Te Whakaheke o Te Wai (TWOTW) Research Programme - May 2021 Update

Raupare Road Spring, on Bostocks Orchard, Heretaunga Plains

From the Project Leaders

Kia ora and welcome to our first quarterly update for the TWOTW research programme. The aim of this update is to keep our stakeholders and collaborators informed of project progress and activities being undertaken.

GNS Science is midway through a national groundwater and surface water age tracer sampling campaign, and NIWA have completed a nationwide stable isotope sampling programme. These projects have already provided important insights into the groundwater and surface water flow systems throughout the country. Groundwater and surface water mātauranga Māori and mōhiotanga Māori is being explored by Amber Aranui with Ocean Mercier from Victoria University of Wellington in partnership with Ngāti Kahungunu. Approaches for combining this knowledge, with other sources of information, are being developed to improve groundwater management. This represents a unique combination of western science and indigenous knowledge and is demonstrating the importance of combining the two knowledge systems. Our ambitious modelling programme is now well underway and has a number of components designed to support decision making, from the national scale through to the very local drinking water source protection zone scale.

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, Catherine Moore and Uwe Morgenstern

Heretaunga Plains Hui & fieldwork

Various hikoi and engagements were undertaken during a two-week long hui in Hawke's Bay from March 8th – 19th 2021. Hui attendees included representatives from Ngāti Kahungunu, Hawke's Bay Regional Council, Victoria University of Wellington, GNS Science and Lincoln Agritech. The korero and mahi centred around identification and mapping of features and indicators in the Heretaunga Plains that hold significance to local iwi. This allowed for

exploration and cataloguing of historical behaviour of groundwater and surface water systems in the Heretaunga Plains. One focus of discussion was the loss of streamflow that has occurred in the Paritua Stream. The timing and frequency of the dry stream bed occurrences and the physical conditions that lead to them are currently being investigated. A database of observations that span both space and time has been developed, including a spring stocktake whereby all known springs have been accurately mapped and identified. Highlights of the hui included a stimulating pōwhiri delivered at the Mangaroa Marae and the chance for attendees to get to know one another and explore the region.

Mātauranga Māori

Amber Aranui (Victoria University Researcher) has whakapapa to the Heretaunga Plains and is weaving mātauranga Māori and mōhiotanga Māori into the project. Recently Amber has been working to better understand the value of Mauri in freshwater. Key concepts include exploring the disappearance of the life force from springs, streams and rivers, wetlands, and flooding. For example, people have changed the natural processes such as straightening of streams and rivers to reduce flooding and have mixed mauri and wairua in waterways. Another concept Amber is exploring is the significance of mahinga kai (kai wairua, kai ngākau, kai hinengaro, and kai tinana), whakapapa and kaitiakitanga in the Heretaunga Plains. She is working with the team and local iwi to compile historic records of photos of river flow and flooding to align with dates for better understanding of catchment function (alluvial compared to limestone). A component of the project is drawing out the relationships between human activities and the impact on waterways. Local examples include change in flow rates of the Paritua Stream (due to perforation of the streambed in 1990's), impact of gravel extraction on the stream bed and groundwater recharge, and interplay between groundwater abstraction, managed aquifer recharge (MAR), border dyke irrigation and the stream in terms of lowering groundwater levels.

In the community and media

Radio New Zealand Interview

Catherine Moore, Uwe Morgenstern and Amber Aranui participated in an interview with Radio New Zealand. The interview with Alison Balance was part of the 'Our Changing World' programme and was aired on 25 February 2021. Cath, Uwe and Amber discussed what they are undertaking within the TWOTW research programme and how the project is helping us to better understand and manage our groundwater resources in New Zealand. You can read the article and listen to the podcast here.

New Zealand Hydrological Society Conference

The New Zealand Hydrological Society annual Conference was held in Invercargill in December, 2020. Researchers from the TWOTW project made presentations at the conference including Uwe Morgenstern, Bruce Dudley, Jing Yang, Brioch Hemmings, Chris Daughney, Catherine Moore and Theo Sarris. Chris Daughney (NIWA) won best paper for his presentation of meta-modelling work applied to the Heretaunga Plains aquifer data. This award confirms the relevance and utility of the TWOTW meta-modelling component of the work programme and the hard work that went into undertaking the modelling, and the excellent skills that Chris has at delivering these difficult concepts to a wider audience.

Publications

To date we have three journal papers published from the research programme. Most recently we had a paper published in Environmental Modelling and Software, a reward for the authors who worked hard to get this paper published (White et al., 2021). The paper details the development of python tools for rapid deployment of numerical models for parameter estimation and stochastic analyses following the PEST framework. You can view and download the paper here.

Hemmings, B, Knowling, M.J., and Moore C.R., 2020., Early uncertainty quantification for an improved decision support modelling workflow: A streamflow reliability and water quality example. Frontiers in Earth Science. doi: 10.3389/feart.2020.565613.

Knowling, M.J.; White, J.T.; Moore, C.R.; Rakowski, P.; Hayley, K. 2020 On the assimilation of environmental tracer observations for model-based decision support. Hydrology and Earth System Sciences, 24(4): 1677-1689; doi: 10.5194/hess-24-1677-2020

White, J.T., Hemmings, B., Fienen, M.N., Knowling, M.J., 2021. Towards improved environmental modeling outcomes: Enabling low-cost access to high-dimensional, geostatistical-based decision-support analyses. Environmental Modelling and Software. Volume 139, May 2021.

Groundwater modelling

An existing Heretaunga Plains groundwater model is in the process of being updated into a new version of MODFLOW software, in collaboration with Hawke's Bay Regional Council. This will allow for 'communication' to occur between the national and local modelling and show the model in more of a national context. The groundwater system is complex. The aquifer in the north of the plains is river-fed, with water that moves rapidly at first but travels very slowly by the time it reaches the coast. In comparison, the aquifer in the south of the plains is recharged from rainfall. Preferential flow paths occur where young groundwater flows quickly underground in old buried river channels. The oldest water identified in the Heretaunga Plains is 4,000 years old at a depth of 250 metres. Most of the water being extracted from the aquifer for use is less than 10 years old. Modellers have been busy exploring relationships between groundwater age and other groundwater variables such as distance to the coast. Exploring these relationships will provide a better understanding of the provenance and pathways of groundwater flowing through our subsurface aquifer systems, and is required to reduce the risks facing groundwater management.

A national groundwater age model is being developed using a hybrid of meta-modelling and numerical modelling approaches. To date this work has focussed on the Heretaunga Plains but now is being expanded to the Wairau catchment, and then will be extended to Canterbury and Southland regions. This will continue until the nationwide groundwater age map is completed. Work is also underway to link this to The New Zealand Water Model (NZWaM) project being undertaken by NIWA.

A local groundwater model focussing on the area around Bridge Pa is currently being developed. The focus of this model is combining mātauranga Māori and mōhiotanga Māori with groundwater models to give a numerical voice to the concerns of the community, and to reduce the uncertainty of model predictions. In addition, new more efficient and robust stochastic approaches for source protection zone modelling (SPZ) are also being developed in collaboration

with ESR. This includes the development of a more comprehensive geostatistical model of the aquifer heterogeneity, using Airborne Electromagnetic data, that informs the probabilistic quantification of risk that accompanies SPZ delineation.

Coming up next ….

The team are currently working to develop a series of outreach videos for the research programme. Make sure you check back in the July update to see us in action! We will also introduce our student researchers. In addition, we have been busy developing a webpage as a way to store and share important information from the project. This will include links to this newsletter, photos and videos, presentations, technical reports, stories, and much more. The project webpage is planned for release by the end of May 2021.

Project Summary

The 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 other 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 (SPZ) modelling are also being developed.