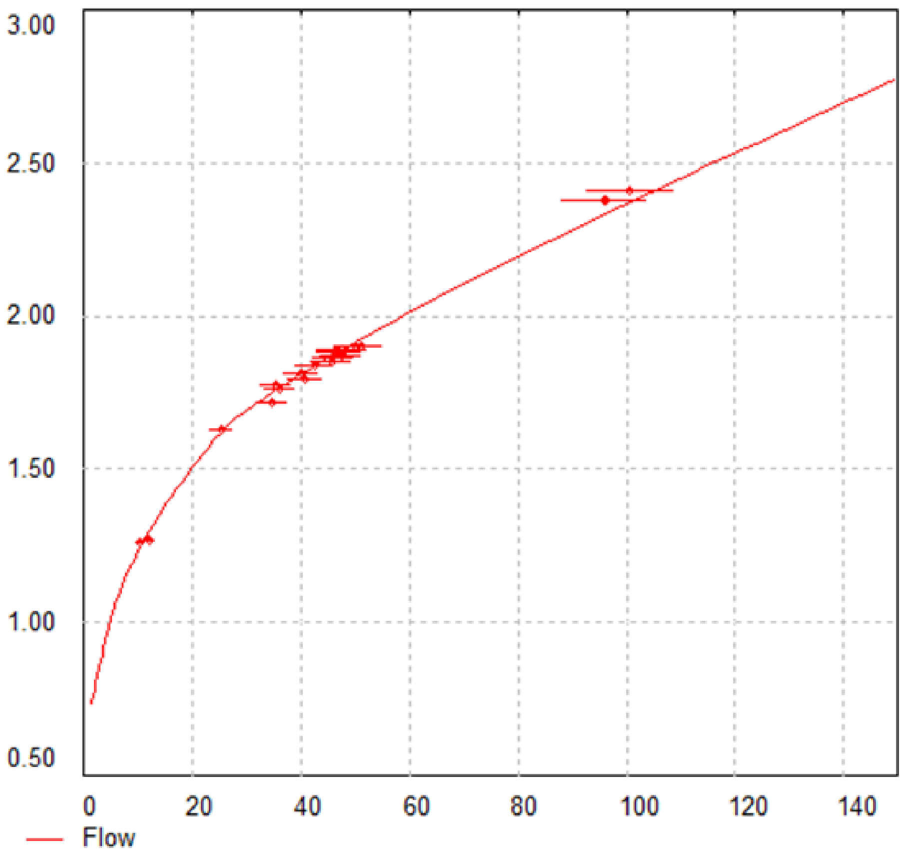


Figure 3: *KU-STIV processed videos with 8% error bars at the Waiwhakaiho Site*

Auckland Council – Nicholas Holwerda

Auckland Council has deployed trail cameras to record videos for flood flow analysis. These are cheap battery powered units that can be triggered remotely via SMS commands. Figure 4 shows flow results from three 20-second videos processed using KU-STIV software. These gaugings all plot within 2.5% of the current flow rating on a stable bed rock control.

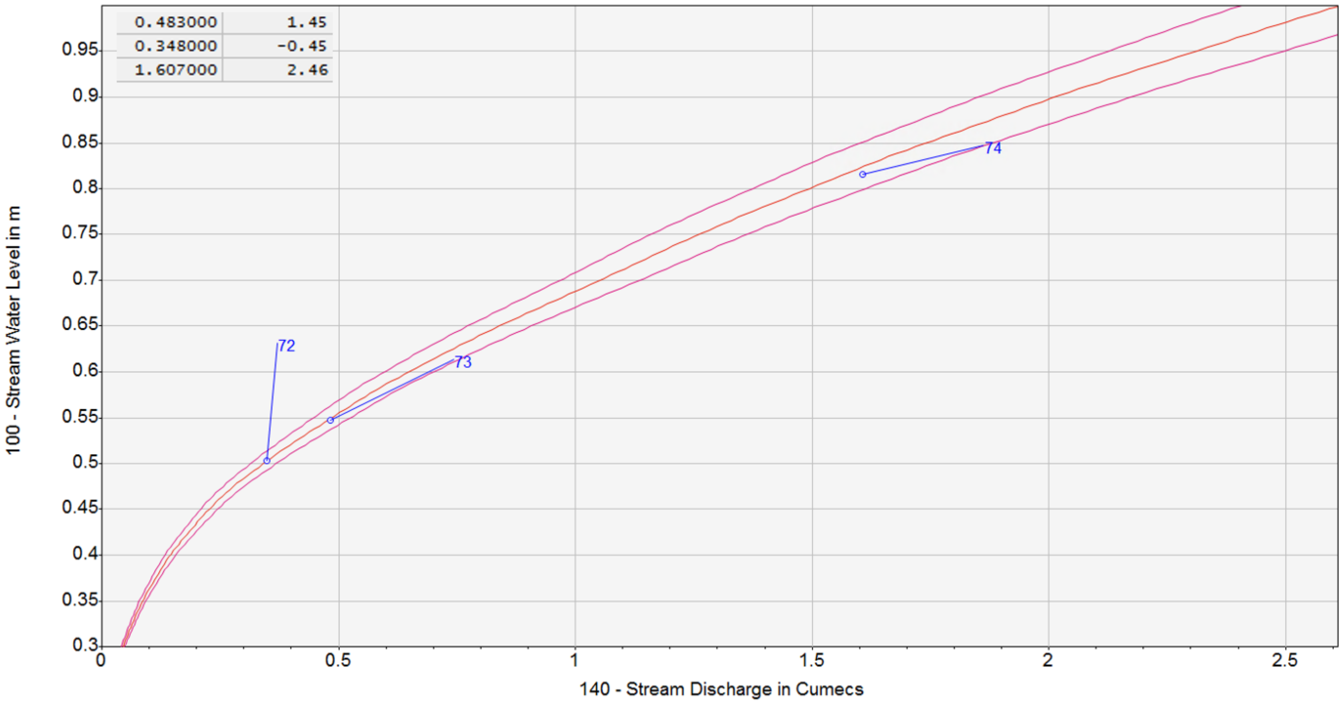


Figure 4: *Camera processed gaugings using KU-STIV on a stable rating*

Discussion

The new version of STIV software (HydroSTIV) is due for release mid-2020 and has incorporated improvements over the earlier version KuSTIV. The new software is a commercial program with regular updates and support available. Mark Randall demonstrated the version that he has in Tauranga. Drone gaugings are far simpler to set up in the software and the camera calibration is now automated rather than having to manually adjust the camera's location to locate the ground control points. Deep learning has been added into the analysis. This is a strength of the new software developer's company. Automation of the gaugings can be added as an extra option where videos sent to an FTP are processed automatically.

Conclusion

Discharge results so far have shown the methodology, software and techniques are very precise. In good conditions with quality video and well-defined surface tracers, the discharge results are plotting within ± 8% of known rating curves.

Image velocimetry provides a safe, reliable method to gauge rivers in flood conditions provided there is a stable cross section. This is particularly useful when gaugings can be captured outside of normal working hours or if conditions are unsafe to perform a conventional gauging at the site. The results to date are also proving accurate in floods, as well as normal to low flow. Having a network of stream cameras also provides other opportunities such as public engagement and indicating when storm grate clearing may be required.

The ability to use cameras to capture river flows has huge benefits for the industry.

- Using remote cameras or drones enables staff to record the required data without deploying expensive equipment directly in the water.
- It has health and safety benefits as staff don't need to go near flooded water ways.
- Cameras can be deployed to record river flow data 24/7.
- Rating curves can be generated over one large event.
- High flow flood measurements can be captured to fill in uncertainty in flow records.
- Mass rollout of flood monitoring can occur at a far cheaper price than traditional methods.

Future Work Programs

Further national development is occurring for surface velocity methods. As part of this, surface to mean alpha computation will be addressed, so a consistent method can be applied. The aim is to produce an operational field manual for competent hydrologists to utilise if they are processing video-based surface flow gaugings.

ARTICLE

Barry Fahey & Andrew Fenemor,
Manaaki Whenua Landcare Research

Transfer of Glendhu Paired Land Use Catchment Study from Landcare Research to Otago University

Barry Fahey (currently a Research Associate with MWLR), and John Payne (Senior Technician) have been responsible for the collection of rainfall and runoff data from the Glendhu paired catchment study in the tussock grasslands of upland east Otago for over 30 years.

The study was originally established in 1979 by the New Zealand Forest Service to determine the hydrological effects of converting tussock grasslands to pine plantation. The pines catchment has now gone through a complete rotation from planting in 1982 to harvesting in 2018. With John approaching retirement, Barry has decided that it is now time to step aside, and let the next generation of hydrologists take over.

A proposal for the official transfer of responsibilities from MWLR is currently under consideration by the University of Otago. Once the details have been finalised the catchments will continue to serve as a natural laboratory in which students and staff can undertake further research into the changes in water yield and sediment production associated with the next forest rotation, and with the natural scrub encroachment occurring in the tussock catchment.

ARTICLE

Amy Lennard, Horizons Regional Council

Insights into the Australian Water and Climate Summer Institute 2020

Earlier this year, in simpler times, I participated in the fourth Australian Water and Climate Summer Institute thanks to the NZHS Kees Toebes Scholarship. The summer institute was held at the prestigious Fenner School of the Environment at the Australian National University, Canberra. The summer institute is organised in collaboration with the Australian Energy and Water Exchange to provide skills-based training that focuses on the use, production and analysis of climate and water data with a particular focus on increasingly extreme climate events. These challenges felt particularly pertinent with recent wildfire, drought and hail storms impacting so many people across Australia. Landing in Canberra was a quite the sight – the grass was long dead, dams were low, buildings were damaged and fires were burning across the ACT. During my two-week trip a series of unusual east coast lows hit south-east Australia resulting in very high rainfall totals and the Warragamba Dam storage increasing by 28% in just over 24 hours. By February, 2020 had already been a year of extremes.

In previous years the summer institute was a six-week programme and was primarily attended by PhD candidates. This year the programme was condensed into a two-week course which allowed wider participation for early-career professionals and researchers. The course was attended by a range of participants from across Australia and I was the lone New Zealand contingent (despite being a Brit). The two weeks were broken into a mixture of hands-on training sessions, presentations and group projects. Much of the hands-on training was run by ANU staff using the National Computation Infrastructure a.k.a the Southern Hemisphere's most highly integrated supercomputer using Python coding to access vast amounts of environmental data. This training was my first foray into accessing and using satellite imagery in a coding environment. I particularly enjoyed the sessions using remote sensing data as metrics for surface water extent and vegetation health.

There were a number of presentations and training sessions from the Bureau of Meteorology, CSRIO, Murray-Darling Basin Authority and Geoscience Australia. These sessions were really interesting and provided a valuable insight into the state-of-the-art science and environmental management underway across these government organisations. The last three days of the course were a “hackathon” to use and develop the skills and concepts we had been exposed to over the course. The hack I was involved in investigated how Himawari-8 satellite products could be used identify areas of severe convective rainfall. On the final day each hackathon group presented their work; it was incredible what could be achieved in a few short days. The whole experience was great and exposed me to new concepts and approaches that could be applied by local government for decision making and environmental management.

I would highly encourage NZHS members to apply for a place at the next Australian Water and Climate Summer Institute. Alongside the new skills gained, I have widened my professional network and got to spend time at a world-leading university with a bunch of fellow environmental scientists and hydrologists. My attendance would not have been possible without the support of the NZHS and Horizons Regional Council. I hope the NZHS will continue to support future applicants.

ARTICLE

SWAT+ Workshops In New Zealand

The Soil & Water Assessment Tool (SWAT) is a small catchment to river basin-scale hydrology model used to simulate the quality and quantity of surface and ground waters and predict the environmental impacts of land use, land management practices, and climate change. SWAT is widely used around the world and its use is increasing in New Zealand. SWAT+, a completely revised version of the SWAT model that provides a more flexible spatial representation of interactions and processes within a catchment, is now available. Late last year, two free SWAT+ workshops (in Christchurch and Rotorua) were organised to train a wide range of NZ scientists, engineers, managers, decision makers, students, and others users. The New Zealand Hydrological Society, University of Canterbury and NIWA sponsored both workshops. Two of the SWAT developers, Prof. Raghavan Srinivasan and Dr. Katrin Bieger from Texas A&M University, USA, were invited to run the workshops and were and hosted by Tom Cochrane (University of Canterbury) and MS Srinivasan (NIWA). The two-day workshop in Christchurch had more than 36 attendees and the one in Rotorua more than 15 attendees. It was wonderful to see the potential opportunities that this model gives us to address many challenges around NZ and the opportunity the workshop provided for modellers across NZ to interact and share experiences. Many thanks to the NZ Hydrological Society for helping support these events and to the SWAT developers for making time to visit us. Further information on SWAT can be found here: swat.tamu.edu/. Those interested in SWAT can join the New Zealand SWAT user group here: groups.google.com/d/forum/swat-nz.

Attendees at the Christchurch SWAT+ workshop

UPDATE

Juliet Clague

Lincoln Agritech

The Environmental Research team at Lincoln Agritech has welcomed four new staff members in recent months: Aaron Dutton and Patrick Durney in the Lincoln office and Jungho Park and James Owers in the Hamilton office. The team have also given oral and poster presentations at the Australasian Groundwater Conference in Brisbane, the NZ Hydrological Society Conference in Rotorua, WAI-BOP Soils Day in Hamilton, the FLRC and Edge of Field workshops in Palmerston North and the NZHS Technical Workshop in Tauranga last month.

***Figure 1:** New LAL employees Patrick Durney (left) and Jungho Park (right) are introduced to the Piako River headwater catchment by Aldrin Rivas (centre).*

NZHS Technical Workshop March 2020

Our catchment hydrologist, Aldrin Rivas, attended the 2020 NZHS Technical Workshop held on 17–20 March at Trinity Wharf, Tauranga. The workshop's theme "The Future of Surface Velocity Measurement" was very interesting and informative about recent technologies such as flow measurement by radar and image velocimetry. He also enjoyed the whole day Gauging Regatta (Fig. 2). Aldrin was one of the three lucky attendees to win a generous raffle item at the conclusion of the workshop. He partly attributed this luck to being an active participant enabling him to collect a substantial number of raffle points that increased his chances of winning.

Figure 2: *Aldrin Rivas enjoyed the gauging regatta at the NZHS technical workshop in Tauranga.*

New Zealand Landcare Trust (NZLCT) Field Day November 2019

Roland Stenger and Aldrin Rivas gave presentations at the NZLCT field day at Tatuanui Hall, near Morrinsville, in November last year. Roland's talk introduced the MBIE-funded Critical Pathways Programme (CPP), which seeks to unravel the pathways nitrogen takes from the land surface to the local streams. Aldrin's talk provided an overview of our pilot-scale denitrifying bioreactor, which was established as part of the SSIF-funded 'Enhanced Mitigation of Nitrate in Groundwater' programme led by ESR. The talk was followed by a site visit to the bioreactor near Tatuanui (Fig. 3), which enabled participants to get a real-life feel for the edge-of-field mitigation technology.

Figure 3: *Aldrin Rivas (far right) gives details and answers questions from the NZLCT field day participants at Lincoln Agritech's denitrifying bioreactor in November 2019.*

MBIE-funded Braided Rivers project uses tTEM for the first time in NZ

Figure 4: *The Braided Rivers Programme uses a towed transient electromagnetic (tTEM) survey to gain information about the resistivity of materials forming the bed of the Wairau River.*

The newly funded MBIE programme 'Subsurface processes in braided rivers – hyporheic exchange and leakage to groundwater', led by Scott Wilson, aims to provide accurate quantification of how much water is lost from braided rivers into groundwater. The programme will collect data and generate models that will enable councils to estimate water loss and provide defensible limits for water management plans. In collaboration with Aarhus University (Denmark), geophysical data collection is about to resume (Fig. 4) in the three braided river catchments under study (Selwyn, Wairau and Ngaruroro).

Recent Publications

Clague, J.C., Stenger, R., Morgenstern, U. (2019) The influence of unsaturated zone drainage status on denitrification and the redox succession in shallow groundwater. *Science of the Total Environment* 660:1232-1244. (doi.org/10.1016/j.scitotenv.2018.12.383)

Friedel, M. J., Wilson, S. R., Close, M. E., Buscema, M., Abraham, P., Banasiak, L. (2020) Comparison of four learning-based methods for predicting groundwater redox status. *Journal of Hydrology* 580: 124200. (doi.org/10.1016/j.jhydrol.2019.124200)

Srinivasan, M. S., Muirhead, R. W., Singh, S, K., Monaghan, R. M., Stenger, R., Close, M. E., Manderson, A., Drewry, J. J., Smith, L. C., Selbie, D., Hodson, R. (2020) Development of a national-scale framework to characterise transfers of N, P and Escherichia coli from land to water. *New Zealand Journal of Agricultural Research*. (doi.org/10.1080/00288233.2020.1713822)

Wilson, S. R., Close, M. E., Abraham, P., Sarris, T. S. Banasiak, L., Stenger, R., Hadfield, J. (2020) Achieving unbiased predictions of national-scale groundwater redox conditions via data oversampling and statistical learning. *Science of the Total Environment* 705:135877 14pp. (doi.org.10.1016/j.scitotenv.2019.135877)

UPDATE

Aqualinc

World Water Day

It was World Water Day on 22 March 2020. The day was rather over-shadowed by the current pandemic, but, for a little light relief, Aqualinc held an internal photo competition. This was judged based on popular vote. Whilst the winning entry didn't actually show a body of freshwater, as John Barr commented, "It is a reminder of how our path might be without planning: so much wasted energy and effort and so little achieved!" View the winning entries at linkedin.com/feed/update/urn:li:activity:6658799286777716736.

Irrigation Management have welcomed the appointment of **Jim Herbison** as the new Business Unit Manager. Jim and the irrigation management team have been busy helping our clients throughout the lockdown period, with the recent irrigation season likely to be one of the longest on record for most of the country. We also welcomed back from maternity leave North Island Area Manager **Melanie Smith**. **Ben Harley** has been brought on full time to manage South Canterbury Area. **Nicole Mesman** has been keeping a close eye on the telemetry sites, and IT Manager **Wayne Hawkins** has ensured the network and associated systems are running smoothly.

Jim Herbison

The Consent & Compliance team have been working with a large number of clients whose water resource consents are coming up for renewal and clients whose consents are being reviewed by ECan because of their potential to affect flows in the Ashburton River. The solution for some is to replace the existing take with deep bores. Where deep groundwater is not available more creative solutions are required and we are helping the Ashburton River Irrigators Association explore options.

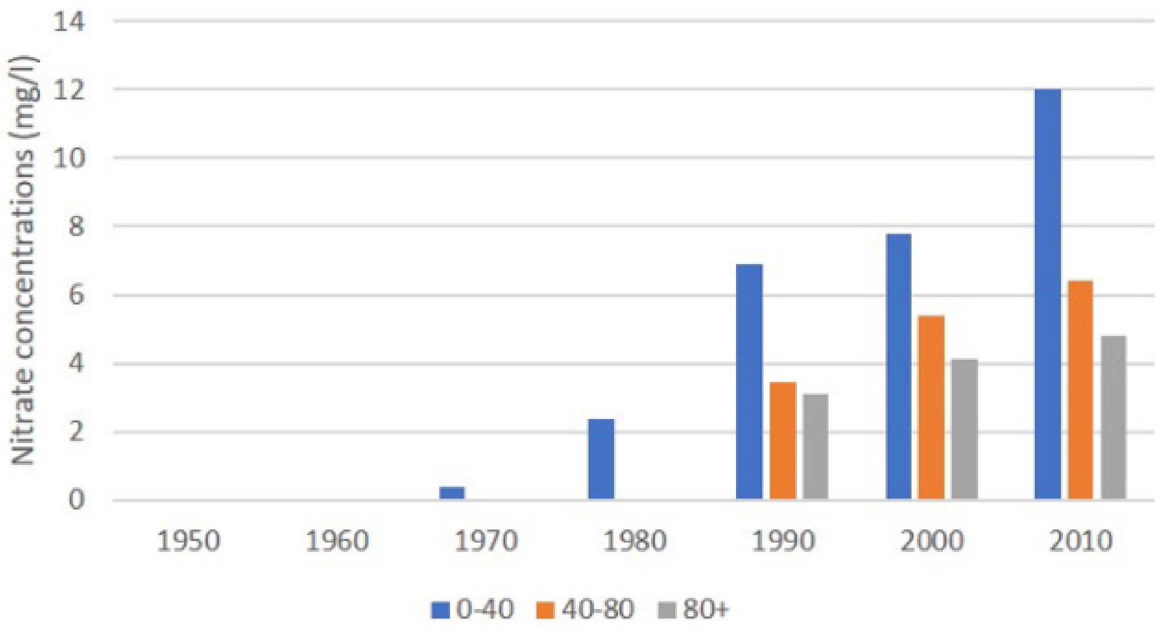
The Consents team welcome aboard Deanna Watson, who joined the company as a graduate in December.

In Other Areas of Aqualinc:

- At the end of last year, we were contracted to download shallow GW monitoring data for Christchurch City Council after the Earthquake Commission gifted the network to the council. The dataset offers an opportunity to investigate responses and processes in shallow groundwater and is an unprecedented dataset, both nationally and globally. Aqualinc have been working with EQC, GNS and the University of Canterbury (including the Waterways Centre) to start to investigate the data.
- We have had ongoing involvement in Raukōkore, where the Provincial Growth Fund is investing in water storage and distribution to support high-value horticultural development.
- Our research on water allocation frameworks has been incorporated into the water management section of the Marlborough Environment Plan, which was released in February following a hearing process.
- What happens in a catchment around a lake is extremely important to the water quality within a lake and we have used SWAT+ to model the Lake Waikare catchment for the Waikato Regional Council. SWAT+ is a completely revised version of the Soil and Water Assessment Tool (SWAT) and provides a more flexible spatial representation of interactions and processes within a catchment. The latest version of SWAT+ allows for lakes to be included as shapefiles in catchment delineation and deals with the issues that can arise with how water flows are routed into and out of lakes. Aqualinc wish to acknowledge Chris George, SWAT+ software engineer, for assistance and for trialling his beta version of SWAT+.

Nitrates Science Fair Project

Science Fairs are a means of encouraging high school students to take on a scientific project, carry out an experiment/assessment, and present the results, in person, to a number of judges. Katherine Rutter (daughter of Helen), carried out an assessment of nitrate trends and patterns in Canterbury, using all available data (rather than just long time series), and presented it at a science fair. Whilst the project drew a huge amount of interest from the judges, she didn't get a prize as there was no experiment, but simply an analysis of data. Ultimately, this spurred the Rutters into writing a paper that has just been published in the NZ Journal of Hydrology. linkedin.com/pulse/nitrates-canterbury-nz-groundwater-helen-rutter/?trackingId=yGSv9I31jQgSAHWeUGJrEA%3D%3D Whilst a good result overall, it does raise the philosophical issue as to what constitutes science. In this case, the project explored data that had previously had little attention, and started to draw conclusions (and questions) about what was driving nitrate-nitrogen concentration changes with depth, time, and by zone. The work highlighted the increase in nitrate concentrations before the start of dairying, the differences between zones, and the fact that nitrates can migrate to depth rapidly. It reinforces the need to better understand the ways in which nitrates are transported through the Canterbury gravel aquifers, and the need for a better understanding of the potential "Load to come". The work has been presented to the Ashburton Zone committee and to ECan, with interest from other zone committees and drinking water experts.



Increase in nitrate-N (mg/l), summarised by depth and by decade for the Ashburton zone

Additionally, Aqualinc is now on IRD's approved research provider list. This makes it easier for businesses that we work with to claim the 15% tax incentive on qualifying R&D work that we complete.

Finally, we would like to say congratulations to **Amanda Brown** and **Ayaka Narita**, both of whom have new baby boys, and are currently on maternity leave.

UPDATE

James Griffiths, NIWA Christchurch

NIWA

Despite the operational impacts of COVID-19, NIWA hydrologists are continuing to keep themselves busy by digging into their research archives for publishable material and continuing to push forward non-field-based research and consulting from their home environments. With the transition to Alert Level 3, however, we are looking forward to getting our Autumn / Winter field plans underway where possible. The following are a few highlights from the last 6 months (mostly pre-COVID days) of hydrology at NIWA.

Hillslope Project – Field Day

NIWA's collaboration with Environment Canterbury, Plant & Food Research and Lincoln University, on quantifying irrigation and recharge in irrigated hillslope loess soils, continued when 25 people attended a field day at which NIWA scientists MS Srinivasan and Channa Rajanayaka (see photo) talked about on-farm instrumentation and model development (LISEM: unsaturated zone, MODFLOW: groundwater). Data from the field site in south Canterbury will be used to develop and validate good management practice guidelines for operational farms, and for verification and refinement of models such as Overseer. Channa and MS were assisted by Julie Wan, a science teacher from Lincoln Primary School who is seconded to NIWA as part of the Royal Society's Science Leadership Programme. [MS Srinivasan, Channa Rajanayaka, Jim Griffiths]

***Photo credit:** MS Srinivasan, NIWA*

***Photo credit:** Channa Rajanayaka, NIWA Collaborations in India and China*

Collaborations in India and China

Shailesh Singh visited Tianjin University, China (under a Royal Society Catalyst Leaders grant) with the purpose of developing more cost-effective, sensor-based irrigation methods to achieve better economic and environmental outcomes. The resulting research will be used to develop a proto-type tool for optimising the number of soil moisture sensors required per farm unit for irrigation. The project will support an evidence-based approach for long-term sustainable water supply and demand management. Shailesh also represented NIWA at a workshop on water availability and its impact on water quality at the Indian Institute of Technology, ISM Dhanbad (IIT-ISM). IIT-ISM is in the process of transforming Dhanbad into an environmentally smart city and presentations were given on hydrological modelling for quantifying water availability. [Shailesh Singh]

Flood Monitoring and Early Warning System

In February, NIWA completed an inception mission to Samoa to discuss development of a flood monitoring and early warning system for the Vaisigano Catchment (Apia), with the Ministry of Natural Resources and Environment. The work is a component of the Samoa Green Climate Fund (GCF) project and involves the delivery of automatic rainfall and river level/flow gauges, development of rainfall and water level forecast and observations-based thresholds, associated impacts-based scenarios for selected flood scenarios, and integration into a flood decision support system. The weather was suitably wet as the photo of downtown Apia illustrates (see below). [Shaun Williams, Graham Elley, Bernard Miville, Jim Griffiths and Mike O'Driscoll]

Photo credit: *Shaun Williams*

Auckland Flood Frequency Study

NIWA have completed a study to provide extreme value frequency analyses of all the available flood peak records for Auckland streams. It covered 65 records with lengths ranging from less than one year to 53 years. One key result was that, of the candidate distributions for flood frequency analysis, the two-parameter extreme value type 1 (or Gumbel) distribution is recommended for prediction of design floods. Another part of the study that compared pre-2000 data with post-2000 data found (in some cases) a tendency for higher floods in the earlier interval; the reasons for this apparent difference should be further investigated using longer Auckland rainfall series. The results will provide essential design parameters for infrastructure projects valued at many millions of dollars. [Alistair McKerchar]

Irrigation Insight

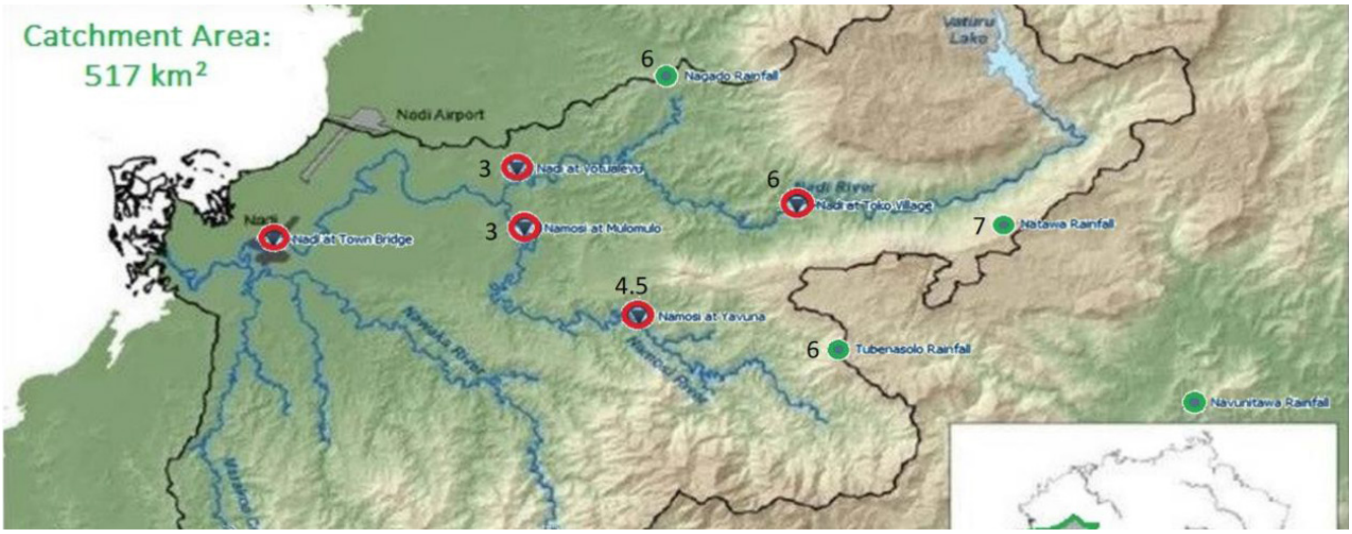
NIWA's MBIE-funded Irrigation Insight programme (2016-21) has now developed three tools to support on-farm irrigation practices: a strategy tool to help farmers understand the limitations and benefits of their current irrigation allocation, supply reliability, soil water holding capacities, scheduling practices and infrastructure; a scheduling tool that helps farmers visualise irrigation and drainage impacts by combining current weather and soil moisture conditions and forecast rainfall; and an operational App-based mobile soil moisture sensor that helps farmers to understand the soil moisture variability across their farms and get a 6-day soil moisture forecast anywhere on-farm. [MS Srinivasan, Graham Elley, Alex Fear, Richard Measures, Paula Blackett, Jordan Luttrell, Stephen Fitzherbert, Trevor Carey-Smith, Murray Kinsman]

Declining Groundwater Table

To better understand the mechanics of a declining groundwater table over the past two decades in the Edendale groundwater system, the groundwater team at NIWA has been contracted by Environment Southland to conduct research to answer the question "What is the main driving force to the declining groundwater table in the Edendale area, climate change or groundwater abstraction?" This research was conducted by combining a statistical method and physically based modelling method. In the statistical method, the relationship between precipitation, groundwater abstraction, and groundwater levels over the past two decades were analysed and the contributions from decreasing precipitation, land surface recharge and increasing groundwater abstraction were quantified. In the physically based method, a groundwater model (MODFLOW) was coupled with a hydrological model (TopNet) to simulate the groundwater flow. Two scenarios, a natural scenario (no abstraction) and current water allocation scenario were also assessed using this coupled groundwater and hydrological model. [Jing Yang, Channa Rajanayaka, Christian Zammit].

Fiji Airport Flood Study

As part of the UN WMO Coastal Inundation Forecasting Demonstration Project, and in conjunction with Fiji Met. Service (FMS), NIWA has developed and delivered a flood warning system for coastal and floodplain inundation in Nadi, Fiji. The system uses data from hydrometric sites operated by FMS and supported by NIWA. The alert system combines information from rain, river and sea level gauges and incorporates tide forecasts to indicate when inundation is imminent. The alert lead time depends on the timing of forecast rainfall, the flood travel time from inland catchments to the Nadi coastal plain and sea level conditions. The project was supported by Korean Government funds. [Graeme Smart, Murray Kinsman, Cyprien Bosserelle]



Calculation of approximate flood travel times (hours) to Nadi Town Bridge (Fiji).

Meeting Otago Challenges

Roddy Henderson continues to work with ORC hydrologists and planners to dig into interesting hydrological questions in some of their more complex catchments. As part of the project Roddy Henderson is working on acquiring meta-data about flow records and their suitability for various forms of analysis, from general water resources to low flows and floods. This includes an attempt at a national assessment of the degree to which flow records may be affected by upstream operations such as storage management and abstraction or diversion. [Roddy Henderson]

Uncertainty Quantification in Australia

Jing Yang was invited to an Uncertainty Quantification (UQ) workshop in Canberra, Australia organised by the Mathematical Sciences Institute of The Australian National University in November 2019. With over 30 participants from more than 7 countries, talks focused on both algorithm development and applications of UQ in areas ranging from aerospace, material and electrical engineering to environmental science. The workshop focused on various issues surrounding high-dimensional parameter spaces, multi-fidelity modelling, parameter inference, optimal experimental design and design under uncertainty. Jing presented a talk on uncertainty analysis for hydrological modelling and it was well received. [Jing Yang, Channa Rajanayaka]

Staff Movements

Dr Matt Wilkins, a mathematician, statistician and software developer formerly of Massey University, has joined the Hydrological Processes group in Christchurch. Matt's first task is to work on multiple GUIs related to the roll-out of the New Zealand Water Model (NZWaM). Matt is also a keen pilot and wood-worker so should dovetail nicely into working at NIWA.

UPDATE

Conny Tschritter

GNS Science Hydrogeology Group

Hawke's Bay 3D Aquifer Mapping Project: SkyTEM Data Collection Completed

GNS Science (GNS) and Hawke's Bay Regional Council (HBRC) have partnered on the largest scale groundwater mapping project ever undertaken within New Zealand. The collection of skyTEM data (airborne Transient Electromagnetic data) was undertaken during 19 January – 8 February by skyTEM Australia. Weather conditions were ideal and data collection was completed two weeks ahead of schedule. Approximately 8000 km of data profiles were collected, with samples taken every ~11 m over the Heretaunga Plains, Ruataniwha Plains, and Otane and Poukawa Basins (Figure 1).

This is the first major milestone in a three-year project (Sept 2019 – Dec 2022) that is jointly funded by the Provincial Growth Fund, HBRC and GNS. The next milestone includes the planning of additional data collection to support the skyTEM data interpretations. GNS will be working on the processing and inversion of the electromagnetic dataset, as well as subsequent hydrogeological interpretations and applications utilising the data.

More information can be found at hbrc.govt.nz/hawkes-bay/projects/3d-aquifer-mapping-project/. Please get in touch with GNS project leader Zara Rawlinson with any enquiries.

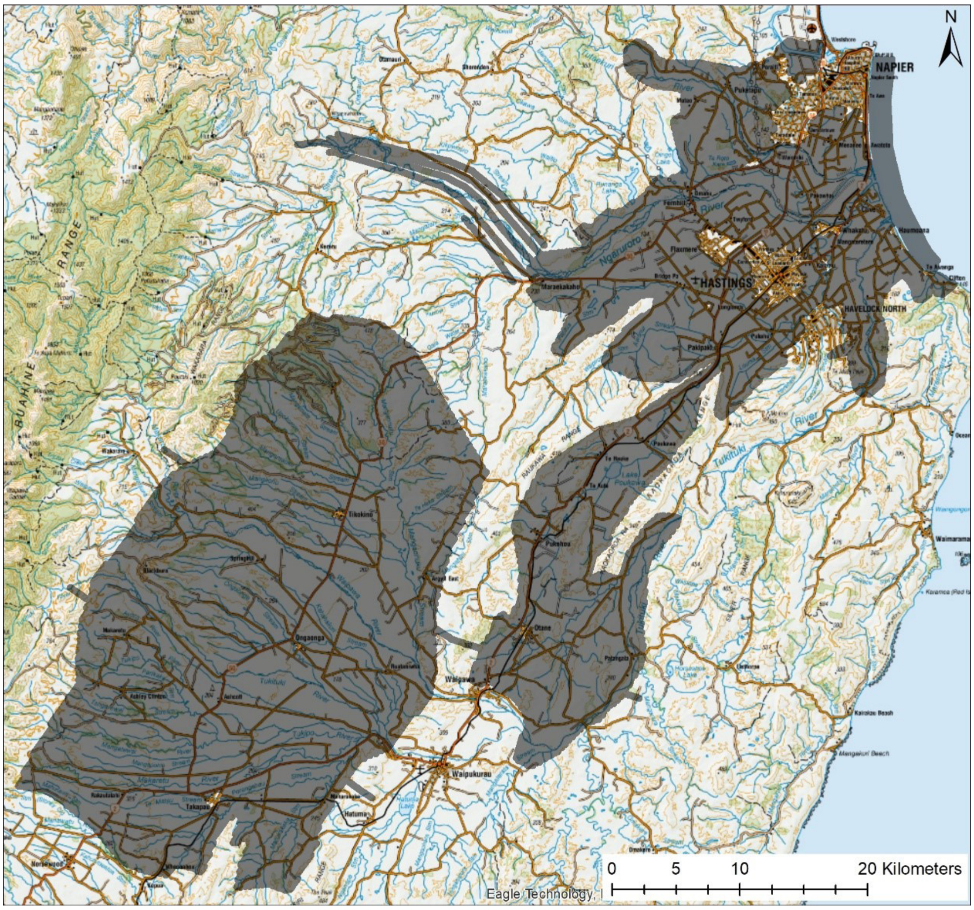


Figure 1: *HBRC skyTEM data coverage.*

Rapid Exploration of Land-Use Change Scenarios Impacts

Stochastic impulse response emulation (SIRE) and optimisation under uncertainty (OUU) have been undertaken through the Smart Aquifer Management (SAM) Endeavour programme and the GNS Groundwater SSIF research programme (Figure 2). These groundwater flow and transport modelling techniques allow rapid exploration of land-use change impacts on key ecological and societal constraints (e.g. stream nitrate concentration) and facilitate land-use optimisation (e.g. to maximise yield, while honouring ecological and societal constraints). Critically, the application of such decision-support modelling techniques incorporates model uncertainty quantification and accommodates the uncertainty (risk) tolerance of managers. Applications of these methods have been demonstrated in Hauraki Plains, Waikato and an illustrative synthetic catchment. The work was published earlier this year in the following peer-reviewed journal papers:

- White J.T., Knowling M.J., Fienen M.N., Feinstein D.T., McDonald G.W., Moore C.R.
  A non-intrusive approach for efficient stochastic emulation and optimization of model-based nitrate-loading management decision support
  Environmental Modelling and Software, Volume 126, 2020
- Knowling M.J., White J.T., McDonald G.W., Kim J.-H., Moore C.R., Hemmings B.
  Disentangling environmental and economic contributions to hydro-economic model output uncertainty: An example in the context of land-use change impact assessment
  Environmental Modelling and Software, Volume 127, 2020 [Open Access]

Please get in touch with Brioch Hemmings with any enquiries.

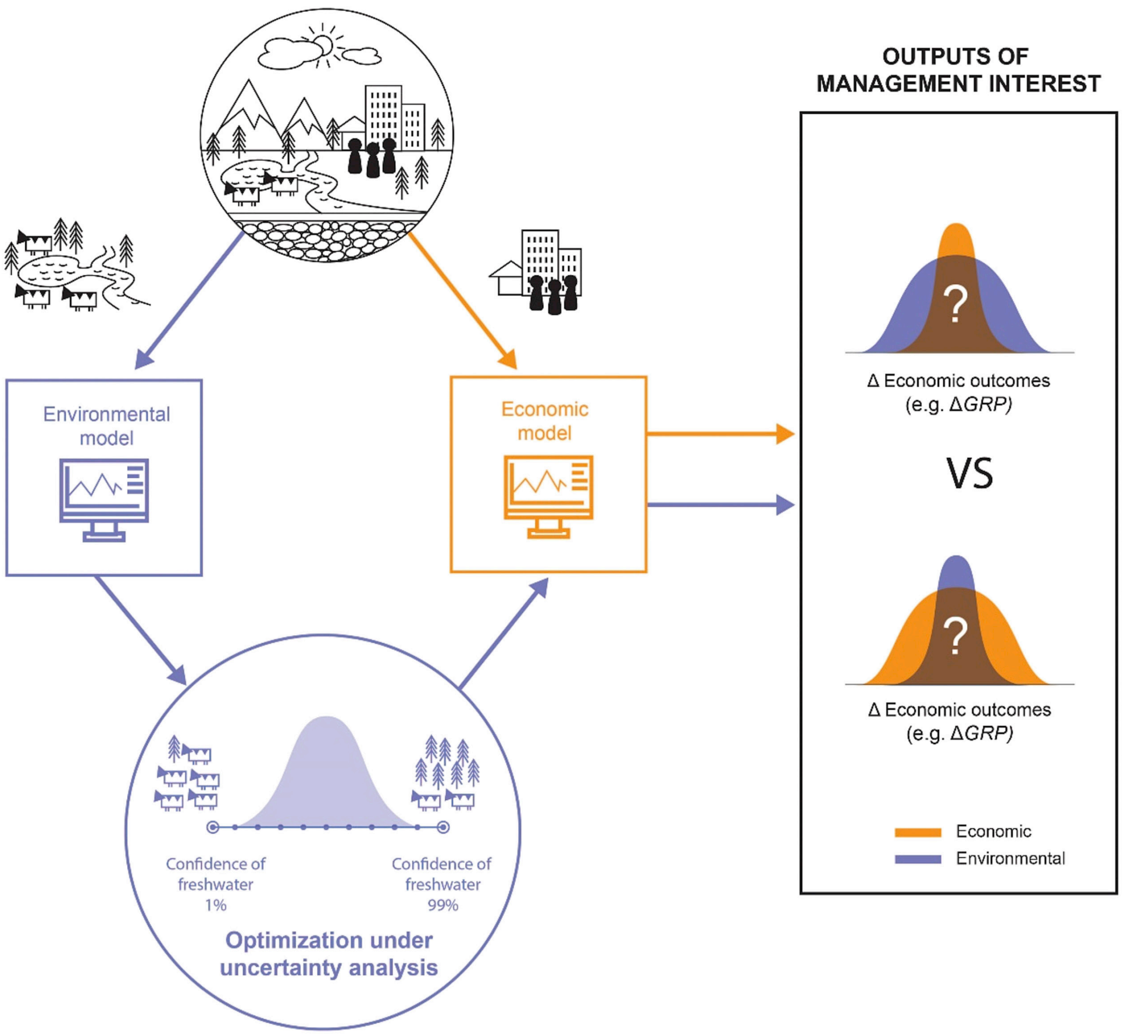


Figure 2: *Schematic of the workflow adopted to quantify environmental and economic uncertainty contributions to hydro-economic model outputs of interest. contributions to hydro-economic model outputs of interest.*

Iwi-led Science: Development of Kaitiaki Flows in Baseflow-Dominated Stream Systems

A 'kaitiaki' flow regime for Awahou Stream in the Lake Rotorua catchment, Bay of Plenty Region, was identified by Ngāti Rangiwewehi and GNS using a mixture of hydrological science and wānanga. Three hui were completed and served as the primary iwi reference for development of this regime. This regime is a new concept to water resource management as it was developed by iwi to meet iwi criteria in the spring-fed, baseflow-dominated Awahou Stream. The flow regime now forms a part of the co-management arrangement between Ngāti Rangiwewehi and Rotorua Lakes Council for the municipal drinking water supply consent from Awahou Stream. This regime plans for improved Awahou Stream flow monitoring with real-time data collection and modern data access systems.

Potentially, the kaitiaki flow method could be applied by any iwi who need to understand their water resources and could be recognised as one of the methods to define minimum flow regimes in streams (e.g., Ministry for the Environment. 2020). The project has received several awards: 'best oral paper' from the 2018 NZ Hydrological Society and Meteorological Society of NZ Joint Conference, and 'gold' status from MBIE. Gina Mohi (Ngāti Rangiwewehi) won the Rural Category in the 'Women of Influence Awards' for her work in this project. The project produced the following outputs:

White PA, Bidois L, Mohi G, Tschritter C, McGrath W. [Accepted]. Derivation of Kaitiaki flow in the Awahou Spring complex. Journal of Hydrology (New Zealand).

White PA, Bidois L-A, Mohi G, Tschritter C. 2018. Kaitiaki flows: iwi-led science to identify spring-fed stream management regimes, Awahou Stream, Rotorua. NZ Hydrological Society and Meteorological Society of NZ Joint Conference handbook: "the hydrological cycle in changing times": 4–7 December 2018, Christchurch. Vol 1. Wellington (NZ): New Zealand Hydrological Society. p. 123–124.

Please get in touch with Paul White with any enquiries.

References

Ministry for the Environment. 2020. Draft guidelines for the selection of methods to determine ecological flows and water levels. mfe.govt.nz/publications/fresh-water/draft-guidelines-selection-methods-determine-ecological-flows-and-water-10

Multi-Objective Groundwater Chemistry Sampling in Four Regions

GNS worked alongside Tasman District Council (TDC), West Coast Regional Council (WCRC), Gisborne District Council (GDC) and HBRC staff to wrap up valuable sampling fieldwork for groundwater chemistry, age tracers and environmental isotopes in both the North and South islands just before lockdown. The samples are now being processed as analytical laboratories reopened under Level 3. The three trips yielded 65 samples from springs and wells, including five samples collected south of Ross, which was a first for GNS and WCRC (Photo 1). When fully analysed and incorporated into models, this new data will help significantly in understanding groundwater systems in these regions.

The aim of the fieldwork was two-fold: to improve the understanding of regional-scale groundwater pathways and, where possible, provide training for regional council staff for age tracer sampling.

Three GNS programmes will utilize these new data: the long-running National Groundwater Monitoring Programme (NGMP), the Groundwater SSIF National Tracer Survey (NTS), and the Endeavour programme Te Whakaheke o Te Wai (TWOTW). The latter project aims to develop a series of maps showing the source and flow patterns in New Zealand's 200 known aquifers and large river catchments to help improve the management of these water resources. GNS will be working to undertake similar sampling in other regions next year. Please get in touch with Magali Moreau (NGMP), Rob van der Raaij (NTS) or Uwe Morgenstern (TWOTW) with any enquiries.

It was the first time Groundwater Geochemist Magali Moreau had done fieldwork on the West Coast, and the strong gold mining history meant she found the occasional borehole that had been deepened because of gold-bearing sands.

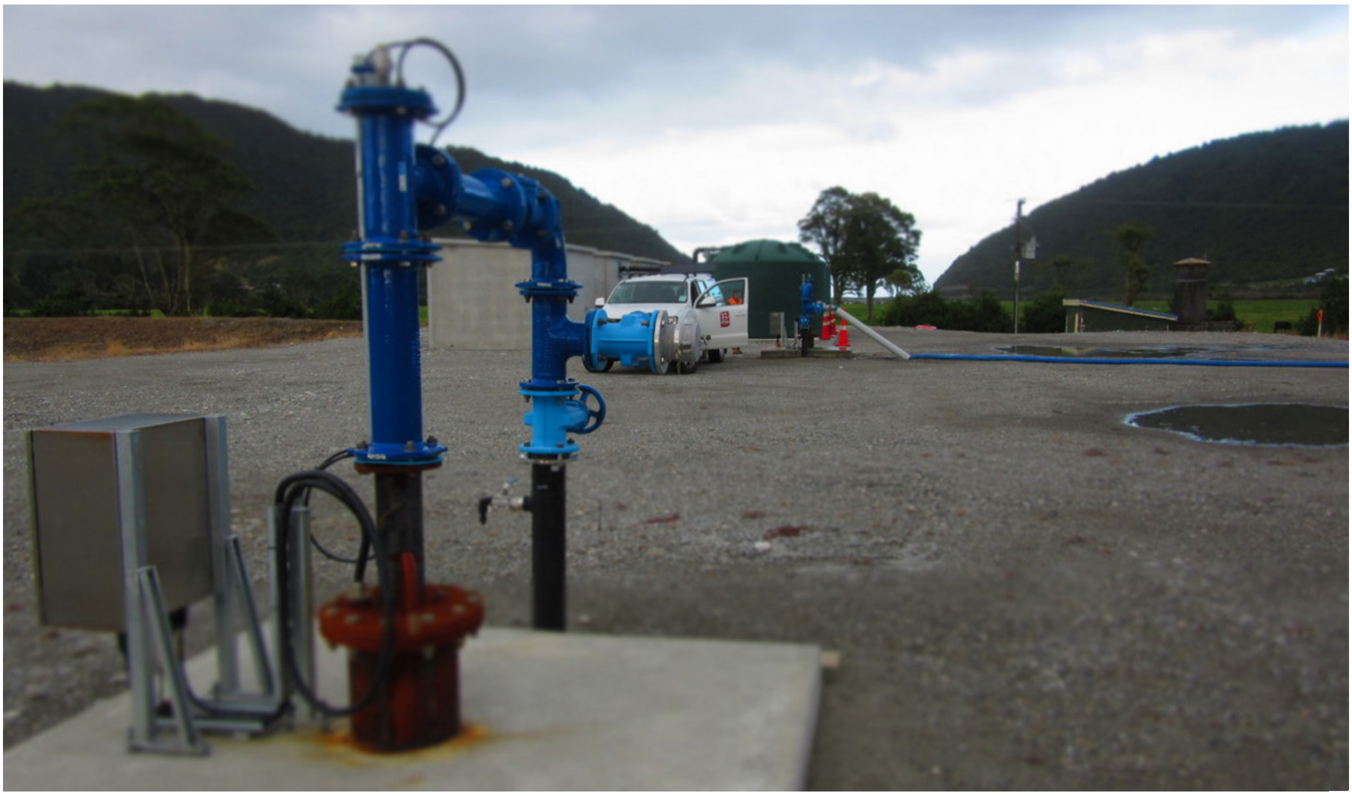


***Photo 1:** Collecting groundwater samples at Runanga, north of Greymouth.*

A Collaborative Satellite Data Workspace for Regional Councils

A GNS-led satellite data workshop, which was attended by approximately 50 people from regional councils and central government (13 RCs, DOC and MfE), took place on Tuesday 4 February at the University of Auckland (Photo 2). This was the first of four planned workshops for the MBIE Envirolink Tools project: 'A Collaborative Satellite Data Workspace for Regional Councils'. The workshop was hands-on with the attendants developing their own methods and scripts for satellite data processing and environmental applications through tailored tutorials in a classroom environment, assisted by experts from GNS, University of Auckland, Indufor, Manaaki Whenua Landcare Research and Xerra.

The 2-year Envirolink Tools project, led by GNS, has two aims: to develop a suite of standard processing methods that apply satellite data to identify and map land, soil, vegetation and inland water consistently across the regions; and to facilitate collaboration, and the exchange of knowledge, methods and scripts, between regional authorities. The suite employs the free Google Earth Engine cloud-computing service for satellite data processing, where code and applications are easily shareable between all regional councils. The next workshop will be in June 2020. More info: Rogier Westerhoff, Conny Tschritter or Frederika Mourot gns.cri.nz/Home/Our-Science/Environment-and-Climate/Groundwater/Research-Programmes/Envirolink-Tools-project.

Photo 2: *Workshop in progress at University of Auckland.*

Groundwater YouTube Video

An 'Introduction to groundwater' video was developed as part of the Groundwater SSIF Dynamic Groundwater Resource Behaviour and its Pressures project and is available on YouTube: youtube.com/watch?v=fqWmweBsDnA. The video explains the basics of groundwater flow and is aimed at the informed layman. Please get in touch with [Rogier Westerhoff]() with any enquiries.

BAU at GNS

Most of the staff were working from home during Level 4, and so its been business as usual for GNS, albeit not from the usual locations. Photo 3 shows a compilation of some of the work stations our people set up at home. Now under Level 2, our labs are back to being operational again.

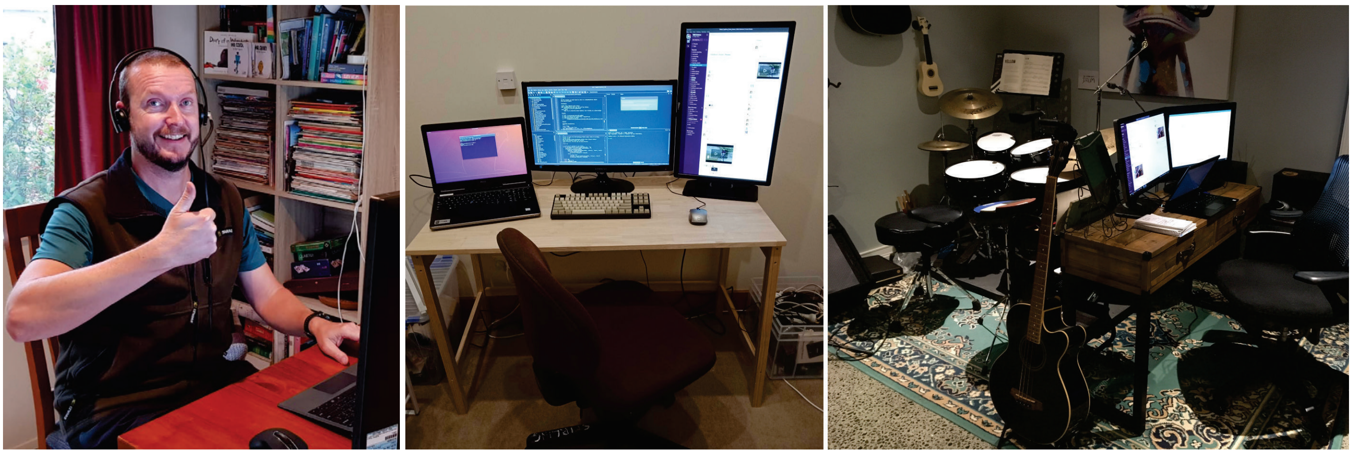


Photo 3: *Some office-at-home setups of the GNS groundwater staff: Rogier Westerhoff, Mike Taves and Zara Rawlinson*