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NEW ZEALAND HYDROLOGICAL SOCIETY
CURRENT NEWSLETTER

INSIDE THIS EDITION

MESSAGE FROM THE EXECUTIVE

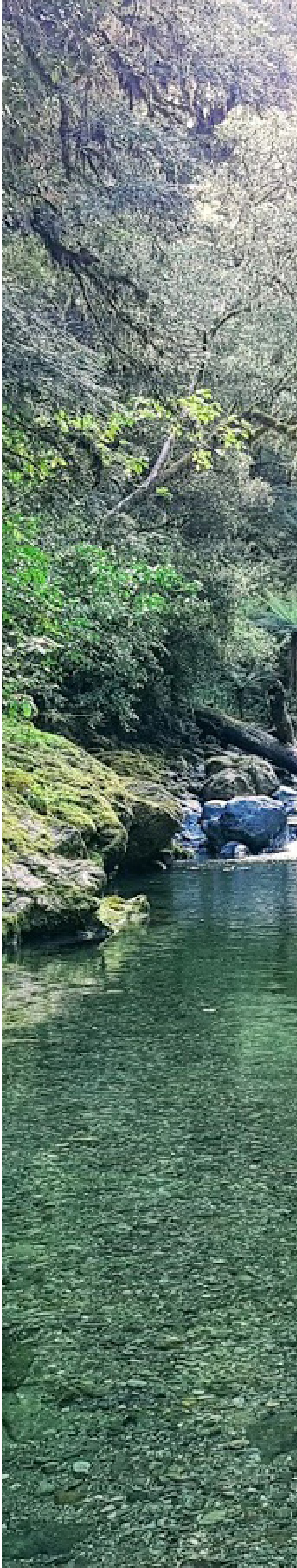
Dr Louise Weaver is senior scientist in ESR's Groundwater Team. She has been involved in a number of groundwater research projects that support both the Our Land and Water and the New Zealand's Biological Heritage National Science Challenges.

Her groundwater research is focused on identifying how land use, such as farming and waste disposal, affects groundwater quality. Her work frequently assists local councils and communities in developing strategies to reduce or eliminate contaminants in their water systems.

Louise is leading a team at ESR investigating microbial diversity in groundwater and how it can be used to assess groundwater health. The Groundwater Health Index project aims to identify the microbial and macroinvertebrate diversity that occurs in groundwater and develop a tool to identify the "health" of the aquifer from the diversity present. The long-term goal is an inexpensive and effective tool for assessing the health of groundwater systems.

As such, Louise was thrilled to be elected to the Executive Committee and is keen to make sure the Society supports and promotes the fantastic science the New Zealand hydrological community undertake. Louise is always impressed with the quality of the science presented at the annual conference and she is looking forward to seeing you all in December in Rotorua.

One of the roles Louise will play in the Executive Committee is assisting the society to get the most out of our affiliation with the Royal Society. Louise is also keen to promote young scientists on their journey into hydrological research.



Louise Weaver

Louise Weaver
Senior Scientist
ESR's Groundwater Team

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ARTICLES

Jeremy Bulleid (NIWA)

Automating Rising Bubble streamflow measurement with AI

Introduction

In the November 2018 and May 2019 issues of Current, we overviewed the Rising Bubble Method (RBM) of streamflow measurement and outlined our progress with the development and implementation of a practical RBM tool to improve the reliable measurement of water flowing in lowland weedy streams. This is part of an MBIE Envirolink Tools project we are carrying out in collaboration with several regional councils.

In principle we release 'precision' air bubbles from a streambed to enable direct calculation of Total Discharge. In this article we focus on automation. We have achieved partial automation, where we capture 5 seconds of video at a remote site, telemeter the file and detect surfacing bubbles in the images by eye. The diagram (figure 1) overviews the manual and automatic processes.

Total Discharge (Q) is calculated using

$Q = Vr * A$,

where Vr is the bubble rise velocity (measured in the Velocimeter – covered previously) and A is the displacement area on the water surface.

To determine area, we identify the surfacing location of each bubble. From this we measure the downstream displacement of each surfacing location, from its origin, and calculate the total displacement area defined by multiple injectors.

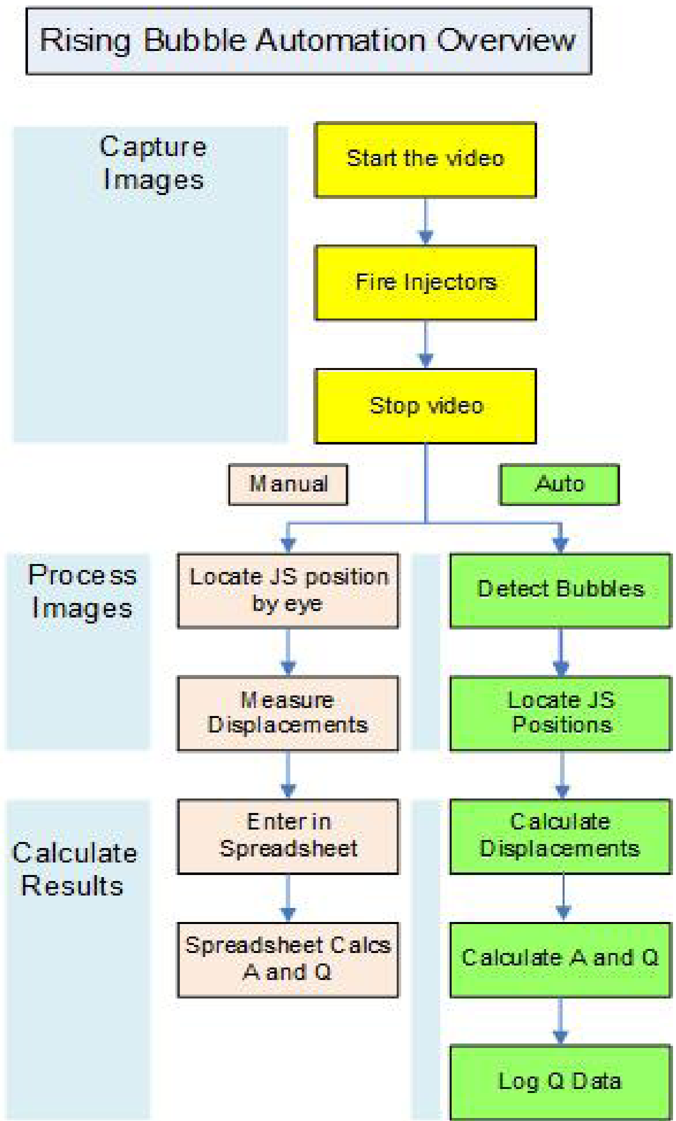


Figure 1: Manual and automatic processing.

Capturing the images

To capture images we've developed a controller that initiates a 300-frame video take, operates the air-valve that simultaneously fires each of the bubble injectors on the stream bed and stops the video after five seconds.

The video clip may be telemetered, from a remote site to the office, for manual processing or for QA verification. Alternatively, it may be processed automatically, on site, to output and log the results of successive Q measurements. Onsite automation minimises the amount of data (per measurement) that would need to be transferred – one Q value vs 300 0.3 MB image files.

Processing the images

We have developed a reliable bubble detector by creating a multi-layered Artificially-Intelligent Neural Network (NN) that detects surfaced bubbles. We chose Deep Learning (DL), a machine learning technique that does what comes naturally to humans - it learns by example. So, with DL we don't need to understand which features best represent the bubbles we're trying to detect – DL uses training images to extract these features for us. But this process requires literally hundreds of training and verification images. Here, video comes to the rescue, as it's easy to derive lots of labelled data from video taken of the water surface at bubble rise time.

Another reason for using DL is that, unlike conventional Machine Learning (ML) where features are manually extracted, if necessary, we can keep training with more, and more-diverse images. This strategy can facilitate development of a detector that is more robust and can give better results over a wider range of natural conditions. In contrast, where DL can go on learning indefinitely, ML (with manual feature extraction) will require a lot of human input and approach a precision 'ceiling'.

There are three stages in the AI process: creating the NN, training the NN to detect bubbles and creating/using the bubble detector.

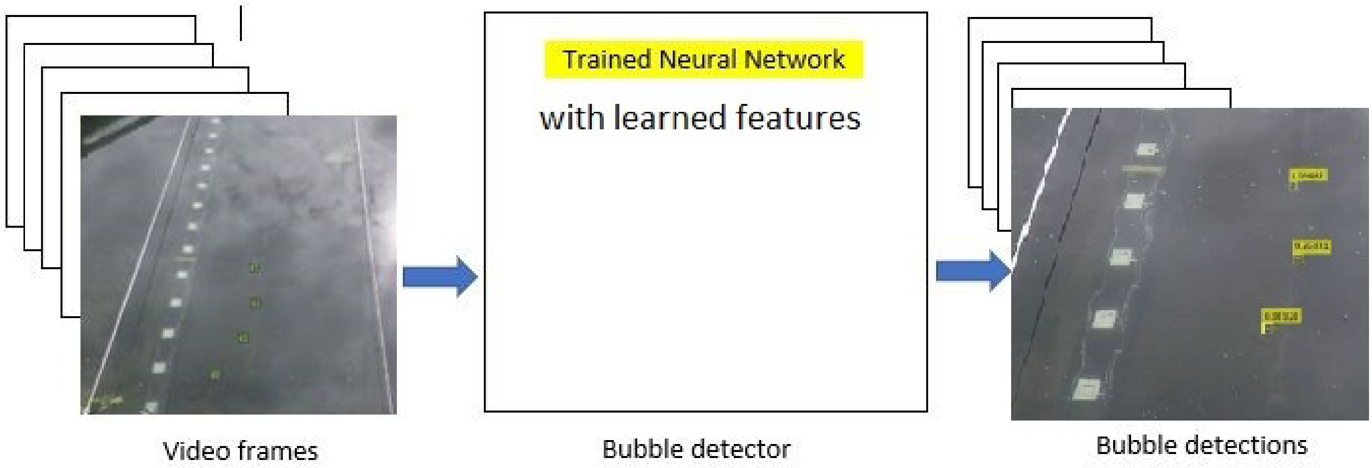


Figure 2: Using the trained bubble detector.

Because of the need for large training datasets, and hence long training times, we needed to exploit the power of a High-Performance Computing Facility (HPCF). Even with this extended capability it took over three days to train the neural network used to obtain the results below. Once trained, the detector software can be compiled into a relatively compact 'Q measurement' firmware application (app) and embedded into a small processor to enable 'stream-side' processing. In comparison to the long training process, the detector portion of the firmware works very fast (minutes), as it uses just enough features to uniquely identify its target.

Calculating the results

In the May 2019 issue of Current, we looked in detail at the results from flow measurements carried out at Raupare Stream in Hawkes Bay. We calculated these manually, by stepping through video frames, measuring bubble surfacing positions on-screen with a ruler and inserting these measurements into a processing spreadsheet. We now use these manual results to compare the automation results against. Figure 3 shows 'surfaced bubble' detections, by the deep learning network, in a single frame of video. The inset bubble image is an actual training image and exemplifies how little resolution is required to obtain valid detections.

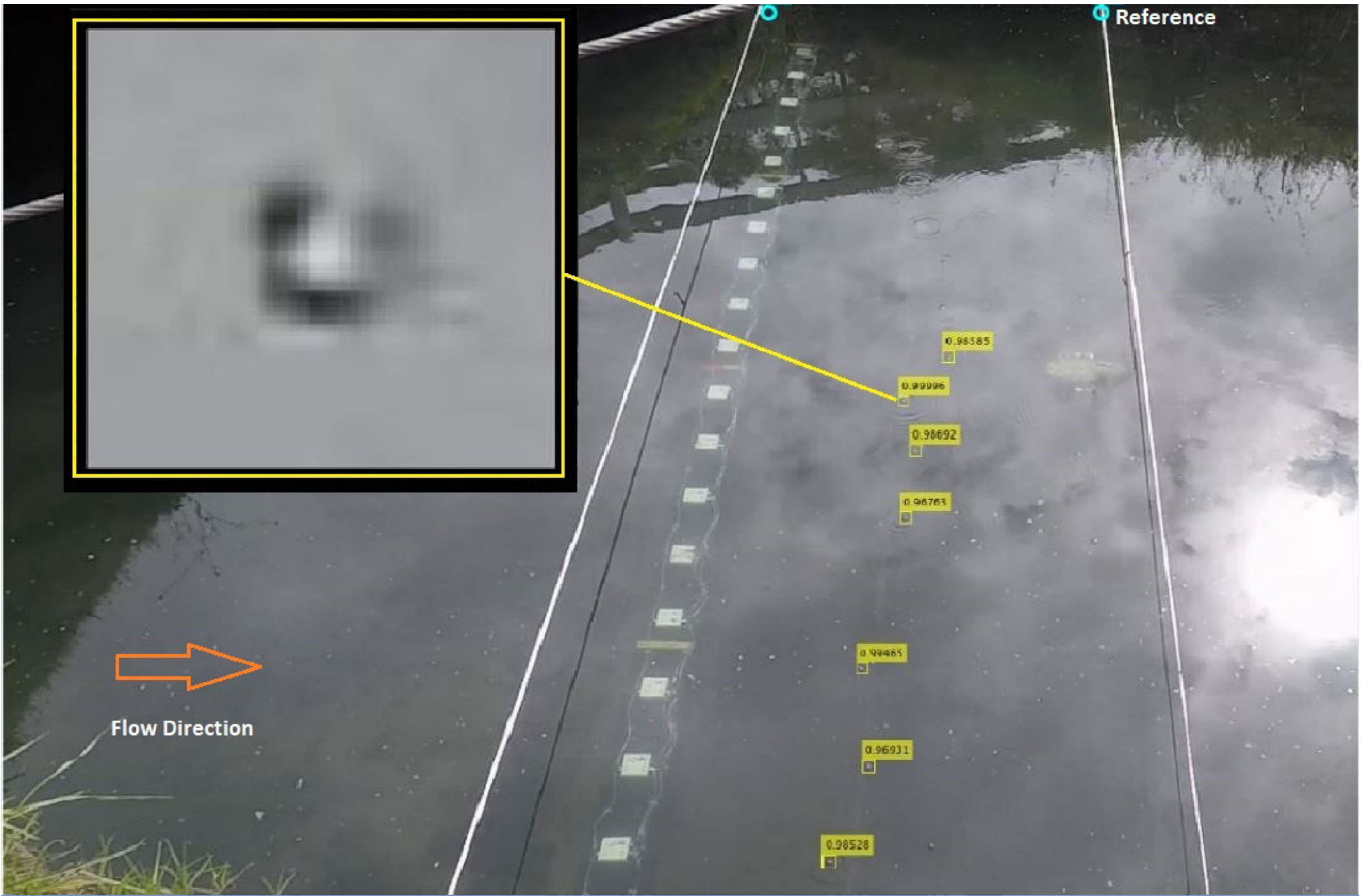


Figure 3: Raupare Stream; view from the Stilling-well Tower and is the location of the video shoot. This shows the detections obtained from a single frame of video. Each annotated bubble shows the detector's confidence in having achieved a correct detection.

There were 20 injectors spaced 0.2m apart. The injector images are refracted at the air/water boundary so, even though they are visible, we can't use their 'apparent' underwater positions for reference. All measurements are referenced to the plane of the water surface.

From the bubble surfacing displacements, the app calculates the 'just-surfaced' image position (in pixels) relative to the reference (SDR), converts it to true displacement (in metres) and calculates the partial area (pA) and partial discharge (q) contributed by each injector (Table 1). We limited this example to nine injectors.

Table 1

dischargeStruct

1x9 struct with 4 fields

Fields	SDR	TrueDispl	pA	q
1	[]	[]	[]	[]
2	0.3985	0.4901	0.0980	0.0215
3	0.4295	0.5283	0.1057	0.0232
4	0.4108	0.5053	0.1011	0.0222
5	[]	[]	[]	[]
6	0.5558	0.6836	0.1367	0.0300
7	0.4672	0.5747	0.1149	0.0252
8	0.5035	0.6193	0.1239	0.0272
9	[]	[]	[]	[]

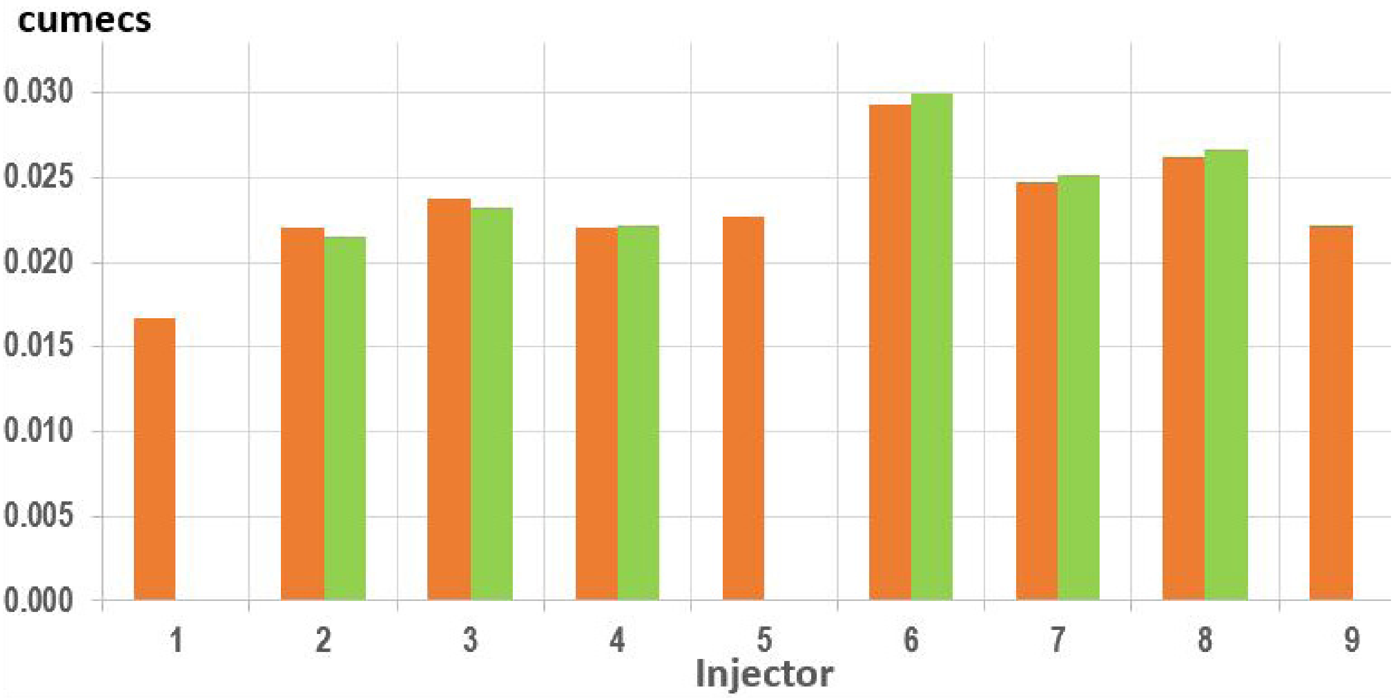


Figure 4: Verifying the automation process.

Verifying the automatic process

The bar graph in figure 4 shows the partial discharge calculated at injector positions one to nine. The results from the automatic calculations (green bars) are shown beside the reference values (orange bars). When the video was taken we were carrying out a 'three-point' FlowTracker gauging (0.482 cumecs). This took over half an hour. The manual RBM calculation was 0.462 cumecs, taken from a series of 10 'shots' at 1.7 second intervals.

Summing the six partial discharge values gave: manual 0.149 cumecs, and automatic 0.148 cumecs.

Conclusions

These initial results indicate that automatic operation is achievable. To obtain robust operation over a wide range of locations and conditions, much more training will be required. However, video for training purposes is easy to acquire and label.

The next stage will be to increase the diversity of the training, set up the prototype monitoring system at Raupare and carry out end-to-end trials.

In addition to calculating discharge, we can also calculate depth-integrated and surface velocities using the displacements and the time derived from the camera's frame count at 60 frames per second.

Acknowledgements

MBIE Envirolink for funding;

Thomas Wilding, Hawke's Bay Regional Council;

Andrew Starr, NIWA, for the design and construction of the control box;

NIWA, HBRC, ECan for their support.

ARTICLES

Daniel Marc G. dela Torre

My experience in the Australian Climate and Water Summer Institute

Doing a PhD or research masters is mostly an independent and, at times, solitary endeavour. As a doctoral student, I am mostly on my own when making major decisions about my study – problems such as my research questions, where to do my fieldwork, what models to use, and how to write my report (with my supervisor's support, of course!). I sometimes wonder how it's like working with a team and on a different problem.

I consider it a significant upskilling on my end to have participated in the Australian Climate and Water Summer Institute (SI). A six-week programme held annually in the Australian National University (ANU) in Canberra, the Summer Institute is organised by the Australian Energy and Water Exchange Initiative (OzEWEX) with the goal to foster collaboration, data sharing, and inter-institutional engagements on climate, water, and energy cycles. Thanks to the Kees Toebes Scholarship Grant, early-career researchers from New Zealand are able to join the programme. I for one learned a lot from the SI, and I'd like to share why you too should attend next year's Institute:

1. Exposure to new ideas

Over the first two weeks, the participants went through a 'boot camp' where we explored available climate- and water-related datasets from institutions such as Australia's Bureau of Meteorology, Murray-Darling Basin Authority, and Terrestrial Ecosystem Research Network. We also had a fascinating tour inside CSIRO and Geoscience Australia. As a remote sensing scientist myself, I was beyond thrilled to learn about exciting new developments in our field of research like Digital Earth Australia. The lectures broadened our minds on available data that we could use for research and how we can contribute to existing knowledge.

2. Opportunity to work as a team

The following four weeks were dedicated to participants collaborating on research projects in groups of two to four. An interesting array of research projects arose, ranging from determining relationships between vegetation and fuel moisture content in Australia, to detecting algal blooms in the Murray-Darling, and measuring lake water content using satellites. On our own project, I got the chance to collaborate with researchers from ANU, Charles Darwin University, and James Cook University to study the use of machine learning algorithms to upscale flux tower measurements at the entire Australian continent. It was a great experience to work closely with others on a single project— I would say it is almost the total opposite of (or you could say a massive relief from doing) a solitary PhD journey! Understanding the voluminous data and developing neural networks in such a short period of time were no easy tasks but going through it as a team made it more doable and enjoyable.

3. Development of 'hard' and 'soft' skills

Our cohort was a diverse group - career- and skill-wise. A couple just finished their honours, some were masters students, while a few got their doctorates recently. It was a perfect opportunity for us to develop new skills and learn from each other. Many of us learned to program in another language like Python while others were exposed to new models to tinker with. We also had a great training from the Bureau of Meteorology on using their hydrological model, AWRA-L, and from Geoscience Australia, where we were taught how to access Digital Earth Australia. The National Computation

Infrastructure (NCI) allowed us to access Australia's supercomputer and their cloud computing capabilities. We also had the opportunity to present our research with posters and give a talk on our project at the OzEWEX workshop, which was held on January 31 to February 1, 2019. Working on a project with others not only helped me explore new technical skills but also developed my teamwork, communication, and time management abilities.

4. Broadening your network

A very important aspect for any young researcher, the SI is a unique opportunity to collaborate with other researchers and develop contacts within the region. We worked closely with partner organisations on topics with national and regional importance. Personally, the greatest highlight for me was gaining new friends and forging linkages for the future. The two-day workshop at SI's conclusion was an excellent way to get up to date on current issues facing climate and water resources in the region and to meet experts in the field. Finally, it wasn't all work... we had plenty of fun! We rode bikes around Lake Burley Griffin, climbed Australia's tallest peak, and went on a camping trip. There was heaps to do in and around Canberra.

I am very fortunate to have been part of the SI which would not have been possible without the scholarship from the New Zealand Hydrological Society. I am grateful as well to my supervisors for being supportive of my participation. I encourage more Aotearoa-based scholars to apply for this year's institute. It's worth it!

Daniel Marc dela Torre is a PhD Geography candidate in the University of Auckland working on crop yield modelling using remote sensing in light of climate change. You can follow him on Twitter @ DanOfTheTower.

1. Summer Institute fellows with ANU Prof. Albert van Dijk. (Credits: ANU)

2. Bike rides around Lake Burley Griffin.

3. At Mt. Kosciuszko, Australia's highest mountain. The breeze felt just like New Zealand! (Credits: James Milner)

ARTICLES

Hoa X. Pham and Jean-Charles Perquin, Northland Regional Council

Does Meteorological Drought Have Immediate Effect on Low Flow in Northland Rivers?

The Northland region has been experiencing a dramatic reduction in stream water level over the past year, and in particular low flow drought conditions. The most direct connection is likely to be between deficit rainfall and stream flow during both brief and prolonged dry periods.

The Northland meteorological drought tool well defines the degree of dryness (rainfall deficit) and the length of the dry periods. However, the gap remains in quantifying the impact of dryness on stream flow.

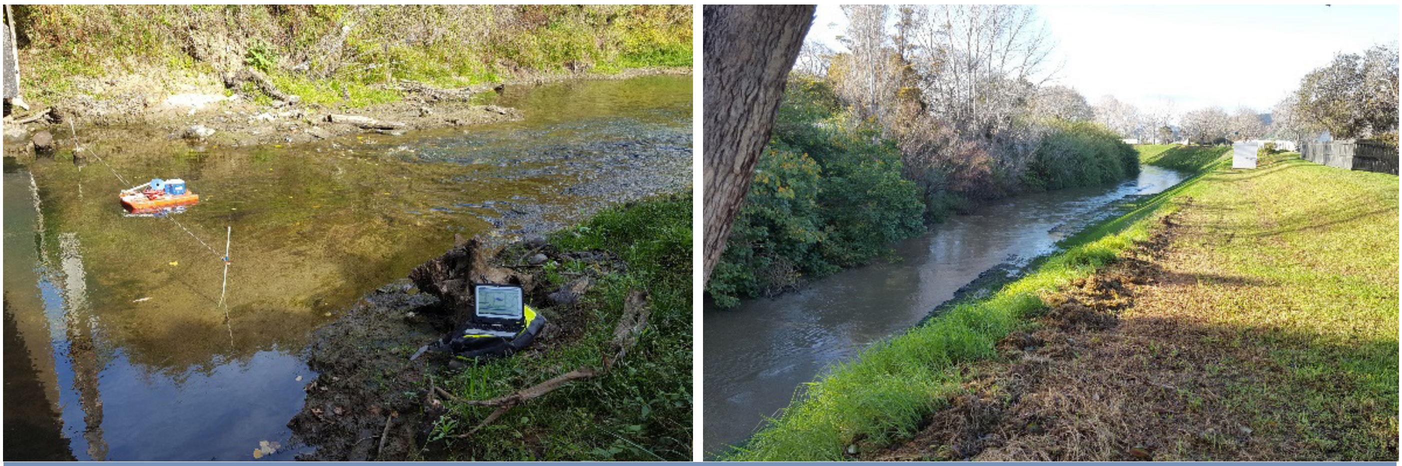


Figure 1 Awanui river at School Cut flow recorder site in May (left) and early June 2019 (right)

Aims

This study aims to investigate the best practice to identify drought events with reference to a particular flow site.

Specific objectives are:

- Investigate dry periods as well as the severity of these occurrences, and
- Examine the relationship between meteorological and hydrological droughts.

Methodology

Literature demonstrates that droughts cannot be simply characterised by a lack of precipitation via meteorological drought, especially when dealing with complex hydrological processes (Van Loon, 2015; McKee, Doesken, & Kleist, 1993; Wilhite & Glantz, 1985) (Figure 2). Hydrological drought is most often associated with low flow periods in rivers and low levels in lakes, reservoirs and groundwater resulting in lack of available water in the hydrological system (Nalbantis & Tsakiris, 2009). The Literature also reveals quantitative links in the arrival time and/or period between meteorological and hydrological droughts which can be estimated through drought indices (Tokarczyk, 2013; Ye Zhu, Wen Wang, Vijay P. Singh, & Liu, 2016).

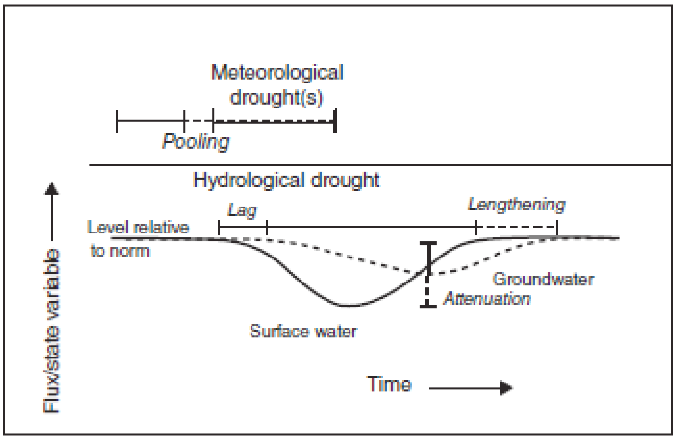


Figure 2 Features characterising the propagation of meteorological drought(s) to hydrological drought: pooling, lag, attenuation, and lengthening (Van Loon, 2015).

In this study, the Standardised Precipitation Index (SPI) and Standardised Discharge Index (SDI) as indicators of meteorological and hydrological droughts, respectively, were selected. Pearson's tests with different time delays were employed to examine the relationships between the two drought types, and linear regression equations were established where appropriate. Comparison of intensity and duration were also made between meteorological and hydrological droughts.

SPI and SDI allow comparisons to be made between current and historic drought events as well as among monitoring sites (WMO, 2012) which are computed using the equation below:

$$SPI_{ik} = \frac{R_{ik} - \overline{R_k}}{S_k}$$

$$i = 1,2, \ldots \quad k = 1,2,3,4,5,6$$

where: and is monthly mean rainfall/streamflow and its standard deviation for time step (k) for year (i).

Table 1 Drought classification

No drought	SPI/SDI > 0.0
Mild drought	-1.0 ≤ SPI/SDI < 0.0
Moderate drought	-1.5 ≤SPI/ SDI < -1.0
Severe drought	-2.0 ≤ SPI/SDI ≤ -1.5
Extreme drought	SPI/SDI < -2.0

Results

Daily rainfall and flow data were collected at 16 rain and flow gauges within seven small to medium sized catchments. SPI and SDI-1, 3, 6, 9 and 12 were computed for one, three, six, nine and twelve months, respectively.

The annual pattern of rainfall is similar for the investigated rain gauges. Rainfall is generally high in winter and low in summer seasons. The longest period of rainfall deficit occurs in summer months. Runoff regime for the investigated catchments is seasonally influenced with the lowest runoff also occurring during summer.

Conventionally, the main parameter used to define drought low flow is threshold discharge, which was adopted at 1-in-5-year 7-day low flow (Q5) and presented in Table 2. The number of days stream flows are under Q5 threshold differs from site to site, depending on catchment natural and artificial processes. Flows at selected gauges may or may not be representative for the catchments due to water abstraction, diversion, etc. In this traditional approach the mutual relationship between rainfall deficit and low flow is not explicitly explained.

Alternatively, the use of SPI and SDI indices can successfully quantify the duration and severity of meteorological and hydrological droughts. Figure 3 presents the variability of SPI and SDI for one month, SPI-1 and SDI-1, at all study sites. Table 3 shows the relationships between SPI and SDI which vary with different lag times. Significant correlations are found between SDI-1 and SPI-1 and gradually decrease for SPI-3, 6, 9 and 12. This would suggest that meteorological drought has immediate effect on the hydrological drought. These relationships are clearly demonstrated in Figure 5. A specific example is also represented in Table 4 and Figure 4 for Mangakahia catchment for current dryness. Figure 6 also reveals historical meteorological and hydrological droughts are similar in timing and pattern for Hatea.

Table 2 Summary on conventional drought low flows

Flow recorder sites	Start year	CA (km2)	Q5 (l/s)	Number of drought low flow days	Drought flow days (post-2009) ((%)
Maungaparerua at Tyrees	1967	11.1	23.2	313	35
Hatea at Whareora	1986	38.5	87	108	0
Mangakahia at Gorge	1964	246	1210	301	8
Ngunguru at Dugmores	1969	12.5	61	401	16
Opouteke at Suspension	1984	105	497	105	5
Waihoihoi at Marrys	1984	25.1	61	185	5
Whakapara at Cableway	1959	162	602	416	24
Awanui at School Cut	1958	222	472	301	37

Note: data used in this table is up to June 2019

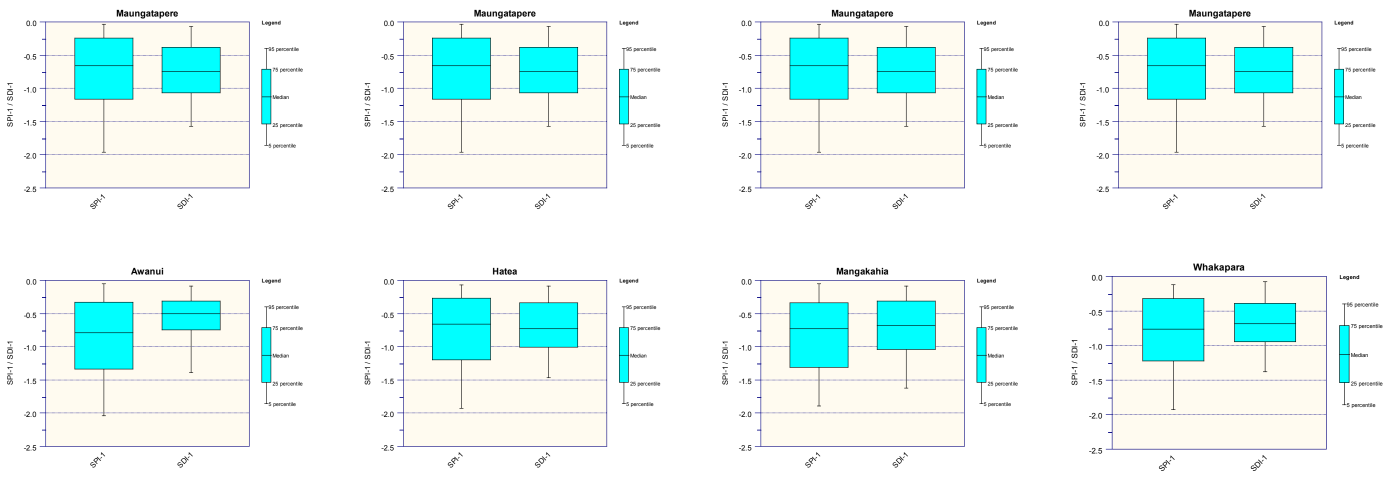


Figure 3 Variability of SPI-1 and SDI-1 during dry periods

Table 3 Correlation coefficients between SDI and SPI for different lag times

Flow recorder sites	Rain gauges	Catchment Area (km^2)				
		SPI(1)	SPI(3)	SPI(6)	SPI(9)	SPI(12)
Maungaparerua at Tyrees	Kaeo at Bramley	0.82	0.75	0.60	0.43	0.40
Hatea at Whareora	Hatea at Glenbervie	0.80	0.71	0.63	0.48	0.40
Mangakahia at Gorge	Mangakahia at Twin Bridge	0.82	0.61	0.49	0.41	0.36
Ngunguru at Dugmores	Ngunguru at Dugmores	0.73	0.72	0.66	0.53	0.23
Opouteke at Suspension	Opouteke at Brookvale	0.81	0.63	0.49	0.38	0.36
Waihoihoi at Marrys	Waihoihoi at Brynderwyn	0.78	0.65	0.46	0.41	0.35
Whakapara at Cableway	Whakapara at Puhipuhi	0.80	0.69	0.58	0.47	0.38
Awanui at School Cut	Kaitaia EWS	0.54	0.36	0.395	0.28	0.28

Note: Pearson's test was performed at 95% of confidence

Table 4 Linear regression equation developed for Mangakahia at Gorge

Mangakahia at Gorge	SDI (1) = -0.1 + 0.703 * SPI(1) + 0.247 * SPI(3) + 0.0416	$R^2 = 0.71$

Note: This equation may change with consideration of more variables and longer data time series

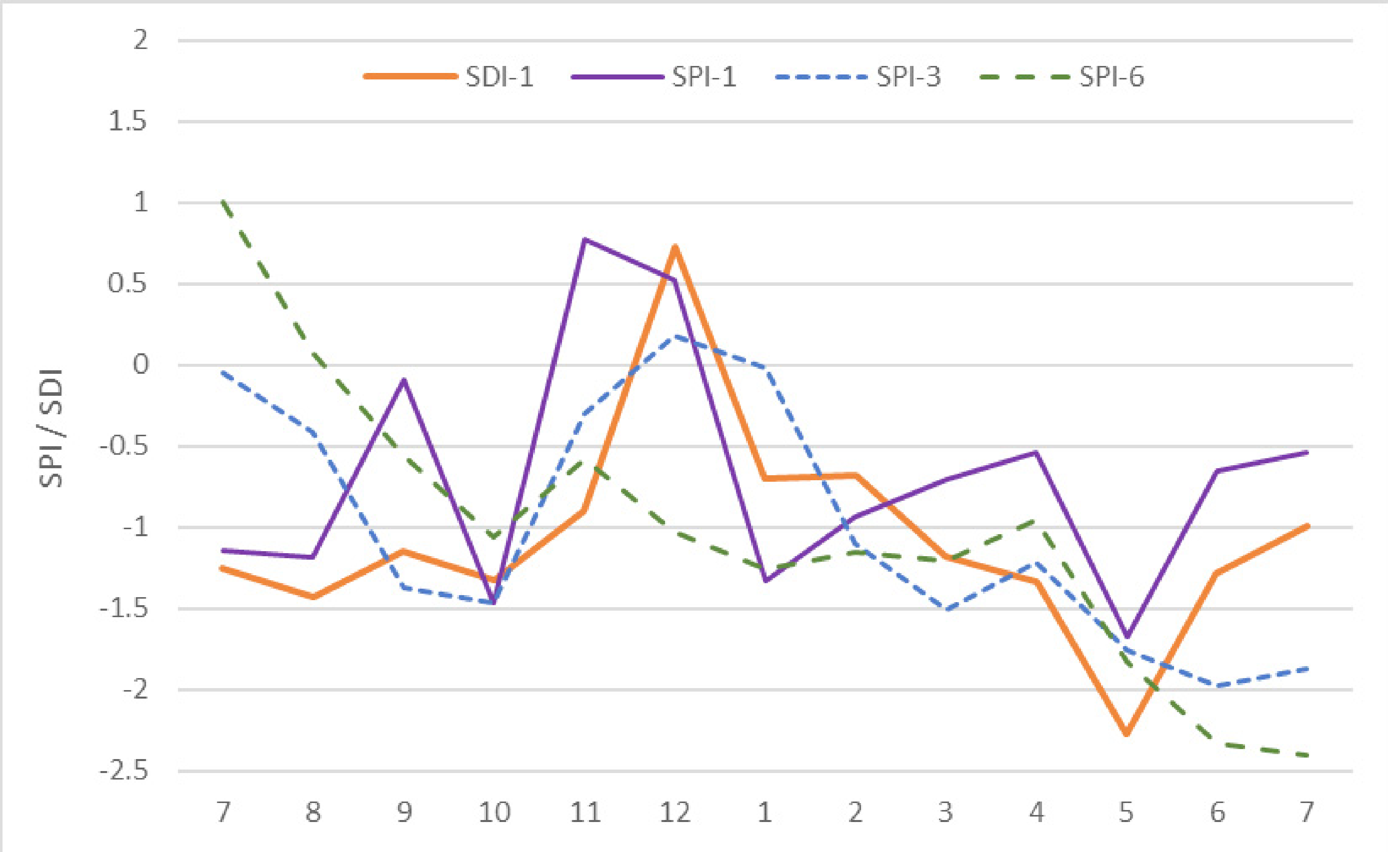


Figure 4 Relationships between SDI-1 and SPI-1-3-6 at Mangakahia during July 2018 – July 2019

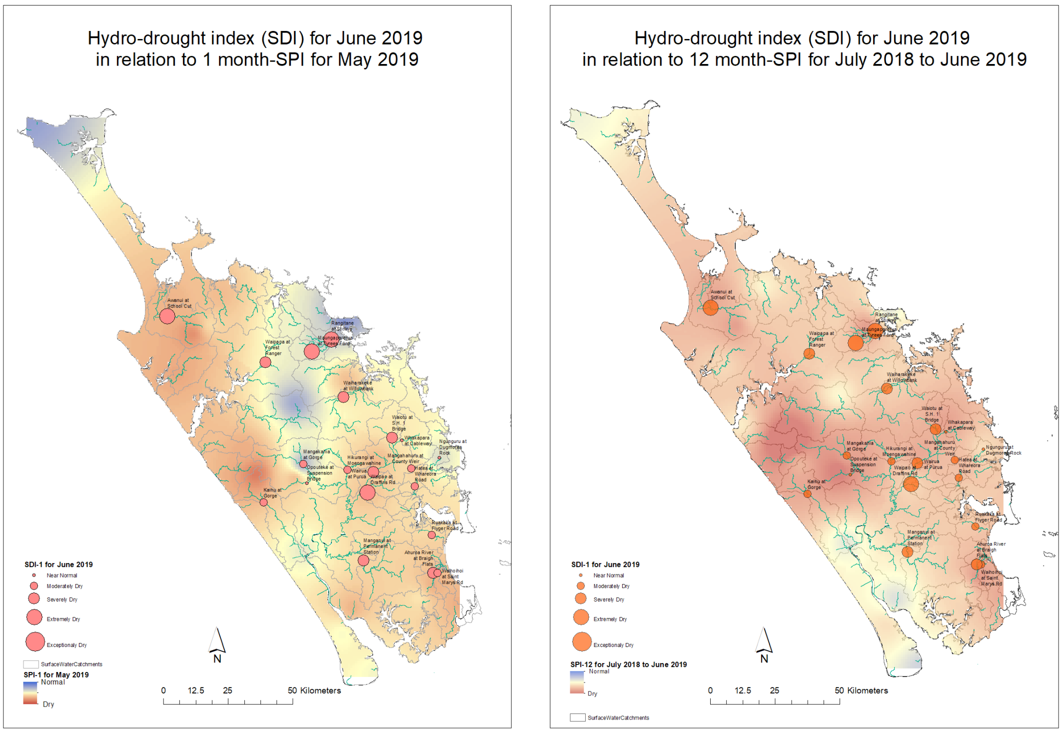


Figure 5 Spatial relationships between SDI-1 and SPI-1 (a, left) and between SDI-1 and SPI-12 (b, right)

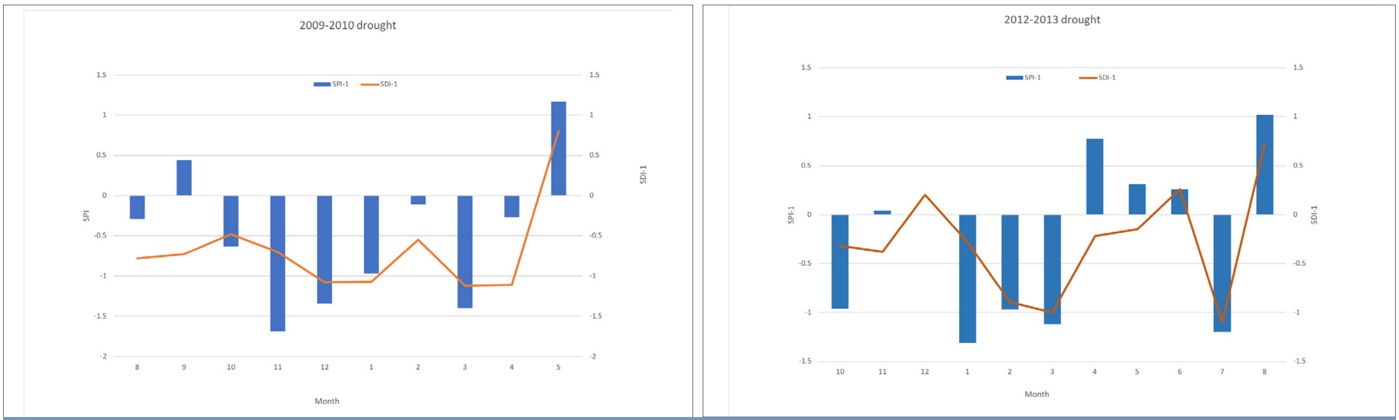


Figure 6 Relationships between SDI-1 and SPI-1 in Hatea catchment for historic drought events

In conclusion, the combined SPI and SDI is an effective practice for hydrological drought detection, the commencement and magnitude of a drought event, with reference to a flow gauge. This is proved for the investigated flow gauges.

Recommendations

For robust assessment of the impacts of meteorological drought on hydrological drought for Northland, the following further investigations are recommended:

1. to include a wider range of catchment in terms of catchment characteristics and activities;
2. to compute catchment areal rainfall instead of using only single-point data at rain gauges;
3. to verify the SPI-SDI relationships for drought magnitude using more historical drought events;
4. to establish the relationship between meteorological and hydrological drought duration based on SPI and SDI indices; and
5. to integrate results with evapotranspiration, soil moisture, groundwater and remote sensing-based indices.

Selected references

McKee, T. B., Doesken, N. J., & Kleist, J. (1993, 17-22 January 1993). The relationship of drought frequency and duration to time scales. Paper presented at the 8th Conference on Applied Climatology, Anaheim, California.

Nalbantis, I., & Tsakiris, G. (2009). Assessment of hydrological drought revisited. *Water Resour Manage*, *23*, 881-897.

Tokarczyk, T. (2013). Classification of low flow and hydrological drought for a river basin. *Acta Geophysica*, *61*(2), 404-421.

Van Loon, A. F. V. (2015). Hydrological drought explained. *WIREs Water*, 2, 359-392.

Wilhite, D. A., & Glantz, M. H. (1985). Understanding: the drought phenomenon: the role of definitions. *Water International*, *10*(3), 111-120.

WMO. (2012) Standardised Precipitation Index - User Guide. In Svoboda M., Hayes M., & W. D. (Series Ed.). *WMO-No. 1090*. Geneva.

Ye Zhu, Wen Wang, Vijay P. Singh, & Liu, Y. (2016). Combined use of metorological drought indices at multi-scales for improving hydrological drought detection. Science of the *Total Environment*, *571*, 1058-1068.

ARTICLES

Stephen Collins, PhD student, Massey University;
Groundwater Scientist, Horizons Regional Council

Water quality insights from Denmark

What the Danish experience in water quality management means for New Zealand

Edge-of-field mitigations such as constructed wetlands, bioreactors and saturated buffer zones feature heavily in the Danish agricultural landscape. They are part of a range of measures employed to reduce the nutrient load from farms to the Baltic Sea in the agriculturally intensive nation.

These are just some observations from my recent visit to the country. I was there to attend the 2019 Land Use & Water Quality conference in Aarhus, but also met with researchers from SEGES, Aarhus University and the Geological Society of Greenland and Denmark as part of my PhD study.

As an EU member, Denmark is committed to achieving a "good" ecological status for its water bodies under the EU's Water Framework Directive. A bit like New Zealand's National Policy Statement for Freshwater Management, it requires member states (regional councils in our case) to achieve ambitious goals for water quality.

Since the 1980s, a series of "action plans" have been implemented aimed at reducing nitrogen losses from farms to freshwater and the marine environment. These plans have been effective in reducing nitrogen losses by about 50% over 30 years, primarily from reduced fertiliser use. Whereas New Zealand has recently established regulatory systems based on farm outputs, Denmark broadly favours regulation based on managing farm inputs.

An extensive monitoring system makes assessment against these action plans possible. Not only are nutrient loads to the Baltic Sea calculated on an annual basis from stream-monitoring data, nutrient losses from agriculture are also modelled over the entire country, annually.

Denmark uses a modelling software called N-LES4, similar to OVERSEER® in New Zealand, to estimate losses from virtually every farm in the country. Farms are required to have nutrient budgets prepared and these are provided to government and research agencies every year to calculate national nutrient losses. Farmers handing over their data don't just do so through goodwill - in return they get agricultural subsidies that help make farming financially possible in the country.

Subsidies are also used in different ways. They fund the construction of wetlands and saturated buffer zones that help reduce nutrient losses from farms.

Research into constructed wetlands is progressing because of their effectiveness at reducing farm nutrients from drainage water. Because of Denmark's extensive post-glacial landscapes, much of the farming land requires drainage to make it productive. There are about 300,000 km of drainage pipes woven into Denmark's landscape, making it possible to direct drainage water from farms into a wetland before it is then discharged into drains and streams. These systems can be very effective at nutrient removal, with results typically showing about 30% of nitrogen and 50% of phosphorus is removed from drainage water.

The nature of pastoral farming is also very different from New Zealand farming. New Zealand takes pride in its grass-fed pastoral farming tradition, but with space and climate limitations in Denmark, most animal farming takes place indoors. We visited a typical dairy farm where cows are housed year-round in open sheds and advanced technology enables milking to take place by machines, not people. Effluent was able to be stored on site for up to nine months before it is irrigated.

Despite these promising steps for Denmark, a country about the same size as the Canterbury region, there is still a way to go before a "good" ecological status is reached. For example, in the Norsminde catchment, nitrogen still requires a reduction of about 70% to meet coastal water quality targets.

There is a belief the easiest gains have been made and further reductions will rely on understanding where in the landscape these mitigations or land-use policies will have the greatest effects for water quality improvements.

Denmark has a good grasp of its water quality through years of research and investment. But it still faces hard decisions about how it will achieve the rest of its water quality goals. The lesson for New Zealand is that we can't afford to play catch-up. We need to start making these hard decisions, now.

Stephen travelled to Denmark with financial assistance from the NZ Hydrological Society and the Royal Society Te Apārangi funded Catalyst Seeding project. Titled "targeted and effective water quality management", its aim is to share and advance science and policy tools between Denmark and New Zealand to manage nutrient flow pathways and attenuation in sensitive agricultural catchments. This project is led by Massey University in collaboration with Aarhus University, Denmark.

Fig 1: Arable farming in the Norsminde catchment, where nitrogen loads still need to reduce by about 70% to meet targets

Fig 2: Charlotte Kjægaard, of SEGES, shows us a constructed wetland and bioreactor at a farm in the Norsminde catchment

Fig 3: Indoor dairy farming in Odder, the collars on these cows enable them to be individually identified as they get milked

ARTICLES

Investigating how rivers flow in Minecraft compared to real life: engaging the next generation of hydrologists

This year, budding hydrologist Daisy Stockley (age 11) investigated how rivers flow in the computer game Minecraft compared to real life as part of the 2019 West Australian Science Talent Search (STS) competition.

ABOUT MINECRAFT: Minecraft has received critical acclaim and won numerous awards, and has been described as one of the most influential and greatest video games in history. Social media, parodies, adaptations, merchandise, and the MineCon convention played large roles in popularizing the game. It has also been used in educational environments, especially in the realm of computing systems, as virtual computers and hardware devices have been built in it. It is the single best-selling video game of all time, selling over 176 million copies across all platforms by late 2019, while having over 112 million monthly active players. SOURCE: WIKIPEDIA

Part of the inspiration for the project came from New Zealand, namely a two-year research project funded by the NZ National Science Challenge, where the Minecraft video game was used as a platform to recreate specific areas of their community and eventually collect, plot and analyse spatial data as well as simulate scenarios of disaster risk and resilience within the game environment.

ABOUT NZ NSC MINECRAFT PROGRAM: Year five and six students at Maraekakaho School in the Hawkes Bay region have been using the computer game Minecraft, and Lego bricks, to map their community. Researchers from the University of Auckland, Auckland University of Technology (AUT) and East Coast LAB (Life at the Boundary) developed a series of lessons and activities for students to learn more about natural hazards, vulnerabilities and resources. The project aims to trial the use of these two popular pastimes for disaster risk reduction and explore if these are effective tools for children to use. www.eastcoastlab.org.nz/our-science/our-projects/participatory-technology/

Daisy was specifically interested in river hydraulics. A simple hydraulic investigation was formulated and then undertaken in two components:

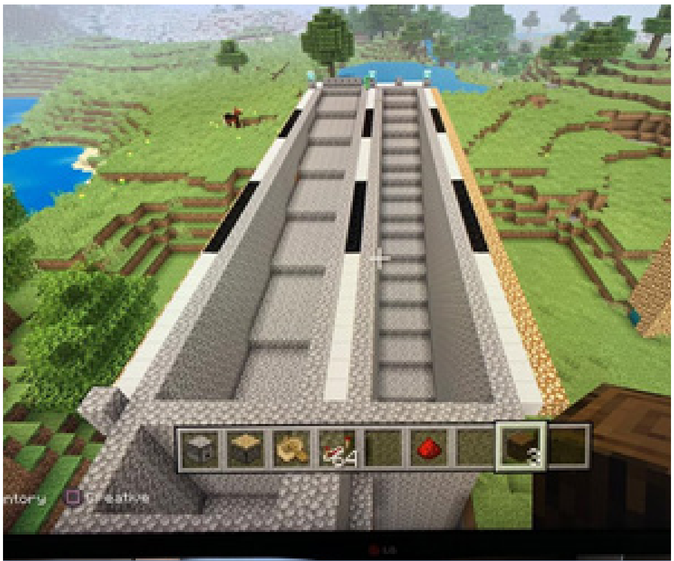
Real Life Measurements – Float gaugings were undertaken at two parts of the same river, through a fast moving steep section and through a slow moving section with a gentle slope.

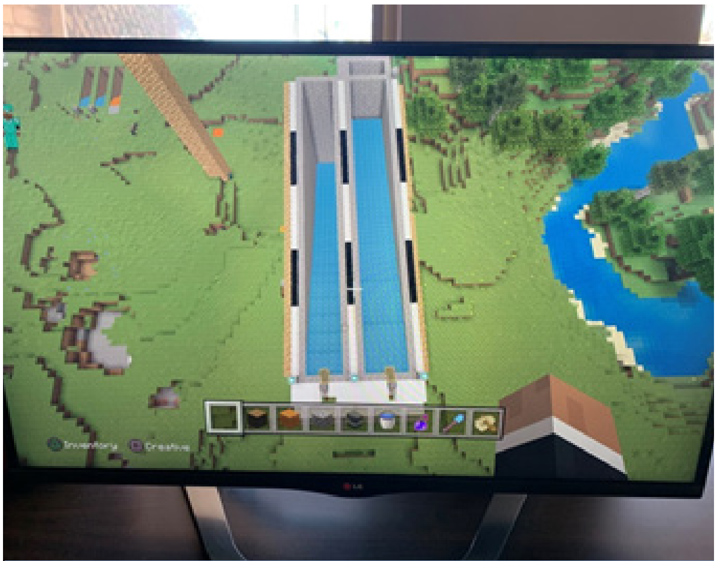
Minecraft Measurements – Two channels were created in Minecraft with different slopes and float gaugings undertaken using the available in game mechanics, namely boats that move with the water current.

Table 1: Photos of Real Life and Minecraft Channels


FLOAT GAUGING SECTION 1: Bells Rapids; Steep Section


FLOAT GAUGING SECTION 2: Bells Rapids; Gentle Section


Minecraft Generated Channels, Steep and Gentle Sections


Minecraft Generated Channels, Steep and Gentle Sections

Anatomy of a float gauging in a real river as detailed by an 11-year-old


Use of boats in Minecraft to simulate a float gauging. Both boats are pushed into the channel simultaneously using redstone mechanism

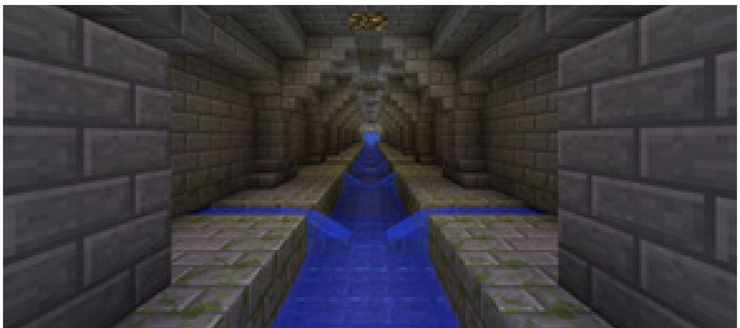
Table 2: Results from Float Gauging measurements

REAL RIVER		MINECRAFT RIVER	
GENTLE SLOPE SECTION		GENTLE SLOPE SECTION	
	Time Taken (s)		Time Taken (s)
1	137	1	22
2	133	2	22
AVERAGE	135	AVERAGE	22
STEEP SECTION		STEEP SECTION	
	Time Taken (s)		Time Taken (s)
1	26	1	28
2	26	2	28
AVERAGE	26	AVERAGE	28

Unfortunately due to how flowing water is simulated in Minecraft, the results were not as expected; namely the boat moved faster through the channel in the gently sloped channel in the Minecraft simulation. So in this case real life flow characteristics did not fit the computer simulation: a useful first lesson for any would-be hydrologist.

Even though the results were not consistent with real world hydraulics, the computer program Minecraft provides people an accessible program to create both natural and human-made environments and conduct experiments and simulations. As Minecraft continues to be very popular with a very large user base, it presents a very good introduction for children to relate things in the game world to the real world. Experiments can be designed and tested with a view to getting a better understanding of computer simulations as well as real world properties of water hydraulics.

Natural River System in Minecraft



Sewer Drainage System in Minecraft

SOURCES

Minecraft & Lego used to teach emergency preparedness in school
School News Tuesday, May 1, 2018

In case of emergency: Children map community using Lego and Minecraft
RNZ Online News, August 20th,2018

ARTICLES

John Pfahlert, Chief Executive, Water New Zealand

3 Waters Regulatory Changes

In August 2016 sheep faeces contaminated the public water supply in Havelock North, making over 5000 people sick with campylobacter and contributing to the deaths of 4 people. A public inquiry into the causes of the outbreak resulted in a report which identified systemic problems with the way in which public authorities operate water supply services in New Zealand.

Subsequently, the Department of Internal Affairs was directed by Government to examine the Inquiry recommendations and investigate what changes should be made to the regulatory environment of 3 Waters service delivery. The scope moved from looking at just drinking water and extended to wastewater and stormwater service delivery.

The DIA investigations confirmed the recommendations of the Havelock North Inquiry, identifying the following shortfalls with the current system:

- Risks to human health
- Low levels of compliance, monitoring and enforcement
- Capacity and capability challenges – especially within small District councils
- Issues of affordability in terms of providing adequate service delivery – again at small councils
- Inadequate system oversight by central government
- Variable asset management practices
- Lack of good asset information
- Poor reporting framework

The Government recently signed off on proposals to establish a new drinking water regulator with some responsibility for oversight of wastewater and stormwater management.

It has been agreed that regulation of water supply will be removed from the control of the Ministry of Health and placed in a new agency where water supply will be regulated down to the level of one step above individual household supply. At present the focus of regulation has principally been at the territorial local authority level. This will have the effect of capturing small waters system supply within the ambit of regulatory control – such as marae, rural schools and holiday accommodation.

The new regulator will have six broad functional areas of responsibility.

1. Sector Leadership - at present any sector leadership is exercised in a voluntary, non-regulatory capacity through trade associations such as Water New Zealand. The new regulator is expected to be responsible for:
    - Promoting the importance of safe drinking water
    - Coordinating between different parts of the system
    - Leading or overseeing the response to drinking water emergencies
    - Leading emergency response planning by the drinking water sector
    - Identifying and monitoring emerging contaminants and coordinating national policy responses
2. Setting Standards - the new regulator will take over enforcement of the current drinking water standards under the Health Act. They will be responsible for reviewing national water quality standards and developing mandatory treatment requirements
3. Compliance, monitoring and enforcement – the new regulator will be charged with:
    - Ensuring regulated parties understand what is required of them and how to demonstrate competence
    - Assessment and auditing Water Safety Plans
    - Incident response and management
    - Monitoring performance of Regional Councils and Territorial Authorities in management of activities to protect source water
    - Receiving and investigating complaints against suppliers
    - Enforcement of non-compliance by suppliers
    - Addressing supplier failure
4. Capability building, accreditation and licensing – the regulator will be responsible for:
    - Maintaining a register of drinking water suppliers
    - Setting accreditation or certification requirements for drinking water suppliers, and providers of water sampling and testing (laboratories)
    - Setting training or registration requirements for professionals working in the drinking water industry
    - Setting requirements for professionals monitoring the performance of drinking water suppliers (drinking water assessors)
    - Working with training providers to ensure suitable training is available
    - Accrediting drinking water suppliers and laboratories
    - Licencing professionals

5. Information, advice and education – the regulator will be responsible for:
    - Maintaining technical expertise in house and facilitating research into drinking water science
    - Providing best practice advice and guidance to the sector
    - Promoting compliance through advice and assistance to suppliers
6. Performance reporting – the regulator will be responsible for national-level collection, collation and publication of drinking water compliance and performance information

In the area of wastewater and stormwater management it is expected that the Ministry for the Environment will be charged with developing several new national level regulations under the RMA. They will be developing a new National Environmental Standard on wastewater discharges and overflows, as well as a new risk management plan framework for wastewater and stormwater.

They will also be asked to review the existing National Environmental Standard for protection of sources of human drinking water.

These proposed changes will obviously take some time to implement. They represent a significant change to the water regulatory environment, but are designed with the objective of ensuring adequate standards are met in the delivery of public water services.

The new regulatory functions are expected to be given effect through a Bill to be introduced to Parliament before Christmas 2019 called the Water Services Bill, and passed into law prior to the General Election 2020.

ARTICLES

NZHS delegation to Korea

Following the call for applicants to be part of this year's NZHS delegation to South Korea, the two successful applicants Matt Hope (Auckland Council) and Conny Tschritter (GNS Science) travelled together with a member of the NZHS Executive Committee, Mike Ede (Marlborough District Council), at the end of May to South Korea.

The main purpose of the trip was the Korea Water Resources Association (KWRA) Annual Conference, which was held in Yeosu on 30 – 31 May 2019. KWRA is a long-term partner of the NZHS. Part of this partnership is the yearly exchange of researchers to present at the KWRA and NZHS annual conferences. In addition to the conference, Mike Ede and many helpful Korean researchers organised a number of interesting visits to Korean freshwater science and infrastructure institutes and also showed us around many tourist sights. Some of the places we visited were:

The K-Water Gyeongin Port Integrated Operation Center (Figure 1)

K-Water, or Korea Water Resources Corporation, is a governmental agency responsible for water resource development and providing municipal and industrial water in South Korea. Along with delegations from Japan and Thailand, we were invited on a yacht tour on the Ara Waterway – an 18 km long artificial waterway that was built primarily to prevent flood damage.

Figure 1 Left: Inside the K-Water operation centre where they monitor the Ara Waterway. Right: On the Ara Waterway.

Han River Flood Control Office (HRFCO)

The HRFCO is in charge of hydrological observations, data management and flood forecasting for a number of rivers in central South Korea, including the Han River that flows through Seoul.

Korea Institute of Construction Technology (KICT) Department of Land, Water and Environment Research

This department focuses primarily on the minimisation of flood and drought damage, sustainable and integrated water quality/quantity management, and water quality improvement and river restoration. We were able to visit their two flood damage/river experiment sites: a small-scale one (Figure 2) and a full-scale one (Figure 3), which were both very impressive.

Figure 2 Left: KICT hosts a large warehouse and some outside space to host numerous small-scale flood damage and river experiments. Right: This one is used to model flooding in a subway station.

Figure 3 River experiment at the full-scale KICT experiment site in Andong, where three channels are capable of carrying up to 10 m^3/s. Using puffed rice, researchers from KICT and from a Finnish University aim to identify differing flow patterns and velocities around vegetation zones with different shapes in rivers.

We also managed to slot some sightseeing in to see Seoul, some important sites of Korean history (Figure 4), and the odd craft beer brewery. Altogether, this was a wonderful trip and we encourage more NZHS members to apply for next year's opportunity to attend the KWRA annual conference.

Figure 4 Left: Visiting historical sites at a stopover in Namwon on our way from Yeosu to Seoul. Right: On the Han River together with one of the professors and her students

Those of you who have engaged with our Korean peers before will well know the power of the business card. This year, the Thai delegation lifted it to another level. During the trip, Dr Kasem Pimthong created and gifted to each international guest a water colour painting (Figure 5).

Figure 5 Dr Kasem Pimthong's business card.

The authors would like to thank the NZHS and the KWRA for this opportunity.

ARTICLES

Mike Ede (Marlborough District Council, NZHS Committee),
Mic Clayton (Australian Regional Council, AHA – FAHA)

Space Time Image Velocimetry Training Workshop, Wellington, July 2019

Introduction

In mid-July, the New Zealand Hydrological Society (NZHS) conducted a 4-day training workshop in the use of Space Time Image Velocimetry (STIV) techniques for stream discharge measurements lead by Mark Randall (Senior Project Officer Water Services, North Region Department of Natural Resources, Mines and Energy Program Australia) who has experience in this emerging technology.

The fully subscribed course had more than 30 Technical Field hydrologists from a majority of Regional Councils around New Zealand participating as well as some vendor and surveyors. There was even a participant from that oft forgotten Australian Regional Council!

STIV is part of a cluster of non-contact measurement techniques including Particle Tracking Velocimetry (PTV) and Large Scale Particle Image Velocimetry (LSPIV), which utilise video imagery of stream surface velocities then with application of appropriate algorithms and stream hydraulic assumptions to generate stream mean velocities and hence indirect calculation of stream discharge.

Other non-contact techniques include radars (fixed and handheld) to measure surface velocities but still need the application of correct algorithms to produce discharge measurements of suitable accuracy.

Background

The use of video imagery collection and processing for flood discharge measurements has seen growing traction in recent years with various visual analysis techniques being developed in a variety of research and field application environments.

In New Zealand, more deployments of bank side fixed cameras and drones are being used to video floods. There is growing interest in the types of equipment to purchase, how to install sites, best methods to use, drone or fixed, and how to use the various video processing STIV softwares.

This training was driven from a presentation Mark Randall gave at the 2019 New Zealand Hydrological Society Technical Workshop in Blenheim. Mark had previously presented on STIV technologies at the 2018 AHA Conference in Canberra where he was voted the best presentation and awarded the Alex Millar Award.

Jérôme Le Coz (IRSTEA France) gave similar presentations at the 2016 NZHS Technical Workshop and other organisations presented around the techniques and technologies at the WMO/IAHR/IAHS International Hydrometry Workshop held in conjunction with the New Zealand Hydrological Symposium in 2016.

Imagery being collected by today's now relatively cheap technologies (fixed cameras and drones) contain a lot more information than just the soft relaxing images of water for meditative activities! Image data collected also contains information such as time and movement, pixels, rasters and the ability to apply Guassian processes to calculate velocities from random patterns and particles in the stream!

Over time the quality of video has increased (providing more information for processing) while site establishment costs have decreased (meaning a cost effective additional tool in the hydrometric toolbox).

Workshop Program.

The program over the first three days was as follows:

Day 1 (Training Room)

- Introduction to image velocity methods – PTV, LSPIV and STIV
- Image velocimetry best practice - getting good videos and data for STIV and LSPIV,
- IP camera setups, resolution, ground control point setup, drones, data collection standards
- Surface velocity coefficients (Stream Alpha) – derivation from ADCP data, drones, and current meters
- STIV – Australia. Field experience (IP cameras and drones), methods and discharge results, future directions
- Introduction to KU-STIV software
- KU-STIV data walk through
- Field day preparation – groups/setups/tasks

Day 2 (Field)

Field data collection day at Hutt River at Taita Gorge steam gauging station north of Wellington, organised and run by Greater Wellington Regional Council, where three groups were tasked to establish a fixed image velocimetry site including:

- Camera placement
- Ground control placement
- RTK survey of ground control points and cross section (assisted by the survey team from Palmerston North)
- Fixed camera data collection

In addition to the teams setting up and collecting imagery, an assortment of drones with differing features were sent aloft to capture aerial imagery for processing as well as providing opportunity for those with little or no drone experience to have some hands on with the technology.

Greater Wellington Council staff also undertook simultaneous ADCP gaugings for comparison of results as well as providing bathymetric data and additional stream velocity data for the determination of alpha (stream velocity co-efficient)

Day 3 (Training Room)

Basically it was the number crunching day using the previous day's image and site survey and bathymetry data!

- KU-STIV software use
- practical processing of fixed camera data,
- preprocessing data and imagery from drones for use in KU-STIV

Day 4 was an optional extension day for participants wishing to work on image data collected from their own networks and for further practical learning with the KU-STIV software.

KU-STIV

KU-STIV software was used in this training workshop. Ichiro Fujita, a Professor at the Graduate School of Engineering in Kobe University, has led the development of this software through research programmes since 2007 and a number of organisations are looking at ways to utilise this image processing process in hydrometric data processing systems.

In a simple description of the software, the basic workflow the software undertakes is:

- Orthorectification of the video imagery (removing the effect of perspective and creating a 2d image area for analysis)
- Superimpose “searching lines” (each between 10 and 20 meters long) on footage of the river as measurement standards.
- Calculate the water’s surface speed from the time it takes water surface features and floating matter on the surface of the river to move through these lines,
- Analyse velocity distribution, with suitable ‘alpha’ co-efficients, to indirectly calculate the river flow rate.

Figure 1. A screen shot from KU-STIV software

Depending on the strength of the luminescence of features and patterns on the water surface the technique will have varying degrees of the initial computation of the surface velocities – lots of features and particles result in good confidence. Conversely though, where there is limited or no particle or pattern movement along the lines – confidence is lowered. Apparently Rice Bubbles or Doritos tortilla chips cast across the stream make for good particle tracers!

Manual calibration of the velocity lines is available to the user, as the human eye and mind can often see flow patterns the software may not consider useable or be fooled by. This was particularly evident when reviewing velocity lines that where in sections that the image was partially blocked by bank vegetation where the vegetation movement or lack of was the dominate feature the software focused on to determine velocity. At the end of the day strong particle or surface flow features provides strong ‘data’ for the software to interpret and analyse.

The software was initially designed to do all that fancy orthorectification stuff to correct the perspective from the angles of bank mounted cameras, but when it comes to a drone looking straight down on a river (eliminating almost completely any need to correct for perspective), the software in its current version needs to have data and information worked on before entry final analysis in the KU-STIV software. This is achieved by calibrating the pixels in the captured footage to known distances between features close to the water surface datum, then inputting these values back into the software.

The next version of the software, due for release in October this year, is expected to have improved features catering for vertically positioned drone footage.

Observing the group working through the software and how data needs to be prepared, we were very impressed how all the participants 'got it'. Even though the processing into and around the software is a bit clunky (Japanese research mind meets easy going Kiwi and Oz Minds!) and the little help hovers over some of the buttons are good if you can read Japanese, it brought the participants a better understanding of the process and the need for good metadata around the gauging locations including:

- Clear and fixed control points – well surveyed and documented
- Cross sections developed for the measuring sections
- Everything related to a common datum!

Collection and evaluation of Data – The Field Day on The Hutt River at Taita Gorge

The Hutt River in the days leading up to the field day had been running at approximately 15 cumecs for a long spell, but reflecting the recent form of recent NZHS workshops some precip events turned up and on the day we were measuring flows between 90-100 cumecs on a slowly falling limb (marked on graph, Figure 2).

A couple of workshop participants even bunked off on the first day to ensure that some drone footage was captured on the peak of the event at around 380 cumecs.

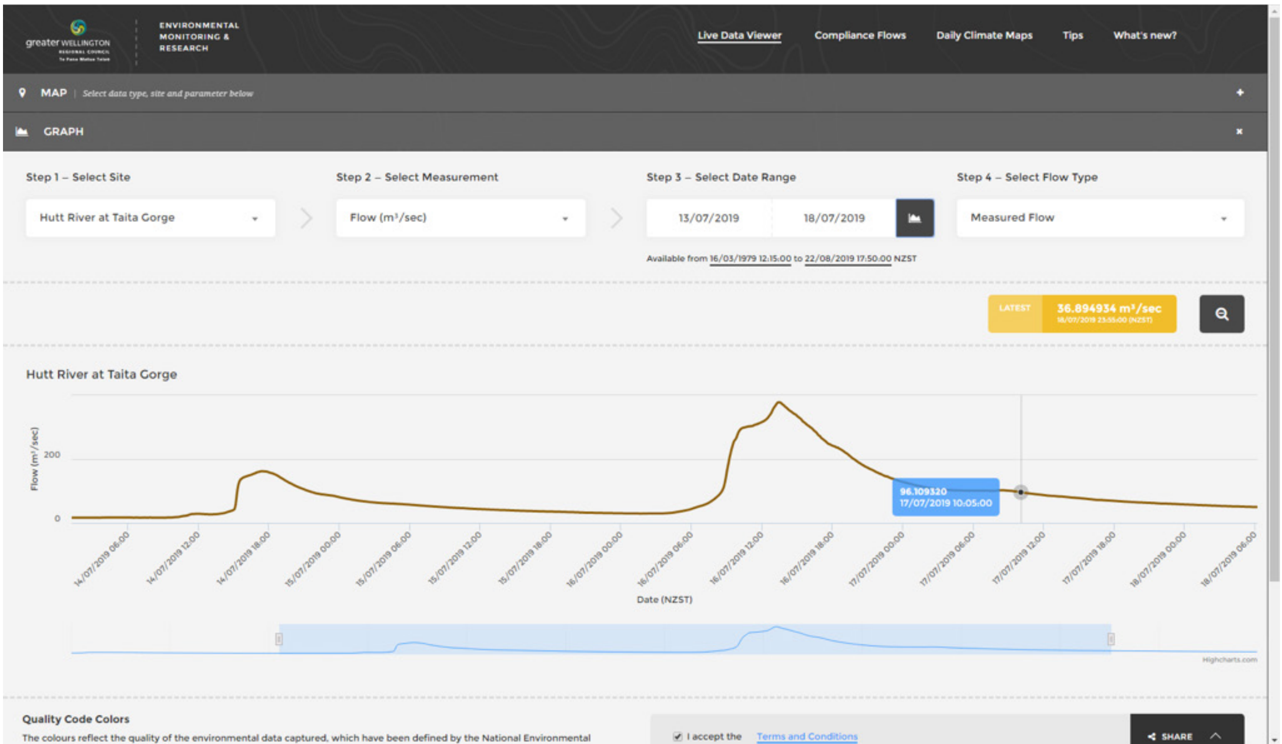


Figure 2. Hutt River at Taita Gorge stream flow information. (Blue marker STIV training day) – Source, Greater Wellington Council website

Three teams set up fixed camera installations (basically SLR and or video cameras on tripods) on the bank of the river, while the surveyors surveyed in Ground Control Points on both sides of the river and water surface levels to tie the points into gauge datum. (Orange cones and markers Figures 3 and 4)

All the fixed camera installation sites suffered to some degree from vegetation and other obstructions in the field of view and it was initially perceived that the teams might have missing data and hence lower quality data to work with. It was surprising though, during the following days post processing and analysis of the data in these obstructed areas, there was still good information available to analyse velocities and in some cases it improved the ability to identify velocity lines compared to the main unobstructed vision!

Figure 3. “Fixed” camera installation setup

Figure 4. Total Station survey of ground control points

Drone vision collected for post processing into the software was collected with a DJI Phantom Pro and DJI Spark.

A River Ray ADCP deployed via a HS Cable Fox collected a measurement as well as providing bathymetry data for use in the following day’s image data processing exercises.

Following the primary data collection excercises at Hutt River, and prior to the workshop dinner, the group relocated to an area where opportunity for participants was provided for familiarization and flight time with a variety of drones. This provided a great opportunity for those with little or no experience with the technology to gain appreciation that drones are a cost effective tool that can be used to capture great hydrological information and data that you can work with in conjunction with other gauging techniques.

Figure 5. Participants get an opportunity to familiarize themselves with the variety of drones used at the workshop.

Post Analysis Data Processing

The flow at the site was approximately 90 cumecs (slow falling limb through the morning), and day three of the workshop was devoted to processing the data files from the fixed installations and the drone imagery.

A majority of the post processing analysis seemed to be bracketed in the 80 to 100 cumec range.

OK. So approximately +/- 10% of the rated and ADCP measured flows. A problem - some might say? Not necessarily so! Consider the potential error that can be generated in a flood gauging, whether by current meter or ADCP techniques, so the results being generated during the workshop could be considered robust in the light of the uncertainties accepted within these other methods.

Earlier in the year at the NZHS workshop the ADCP regatta results included a ‘drone’ gauging of a low flow. The ‘drone’ gauging was 0.452 cumecs, the rated flow was 0.420 cumecs, the mean of gaugings on the day was 0.422 cumecs. The following is a plot of all the gaugings undertaken using a variety of techniques. The drone gauging at this other end of flow magnitude (less than a cumec) sits well within the spread of discharge results obtained during that workshop.

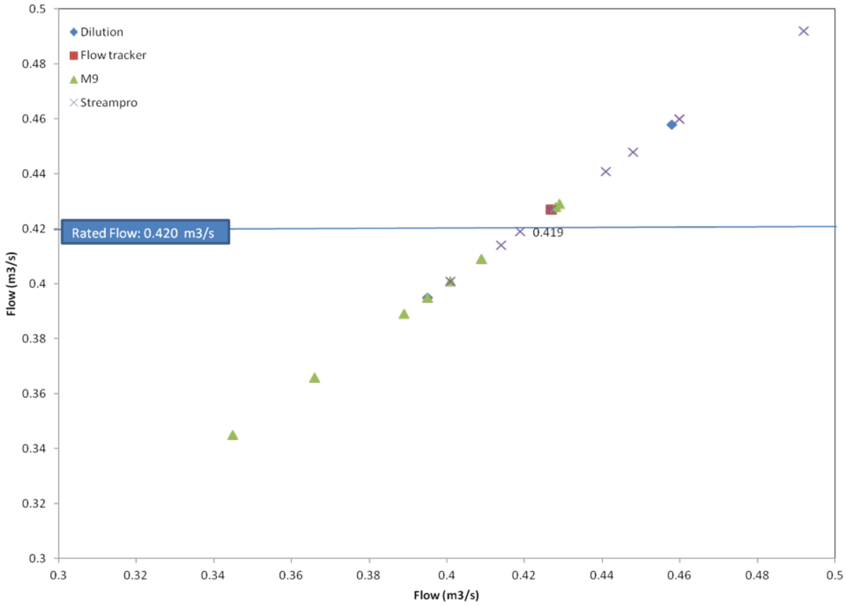


Figure 6. Spread of gauging results from NZHS regatta, 2019. (The 'drone gauging was at 0.452 cumecs)

Out of Session Workshop Activities

Collaboration outside the formal workshop timetable occurred well into most evenings. A fine workshop dinner was hosted at the Boneface Brewing Company in Upper Hutt following the field day component of the workshop.

Figure 7: Technical selection at Boneface Brewing Company

Boneface Brewery is located in a now repurposed industrial complex that was once the Dunlop Tyre Factory! The complex also accommodates a number of other craft breweries and has become a fantastic social hub in the Upper Hutt area.

The workshop dinner also included a brewery tour with our guide explaining the brewing process from raw material through to the final pouring.

Figure 8. Workshop dinner brewery tour, Boneface Brewing.

Final Summary

This workshop event provided by the NZHS was a fantastic opportunity for participants to investigate and become familiar with an alternative measuring technique and how it could potentially fit in with their monitoring programmes. It is envisaged that this technique will become an additional accepted method of discharge measurement complimenting current measurement and monitoring techniques. In Australia this non-contact technique, along with other non-contact techniques such as radar, was tabled at the May 2019 meeting Water Monitoring Standards Technical Committee as a proposed National Hydrometric Guideline.

Safety improvement potential, being able to gain measurement data from locations that may become inaccessible during a flood using fixed camera technology, and utilising drone technology during flood events when resources become stretched for more mainstream gauging flood gauging techniques were amongst a number of improvement opportunities identified during the workshop.

The hands on activities, collecting data and processing with the software, highlighted the need for having good metadata for the site (survey data, bathymetry etc) as well as going back to basics and having an understanding of basic stream flow monitoring, including impacts of stream roughness and geometry on mean velocities. This re-appreciation of basic stream hydraulics and metadata also extends to better evaluation techniques of the other gauging techniques including ADCP and current meter gaugings.

Nationally co-ordinated workshops like this are extremely important as they also enable the hydrological profession to develop consistent application knowledge and guidelines for alternative monitoring techniques as they develop.

OTHERS

Science Media Centre – how you can help them and they help you

Communication of science to the public, through the media, can be a challenge. The aim of the Science Media Centre is to promote accurate, evidence-based reporting on science and technology by helping the media work more closely with the scientific community. There are a number of ways they can help promote your research or speak to the media on topics relevant to your expertise.

If you have a big paper coming out, they can promote your research under embargo to journalists and help you work with your institute's media office to ensure that you attract attention.

They also maintain a database of experts willing to talk to journalists. You can create an expert profile with your expertise and which topics you're willing and able to talk to media about. Additionally they collect independent commentary from researchers on science in the news, aiming to provide reporters with context and background on breaking issues.

There is useful information on their website if you are interested:

https://www.sciencemediacentre.co.nz/for-experts/

aqualinc

UPDATES

News from Aqualinc Research Ltd.

Compiled by Tim Kerr

New Logo for Aqualinc

Aqualinc Research Limited has undertaken a refresh of our brand. This follows the acquisition of HydroServices Ltd. by Aqualinc Research Ltd. in 2018. The new motif represents the continuous process of water and land flowing into each other. This is a reflection of Aqualinc's expertise, in those areas of the environment and society where land and water merge: Surface water, soil moisture and groundwater.

Soil Moisture Season underway

Eight seasonal staff, six new vehicles, and a new Neutron probe have been aquired to make the soil moisture monitoring season run smoothly. All this extra resource will support the Field Service team's area managers: **Hamish Maxwell** (North Canterbury); **Mark Fitzgibbon** (South Canterbury); **Phil Neill** (Central Otago, as well as the whole of New Zealand!); and **Josh Harlen** (North Island) while **Melanie Smith** is on maternity leave (congratulations Melanie).

Figure 1. Neutron soil moisture probe with one of the new vehicles.

Adaptive Management Consent Renewals

About 200 adaptive management water take consents have all come up for renewal in Canterbury. It has been about 10 years since these were first implemented as a result of group consent hearings. Aqualinc's Water and Land Use Consents team, consisting of **Matt Bubb, John Knight, Rose Edkins** and **Neal Borrie,** have all been hard at work processing about a third of these renewals taking the opportunity to enable supplementary water source arrangements where required and where possible.

Figure 2. Aqualinc staff participating in a riparian planting project organised by Te Ara Kakariki.

Planting Day

Many of the Christchurch staff participated in a riparian planting activity coordinated by Te Ara Kakariki. A thousand locally sourced native seedlings were planted around a small waterway on a dairy farm near Sheffield. Staff from ESR, Antarctica NZ, Manaaki Whenua Landcare Research and MyMilk were also involved.

Figure 3. An example of the type of drinking water well head infrastructure that Aqualinc regularly assesses.

Drinking Water Well Head and Source Protection Zones

Julian Weir and **Ross Hector** have recently undertaken numerous assessments of drinking water well heads and associated source protection zones. Territorial authorities have welcomed the expertise Aqualinc has provided. The assessments combine on-site inspections with desktop hydrological analyses. This work has been complemented by a national assessment of drinking water source protection zones by **Tim Kerr** recently released by the Ministry for the Environment, and available at

https://www.mfe.govt.nz/publications/fresh-water/drinking-water-source-protection-zones-delineation-methodology-and

Best Paper at the 3rd World Irrigation Forum

Birendra KC, with Aqualinc co-authors **Ian McIndoe** and **Helen Rutter** won one of the Best Paper awards at the 3rd World Irrigation Forum in Bali. His paper described his observations of spatial variability in soil moisture and the need to account for it when optimising irrigation. The paper was presented by Professor Emeritus Bart Schulz from IHE Delft, one of the co-authors of the paper. The paper may be accessed at https://www.icid.org/wif3_papers_content_1_3.html

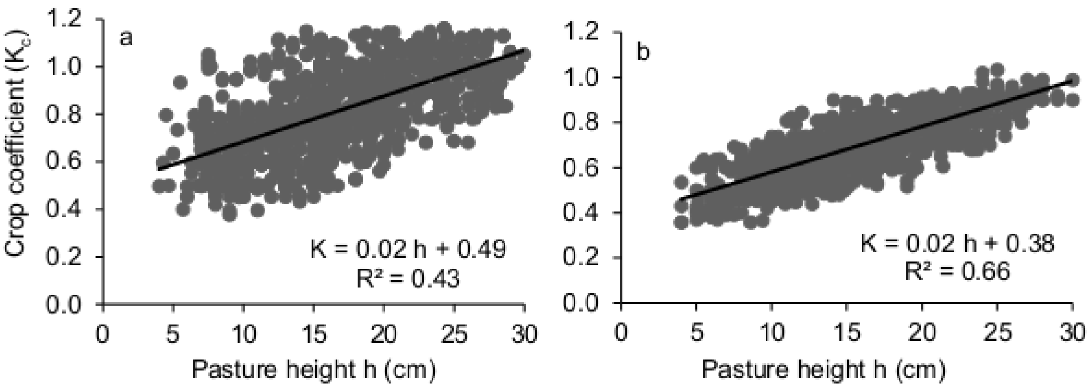


Figure 4. Crop coefficient relationship to pasture height based on a single soil moisture measurement (left) and adjusted for observed change in soil moisture with depth (right).

Government Freshwater Proposal

One of the more important national changes to freshwater quality policy, the Proposed National Environmental Standards for Freshwater, has been the cause for much recent activity. **John Bright** and **Matt Bubb** have been assisting clients with submissions as well as preparing Aqualinc's own. From Aqualinc's perspective the proposal indicates that there is still a lot of research required to clarify freshwater quality cause and effect relationships.

Kaikōura Earthquake Impact on Shallow Groundwater

Rose Edkins and **Justin Legg** have been assisting the Kaikōura Plains Recovery Project (funded by the Ministry of Primary Industries) with land drainage issues. An interesting issue with implementing drainage trenches is the development of iron precipitate (locally know as iron ochre) from the saturated soils into the drainage waters. It seems the soils, which are marine/estuarine in origin, when exposed to air, allow the oxidiation of the in-situ reduced iron into red iron oxide. Options for minimising the impact of the precipitate on drainage receiving waters are being explored.

Figure 5. Trench wall when dug, with Justin's legs for scale (left) and 7 days later showing iron oxide precipitate (right).

UPDATES

Update from Environment Canterbury

Compiled by Maureen Whalen and Suz Gabites

Comings and goings in the Groundwater Section

There have been a few people moving on from the groundwater section recently. Zeb Etheridge has started his own groundwater consulting business, Matt Hanson resigned a few months ago and Hamish Graham has started a two-year secondment with surface water hydrology. Nicole Calder-Steele was elected to our council in October! Good luck to all.

Hana Sorek and Kurt Van Ness have recently started with us as Science Analysts – welcome.

What's going on in the Groundwater Section

Over the last few years the science teams have been supporting Canterbury Water Management Strategy (CWMS) sub-regional planning processes. Carlos Rosado, Marta Scott and Philippa Aitchison-Earl have provided advice for the process in the Orari Temuka Opihi Pareora (OTOP) zone. Amber Kreleger, Matt Hanson and Zeb Etheridge have been supporting the CWMS Zone Implementation Programme Addendum and draft plan change for the Waimakariri zone. Their focus has been on nitrates in groundwater and groundwater allocation[1].

Lisa Scott has been busy looking at the impacts to groundwater quality from quarries and legacy landfills. Fouad Alkhaier and Nicole Calder-Steel have been evaluating our groundwater monitoring network against CWMS and plan recommendations.

Mark Trewartha has been busy providing support for the Hinds Managed Aquifer Recharge project and recently has been supporting the consents review process for the Ashburton River/ Hakatere. Marta Scott returned from maternity leave earlier this year and is leading an investigation into improving our understanding of nitrate getting into Washdyke lagoon near Timaru. Philippa Aitchison-Earl has recently completed an investigation near Tinwald, Ashburton, looking at chemistry and isotopes to identify the origins of the measured high nitrates in that area. Carlos Rosado is working on a coastal groundwater investigation focused on understanding the onshore-offshore aquifer structure in Christchurch.

Our groundwater field team have been busy with our state of the environment monitoring and systematic system improvements. Dave Evans and Ross Cressy have recently started the annual groundwater quality survey. We survey over 300 wells a year. Tom Johns has been instrumental (pun intended) in setting up a field site for the South Canterbury Collaborative Hillslope project. Tom will be presenting on his work at Rotorua later in the year. Dave Evans, Hamish Carrad and Shaun Philips have been supporting the Managed Aquifer Recharge projects being undertaken in Hinds, Silverstream (near Kaiapoi) and Selwyn River/ Waikirikiri.

See here (specifically under - 2. Public Notification/ Supporting documents and technical reports) for the technical information supporting both the OTOP and Waimakariri processes.

Comings and goings in Surface Water Hydrology

Like the Groundwater team, we have also had some major changes since July this year. Mike Exner-Kittridge, Jeanine Topélen, and Ilja van Nieuwpoort have been seconded for 2 years from our team to the newly created internal Water Data Team. While we miss them in our team, we appreciate the need for expertise to be part of this essential process to really 'sort out' ECan's HUGE Water dataset. To fill this 'gap' we have the pleasure of Hamish Graham, all the way from the Groundwater Team, and Carey Lintott, who joins us from Beca.

What have we been up to in Surface Water Hydrology?

As with the Groundwater team our team, has also been supporting Canterbury Water Management Strategy (CWMS) sub-regional planning processes in the Orari Temuka Opihi Pareora (OTOP) zone. Dan Clark was the Technical Lead for most of this process, with support from Kate Steel and Jen Dodson. Dan also started his Masters earlier this year. He is modelling the surface water and groundwater interactions on the Selwyn River.

Kate Steel, with support from Adam Martin, has been continuing with the region-wide Flood Frequency Analysis. This piece of work is in its final stages now. Jeanine Topelen and Suz Gabites have been supporting the consents review process for the Ashburton River/ Hakatere including the completion of an analysis of the likely impacts on the water availability as a result of the consent review. Wilco Terink continues his work on the Rakaia Water Balance Model using the WEAP platform. After returning from maternity leave in January, Jen Dodson has been busy completing an analysis on the flows in the southern tributaries of the Waitaki River which have long-standing 'Mining Rights' expiring in 2021.

Our two field teams in Timaru and Christchurch, who are ably assisted by our mostly office based Analyst team, have been incredibly busy this year, with some personnel changes and pressures coming at them from many angles; more requests for monitoring sites (water level and rainfall), more demands for low flow monitoring, new NEMS expectations, numerous repairs from flood damage in late 2018, and the northern team still dealing with Kaikōura Earthquake related issues.

Figure 1. Surface Water Science Section Team Building exercise, Cass July 2019

Figure 2. Surface Water Science Section in Cass July 2019

UPDATES

Update from ESR Groundwater Group

National Survey of Pesticides and Emerging Organic Contaminants in Groundwater

In 2018 ESR coordinated a survey of pesticides in groundwater throughout New Zealand on behalf of the regional and unitary councils. The survey has been completed every four years since 1990 with 2018 being the eighth consecutive survey. As well as pesticides, the survey for the first time tested for glyphosate (the active ingredient in Roundup, a popular weed killer) as well as a suite of Emerging Organic Contaminants (EOCs). Regional and Unitary Authorities carried out the well sampling, with the pesticide and glyphosate analyses being carried out by AsureQuality and the EOCs being analysed by Northcott Research Consultants Ltd.

There were a total of 279 wells sampled and analysed for the pesticide suites, including 41 wells from Waikato Regional Council and an additional 71 wells from Environment Canterbury that were included to give a national perspective. There were 68 wells (24.4%) with pesticides detected, with 28 of these wells having two or more pesticides detected. The maximum number of pesticides detected in one well was six. Herbicides were the most frequently detected pesticide group with 98 detections (88%) of 17 different herbicides and their metabolites. There were three pesticide detections exceeding 1 µg/L with none of the sampled wells exceeding the Maximum Acceptable Value (MAV) for drinking water. The highest detection as a percentage of the MAV was dieldrin, which was detected at a concentration of 0.025 µg/L that was 62.5% of the MAV of 0.04 µg/L (Ministry of Health 2018). Most pesticide detections were less than 0.5% of the MAV. The majority of the wells in the current survey showed no change in the amount of pesticides present compared to previous surveys with less than a quarter of the wells having low levels of pesticides detected.

A total of 135 wells were analysed for glyphosate, glufosinate and their principal metabolites. There was only one detection of glyphosate at a concentration of 2.1 µg/L. This well showed evidence of poor well-head protection and the contamination likely came from containers that were stored near the well. No MAV for glyphosate in drinking water has been set in New Zealand. New Zealand follows WHO guidelines when setting its MAVs but there is currently no WHO guideline; however, WHO does have a Health Based Value for glyphosate of 900 µg/L (WHO 2017). The detected level of 2.1 µg/L is far below this value.

There were EOCs detected in 85 (70%) of the 121 wells sampled and analysed for a suite of EOCs. All regions that had samples analysed for EOCs had at least three wells with EOCs present. There were 29 different EOCs in the analytical suite and 25 different EOCs were detected in at least one well with the maximum number of EOCs detected in a single well being 13. Most EOCs are used extensively by people or are produced by people (e.g., estrogenic steroid hormones) and most do not have significant human toxicity when used under normal conditions. There are no MAVs for drinking water associated with these EOCs. However, some of these compounds have shown some endocrine disrupting effects in surface waters and the main concerns with these EOCs are environmental or ecological impacts. There are no or very few guideline values for EOCs regarding ecological impacts as the relevant studies are sparse. Some EOCs, such as sucralose and caffeine, can act as tracers of the presence of human activities or wastewater impacts in the groundwater system.

These results indicate that EOCs, sourced from either animal or human effluents/activities, are making their way into shallow groundwater systems and can be detected at low concentrations. Currently there quantify the likely risks for the EOCs most frequently detected in this study. Contact Murray Close for more details.

Understanding aquifer physical and chemical heterogeneity to improve water quality and minimize economic impact

Concerns of degrading water quality in agricultural areas from nitrate have globally raised interest in management and regulation options that aim to improve fresh water quality. Nitrate that leaches into groundwater can be mitigated naturally under favourable geochemical conditions, as it is transported in an aquifer. Understanding where in a catchment nitrate is removed is key for designing effective land use management strategies that protect water quality, while minimizing the impact on economic development.

ESR's groundwater team has been investigating how detailed field-based characterization using physical and geochemical methods should complement numerical simulations to design efficient management strategies, in catchments with denitrification potential. In a paper published recently in Journal of Environmental Management (Sarris et al., 2019) it is demonstrated that there are significant benefits of implementing spatially targeted regulation compared to uniformly applied regulation. In Reporoa basin in the Upper Waikato region, which was used as the study area, if nitrate leaching limits were applied uniformly across the catchment only 25% of the uniformly applied nitrate mass reduction levels would be translated in reduction to freshwater nitrate discharges through groundwater. Regulating nitrate leaching limits in areas where nitrate residence time is short, such as riparian zones or areas with low naturally occurring denitrification, results in lower levels of nitrate discharges through groundwater, increasing the environmental benefit by a factor of 1.5 compared to uniform regulation. Even greater efficiencies can be achieved when delineation of management zones considers the chemical heterogeneity and groundwater flow paths, increasing the environmental benefits by a factor of 3.5 compared to uniform regulation. These improved efficiencies are achieved by adopting management rules that regulate land use in discharge sensitive areas, where leaching changes contribute the most to the catchment nitrate discharges. Contact Theo Sarris for more details.

References

Murray Close and Bronwyn Humphries. National Survey of Pesticides and Emerging Organic Contaminants (EOCs) in Groundwater 2018. ESR Technical Report CSC19016, 54 p.

Sarris, T. S., D. M. Scott, M. E. Close, B. Humphries, C. Moore, L. F. Burbery, C. Rajanayaka, G. Barkle, and J. Hadfield. 2019. "The effects of denitrification parameterization and potential benefits of spatially targeted regulation for the reduction of N-discharges from agriculture." Journal of Environmental Management 247:299-312. doi: https://doi.org/10.1016/j.jenvman.2019.06.074.

UPDATES

News from GNS Science

Update from the GNS Science Hydrogeology Group; Compiled by: Conny Tschritter

GNS Science's new Groundwater SSIF Research Programme

Over the last two years, GNS Science has restructured its MBIE Strategic Science Investment Funding. As a result, funding in groundwater research was increased from $0.9M to $2.4M, resulting in a redesign of GNS Science Groundwater SSIF research programme.

The primary aims of the new Groundwater SSIF programme are: to develop advanced hydrogeological maps, methods and models (in 2D, 3D and 4D, applicable from local to national and seamless between scales) that will improve the sustainable management of groundwater resources, with the aim of enhancing economic, social, cultural and environmental outcomes for the nation. Collaboration with national and regional authorities, research institutions, industry organisations, and other CRIs is integrated throughout the programme.

As part of the design process, a stakeholder survey was sent out to 156 stakeholders, comprising national and regional government representatives, including both managers and scientists. The stakeholder survey included the high-level project structure of the proposed programme. Feedback was received from 50 stakeholders. This feedback contributed to the design of workstreams and detailed project plans.

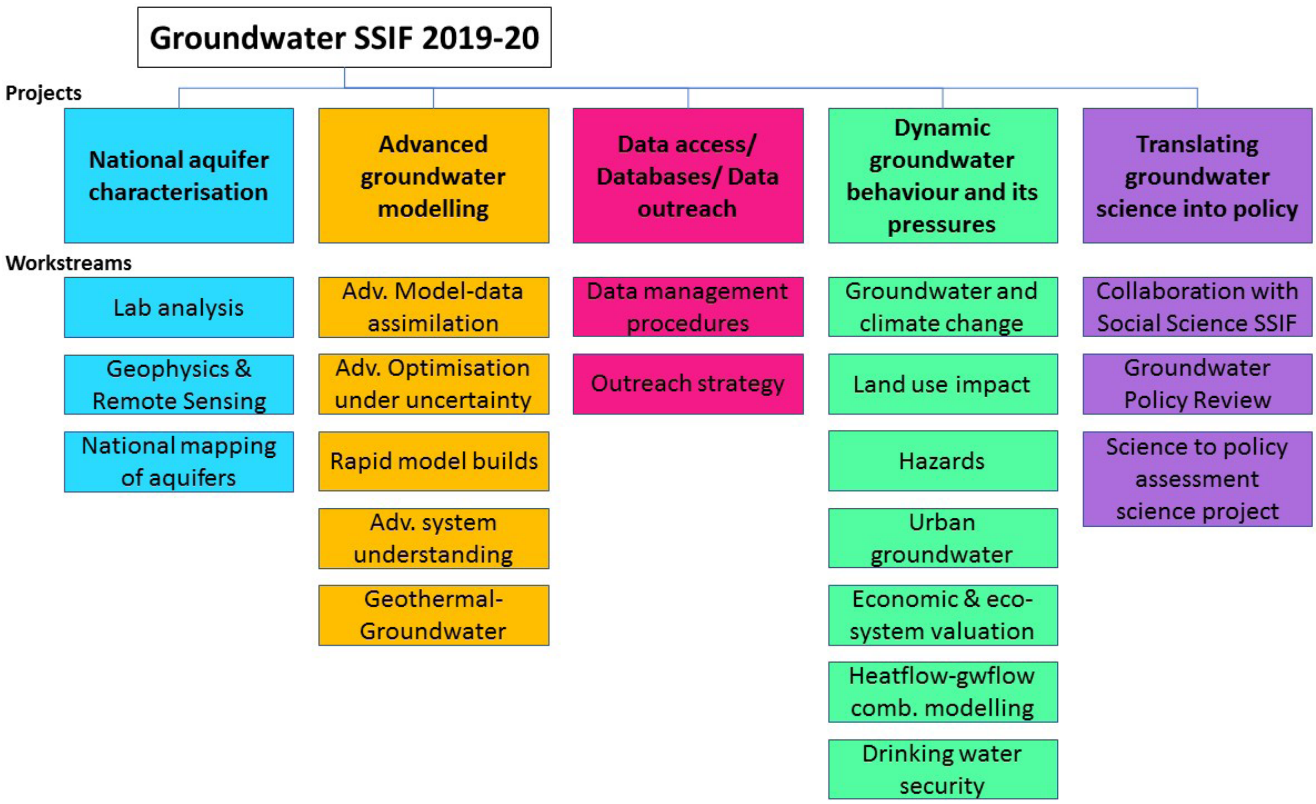


Figure 1. Structure of the 2019-20 project plan of the Groundwater SSIF Research Programme at GNS Science.

Using UAVs to acquire high-res groundwater recharge information

A large Envirolink Grant project with Hawke's Bay and Bay of Plenty Regional Councils on the use of Unmanned Aerial Vehicles (UAV) to acquire high resolution groundwater recharge information has just been completed by GNS Science. The project utilised UAV and satellite multispectral data on dairy farm pastures and vineyards located near existing rainfall recharge lysimeter sites, and the Google Earth cloud-computing platform. Proof of concept of the technique was established, with the potential to significantly improve knowledge of how rainfall recharge to groundwater systems varies spatially at the local and catchment scale. This information will be beneficial to regional councils to improve recharge models and assessments of sustainable allocation limits, especially in the context of climate change, where more variable rainfall inputs are expected.

Figure 2. UAV multispectral data acquisition in the Bay of Plenty.

https://www.envirolink.govt.nz/assets/1951-HBRC245-Better-spatial-characterisation-of-evapotranspiration-and-rainfall-recharge-estimates-to-groundwater-using-remote-sensing-multispectral-techniques-at-lysimeter-sites.pdf-.pdf

F Mourot, R Westerhoff, N Macdonald, S Cameron. 2019. Better spatial characterisation of evapotranspiration and rainfall recharge estimates to groundwater using remote sensing multispectral techniques at lysimeter sites. Lower Hutt (NZ): GNS Science. 80 p. (GNS Science report; 2019/17). doi:10.21420/Z3NQ-CE33

Groundwater studies in Dunedin

Shallow groundwater monitoring in Dunedin was improved substantially during the first half of 2019, with an upgraded monitoring network installed across low-lying parts of the city. The city has substantial areas where depth to groundwater is < 2 m. Groundwater monitoring now occurs at 23 sites (cf. 6 in 2018), spaced < 1 km apart, with levels and temperatures recorded at 15-minute intervals. Four sites also record electrical conductivity for understanding tidal-driven flow of sea water. Data show a dynamic and spatially variable response of the water table to drivers such as rainfall, tides, and even evapotranspiration.

Changing groundwater levels are being examined for their relationships to flooding hazard, liquefaction potential, city stormwater and foul-sewer infrastructure. In conjunction with Dunedin City Council (Jared Oliver, Mike Axton), GNS Science (Simon Cox & Frederika Mourot) are interrogating the water table position and drainage by infrastructure as part of a SSIF Urban Groundwater project. In parallel, University of Otago (Sarah Mager & Sarah Yeo) have been completing geochemical and isotopic surveys to identify the possible sources of water, subsurface flow and mixing.

The data are primarily being collected to understand the spatial impact of sea-level rise on surface flooding and groundwater inundation. Analysis and modelling by GNS Science (Simon Cox, Matt Knowling) is part of the MBIE-funded NZSeaRise project, led by Victoria University, with input from local partners at Otago Regional Council (Marc Ettema, Amir Levy). GNS Science have also been providing data to a team from University of Otago Accounting and Finance (Ivan Diaz-Rainey, Quyen Nguyen) who are modelling the resulting impact on property values.

Figure 3. Sarah Yeo (Otago University Masters Student) and Simon Cox (GNS Science) sampling water from a groundwater monitoring bore in Kennedy Street, South Dunedin (Photo Marc Ettema, Otago Regional Council).

UPDATES

News from NIWA

Compiled by James Griffiths

Presentations to the European Geophysical Union (EGU)

Two hydrology group staff gave talks at the EGU General Assembly 2019 in Vienna. The presentations covered research on 'Increased water use efficiency through Variable Rate Irrigation' and 'Ensemble hydro-meteorological forecasting'. Both presentations were well received. Celine Cattoën-Gilbert also co-convened and co-chaired a session titled 'Operational forecasting and warning systems for natural hazards: challenges and innovation'. Staff also served as judges for poster and PICO (Presenting Interactive Content) presentations. Over 16,200 scientists from 113 countries participated in the conference. [Rajanayaka, Cattoën-Gilbert]

Co-designing tools for improved water use efficiency

MS Srinivasan and Graham Elley were invited by ECan's joint science-policy-consent management teams to present a talk on the use of co-innovation principles for water use efficiency. This invite stemmed from ECan's attendance at the recent Irrigation Insight farmer workshop held at Rangiora, where the NIWA team ran an irrigation tool design activity with farmers, industry and government stakeholders. MS presented a talk on how to use a co-innovation approach in a biophysical project, using examples from the Irrigation Insight Endeavour programme. [Srinivasan, Elley]

Workshop at the Indian Institute of Technology, Hyderabad (IITH)

NIWA attended a workshop and held discussions at the Indian Institute of Technology, Hyderabad (IITH), on flood hazard, hydrology and remote sensing. Presentations were given on Flood Hazard Prediction Models and River and Coastal inundation changes due to Earthquakes. Unfortunately, water data is a matter of national security in India and it was revealed that high-resolution satellite data could not be released for use in research in IITH projects. [Smart]

Award for development and implementation of Coastal Inundation Forecasting Projects

A certificate from the president of the UN World Meteorological Organisation was awarded to NIWA for contribution to the development and implementation of Coastal Inundation Forecasting Projects, particularly in Indonesia (https://www.youtube.com/watch?v=JDC5TpqTOF4) and Fiji. The certificate was accepted on behalf of Graeme Smart by John Fenwick at a small ceremony in Geneva. [Smart]

John Fenwick accepting award on behalf of Graeme Smart in Geneva

Collaboration with University of Bristol (UK)

Staff from the hydrology group in Christchurch travelled to the University of Bristol (UK) to continue a collaboration on the topic of groundwater model parametrisation and regionalisation. Workshop attendees from the university included Dr Ross Woods, Prof. Thorsten Wagener, Dr Gemma Coxon and Professor Jim Freer. Parameter-set simplification for the TopNet-GW model was discussed with reference to a similar approach being used by the Bristol team in the Dynamic fluxEs and ConnectIvity for Predictions of HydRology (DECIPheR) model. The collaboration was funded by a Royal Society Catalyst (Seeding) grant and consists of a further two workshops to define a parameterisation and regionalisation methodology for groundwater models in New Zealand. En route back to Christchurch the NIWA staff called in to the Centre for Hydrology and Ecology (CEH) where they were hosted by Dr Mike Hutchins, and Christian Zammit presented a seminar on the New Zealand Water Model (NZWaM). [Yang, Griffiths, Zammit]

Mike Hutchins from CEH (centre) meets Yang Jing (left) and Christian Zammit (right).

Sharing progress with the New Zealand Water Model (NZWaM)

NIWA were invited to present a seminar by the 'Complex Systems, Big Data and Informatics Initiative' (CSBII) at Lincoln University. The title of the seminar was 'Hydrological Modelling in a Changing New Zealand'. It covered hydrological modelling being practised at NIWA (including the New Zealand Water Model, flow forecasting, isotope, irrigation, remote sensing, climate change, drought analysis) and detailed content of groundwater-surface water modelling. The seminar generated interest among academics and post-graduate students and led to stimulating discussions, primarily on impact of earthquakes on the water resources, and water quality and quantity issues due to land use changes. [Rajanayaka]

AeroSpace Challenge NZ

A team representing NIWA was accepted onto the incubator programme of the NZ AeroSpace Challenge in June. The team competed against 20 other teams aiming to develop innovative products or services to detect, monitor or measure soil or water pollution in agricultural land. Teams were supported by Airbus, Xerra Earth Observation Institute, SpaceBase, and the University of Canterbury. The NIWA team claimed a runner-up prize of €4,000 worth of Airbus remote sensing imagery data. Their winning design was a prototype data-analysis service for identification of nitrate hotspots at the sub-paddock scale. The concept attracted interest from MPI, MfE, Christchurch Aerospace Centre, and Airbus. Potential collaboration with Lincoln University on the use of thermal imagery for estimation of nitrate uptake by plants was also identified. [Griffiths, Schimel, Steinmetz, Singh, Goeller, Smart, Biggs]

New paper on mapping water use by forests accepted for publication.

Pressure on water resources is increasing across the primary sector; new tools are required to understand the impacts of planted forests on water fluxes at catchment and regional scales. An article presenting a new method to calculate forest use of water resources has been accepted for publication in Forest Ecology and Management. This work combines LiDAR data with stable isotope data collected from tree stems to map water sources for trees across landscapes. This information will help to guide planting of trees to minimise impacts to water resources. [Dudley]

WGA
WALLBRIDGE GILBERT AZTEC

UPDATES

News from WGA

Compiled by William Dench

New Staff

WGA NZ are excited to announce Nick Dugan and William Dench have joined the Integrated Water Management (IWM) team based in our Christchurch office.

Nick Dugan

Nick Dugan is an experienced civil engineer and project manager who specialises in hydrologic and hydraulic assessment and design of waterway structures including bridges, culverts, floodways and weirs. He has project experience in New Zealand and Western Australia, including the cyclone-impacted Pilbara Region, and worked on rail, highway, rural roads and mine infrastructure projects. Nick is highly skilled in applying an appropriate level of site investigation, analytical thinking, modelling and calculation necessary to determine flow conditions required to satisfy relevant design standards and specifications. He will lead WGA NZ's civil engineering business from Christchurch; in doing so he will be looking at opportunities that integrate WGA's 3 Waters and IWM expertise within New Zealand.

Nick Dugan

William Dench

William Dench

William Dench is a Hydrogeologist and is leading WGA's field and data collection services. William, originally from Canterbury, has worked extensively in Mid-Canterbury and completed a Masters in Water Resource Management and a BSc in Geology and Environmental Science, both at the University of Canterbury. William is also supporting our groundwater modelling projects in both New Zealand and Australia working in MODFLOW, MT3DMS, and Leapfrog software packages to conduct ASR and ASTR injection systems assessments.

Oreti Managed Aquifer Recharge (MAR) Pilot

In July 2019, Shane Jones announced the government's Provincial Growth Fund had selected the Oreti MAR Pilot programme for funding support. The project covers a period from 2019 through 2021 and includes strategic partnerships with Environment Southland, Institute of Environmental Science and Research (ESR) and the Oreti MAR Community Trust. The Oreti basin is located in the Five Rivers area near Lumsden and is targeting an integrated management approach using the various tools of MAR.

ORETI MAR TRUST

The WGA NZ Team were busy this year completing stage 1 of this project including a feasibility assessment for MAR within the Oreti Basin. The project is focused on a fundamental Southland question:

'Can the proactive management of groundwater storage provide a viable tool to enable reliable water supply whilst helping us prepare for a changing climate?'

Oreti MAR Community Trust Directors with WGA's Bob Bower and Clare Houlbrooke.

Oreti River near Mossburn

Integrated Water Management for Community Resilience and Climate Adaptation

WGA's Integrated Water Management (IWM) team has been recognised by the Australian Water Association through the 2019 **Innovating for Sustainable Water and Environmental Outcomes Award for Western Australia.** WGA developed the integrated water management strategy and recommendations which will inform future decisions about water infrastructure investment and water security in an area predicted to undergo significant urban growth to 2050. The strategy, which encapsulates a region-wide approach, is designed to support population growth in a way that maintains liveability standards in line with the expectations of the community. We have a number of IWM projects across the Australasian region which vary from the use of reclaimed land to replenish groundwater supplies as well as enabling our clients to develop sustainable groundwater management strategies for water scarcity, quality and our changing climate.

Conferences

Clare Houlbrooke and William Dench will be presenting at the NZHS Conference in Rotorua this December. Clare will explore the question: 'Can we store water below ground to provide reliable water supplies, Oreti Basin, Southland?'. **William** will be presenting his research which looks to answer the question: *'Is small-scale managed aquifer recharge able to achieve big outcomes? Learnings from the Hinds-Hekeao plains.'*

Bob Bower recently provided a Plenary Session talk at this year's Resource Management Law Association Annual Conference in Christchurch, discussing the importance of sustainable groundwater management in the development of IWM thinking. Recently appointed as the Scientific Programme Chair for the International Symposium for Managed Aquifer Recharge (ISMAR 11 – LongBeach California in 2022), Bob will lead the collaboration between International Association of Hydrogeologists (IAH), the American Society of Civil Engineers (ASCE), the Groundwater Resources Association of California (GRAC), and the Orange County Water District (OWRD).

UPDATES

Update from WSP

Water Resources and Flood Risk Management – Wellington Water Resources Team - by Lizzie Fox

Big changes!

This year has seen the final transition of Opus into WSP! Look out for our new branding! This has also involved a name change from the 'Environment Division' to 'Water Resources and Flood Risk Management'(WRFRM).

Staffing

There have been several changes within the Wellington Water Resources team over the last year. **Matt Balkham** has now progressed up to be the Business Manager of the WRFRM group since the start of the year, which includes leading the Wellington-based team but also the Auckland, Hamilton and Christchurch water teams too. **Louise Algeo** stepped up to the Work Group Manager role, as well as continuing to provide expert flooding modelling advice alongside **Dr Jack McConchie**, the Technical Principal of Hydrology and Geomorphology.

We have had four new starts: **Dr Deborah Maxwell** has joined as a Senior Hydrologist, bringing key expertise in LUCI modelling, GIS skills and hydrology modelling and analysis. **Courtenay Giles** is a new Graduate Water Resources Engineer, who has a keen interest in fluvial modelling. At the University of Canterbury, she focused on water quality analysis and environmental fluid mechanics. **Mika Zollner** has come on board part-time as she finishes her Masters in Environmental Science at Victoria University of Wellington. For her thesis she is looking at the importance of continuous monitoring in urban streams where there is increased catchment densification, in order to capture the extent of acute contamination during rainfall event. **Joe McGowan** has come all the way from the UK as a Water Resources Engineer, who specialises in hydraulic modelling and stormwater management. He has experience in producing flood risk assessments, catchment management plans and integrated one-dimensional and two-dimensional stormwater flood models. He replaces **Daniel McMullan** who has moved back home to Christchurch.

Our new engineers work alongside Senior Engineer **Franciscus (Kos) Maas**, and Water Resources Engineers **India Eiloart** and **Leila Sadeghi,** who have specialities in fluvial modelling and design. Our other recent starts will be working with the Water Resource Scientists, Groundwater Scientists and Hydrologists: **Samwell Warren, Ella Boam, Lizzie Fox, Kirsty Duff, Courtenay Bremner** and Senior Hydrologist **Lennie Palmer.**

This brings the Water Resources team to 15 individuals, who are located across Wellington, Palmerston North and Tauranga.

Awards

There was some very exciting news in September at the Water New Zealand Conference where **India Eiloart** was named as Beca Young Water Professional of the Year. The highly-regarded award acknowledges and rewards a professional who has made a significant contribution to the water industry and the general community and has demonstrated exceptional achievement in the early stages of their career.

Projects

The team works on a variety of projects, specialising in hydrology, geomorphology, coastal dynamics, hydraulic engineering, and modelling. Below are some key projects which the team has worked on over the last year, that highlight the diversity of the team's expertise.

Impact of the Kaikōura Earthquake on River and Groundwater Interactions

The Ward community relies on the Flaxbourne and Waima/Ure Rivers for a diverse range of agricultural practices and land uses including irrigation, stock water, and domestic potable water supply. Dramatic changes to the landscape and waterways have occurred since the Kaikōura Earthquake, including potential changes to the flow regimes of the rivers and the connection between surface water and groundwater.

This project aimed to characterise the low flow regime, the nature of the low flow recession, and the gaining and losing reaches of these rivers to identify how the flow dynamics of each river has changed as a result of the Kaikōura Earthquake.

Comparison of gauged flow from the upstream Waima River at Blue Mountains to the downstream Waima at SH1 pre- and post-earthquake showed a distinct change in the low flow regime (Figure 1). The apparent shift in the previously developed relationship between flows at Blue Mountain and at SH1 has significant water resource implications. There appears to be significantly less surface flow at SH1 relative to Blue Mountain since the Kaikōura Earthquake. The reduction in surface flow in the lower Waima/Ure catchment has implications for the management and maintenance of surface flows, instream services and ecological values, and the connectivity between surface water and groundwater. There are also potential consequences for both surface water and groundwater abstraction. The results obtained so far were atypical and therefore further gaugings are planned for the coming summer.

The preliminary findings will be presented at the New Zealand Hydrological Society Conference in Rotorua this year by **Samwell Warren.**

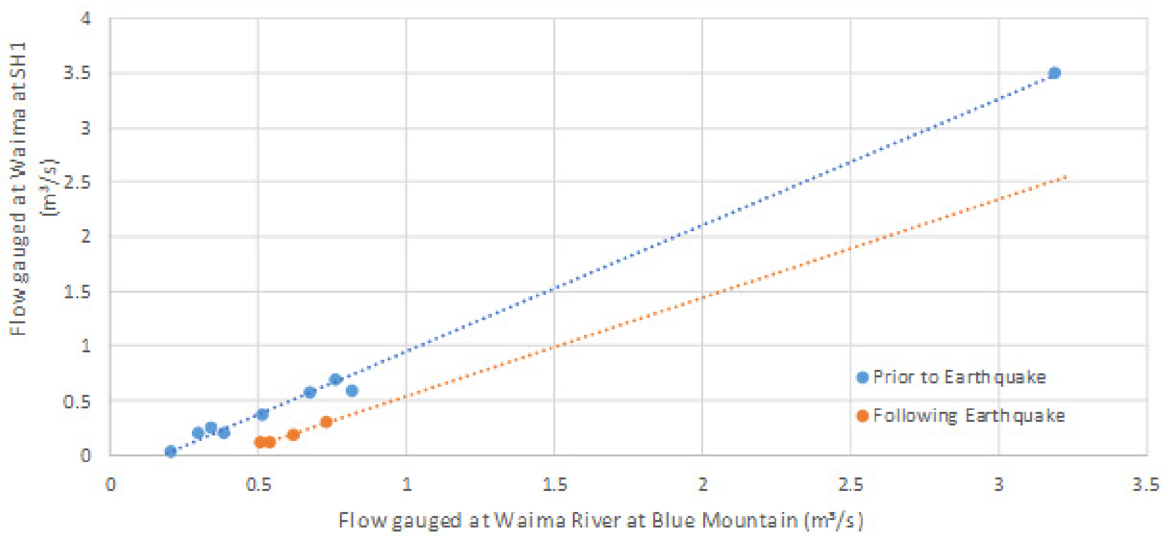


Figure 1 - Correlation of flows recorded in the Waima Ure River at Blue Mountian and SH1

Hydraulic Modelling for Bridge Design

There is a long-standing 'gap' in the walking and cycling network in New Zealand, where there are limited options for alternatives to driving. The client therefore was interested in a walk/cycleway bridge to be included on existing bridge infrastructure. As an initial exercise, three structural options for a new dedicated walking and cycling facility were investigated: a clip-on walkway attached to the main girders of the existing bridge; a walkway supported at the piers of the existing bridge; or a stand-alone footbridge (with sub options of full length and main channel spans).

A hydraulic assessment was therefore required to identify the risks posed from the hydraulic regime of the river, as well as investigate the hydraulic and hydrodynamic effects of the proposed work on the different bridge designs. This utilised the existing HEC RAS 2D model developed and extending in downstream to incorporate the bridge site and other areas of interest. This is shown in Figure 2. This model can also be used as a base for any subsequent work to be performed in the area.

This was one of many hydraulic models completed over the year for a diverse range of clients, as technology is making it easier and more accessible to carry out detailed analysis to get the best answer for specific scenarios.

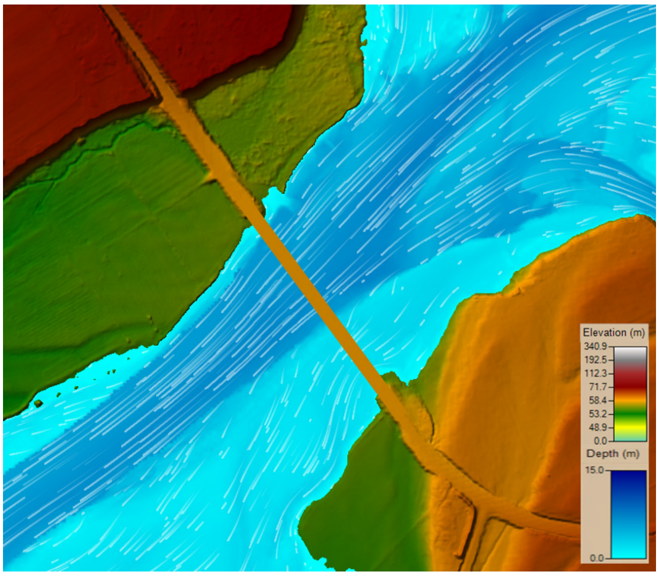


Figure 2 - Hydraulic model of bridge design

Water Safety Plans

The New Zealand drinking-water standards (DWSNZ) and best-practice approach to water supply management have been enduring significant scrutiny in the past few years, with each update and recommendation putting pressure on water suppliers around the country to keep up. Our wider Drinking Water Advisory team, within which India is a part of, has been working with water suppliers around New Zealand, from vast council supplies to small community supplies, to pre-empt requirements, inform on implications of guidelines and standards changes, and navigate and agree on the most appropriate ways to retain the safety and security of these water supplies.

One client we began working with in mid-2017 had ten supplies requiring Water Safety Plan (WSP) updates, and since then we have been assisting them through this time of regulatory and best-practice change. One of many modifications since the first WSP drafts is that chlorination has been added to some supplies to follow the multiple barrier approach, which is now included in the foreword of the DWSNZ 2018 among the six principles for potable drinking water. An increased focus on source water protection in these principles has also resulted in our developing Cyanobacteria Management Plans for their surface water sources. Best practice protocols are ever involving, as the science community collects new data and presents new findings, and the environments within which we work change and present new challenges.

Tile Drainage effects on hydrological responses

There has been an increase in sub-surface “tile drains” on the Gisborne Flats, especially with the conversion of pastoral land to kiwifruit orchards. The client wanted to investigate the potential influence of increasing horticulture tile drainage on the flood hazard of their surface drainage network. This network has a 5-year ARI design service level which was the magnitude event of focus for this project.

From the review of previous studies, tile drainage increases rainfall losses to soil water storage. This water drains more effectively, reducing evaporative losses and surface runoff and hence peak flows. Peak flows can be up to 80% lower with tile drainage; the soils, slope, rainfall intensity and tile spacing influencing the surface hydrograph magnitude and shape. There is a “lag” with the tile drainage hydrograph, namely it is longer and flatter than the comparable surface hydrograph.

HEC HMS simulations were run with and without drainage and using varying initial and continuing loss values. The results showed that tile drainage would decrease the peak flow considerably. Furthermore, due to the low hydraulic conductivity of the soils and from local practical experience, maximum flows will be less than half of this. The tile drainage flow will occur some hours after the commencement of rainfall, and after the surface hydrograph peak has passed. Figure 3 shows a comparison of results of several model runs, comparing undrained to drained using two different coefficients for initial and continuing loss values.

These findings will be presented at the New Zealand Hydrological Society Conference in Rotorua this year by **Lennie Palmer.**

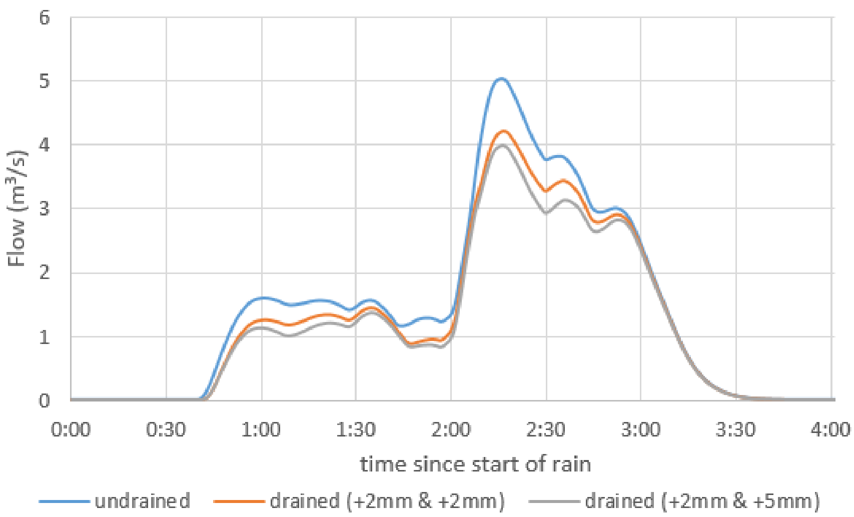


Figure 3 - HEC-HMS models for the 5-year flood hydrograph using SCS UH initial and continuing loss models to represent the catchment with and without sub surface drains

ARTICLES

News from Lincoln Agritech Ltd

Lincoln Agritech collaborating with Danish scientists

Participating in the Land Use and Water Quality (LuWQ) conference series since 2013 highlighted to Roland Stenger not only the similarity of agro-environmental issues between the two countries of similar population size, but also the common scientific interest in elucidating transfer pathways and nitrate attenuation between source and receptor.

Gaining MBIE funding for the Critical Pathways Programme (CPP) in late 2018 finally offered the opportunity to establish a formal relationship with scientists from the Geological Survey of Denmark and Greenland (GEUS) and the HydroGeophysics Group (HGG) from Aarhus University. As this year's LuWQ conference was fortuitously held in Aarhus, Roland Stenger, Scott Wilson, and Mike Friedel (since then returned to US) travelled in May to Denmark to present at the conference and hold a knowledge exchange workshop with their Danish collaborators. The group discussed research subjects ranging from airborne and ground-based geophysical surveys to groundwater redox chemistry (Fig. 1). In addition to sharing their latest findings, the Danish hosts took the New Zealand team to see some of their field sites (Fig. 2).

The initial workshop was followed by a period of comprehensive analysis of the vast datasets originating from the airborne electromagnetic surveys that we carried out earlier in the year in our two contrasting CPP pilot catchments, the Waiotapu Stream catchment (approx. 300 km^2) and the Piako River headwater catchment (approx. 100 km^2). Scott Wilson returned to Aarhus in early October for in-depth discussion of the results, their interpretation in the geological context of the two contrasting catchments, and identifying catchment areas particularly interesting for higher resolution ground-based surveys. Success in this year's Endeavour Fund investment round with our 'Braided Rivers' proposal meant that we now can take our collaboration to the next step and welcome a couple of our collaborators from HGG in Aotearoa New Zealand in 2020 to jointly carry out innovative field research.

Fig 1: Researchers from GEUS, HGG and Lincoln Agritech discussing their pathways and attenuation research at Aarhus University.

Fig 2: Introduction to field research sites in the hilly glaciated landscape of eastern Jutland.

New research to uncover crucial knowledge on braided rivers

Lincoln Agritech Ltd has recently been successful in attracting MBIE funding for a 5-year research programme that will provide the first accurate information about how much water is lost from braided rivers into groundwater (Fig. 3).

Programme Lead Scott Wilson highlighted that regional authorities currently set water limits and identify management plans for braided rivers without knowing how much water is lost as these rivers traverse their alluvial plains. The impact on groundwater recharge and river flow during dry periods is also unknown. The programme will deliver new knowledge regarding the Selwyn/Waikirikiri, Wairau and Ngaruroro rivers, along with models allowing councils to estimate water loss from any part of any braided river. It will also quantify the environmental and economic benefits of different river management strategies.

This new understanding will help manage the trade-off between environmental and economic benefits, ensuring that rivers can continue to have a role in agriculture, while providing high-quality drinking water, recreational activities and important native habitat.

The multidisciplinary research team includes experts from Lincoln Agritech Ltd, as well as NIWA, Lincoln University and its Agribusiness and Economics Research Unit (AERU), University of Canterbury - Waterways Centre for Freshwater Management, Flinders University (Australia), Technische Universität Dresden (Germany), and Aarhus University (Denmark). Partners in our case study areas include Environment Canterbury and Te Taumutu Rūnaka, Marlborough District Council, and Hawkes Bay Regional Council and Ngāti Kahungunu.

Fig. 3: The freshwater science programme will closely monitor the braided Wairau River. Photo courtesy of Peter Hamill, Marlborough District Council.