JULY 2022 (NEWSLETTER V)

TE WHAKAHEKE O TE WAI

A quarterly newsletter for stakeholders of the TWOTW Research Programme

Lost Lagoon of Kuratau, Waikato (Uwe Morgenstern)

FROM THE PROGRAMME LEADERS

Catherine Moore and Uwe Morgenstern

Kia ora and welcome to our July 2022 update for the TWOTW research programme. Work across all of TWOTW components has been going really well and this Newsletter highlights the progress made on each of the workstreams.

This work seems more important than ever. Degradation of groundwater resources due to inadequate understanding of groundwater systems is a global issue. Management and restoration of these resources without knowledge of complex flow pathways in groundwater systems is challenging. Achieving Te Mana o te Wai as required under the NPSFM requires this knowledge.

In this newsletter we highlight the work of Amber Aranui and Ocean Mercier, who with Ngāti Kahungunu have been exploring surface and groundwater mātauranga Māori to inform groundwater management. This work has been gaining national and international attention - see Nature: https://www.nature.com/articles/d41586-021-02697-y.

We also highlight our National groundwater model of groundwater age, origin and flow paths (see Wes Kitlasten's profile). Downscaling of this model also lays the foundation of smaller models tailored to address specific water management issues. NIWA have also adopted this model in their national hydrologic modelling platform (NZWaM).

Thank you for all your support for this project so far. We are looking forward to sharing and discussing more of this emerging science with you.

Ngā mihi, Cath and Uwe.

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TRACER PROGRAMME UPDATE

The sampling and analysis of groundwater and surface water tracers across New Zealand is a foundation of the TWOTW programme. The tracers applied in TWOTW can be used to characterise entire hydrologic systems (rivers, catchments, and aquifers), using tracer concentrations integrated along the entire water flow paths. This enables improved water management decisions without the need for expensive instrumentation of catchments.

Over the last quarter, the sampling programme has been completed for the Greater Wellington and Bay of Plenty regions and has mostly been completed for the Waikato and Northland regions, with minor augmentation of data left. The remaining six regions of New Zealand will be covered within the next two years, filling essential knowledge gaps.

A focus of the programme are springs (see photos below) because these are the natural discharges of the groundwater systems. The tracer signature of springs can therefore characterise the entire active groundwater flow system captured by the spring. In addition, NIWA has completed a nationwide stable isotope sampling programme, which estimates young water fractions in rivers.

To support the restoration programme of the Te Hoiere/Pelorus catchment (Marlborough), we interpreted previous baseline data to provide detailed understanding of the catchment functioning. The current environmental quality of Te Hoiere catchment is good but is deteriorating. This is evident in some of the sub-catchments, where water quality is being degraded. Marlborough District Council, Ngāti Kuia, the Department of Conservation, and the wider community are in the process of designing a groundwater restoration programme in the Te Hoiere/Pelorus catchment with the aim to holistically manage the entire catchment, from the mountains to the sea (ki uta ki tai).TWOTW provides the understanding of the flow of groundwater and associated contaminants (nitrate) through the catchment. These projects have already provided important insights into the groundwater and surface water flow systems throughout the country.

Uranui Spring, Waikato (Uwe Morgenstern)

Blue Spring, Waihou River, Waikato (Uwe Morgenstern)

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WORKSTREAM UPDATES

National Modelling

The national scale groundwater model of New Zealand developed in TWOTW has been modified to investigate the role of model structure on estimates of age. Models of large areas require coarser discretization to achieve reasonable model run times, especially for history matching. Recent research has investigated different layering approaches, and hence their ability to represent subsurface heterogeneity, in the context of predicting groundwater age.

This research shows that these model simplifications can result in poor predictions of groundwater age. We are now determining the appropriate balance between representing heterogeneity through finer discretization in models of smaller areas and the approximation of boundary conditions required when representing smaller areas (e.g., when model boundaries do not coincide with obvious boundaries in the real world, like watershed boundaries or coastlines). The results of this current research will be used to inform the the national scale model of groundwater age. They are also being used in NIWA's national hydrologic modelling platform (NZWaM), which aggregates the detailed TWOTW national model into surface water catchments.

Bridge Pā model

This model is hindcasting to pre-European conditions, history matching to measured data and community observations, and exploring restoration scenarios, and represents a co-creation of indigenous and other knowledge systems. The history matching process is now well underway.

Meta-modelling

Two independent meta-model techniques have been developed to use available groundwater hydrochemistry to predict groundwater age in the Heretaunga Plains. A study detailing and comparing these two methods (Symbolic Regression and Gradient Boosted Regression) has been submitted for discussion and publication in HESS. Parallel meta-modelling studies into the use of even more widely available physical variables such as groundwater age predictors is on-going.

Isotopes

NIWA are exploring sinusoidal and machine-learning based models to describe patterns of precipitation isotopes nationally. Output from these models may provide input data to stable isotope based calculations of river water age at a national scale. Early results suggest that influences of moisture source (and trajectory) on precipitation isotope values are important. The machine-learning approach provides a promising method to capture the effects of these processes.

Source Protection Zone (SPZ)

Using West Melton and Hastings case studies, we are examining how model parameterisation can affect SPZ delineation. In particular we are investigating how aquifer heterogeneity can be incorporated in SPZ modelling, using council lithology records, and how model parameters need to be calibrated and scaled. We are currently focusing on ways that simple homogeneous models or analytical solutions can provide a simple alternative to complex stochastic simulations. Early results indicate that such simpler approaches may need to carefully account for local flow conditions.

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WORKSTREAM UPDATES

Vision Matauranga

Work has continued to focus on historical mapping of the waterways and wetlands, as well as writing up the results of the research for publication. Initial discussions with the Museum of New Zealand Te Papa Tongarewa have started in creating a short video made by the community on the issues of the wai for them.

COMMUNITY ENGAGEMENT

Ocean Mercier featured on the "Water Underground Talks". These talks have been compiled for people to learn about passionate researchers and their latest work on connections between groundwater, climate, food, and people (https://www.waterundergroundtalks.org/). The first part of the talk was an interview where Ocean shared experience of how her relationships with water developed, insights into her her academic journey, and her interest in epistemic equity (indigenous knowledges playing a role in a more ethical future in sustainable management of our resources). She then provided a presentation on the Te Whakaheke o Te Wai research program with a key focus on merging of mātauranga-a-iwi/hapū with western science for better conceptual understanding of groundwater.

A link to Ocean's presentation is here: https://www.youtube.com/watch?v=J3MLKICH6NM&t=775s

INTRODUCING OUR TEAM

Ocean Mercier and postgraduate scholarship recipients from Te Herenga Waka / Victoria University of Wellington. Left to right: Alyssa Thomas, Willow Milligan, and Oscar Arnold.

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INTRODUCING OUR TEAM

Amber Aranui

Amber (Ngāti Kahungunu, Ngāti Tūwharetoa, Ngāti Tahinga) is an experienced Archaeologist with a demonstrated history of working in research. Since 2008 Amber has been a researcher for the Karanga Aotearoa Repatriation Programme based at the Museum of New Zealand Te Papa Tongarewa and is a part time research associate at Te Herenga Waka. Amber's PhD examined the issues relating to the repatriation and the 'scientific research' of Māori ancestral remains. It was Amber's work as a researcher for the repatriation programme that stimulated her desire to engage in PhD research on this topic. She hopes the research will contribute to the wider knowledge of repatriation and that it will aid in the facilitation of relationships between the scientific community and iwi. Amber's role in TWOTW includes incorporating mātauranga Māori as a data source in modelling for the improvement of water protection and safety, as well as aiming to better understand the Heretaunga Aquifer.

Ocean Mercier

Ocean (Ngāti Porou) is an Associate Professor at Te Kawa a Māui / School of Māori Studies, at Te Herenga Waka / Victoria University of Wellington. She has a PhD in condensed matter physics. Her teaching explores how science and mātauranga can support each other, and her research examines how these relationships play out in environment-focussed contexts. These projects include working on the TWOTW programme, exploring the contributions of mātauranga and science of groundwater to enable better management of underground water reserves. Ocean has been a TV presenter for Project Mātauranga and Coast New Zealand, and was subsequently awarded the Cranwell and Callaghan medals for science communication.

Wes Kitlasten

Wes is a senior groundwater modeller with 10 years experience in government (US), academic research, and consulting. Wes has a broad range of modelling experience ranging from fluid flow and stable isotope transport in hydrothermal metamorphic systems, heat transport, soil erosion, watershed processes, surface water-groundwater interactions, water allocation, and groundwater dependent wetlands. Much of Wes' work has focused on processing diverse datasets to create model inputs and ensure consistency between simulated quantities and real-world observations for history matching. He has contributed to pyEMU and PEST++ suites, as well as development of custom python scripts developed for specific types of data. Wes is currently building a national scale groundwater model for New Zealand and a methodology for rapidly producing "child" models of smaller areas of interest in a consistent and repeatable way to help support a range of management decisions.

TWOTW PROGRAMME SUMMARY

Te Whakaheke o Te Wai (TWOTW) is a five-year research programme funded by MBIE's Endeavour Fund and led by GNS Science. Multiple national and international organisations and stakeholders are involved in the collaboration. Primary collaborators of the research programme include NIWA, ESR, Te Tai Whenua O Heretaunga, Victoria University of Wellington, and Watermark Numerical Computing. Hawke's Bay Regional Council support the major case study area, the Heretaunga Plains. Other regional councils and organisations also contribute to the research project, including with co-funding.

The TWOTW programme aims to better support water management based on improved understanding and integration of flow sources, pathways, water travel time, and cultural knowledge and values in New Zealand. The research is underpinned by the concept and defining of 'Te Whakaheke o Te Wai' of groundwater throughout the main catchments and aquifers in New Zealand. The 'Te Whakaheke o Te Wai' of groundwater - our largest freshwater resource - is largely unknown, yet stakeholders recognise that this knowledge is urgently needed to protect and sustainably manage groundwater and the rivers and streams it feeds. Outputs from this research are to provide decision-makers with much needed knowledge for improved water management at national, catchment, and local scales. Outputs from the research will be publicly available and benefit people and institutions involved in water management.

The programme is currently developing the world's first nationally continuous maps of groundwater age, origin and flow paths. A technical foundation of the research project is the development of new modelling technologies. This project builds on the current knowledge and implementation of data assimilation and uncertainty quantification commonly expected and often required in modelling projects. This research is evolving modelling capability from simply understanding uncertainty (which is now generally accepted in modelling), to the design of novel models with an ability to reduce that uncertainty. This includes combining mātauranga Māori and mōhiotanga Māori with aquifer models to reduce this uncertainty. This is a unique combination of western science and indigenous knowledge that demonstrates the importance of combining the two knowledge systems. New stochastic approaches for source protection zone modelling (SPZ) are also being developed.

Key researchers

GNS Science: *Catherine Moore, Uwe Morgenstern, Brioch Hemmings, Conny Tschritter, Sapthala Karalliyadda, Wes Kitlasen, Mike Taves, Paul Oluwunmi, Susana Guzman, Lee Chambers, Magali Moreau, Stewart Cameron*
VUW: *Ocean Mercier, Amber Aranui*
ESR: *David Scott, Murray Close, Theo Sarris, Alannah Kenny*
NIWA: *Bruce Dudley, Jing Yang, Chris Daughney*
Students: *Tara Fostner, Willow Milligan, Oscar Arnold, Alyssa Thomas*