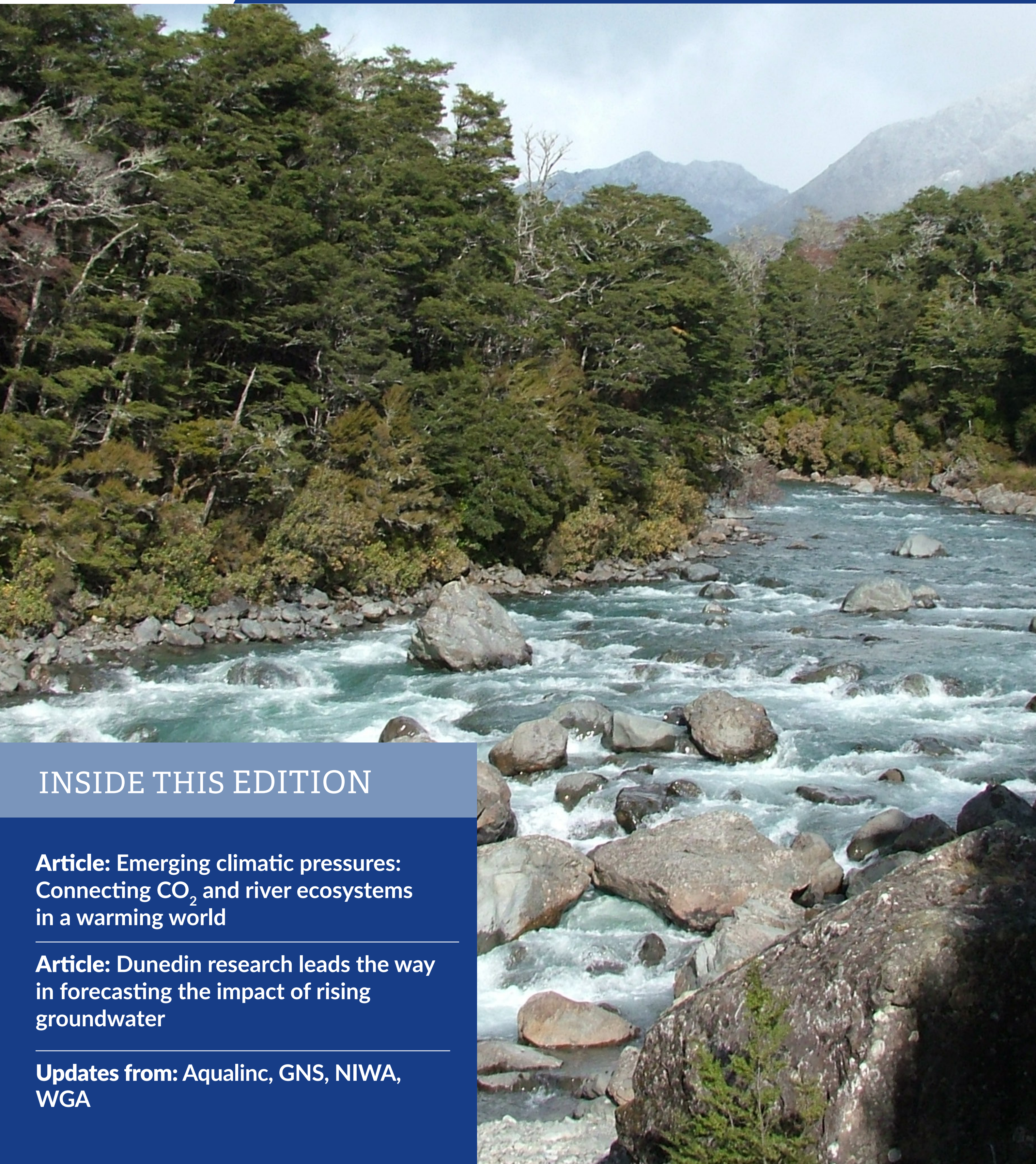
NZHS E-CURRENT NEWSLETTER • NUMBER 65 • MAY 2024

NEW ZEALAND HYDROLOGICAL SOCIETY

E-CURRENT NEWSLETTER



INSIDE THIS EDITION

MESSAGE FROM THE EXECUTIVE

Welcome to the Autumn issue of e-Current

Water, either too much or too little, is once again making headlines. Many regions of New Zealand are reeling under below-normal rainfall and river flow conditions. At the same time floods inundated parts of the West Coast of South Island. It is a stark reminder that although New Zealand is blessed with plenty of water, its distribution – availability at the right place and at the right time – still poses challenges.

April has been a busy month for the Society. First, we hosted the Annual Technical Workshop in Queenstown. Second, on 12th April, the Society honoured David Scott and Peter Callander, the two recent Outstanding Achievement Awardees, at a small function at ESR in Christchurch. The Christchurch function was held as David and Peter were unable to attend the Auckland Annual Conference to receive their award in person. At the Christchurch function, Joseph Thomas presented the medals to the awardees, which was followed by acceptance speeches by the awardees. It was great to see families and friends of awardees joining the celebration. We congratulate David and Peter for their outstanding contributions to New Zealand hydrology.

We also wish to congratulate Aqualinc Research Limited. Aqualinc turned 20 last year, were the first Society sponsor, and remain one of our champions. We wish the Aqualinc family all the best. The NZHS web portal is open for project and travel grants. Visit the NZHS website for more information. Particularly, we encourage student members to avail themselves of the funding opportunities.

As a professional Society, NZHS always takes pride in recognizing and celebrating the exceptional contributions and outstanding achievements of its members. Our Early Career Scientist and Outstanding Achievement awards recognise the professional contributions of our members. We encourage the members to nominate deserving fellow members to these NZHS awards. Self-nominations are also welcome. Please send through your nominations via the NZHS web portal. For questions on awards and grants, contact admin@hydrologynz.org.nz.

Do you have a report or processed datasets that would make a good paper to the Journal of Hydrology (New Zealand)? Please contact the editor.

The Blenheim Conference Committee is busy working on organising the next annual conference. Mark your calendar for the conference dates: 26 to 29 November. A call for abstracts is already out, and abstracts are due by 2 August. If you wish to suggest topics for special sessions or organise a pre-conference workshop, please contact the Conference Committee as soon as possible.

For all conference updates, visit www.nzhs2024conference.co.nz. We are looking forward to seeing you at the Blenheim conference.

Ngā mihi nui | Kind regards

MS Srinivasan

CONTENTS

e-Current is the newsletter of the New Zealand Hydrological Society Inc. Contributions are welcome from members at any time and can be sent to admin@hydrologynz.org.nz

Advertising space is available; contact Lea Boodee at the above address for more info.

NOTICES

Journal of Hydrology (New Zealand) a call for papers & notes

The Journal of Hydrology (New Zealand) is published twice a year. - https://www.hydrologynz.org.nz/journal-of-hydrology

Papers and Notes can be sent to the Editor (admin@hydrologynz.org.nz) at any time. I aim to have papers and notes reviewed in under two months and publish accepted material within a year. 'Notes' are generally short, maybe 4 to 8 pages. Notes are intended to be pilot studies, work that is not completed or technical information (ie interesting and relevant material that is not a final article). Papers and Notes have been published on all aspects of hydrological science and management. I encourage you to consider sharing your work with others through publication.

I am keen to publish a special issue of the Journal on the extreme weather events of 2023. While there will be research for many years on its impacts, I am hoping that people have interesting papers and notes they wish to share.

If you want to discuss your potential publication please don't hesitate to contact me.
Richard, Editor, Journal of Hydrology (New Zealand)

Awards

At the 2023 NZHS Annual Conference, Peter Callander and David Scott were awarded the Society's Outstanding Achievement Award for their invaluable contributions to NZ hydrological sciences. As neither was present at the conference to receive the award in person, on 12 April NZHS held an event at ESR, Christchurch, to present the awards in person and celebrate their contributions. At the event, Hilary Lough and Murray Close read out the citations of Peter and David, respectively, and Joseph Thomas, NZHS President, presented each awardee with a medal and certificate. Many current and ex-colleagues of Peter and David attended the event, along with Christchurch-based NZHS Executive members. Once again, the Society congratulates David and Peter for their contributions and thanks their nominees and referees.

AGC NZHS 2023 Conference

Many thanks again to all of you who made our combined AGC NZHS 2023 conference a resounding success. It was wonderful to bring both societies together, resulting in a diverse range of topics structured around themes such as the application of hydrological science, integration of indigenous knowledge, and innovative strategies for water resource management. This ensured a holistic approach to discussions on hydrology, hydrogeology, and sustainability.

We were thrilled to welcome a diverse group of delegates from across industry, consulting, government, research, and academia, not only from the Australasian region but also globally. Altogether, we had 380 attendees, of which 150 made the journey from Australia to be part of the conference. Participants enjoyed a stimulating technical programme that included 3 inspiring keynotes, 230 oral presentations, and 32 posters; various social events that provided excellent networking opportunities; and engaging field trips to Waiheke Island and the Waitakere Dam.
A special highlight was the awarding of the Outstanding Achievement Awards to David Scott and Peter Callander, recognising their significant contributions to hydrological science in New Zealand. Although they were not able to attend, the awards were presented to them after the conference.

Another highlight was the conference dinner at the beautiful Auckland Town Hall, which featured scrumptious food, creative costumes, and, as usual, enthusiastic dance performances.

Special thanks are due to the Organising Committee for their dedication and hard work: Theo Sarris, Conny Tschritter, Kelly Jane Wallis, Mauricio Taulis, Joseph Thomas, Sam Trowsdale, Kolt Johnson, Andy Pearson, and Tracy Young.

We hope the insights gained and connections made at the conference will inspire and empower all attendees to continue their important work in hydrology and hydrogeology.

Thank you once again for making the conference a success. We're looking forward to seeing you all in Blenheim this year.

View more AGC NZHS Conference photo here.

Outstanding Achievement Award: David Scott

David Scott has made a significant contribution to groundwater science in New Zealand, specialising in the use of computer models for groundwater resource assessment, analysis of surface water/groundwater interaction and groundwater management and planning, leading to more than 25 published and numerous unpublished papers and reports.

David's achievements started young, being the Dux of Burnside High School for three consecutive years (albeit the school was newly opened and his was the eldest year group). He went on to complete a Bachelor of Engineering (Civil) at the University of Canterbury from 1966 to 1969, followed by a Master of Engineering (Agriculture – with distinction) at Lincoln College from 1970 to 1973.

David first worked at the Hydrology Centre of the Ministry of Works and Development where he was one of the first in New Zealand to develop expertise in groundwater modelling. His first major project as a new graduate, together with Hugh Thorpe and Rob Burdon, was the potential for contamination of the Heretaunga Plains aquifer David was assigned the role of modelling the aquifer, mentored by Bruce Hunt of the University of Canterbury. This was a time when expertise in groundwater and groundwater modelling was limited in New Zealand, yet the team met an 18-month deadline in a complex political situation, leading to the MWD Research Director winning a bet with the chair of the Catchment Board for two bottles of whisky, with the winnings going to the Napier field staff.

David became lead of his second major project, modelling proposed irrigation between the Rakaia and Ashburton Rivers to identify how much irrigation could be sourced from groundwater compared to from the Rakaia River. The resulting 'Scott and Thorpe (1986)' report continues to be a foundation of knowledge of the groundwater resource in an area of intensive farming and groundwater abstraction.

David contributed to a growing understanding of groundwater science in New Zealand through short courses run by the Water and Soil Division. In such a new field, the tutors were apparently often not far ahead of the students they were teaching. He maintained this teaching role throughout his career by presentations through the Hydrological Society, short courses and one-on-one coaching and mentoring for many of New Zealand's groundwater modellers.

The first regional-scale numerical model of the Wairau Plain was developed by David during his time as a groundwater scientist in the late 1980s to early 1990s working for the Geology and Geophysics Division of the DSIR. This MODFLOW-based model characterised the hydraulic link between the Wairau Aquifer and freshwater springs and formed the basis for a groundwater allocation limit in later planning.

From 1993, with the disbandment of the DSIR, David moved to the Canterbury Regional Council Groundwater Science team. He developed a model of the Christchurch aquifer that allowed the impact of groundwater abstraction on spring-fed stream flow to be assessed. David wryly noted that his model, which identified zones around springs where pumping schedules could be managed to minimise impacts on spring flow, led to the inadvertent consequence of abstraction wells being relocated further away where the shorter-term effects became harder to manage.

An important part of David's work at the council was using his modelling and programming skills to test scenarios and inform groundwater management plans. He has been able to appreciate the benefits of various forms of groundwater modelling from the complex numerical types to the simpler analytical methods. His work was foundational in creating groundwater allocation limits, well interference and stream depletion policy. He was unique in his ability to manipulate large data to create model inputs such as land-surface recharge by water balance models, where he contributed to research papers on the groundwater dynamics with Vince Bidwell and others. He identified shortcomings in how Canterbury gravel aquifers with connected streams were represented in effects analysis, and worked with Bruce Hunt of the University of Canterbury to test, develop and publish solutions with real-world applicability.

David completed two 2-year assignments as a groundwater hydrologist working on aid-funded projects for the South Pacific Applied Geosciences Commission. These involved groundwater assessments for Kiribati, the Kingdom of Tonga and Rarotonga.

David next moved to ESR in 2013 where his worked focused, among other things, on how to characterise rapid transport pathways permeating alluvial gravel aquifers, informing drinking water protection measures. He also continued to develop the type of numerical experiments that explore an idea and illuminate truths that seem obvious once you see his work, but were not at all obvious beforehand. His modelling work shed light on the complex distributions of preferential transport pathways in Canterbury's alluvial gravel aquifers. With his deep understanding of flow and transport processes in aquifers he provided technical guidance and leadership on some challenging projects in the drinking water safety area, identifying limitations and opportunities. He also played a crucial role in the technical and professional development of young (and not so young) hydrologists.

David has kept a low profile; his philosophy on work life shared on the squash court is 'to be clever and helpful'. He is approachable and open-minded. This quiet, behind the scenes helpfulness has supported the achievements of many others and together with his practical solutions is why David is held in such high esteem by his colleagues.

Outstanding Achievement Award: Peter Callander

Peter Callander has contributed significantly to the management of New Zealand's water resources over his lengthy career.

Peter completed his BSc in Geology at the University of Auckland in 1982, followed by specialist groundwater training at the University of Waterloo in Canada with a scholarship for outstanding academic credentials, graduating with a Master of Engineering Geology in 1984.

He returned to New Zealand to work as a hydrogeologist with the Canterbury Regional Council (formerly the North Canterbury Catchment Board and Regional Water Board) from 1984 to 1991. Peter's very early career was that of a traditional hydrogeologist at the time. Camping in a caravan onsite to take manual water level readings during pumping tests through the night was a regular part of the job. Peter progressed to lead the Groundwater Group there from 1989 to 1991.

He completed further training at the University of Canterbury in 1991, provided by Dr Bruce Hunt, gaining a Certificate in Proficiency in a Master of Engineering course on the mathematical analysis of groundwater resources. He has also been an occasional guest lecturer at that university.

Peter moved to Pattle Delamore Partners (PDP) in 1991 to successfully establish and manage the PDP Christchurch office. He was a long-serving, well-respected director on the PDP board of directors from 1996 to 2021, overseeing the company expanding from its groundwater and contaminated land focus to a wide-ranging environmental and engineering consultancy.

Peter has been instrumental in the preparation of various guidelines that have been widely applied for water resource management in New Zealand. These include the 2000 Guidelines for the Assessment of Groundwater Abstraction Effects on Stream Flow for the Canterbury Regional Council, the 2002 Groundwater Model Audit Guidelines for the Ministry for the Environment, the 2005 Methodology for Delineating Drinking Water Catchments and subsequent updated guidance for the Ministry for the Environment, and the Envirolink 2011 New Zealand Guidelines for the Monitoring and Management of Sea Water Intrusion Risks on Groundwater.

He has produced scientific papers published in New Zealand and international journals on groundwater topics ranging from geophysical investigations to hydrogeological analytical tools, including stream depletion equations, and given many NZHS conference presentations. Peter has presented evidence at numerous resource consent hearings, including proceedings at the Environment Court, District Court and High Court.

Peter's technical competence and exceptional communication skills have seen him appointed as an independent hearing commissioner on a number of hearing panels dealing with wastewater discharges to surface waterways and land, irrigation, managed aquifer recharge and groundwater abstractions. He has been a member of various expert peer review panels including the remediation of the former Fruitgrowers Chemical Corporation contaminated site at Mapua, has managed a hydrogeological evaluation of the Canterbury region to select potential sites for a new regional landfill, with subsequent detailed evaluation of the Kate Valley site, and has been involved in numerous water allocation projects, including recent work for Environment Southland to assist understanding allocation issues for the Mataura River.

Peter is currently a technical director in PDP's water resources team, passing on his expert water resources knowledge and judgement to colleagues and continuing to help ensure a high standard of management for New Zealand's freshwater, for which he is greatly appreciated.

ARTICLE

Emerging climatic pressures: Connecting CO_2 and river ecosystems in a warming world

Adam Hartland
Lincoln Agritech Ltd, Ruakura

Figure 1. The Waikato River (Kirikiriroa, Hamilton) is at the centre of a 5-year study led by Lincoln Agritech Ltd into the interacting effects of rising atmospheric CO_2 and climate-induced shifts in the metabolism of river ecosystems.

This article introduces the Emerging Climatic Pressures (ECP) MBIE Research Programme, including its aims and the scientific hypotheses being investigated. We aim to periodically update the NZHS community on our progress over the next five years.

What's ECP?

The Emerging Climatic Pressures MBIE Research Programme is a five-year study of the ecological and biogeochemical effects of rising CO_2 pressures on the Waikato River (Figure 1) and freshwater environments more generally. These 'rising pressures' originate from both the atmosphere ($CO_{2\ (g)}$) and from within catchments ($CO_{2\ (aq)}$).

In terms of the carbon cycle, river corridors can be thought of as the largest nexus, or interface, between the continents, oceans, and atmosphere (Dean & Battin, 2024). The ECP programme examines whether CO_2 exchanges occurring across this interface are responsible for defining emerging trends in water quality (Figure 2).

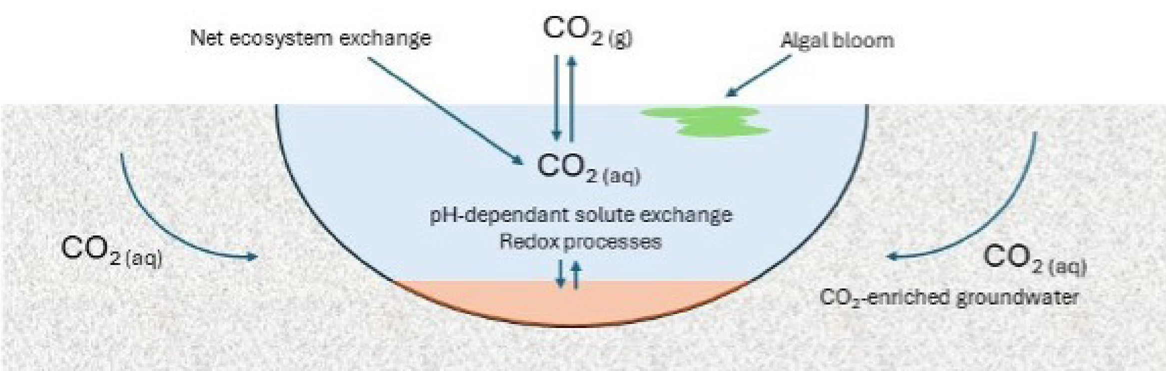


Figure 2. Conceptualising C exchange, nutrient biogeochemistry, and algal growth responses.

Our programme therefore asks fundamental questions about the relationship between CO_2 exchange and water quality (i.e., pH, dissolved nutrients, carbonate saturation) and how future atmospheric CO_2 levels could influence ecosystem phenology (e.g., phytoplankton succession) and the habitability of freshwater for molluscs (e.g., kākahi). These scientific questions are relevant to water quality attributes that matter to communities (e.g. safety for contact recreation), industry (e.g., drinking water source contamination), and Māori (e.g., mahinga kai).

Under the hood

Our project sets the ambitious goal of developing a mechanistic understanding of the relationship between pCO_2 (the partial pressure of carbon dioxide) and phytoplankton growth responses to dissolved inorganic carbon and nutrient bioavailability, thereby allowing prediction of future riverine water quality.

From the first-order controls (i.e., the balance between heterotrophic metabolism and CO_2 efflux), to second-order feedbacks (e.g., pH-dependent changes in nutrient bioavailability), we aim to identify and predict the precursors of harmful algal blooms (HABs) in the Waikato River under plausible climate emissions scenarios (Figure 3). If successful, the mechanistic understanding developed in ECP will have broader relevance for freshwater habitats across Aotearoa New Zealand and globally.

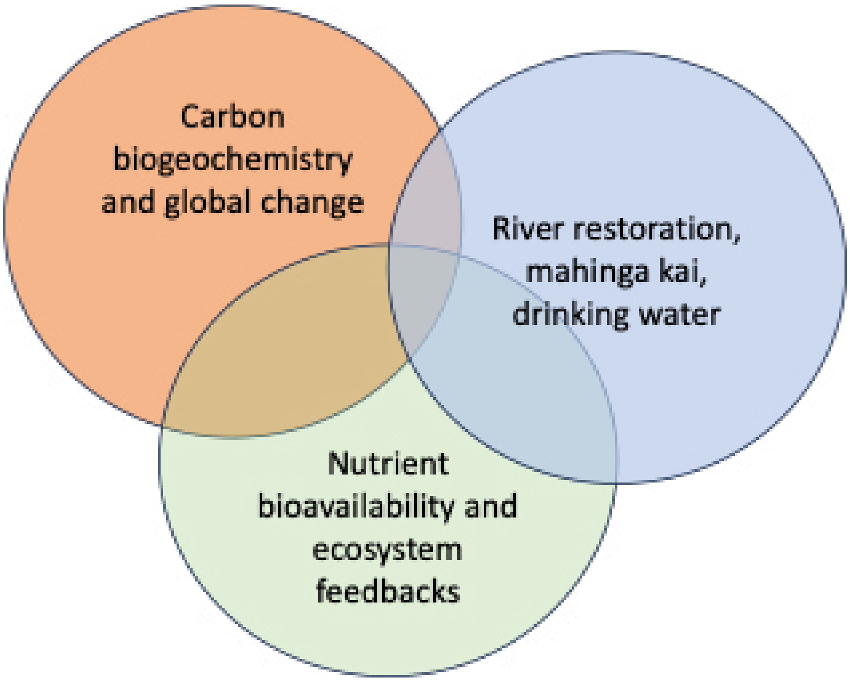


Figure 3. The ECP programme connects adjacent, but traditionally disparate, lines of research to investigate how climate change will affect the composition and health of the Waikato River, freshwater environments across Aotearoa New Zealand, and globally.

The Waikato River has huge cultural significance for tangata whenua, as well as socioeconomic and recreational importance for all New Zealanders. Through provision of drinking water to around one third of Aotearoa New Zealand's population and around 12.5% of our sustainable power generation capacity, the Waikato is a strategically important waterway. The project is therefore aligned with several stakeholders with a direct interest in the Waikato River, including Waikato River Iwi (Waikato-Tainui, Ngāti Maniapoto, Ngāti Tahu-Ngāti Whaoa), the Waikato River Authority, Waikato Regional Council, Hamilton City Council, WaterCare and Mercury Energy Ltd; representatives from all these organisations form our advisory panel to guide our research programme.

The Science

In our project, we will develop detailed process understanding of carbon biogeochemistry and associated feedbacks based on a high-resolution monitoring programme of the Waikato River between Lake Karapiro and Hamilton City. This stretch will be intensively monitored using a suite of sensors including pCO2, chlorophyll-a, phycocyanin, CDOM, tryptophan fluorescence, temperature, DO, and nitrate, iIn addition to a full geochemical suite including all major and minor inorganic components.

Our work includes fundamental research on:

• genomic studies of the tolerance (and potential adaptation) of freshwater mussels (kākahi, Echyridella menziesi) to elevated pCO_2 and associated carbonate undersaturation (which dissolves shell material);
• how pCO_2 affects the processes of inorganic carbon accumulation by phytoplankton and influences algal phenology (e.g., diatoms vs cyanobacteria);
• how riverine pCO_2 influences harmful algal bloom formation via feedbacks in nutrient availability (Figure 2); and
• how flow and meteorological conditions on varying length scales influence CO_2 exchange across the river-atmosphere interface.

These studies will further inform the development of river ecosystem models also to be developed within this programme for forecasting freshwater quality changes under projected climate conditions (up to the year 2100). Kaupapa Maori researchers in our team will then investigate the implications of the programmes' technical findings for Te Ture Whaimana o Te Awa o Waikato, the Vision & Strategy document guiding the restoration of Waikato River.

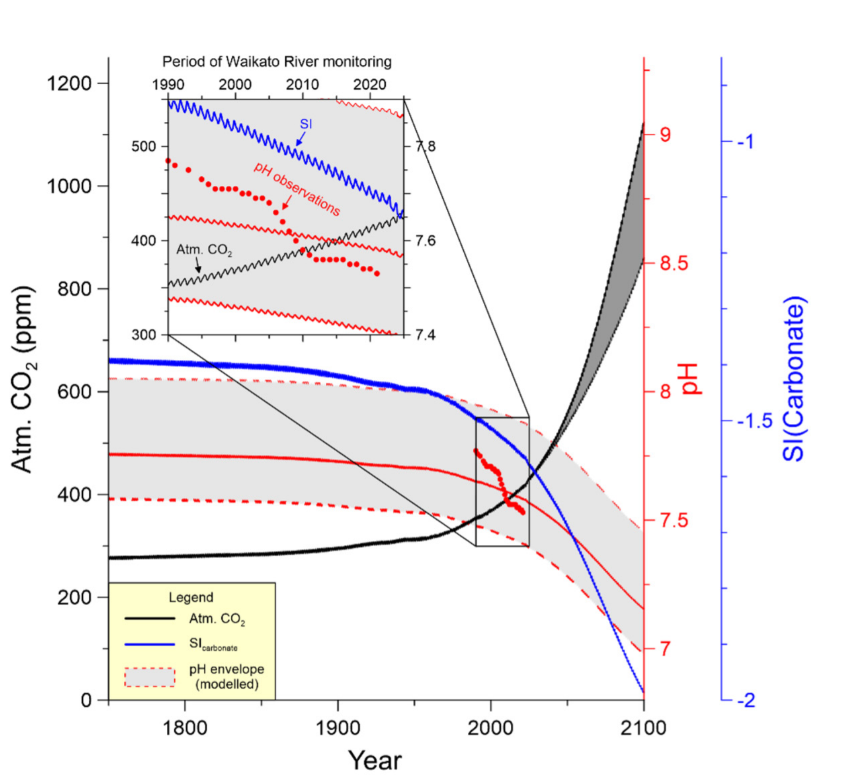


Figure 4. Rapid pH declines in the Waikato River at Hamilton may indicate the combined effects of rising atmospheric CO_2 levels and net ecosystem heterotrophy (in-situ biogenic CO_2 generation). Our project aims to constrain the causes of pH decline in the Karapiro to Hamilton section of the Waikato River.

At its core, our work will evaluate the chemical effects of CO_2 on phosphorus and metal micronutrients. We hypothesise that:

1) CO_2 balance is the main driver of pH and thus controls the charge state of suspended and benthic sediments; in turn affecting
2) the availability of metal cations (e.g., Fe2+, Mn2) and oxyanions (e.g., HPO42-, HVO42-) via reversible adsorption and desorption reactions at their surfaces.

We hypothesise that these pH-dependent effects may already be apparent in recent changes in Waikato River water quality (Gibbs et al., 2023). For example, the trend toward reducing phosphorus availability and algal biomass (Figure 4) may plausibly relate to these CO_2-induced pH changes (Figure 5).

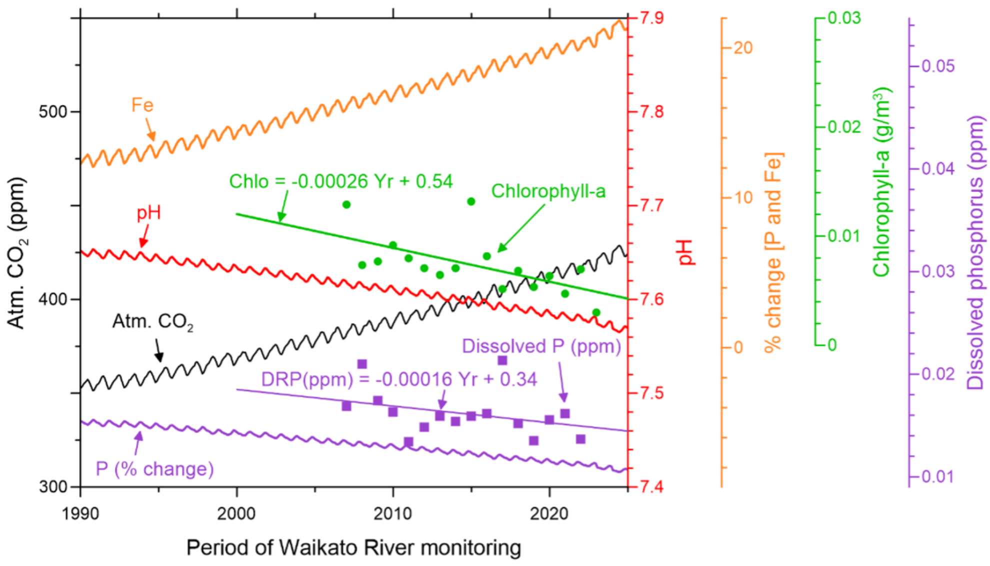


Figure 5. Simulated trends (pH, phosphorus (P), and iron (Fe)) in CO2-induced nutrient availability compared to mean annual dissolved P and Chlorophyll-a trends in the Waikato River. Simulated deviations in P and Fe are given in %.

Looking forward

We are currently working to deliver monitoring infrastructure needed to test our hypotheses and parameterise the planned Lake Karapiro ecosystem model. We anticipate the monitoring stations, including a LimnotrackTM profiler buoy, will be installed and generating data by early June 2024. Following this, research on riverine biogeochemistry with Victoria University of Wellington, Otago University and Cawthron Institute scientists will soon be underway.

The next step in refining our understanding of ecosystem feedbacks to elevated pCO_2 will follow surveys of riverine pCO_2 levels. This information will help guide site selection for studies of freshwater phytoplankton and kākahi.

References

Dean, J. H. and Battin, T. J. Nat Water (2024). https://doi.org/10.1038/s44221-024-00207-8

Gibbs, M. M. et al. Factors influencing summer phytoplankton biomass in a large river system with impoundments: retention time, zooplankton grazing, thermal stratification and internal seiching in a hydro lake. New Zealand Journal of Marine and Freshwater Research 1-24, (2023). doi:10.1080/00288330.2023.2177313

ARTICLE

Dunedin research leads the way in forecasting the impact of rising groundwater

While it is obvious that property immediately adjacent to the ocean may be exposed to direct inundation during storms as sea levels rise, there are also largely unseen and poorly understood hazards from groundwater that are also increasing with the rising seas. Emergent springs and flooding can occur considerable distances inland from the coast when groundwater gets pushed and prohibited from draining from low-lying coastal land by the sea. Pluvial (rain-related) surface flooding can be exacerbated where groundwater is shallow, making areas more impervious as it reaches the surface.

Dunedin is a city with a large number of assets, houses and critical infrastructure situated at, or close to, sea level. Presently protected from coastal inundation by a slightly elevated margin of reclaimed land and fragile sand-dunes, there is concern over the effect of sea-level rise on groundwater and functionality of the city's stormwater and wastewater networks. A new GNS Science Report provides a holistic, multi-hazard forecast of the city's future challenges with groundwater.

The report, produced in partnership with Otago Regional Council (ORC), is based on four years of observations from the ORC-operated groundwater monitoring network in South Dunedin and Harbourside. It examined what causes change to groundwater levels, such as tides, storm surge and rain, then uses this information to develop multi-hazard forecasts of where and when groundwater will rise and cause problems. GIS analysis using the monitoring data has enabled groundwater surfaces to be developed with site-specific (property-scale) spatial precision, accounting for both episodic events and permanent condition. Forecasts of groundwater conditions under sea-level rise were then developed by adjusting grid surfaces with a coastal forcing, using present day observations of tidal amplitude that depend on distance from the harbour or coast.

GNS Science Principal Scientist Dr Simon Cox says, *"The flat, low-lying coastal land of Harbourside and South Dunedin is vulnerable to effects from both the harbour and ocean. Our study shows that in some areas, as the sea level rises, groundwater will contribute to flood problems in two ways – through loss of capacity to store rain, and then flooding from below – and this can be expected before any inundation directly from the sea."*

Shallow groundwater near the coast is controlled by sea level and is expected to rise as sea levels rise. Although the water table (upper surface) always rises and falls, as its average position reaches ever closer to the surface it will generate a variety of issues for the city to address. While the findings show less impact for Harbourside, in South Dunedin rising groundwater is likely to be at the heart of issues as sea levels rise. Both areas are integral to how Dunedin presently functions, so the findings have implications for the whole city.

Otago Regional Council Manager Natural Hazards, Dr Jean-Luc Payan, says, *"This unique research is key to understanding the complexity of what is happening under the ground in South Dunedin and Harbourside area. It builds on monitoring work ORC and GNS have been doing together since 2009.*

It provides a detailed picture of where and when issues will arise, mapped out against 10 cm increases in sea-level rise. This helps us to understand how hazards will evolve and enable planning for the future. It's an important tool in determining adaptation options for the future of South Dunedin."

Figure 1: Dr Jean-Luc Payan (left, ORC) and Dr Simon Cox (GNS) with South Dunedin in the background.

The findings will help to inform the South Dunedin Future programme – an ORC and Dunedin City Council partnership to find ways to respond to climate change, sea-level rise and flooding problems in South Dunedin.

Dr Cox says, *"The forecasts of the different groundwater-related impacts were deliberately based on increments of sea-level rise. We know that sea-level rise is already happening but cannot be specific about the timeframe of exactly how quickly - which depends on global warming and international efforts to reduce emissions. So, we measure what is happening now and forecast at 10 cm steps in sea level, estimating the expected timeframes based on the variety of different Intergovernmental Panel on Climate Change (IPCC) emissions scenarios."*

"The research shows that Dunedin needs to plan for water coming from above, below and sideways from the harbour and ocean. There are some tidal effects near the coast but most of South Dunedin is sitting on relatively old, thick mud which groundwater moves slowly through, and this may mean there are more options for the future. But initially the incremental loss of capacity for the ground to store rainfall as the water table rises, and associated episodic flood events, seems to be the process likely to drive the first community decisions around adaptation, mitigation and/or retreat," Dr Cox says.

Shallow groundwater causes many problems as it rises, including inundation of stormwater and wastewater systems, building instability, and liquefaction vulnerability. Eventually it can lead to flooding from below when groundwater emerges at the surface as springs and causes local ponding.

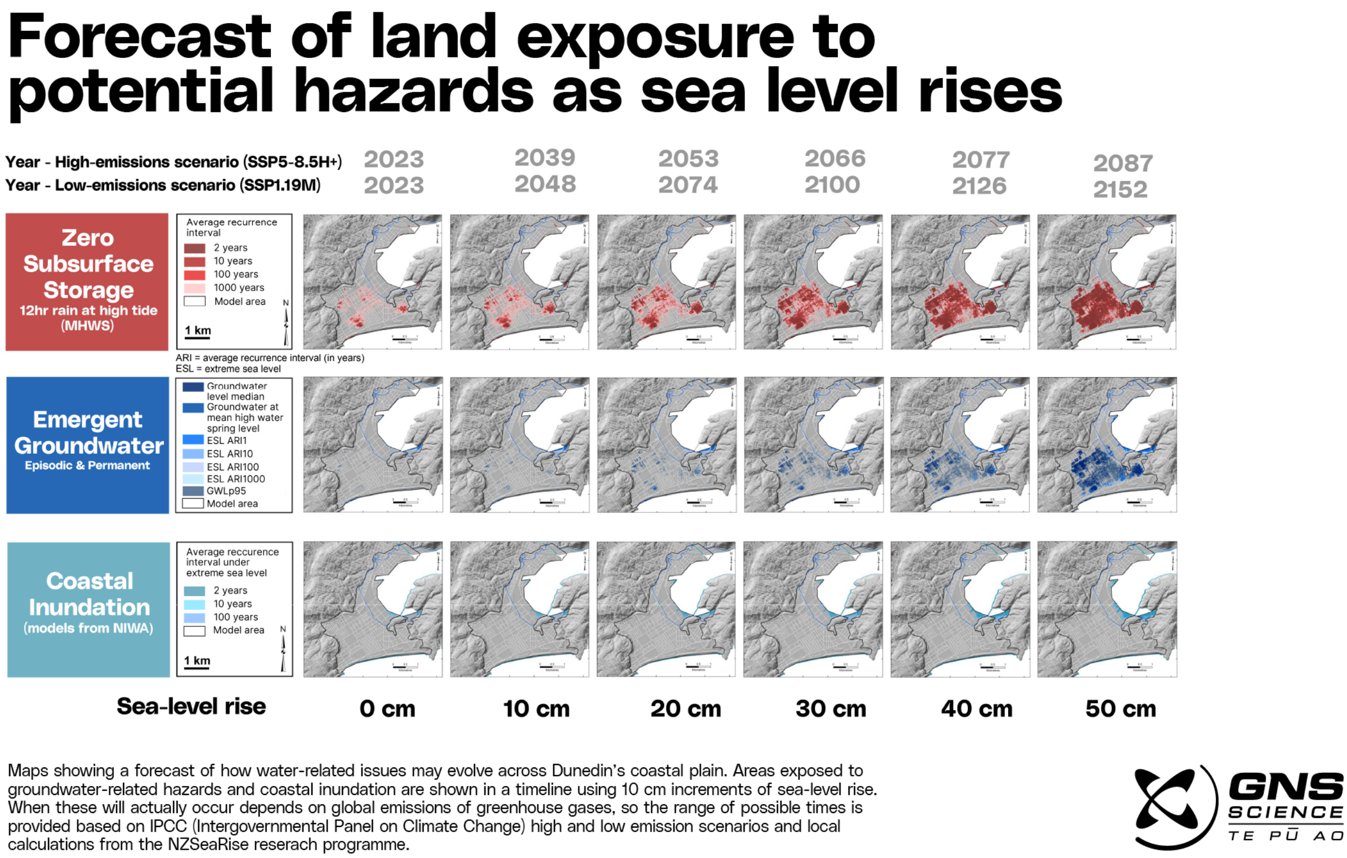


Figure 2: Maps showing a forecast of how water-related issues may evolve across Dunedin's coastal plain. Areas exposed to groundwater-related hazards and coastal inundation are shown in a timeline using 10 cm increments of sea-level rise. When these will actually occur depends on global emissions of greenhouse gases, so the range of possible times is provided based on IPCC (Intergovernmental Panel on Climate Change) high and low emission scenarios and local calculations from the NZSeaRise research programme.

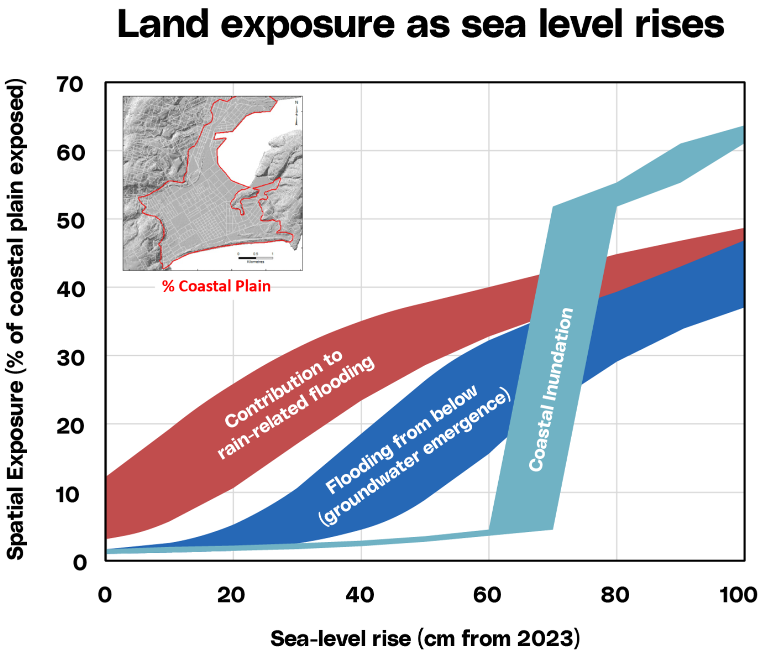


Figure 3: Summary of the overall exposure of Dunedin's 9.2 km$_2$ coastal plain, as a percentage, to various hazardous or hazard-contributing processes. Shaded curves represent a range of processes that can be expected to occur on at least annual to decadal time scale: rainfall exceedance of available subsurface storage (red/brown), emergent groundwater (dark blue), and direct inundation from the coast (light blue, using data kindly provided by NIWA). The figure highlights that annual to decadal hazard associated with groundwater is likely to precede coastal inundation, and groundwater's contribution to pluvial flooding is likely to be felt/experienced prior to the emergence of groundwater.

(1) As groundwater rises, the ability for rainfall to be absorbed into the ground like a sponge decreases. This exacerbates existing rain-related flood issues. This is likely to remain the dominant issue for the next 30 to 40 years.

(2) Groundwater rising to the surface will move from periodic occurrences (at less than 40 cm of sea-level rise expected) to permanent springs and/or flooding (after 40 cm of sea-level rise has been reached, as early as about 50 years from now).

(3) Groundwater-related issues are expected to occur well before the sea inundates land, at least locally in South Dunedin due to the protection sand dunes offer against high-tide. Coastal inundation from the harbour is unlikely to occur until 60-70 cm of sea-level rise (expected around 2100 or later).

This is the first study in New Zealand, and likely internationally, to model groundwater's contribution to multiple sources of flooding hazard. It looks at the episodic and acute hazard conditions that develop as a result of rising groundwater, rather than focusing on long-developing permanent inundation. Groundwater may eventually require substantial management in coastal settings like Dunedin.

"Drawing upon the comprehensive data provided by the groundwater monitoring network was crucial for this research and highlights the value of the partnership between Otago Regional Council and GNS Science. The new understanding gained about the interplay of groundwater-related hazards will be vital for strengthening Dunedin's climate resilience, and also holds important insights for other coastal areas in New Zealand that will face similar challenges in the future," says Dr Cox.

The GNS Science Report 'Dunedin groundwater monitoring, spatial observations and forecast conditions under sea-level rise' is available at the GNS Science Online shop (free to download from https://doi.org/10.21420/5799-N894). There is an accompanying GIS dataset with 646 feature layers provided under Creative Commons Attribution 4.0 (CC-BY-4.0) licence that can be downloaded from from Zenodo as zipped archives: http://doi.org/10.5281/zenodo.10035759.

Reference:

Cox SC, Ettema MHJ, Chambers LA, Easterbrook-Clarke LH, Stevenson NI. 2023. Dunedin groundwater monitoring, spatial observations and forecast conditions under sea-level rise. Lower Hutt (NZ): GNS Science. 103 p. (GNS Science report; 2023/43). https://doi.org/10.21420/5799-N894

UPDATE

Aqualinc Update

Compiled by Kate Mason

Aqualinc turned 20!

The end of 2023 marks the first 20 years of Aqualinc's contribution to water and soil intelligence in Aotearoa New Zealand.

To celebrate this milestone, we are planning an Aqualinc conference towards the end of 2024, that we hope will be a valuable learning and networking event for our clients and collaborators from central and local government, primary sector, research, and consultancy.

Irrigation New Zealand Graduation and Awards 2023

NZ Certificate in Irrigation Design Graduation

Rose Edkins received her NZ Certificate in Irrigation Design after the Irrigation NZ AGM late last year. The course is designed to equip graduates with the specialist skills required to design efficient and sustainable irrigation systems. This involves a huge commitment and there is mention of 1,000 learning hours!

NZ Certificate in Irrigation Design RecognitionAfter the graduation ceremony, Ian McIndoe was recognised for his significant effort and dedication to both the establishment and facilitation of the NZ Certificate in Irrigation Design.

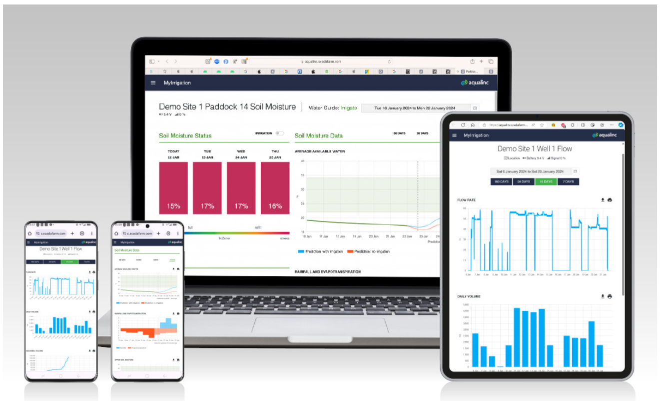
Ian was part of a select group who initiated this course, designed the coursework, and ran several of the training modules and it was great to see him recognised for this effort.

TruSense Soil Moisture Telemetry

We've been busy out in the field upgrading 2G & 3G devices with our latest TruSense Telemetry. The older 2G & 3G devices need to be upgraded before the telecommunication networks are set to turn them off in 2025.

MyIrrigation powered by SCADAfarm

MyIrrigation (powered by SCADAfarm) is the result of a collaboration between Aqualinc and SCADAfarm providing our clients with improved water management, analysis and compliance using a cloud-based system that can be monitored, via your device (phone, tablet or PC), from anywhere in the world. This will allow our clients to manage their water use and consent compliance with ease. As mentioned above, 2G & 3G devices are being phased out; MyIrrigation (powered by SCADAfarm) will only be compatible with upgraded devices.



Stormwater

MyIrrigation (powered by SCADAfarm) is the result of a collaboration between Aqualinc and SCADAfarm providing our clients with improved water management, analysis and compliance using a cloud-based system that can be monitored, via your device (phone, tablet or PC), from anywhere in the world. This will allow our clients to manage their water use and consent compliance with ease. As mentioned above, 2G & 3G devices are being phased out; MyIrrigation (powered by SCADAfarm) will only be compatible with upgraded devices.

Aqualinc have been working with various councils, including Christchurch, Tasman, Selwyn, Buller and Marlborough, investigating various issues with shallow groundwater and land drainage over recent years, from the impacts of sea level rise on groundwater hazards, through to identifying areas which have the capacity for land drainage of stormwater.

Agile, Adaptive Water Allocation Policy

Our report on Agile, Adaptive Water Allocation Policy (funded by MPI as part of the Sustainable Land Management and Climate Change programme) has now been published on MPI's website https://www.mpi.govt.nz/dmsdocument/59737/direct.

In this project, which has featured in several presentations and posters at recent NZHS conferences, John Bright, Andrew Dark and Julian Weir investigated options for allocating groundwater in a way that better protects flows in surface waterways, focusing on a case-study in the Selwyn-Waihora catchment. One of the key findings is that we need to think beyond hydraulic connection and manage the cumulative hydrological impact of groundwater takes on shorter timescales than we do at present. The implication of this is that the security of supply for groundwater users may need to reduce in order to restore surface water flows, which in turn generates a need for solutions such as alternative water sources or storage.

UPDATE

WGA

Exciting Team additions in Christchurch!

We are thrilled to introduce two new members who have recently joined our team at Wallbridge Gilbert Aztec (WGA NZ) in our Christchurch office.

James Manning

James joined WGA full time in March this year after completing his Master's thesis at the University of Canterbury. James's thesis involved studying the groundwater-surface water interactions of the Ōtūkaikino River with the use of geochemical tracers' such as stable carbon, oxygen and hydrogen isotopes. James's passion lies in stream restoration projects and has wasted no time diving into all aspects of WGA's hydrogeology projects. James has experience in pumping test analysis and effects assessments for resource consent applications. James has also been involved in modelling the effects of construction dewatering on nearby wetlands and streams using a combination of techniques including AQTESOLV and Slide2 modelling software packages.

Figure 1. James Manning

Cameron Jasper

In July this year Cameron joined our growing Australasian Water team. Cameron is an experienced consultant hydrogeologist with over a decade of experience. Cameron has been involved in various projects around New Zealand, Australia, and North America. His consulting experience spans various domains including community supply sources, agricultural monitoring, wetland management, hydropower support, wastewater discharge, aquifer recharge, dewatering, landfill assessment, aquifer testing, analytical hydrogeology, contaminant transport, and groundwater modelling. This has given Cameron a wealth of experience in assessing effects on surface water and groundwater systems.

Figure 2. Cameron Jasper

WGA Activities 2023

The New Zealand team of WGA have been engaged in an impressive array of projects throughout New Zealand and Australia. Projects of note include working on the Rotokauri Greenway development. The Greenway is a 4.7 km long fluvial system of swales, artificial wetlands and ponds that runs between Lake Waiwhakareke (high point) and Lake Rotokauri (low point) in Hamilton. The overarching purpose of the Greenway is to effectively manage and attenuate stormwater within the area, including its treatment to enhance the water quality and surrounding natural environments and ecosystems.

WGA was tasked with assessing the short and long-term effects of constructing the Greenway on surrounding sensitive natural wetlands.

Figure 3. Catherine inspecting a Natural Wetland near the Rotokauri Greenway project area.

WGA New Zealand has steadily been continuing work for the Managed Aquifer Recharge (MAR) groundwater replenishment programme in the Ruataniwha basin located in Central Hawke's Bay. Starting in 2018, the programme to develop the trial site has involved a number of development stages, including catchment-scale recharge suitability mapping, field site percolation testing, alongside developing baseline surface and groundwater monitoring. Throughout this process, WGA has worked with mana whenua (Ngāti Kahungunu) to develop the project conceptualisation as well set the stage to support a cultural monitoring programme to run in parallel to the trial testing. The overarching objective of the trial site is to demonstrate how the annual purposeful replenishment of groundwater can be used to sustainably manage groundwater storage and restore and enhance the baseflows to spring-fed streams, wetlands and the drying reach of the Waipawa River.

The trial site focuses on recharge using two primary types of MAR: infiltration from the surface via wetlands and direct recharge from an injection bore. The recharge bore that is being constructed for this project will be New Zealand's first Aquifer Storage and Recovery (ASR), providing a unique opportunity to demonstrate this internationally recognised technique to safely redirect clean winter water into deeper confined aquifers to help offset the increasing abstraction demands being induced by climate change. WGA are excited that in 2024 this trial site is moving towards construction and implementation of a 3-year testing and community consultation programme.

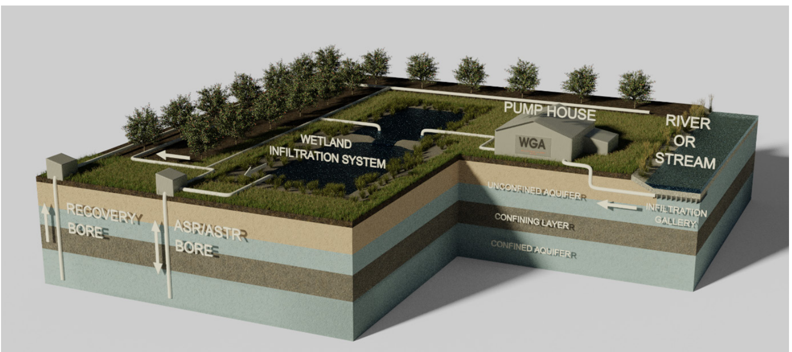


Figure 4. Indicative configuration and components of an infiltration and ASR recharge project site

As part of WGA international programme of works, WGA has also been working with the Yakima Nation, a sovereign native indigenous community located in the Cascade Mountains of Washington State, USA. WGA's team has provided technical guidance for the initial phases of a fledgling Yakama Nation's Groundwater Replenishment program. Chronic and significant aquifer declines coupled with decreasing baseflows to spring-fed streams important to salmonid habitat have resulted in the tribal leaders seeking ways to better manage groundwater supplies. WGA worked directly with their small hydrogeology department to provide hydrology and hydrogeological advice alongside the development of an internal online data repository. Additionally, WGA provided guidance to the Yakama Nation team in how to improve the monitoring and analysis to technically evaluate the operations of their first MAR trial site.

WGA's international experience in developing groundwater replenishment tools for the specific purpose of protecting environmental and cultural values was directly applied in supporting the efforts in the Yakima catchment. The programme WGA is supporting represents the first indigenous-lead MAR programme WGA is aware of in the world. It is focused in building actionable projects that slow down and restore aquifers whilst working to help inform and educate the Yakima peoples on water sciences (See Inset Water Cycle). Additionally, this enables the Yakima people to build resiliency and to offset the impacts of climate change, improve water security and increase protection for taonga species that are important to the Yakima people, such as salmon.

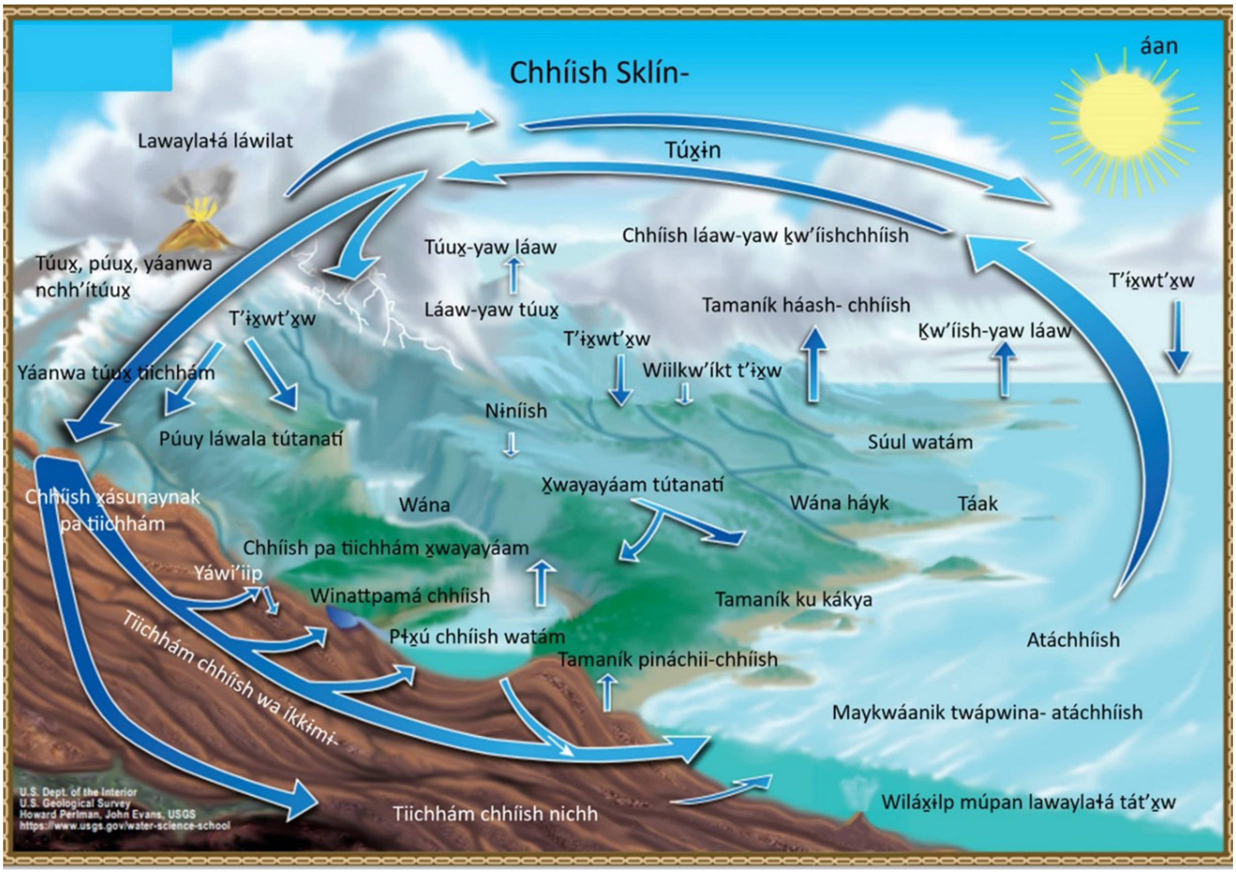


Figure 5. Hydrological cycle in Western Native American.

UPDATE

GNS

Compiled by Maïwenn Herpe

Staffing

Daniel Teka Berhe joined our Hydrogeology and Geophysics Team at GNS in November 2023. Daniel is a senior geoscientist with a background in hydrogeology, hydro geophysics, remote sensing and geospatial modelling. Before Daniel joined us, he was working as water resource modeller and geospatial analyst for the United Nations in Italy for many years. He completed his masters degree in Geoinformation science and earth observation for integrated water resource modelling, at the Faculty of Geo-information Science and Earth Observation, University of Twente, The Netherlands. He has extensive expertise in surface and groundwater studies and evaluation with more than 18 years' professional experience in the field both at national and international level. His skills include geospatial data analytics, numerical groundwater flow/hydrological modelling, geophysical surveys, research and project management. He has also a background in spatio-temporal variability and near real-time water resource and environmental monitoring using satellite-derived information.

Currently Daniel is involved in processing, analysis, and interpretation of SkyTEM data for 3D aquifer mapping of the Aupōuri aquifer system and Ruamāhanga. He is also working on the influence of saline water intrusion on fresh groundwater resources and estimation of fresh groundwater thickness of the Aupōuri aquifer using SkyTEM data.

Figure 1. Daniel Teka Berhe (right) with Rogier Westerhoff (left).

SkyTEM data acquisition in Tairāwhiti/Gisborne

This February, 3654 km of airborne Transient ElectroMagnetic (SkyTEM) data were collected over the Poverty Bay Flats and four smaller northern catchments (Hicks Bay, Te Araroa, Waiapu and Tolaga Bay), as part of the Aqua Intel Aotearoa (AIA) programme. Data acquisition was originally planned in 2023, however, it was postponed due to Cyclone Gabrielle. AIA is a partnership between Kānoa (the delivery arm of the Provincial Growth Fund) and GNS Science. It is a national science platform on regional water availability and storage.

The mapping of these catchments will provide a greater certainty about water quantity, as well as inform and support future regulatory decisions. The mapping of the Poverty Bay Flats aquifers is a priority for the region because of the high water demand and uncertainty about groundwater availability, and to give the community greater confidence in the potential to bring land into sustainable production. The mapping of the four small survey areas will provide better understanding of these systems as very little is known about their groundwater resource potential.

During the survey, two open days were organised in Ruatoria and Gisborne, giving an opportunity for local schools, media and members of the public to discuss the science and experience the helicopter and associated system in action (Photo 2).

For more information, please contact infoaquaintel.co.nz

Figure 2: School kids in Ruatoria watching the helicopter take off with the SkyTEM system attached underneath.

Groundwater Quality Indicator review (MfE-funded)

A review of the selection of sites and variables, as well as the processing methods used, in the 2020 Statistics New Zealand (Stats NZ) Groundwater Quality Indicator was undertaken by Magali Moreau. The Groundwater Quality Indicator informs Stats NZ freshwater reports, which are a requirement under the 2015 Environmental Reporting Act, and was sourced for the first time via data feeds from regional and unitary councils' databases. Also, for the first time, these data were processed by Stats NZ using scripts adapted from scripts used to process data for the surface-water quality indicators. The review's recommendations for future groundwater quality indicator updates included continuation of national-scale research-driven monitoring programmes to inform site and variable selection for reporting, adjustment of state and trend assessments to suit groundwater quality data, use of hydrogeological systems as spatial reporting units, use of reference values to provide context to statistical metrics, development of a framework to add groundwater indicators as they become available or relevant, and coordination of the development of automated data harvesting. The report is available on the Ministry for the Environment's website (here).

For more information, please contact Magali Moreau.

Moreau M. 2023. Technical review of the 2020 groundwater quality indicator to support methodological improvements. Lower Hutt (NZ): GNS Science. 32 p. Consultancy Report 2023/19. Prepared for Ministry for the Environment.

Evolution of geology and groundwater-geothermal systems in the Ōkataina caldera groundwater catchment

The Ōkataina groundwater catchment, within the Ōkataina caldera complex, includes spectacular features such as large caldera structures, rhyolite domes, 11 lakes, numerous cold groundwater systems and 15 geothermal–groundwater systems. Quaternary evolution of this groundwater catchment occurred in four phases and led to the formation of today's groundwater and geothermal–groundwater systems. The Early Phase had development of a graben with the proto-Tarawera River and catchment. Then, Matahina Phase volcanism produced the Matahina caldera with Matahina Formation ignimbrite deposited over a wide area. Groundwater flowed into Lake Matahina which was the location of multiple geothermal fields. Thirdly, the Penultimate Phase produced the Rotoiti caldera and Lake Haroharo. Lastly, the Infill Phase resulted in today's major landforms of the groundwater catchment, for example, the Mount Tarawera and Haroharo domes, multiple lakes, their catchments, groundwater systems and geothermal fields.

For more information, please contact Paul White.

White PA, Leonard GS. 2023. Evolution of geology and groundwater-geothermal systems in the Okataina caldera groundwater catchment. Journal of Volcanology and Geothermal Research. 441:107854. https://doi.org/10.1016/j.jvolgeores.2023.107854

Ruamāhanga Airborne EM Aquifer Mapping Project

The Ruamāhanga (Wairarapa) Aerial Hydrogeological Survey is a two-year project (January 2023 – December 2025) that is jointly funded by Kānoa (Regional Economic Development & Investment Unit), Greater Wellington Regional Council (GWRC), Masterton District Council, Carterton District Council, and South Wairarapa District Council. The central part of the project is the Airborne Electromagnetic (SkyTEM) survey and follow-on hydrogeological mapping and interpretation. The survey was flown in January 2023 and, over the last 12 months, GNS Science has been working with GWRC to process and interpret about 50% of the data collected. This is collaborative work involving staff across GWRC, GNS Science, and several consultants.

A key component of integrating the geophysical data with the geology, borehole data, and hydrogeology is the hands-on workshops where all team members and invited guests work over maps, sections, and 3D computer models to try and understand the complex distribution of aquifers and confining layers. Figure 1 shows a slice through the SkyTEM Model at 140–160 m depth showing the lateral changes in electrical resistivity that indicate changes in potential aquifer materials. The timing of this project has been significantly affected by COVID delays, and the delivery of hydrogeological products derived from the SkyTEM data is currently underway. Some results should start to flow from the GWRC in the next 12 months. For more information on this project, please contact Richard Kellett.

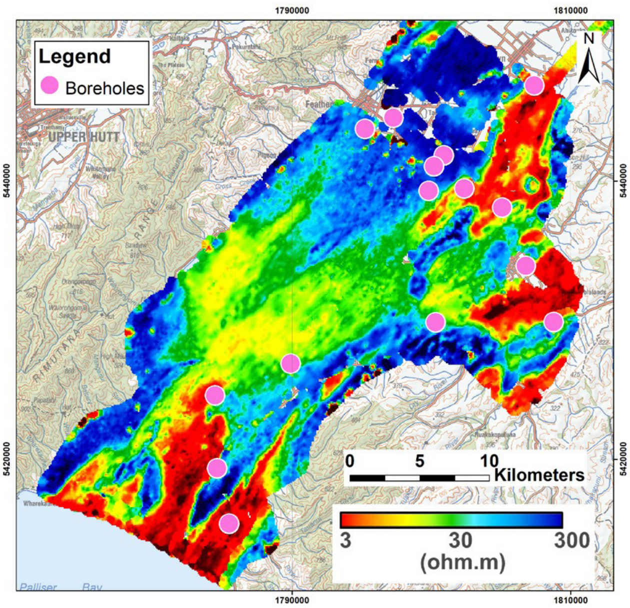


Figure 3: Resistivity slice at 140–160 m depth for the southern half of the Ruamāhanga Airborne survey.

Dunedin research forecasts groundwater challenges as sea level rises

A detailed investigation of groundwater in Dunedin, and potential effects of sea level rise, has been completed by a team from GNS Science (Simon Cox, Lee Chambers & Luke Easterbrook-Clarke) and Otago Regional Council (Marc Ettema & Nigel Stevenson). The research spanning the past 5 years has been funded with contributions from the Urban Groundwater project (GNS Science's Strategic Science Investment Fund), the STRAND Programme (a Royal Society of New Zealand Marsden-funded project led by University of Otago), the NZ SeaRise Programme (an Endeavour programme funded by the Ministry of Business, Innovation & Employment led by Victoria University of Wellington), with co-funding from the Otago Regional Council. The report feeds directly into the 'What is happening?' phase of the Dunedin City Council-led South Dunedin Future programme. A summary of GNS's scientific goals for urban hydrology work and the Dunedin case study is provided in a video 'The rise and fall or urban groundwater' on Youtube. A detailed description of the report is provided separately in this E-current newsletter.

For more information on this project, please contact Simon Cox.

Cox SC, Ettema MHJ, Chambers LA, Easterbrook-Clarke LH, Stevenson NI. 2023. Dunedin groundwater monitoring, spatial observations and forecast conditions under sea-level rise. Lower Hutt (NZ): GNS Science. 103 p. (GNS Science report; 2023/43). https://doi.org/10.21420/5799-N894

UPDATE

NIWA

Compiled by James Griffiths

Characteristics of inland water chemistry in New Zealand under NIWA-Nagasaki University collaboration

In November-December 2023, Prof Kei Nakagawa from Nagasaki University, Japan, visited NIWA as part of the Catalyst exchange project on 'Sustainable allocation of groundwater for agricultural use based on land surface recharge.' During his stay, NIWA's research team, with support from various regional councils, collected water samples from 33 sites across the North and South Islands representing both groundwater and surface water under baseflow conditions. Back at Nagasaki University, the water samples underwent analysis for major dissolved ions, helping to understand their chemical characteristics. Self-organising maps were used to group the samples and create a picture of distribution of water chemistry nationally. Some urban samples indicated the presence of heavy metals or other cations, while samples from rural areas showed agricultural contaminants. The approach aids understanding of groundwater recharge processes, sheds light on how agricultural practices impact our groundwater aquifers and waterways and contributes to strategies to help New Zealand's primary sector adapt to future climate change. Contact channa.rajanayaka@niwa.co.nz

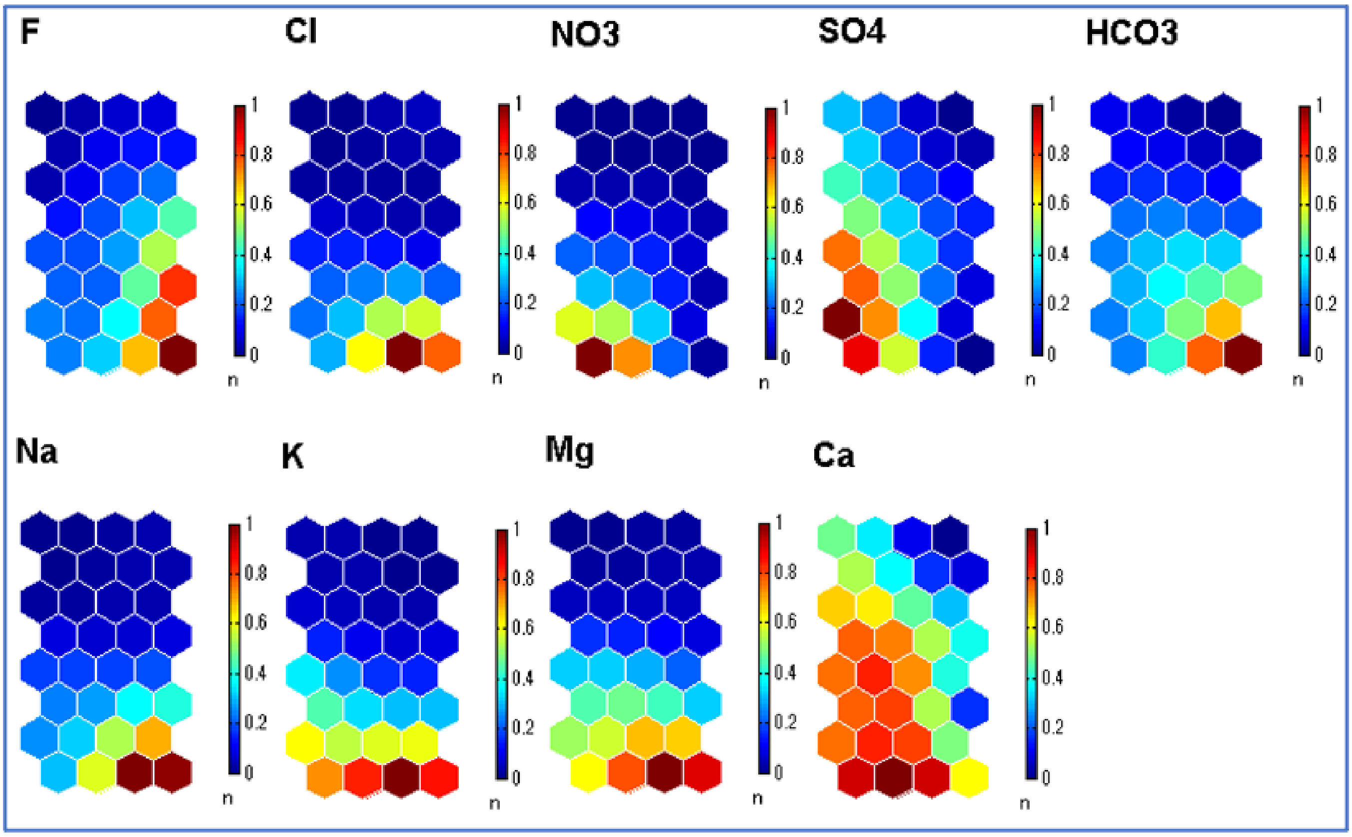


Figure 1. Component maps of samples, each represented by distinct colours, within clusters developed using self-organising maps.

Modelling vegetation and morphology evolution in the Waitaki and Waimakariri Rivers

Gu Stecca and co-authors have published a paper in the Journal of Geophysical Research that looks at the historic trajectories of vegetation encroachment into the braided beds of the Waitaki and Waimakariri Rivers (Canterbury) using a custom-made two-dimensional numerical model. The study established that it is the different hydrology of the two rivers that explains the observed vegetation differences. The Waimakariri, with an alpine, flashy flow regime, is capable of clearing invasive vegetation with frequent floods. By contrast, the flow regime of the Waitaki which is regulated by alpine lakes (Tekapo, Pukaki and Ohau), and the Waitaki Power scheme, is too mild to clear vegetation effectively.

Simulation work clarified that artificial flow regulation due to hydropower production is a secondary contributor to this process, as vegetation would have significantly spread on the Waitaki riverbed even under the river's natural flow regime. The authors used a theoretical framework that leverages parameter indexing of the relative frequency of floods with respect to the speed of vegetation colonisation, and showed that this framework can be used to analyse vegetation presence in other braided rivers in Canterbury, and potentially elsewhere. Contact Gu.Stecca@niwa.co.nz

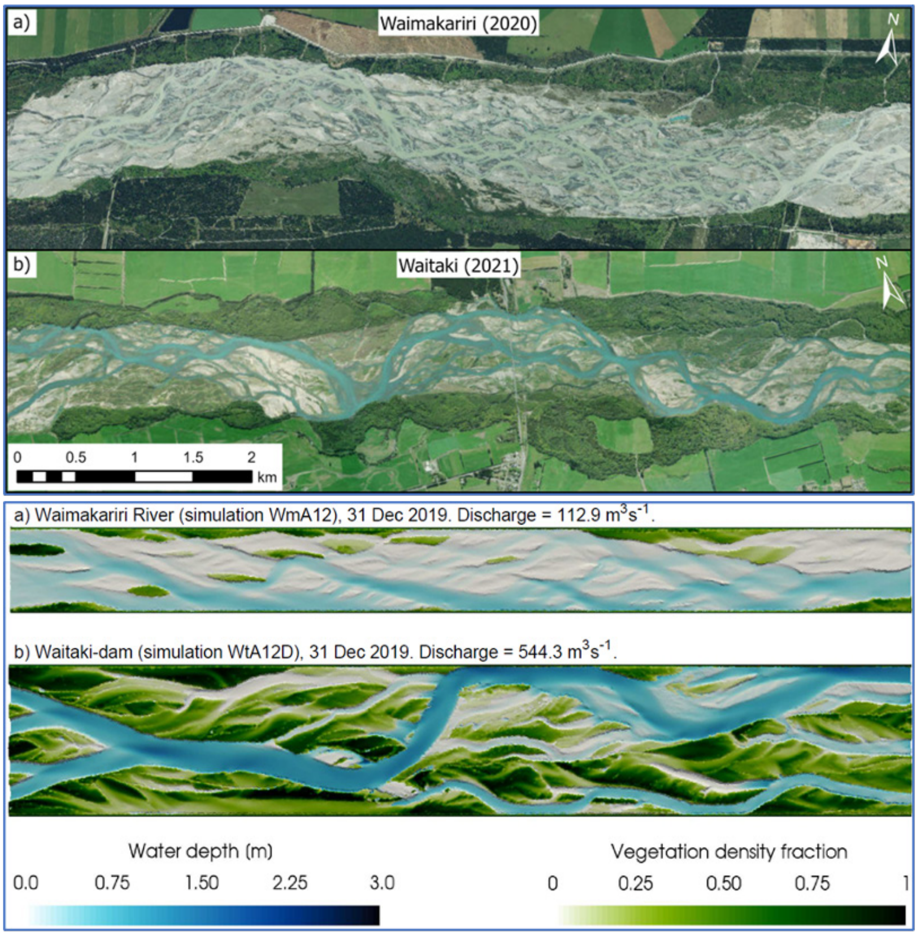


Figure 2. Recent photographs of the study rivers: (a) Waimakariri River: -7 km long portion of the Crossbank reach (2020). (b) Lower Waitaki River: -7 km long portion of the Coastal Reach (2021). (Bottom) Final simulated evolution of the planform of the study rivers by models: (a) Waimakariri River; (b) Lower Waitaki River. Figures from Stecca et al. (in press).

WMO HydroHub and HydroSOS Workshops in Samoa and Fiji

In November 2023, NIWA staff facilitated two WMO HydroHub User-Provider Workshops in Fiji and Samoa that were hosted by the Samoa Water Resources Division of the Ministry of Natural Resources and Environment (MNRE-WRD) and the Fiji Meteorological Service Hydrology Division (FMS-H). The workshops were designed to support service-delivery optimization between the National Meteorological and Hydrological Services (NMHSs) and hydrological information sectorial users. In Fiji and Samoa, several sectors (e.g., watershed management, disaster preparedness and mitigation, infrastructure and industry development, urban planning, energy production, domestic water supply, health, agriculture, mining, tourism, environmental conservation), use hydrological data but there are others that could realize improved decision support from tailored information products. Furthermore, hydrological data collected by NMHSs in much of the Pacific region do not always address the actual needs and requirements of both existing and potential data users. Conversely, potential data users are not always aware of what hydrological data is collected by NMHSs and what services it can support. The User-Provider Workshops were implemented to help address some these service-delivery optimization challenges between NHMSs and hydrological information sectorial users. Outcomes of the workshops will help to guide the development and implementation of future applied hydrology information projects in Pacific Island contexts. Contact shaun.williams@niwa.co.nz

Figure 3. Workshop participants in Samoa and Fiji. A final report of outcomes is available on the WMO web: User-Provider Workshops in Fiji & Samoa | HydroHub (wmo.int). Photo credits: MNRE Samoa (Top left and bottom right); S. Williams (Top right and bottom left).

New Hydrologically Conditioned DEM covering all of Aotearoa New Zealand

NIWA have produced an 8m resolution Hydrologically Conditioned DEM covering all of Aotearoa New Zealand designed for regional scale flood inundation modelling as part of their work in Mā te haumaru ō te wai. The DEM is made of 439 (30 km x 30 km) tiles covering the North, South and Rakiora Islands to a minimum distance of 5 km offshore. The DEMs were generated using LINZ hosted LiDAR on OpenTopography, with preference given to the most recent survey (where overlapping surveys occurred). NIWA look forward to incorporating the full wealth of their procured and managed bathymetry measurements in the future. Hydrological conditioning was achieved using the approach documented in [1]. The dataset processing was achieved using a Cylc workflow run on NeSI over approximately 9 days. The dataset will be periodically updated as more LiDAR becomes available. Contact rose.pearson@niwa.co.nz to arrange access if this dataset might help you in a project, or if you would like to review and provide feedback on the product.

[1] Pearson, R. A., et. al. (2023). GeoFabrics 1.0. 0: An open-source Python package for automatic hydrological conditioning of digital elevation models for flood modelling. Environmental Modelling & Software, 170, 105842.

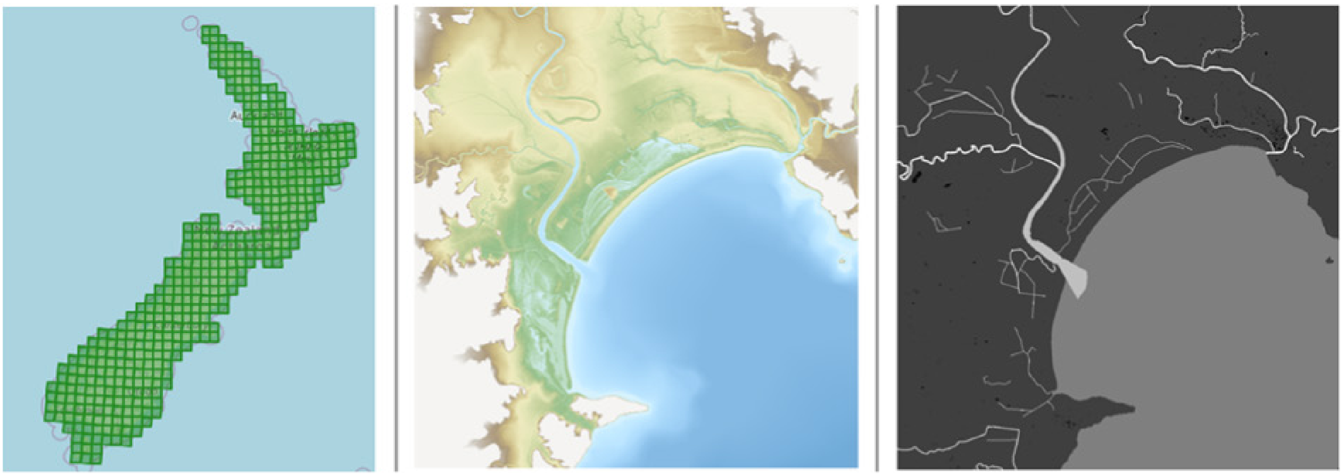


Figure 4. (Left) New Zealand defined by 439 30x30km 8m resolution DEM tiles. (Middle and Right) An example of the hydrologically conditioned DEMs at Gisborne showing the elevation (middle) and the conditioning applied (right) from LiDAR, river depths, ocean contours, day-lighted rivers/culverts.

Staff news

Dr Jason Alexander arrived with his family from the USA in mid-September and started at NIWA on 9 October. Jason has joined the sediment dynamics group but describes himself as a bit of an all-rounder with experience in field work, modelling, coding, consultancy, and people management. He worked as a river geomorphologist from 2000-2007 and then as a hydrologist for the USGS since 2018 before joining NIWA.

Jason is joined in the Sediment Dynamics group by Dr Gergely Torok from Hungary. Gergely obtained his BSc and MSc civil engineering degrees at Budapest University of Technology and Economics, and has always been involved in river sediment transport modelling and field surveying. He did his PhD research on this topic at the same institute and partly at Norwegian University of Science and Technology. As a postdoctoral fellow, he examined large spatio-temporal scaled river morphologic processes.

Figure 5. River geomorphologist Dr Jason Alexander (left), and Dr Gergely Torok (right).