August 2021 Update

From the Project Leaders'

Kia ora and welcome our second 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.

Since the last newsletter GNS Science has continued to work on the problem of the progressive reduction in streamflow that has occurred in the Paritua Stream which runs alongside Mangaroa Marae at Bridge Pā. The timing and frequency of the drying of the stream and unravelling the combination of physical conditions and stressors that lead to these dry stream bed conditions provide the focus of one of the model predictive simulations. This work is being informed by groundwater and surface water mātauranga Māori and mōhiotanga Māori by Amber Aranui with Ocean Mercier from Victoria University of Wellington in partnership with Ngāti Kahungunu. It is also being supported by a combination of isotope, dissolved gas, and hydrochemistry signatures of the groundwater to identify the source of recharge to the aquifer in this area. Geophysical data (SkyTEM) is being used to better define the basement to the aquifer system.

Methods for improving the reliability of model simulations required for delineating drinking water source protection zones is currently being undertaken with ESR. This includes the development of methods for both the characterisation and upscaling of small-scale high permeability pathways that can rapidly transport pathogens.

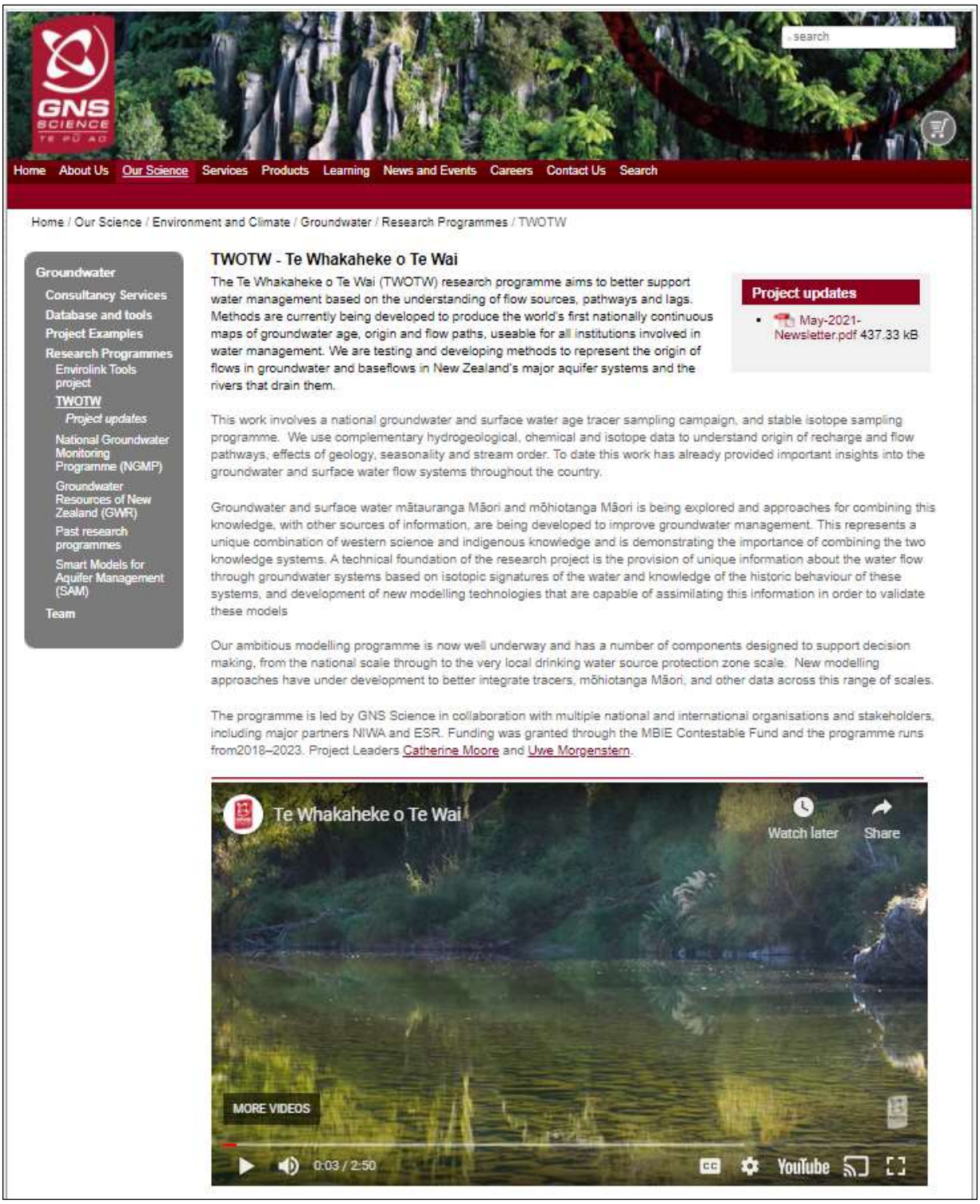
Since the last newsletter GNS Science has also continued work on the national groundwater and surface water age tracer sampling campaign. Information from this sampling campaign is being combined with NIWA's nationwide surface water stable isotope sampling programme. These projects have already provided important insights into the groundwater and surface water flow systems throughout the country.

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

Outreach

The team is pleased to announce that the new TWOTW website is now live. The website will be used to publish information from the research programme as it becomes available. So far, we have included links to the newsletter, a summary of the project, and a list of all publications. The team have also recently enjoyed the challenges of developing content and producing an outreach video. The video explains what research is being undertaken and what the project aims to achieve. You can view the website (including the video) or view the video on You Tube. Please share the website and video with any peers and colleagues who may be interested.



In the community and media

Presentation

Uwe presented at the recent Ngāti Kahungunu Fish Hook Summit on the Te Whakaheke o Te Wai programme. The presentation focussed on the new techniques and approaches that are in development to improve our understanding of the dynamics of the hydrologic cycle using the isotopic signature of the water – to let the water tell the story. The initial phase of the TWOTW programme had a strong focus on the Heretaunga Plains groundwater system. The research is in order to understand the recharge sources and flow processes of this groundwater system, and how it interacts with the surface water. Techniques developed in the Heretaunga Plains are now being applied to all regions of Aotearoa to enable better management of our precious water resources. The presentation is available to view online.

Morgenstern U., 2021. The flow sources, pathways and lags of water moving through the Heretaunga catchment, Kahungunu Fish Hook Summit, 20 May 2021, Napier Conferences and Events Centre, Marine Parade, Napier

Groundwater modelling

Local models in the Heretaunga Plains

GNS Science staff have been working on building the local and regional Heretaunga Plains models and are making good progress. One of the local models is centred around Bridge Pā. The team have recently been focussing on documenting physical changes in the landscape over time that have influenced the hydrological system. These changes include activities such as large-scale drainage of swamps (pre-1867), conversion to agriculture, installation of border dyke irrigation, groundwater abstraction, and gravel extraction from river beds (e.g., Ngaruroro River). The modellers have also been exploring drivers and responses in recharge by exploring river flow and isotope data to understand rainfall recharge and river recharge processes. Meanwhile, work is being undertaken to compile observational information to be included in the model. For instance, a record of weather observations (1859 – 1944) have been used to identify occurrences of drought and flooding. Aerial photography is also being used to identify visual changes in the landscape and hydrology, both around bridge Pa, and further afield, for example the formation of a lake and changes in the Awanui Stream north-east and north-west of Pakipaki. The team have a large workload ahead to run the datasets analyses. This data will be used in a history matching process which involves four main periods: 1) pre-development; 2) post drainage; 3) 1970s (pre-gravel and groundwater abstractions); and 4) the present day.

Incorporation of small scale – rapid transport pathways into source protection zone modelling

GNS and ESR are working on methods that characterise and upscale small scale – rapid transport pathways in source protection zone modelling. This work is to enable more robust assessments of the source protection zone areas required in aquifers with preferred transport pathways, such as in alluvial gravels. This work is being undertaken in a Bayesian context to allow a probabilistic determination of source protection zones in heterogeneous aquifers.

National scale models

Progress has continued to be made with the development of a National Scale groundwater model, using MODFLOW 6 software. This model is co-developed with the New Zealand Water Model project (NZWaM). This model incorporates nationally consistent datasets, providing a seamless coverage over the country. This consistency provides an optimal starting point for the rapid generation of regional and local scale models that can be modified to address specific questions in areas of interest across the country. Regional and local sub-models are able to developed, which inherit structure, boundary conditions, and prior hydraulic parameter values from the national scale model but use a refined spatial and temporal discretisation. These sub-models can then be deployed to provide estimates of a prior predictive probability distribution. In addition, the enhanced parameterisation of the sub-models can then be used to more fully assimilate information from data and reduce the uncertainty of predictions. In TWOTW the key predictions being investigated are the spatial distributions of groundwater and surface water ages.

Meta-modelling

Progress also continues on the national groundwater age metamodel component of the programme. Metamodels are statistical models, trained on observed data, and are used to extrapolate relationships that enable predictions to be made at unsampled locations. They are very quick to run, but like all data-driven techniques are sensitive to data availability, with predictive capacity suffering when the data sets are limited and sparse. Recent work by the metamodeling part of the project has shown strong relationships between groundwater chemistry and age. However, the relatively limited availability of groundwater chemistry measurements limits the utility of such models, especially where national coverage of groundwater age is desired. Current efforts are exploring a hybrid statistical-physically based approach, where the statistical meta-model is able to also harness information generated on the basis of the laws of physics.

Heretaunga Regional scale models

Recent work on the regional model development and data assimilation has included exploration of the age simulations, including selection of different statistics from the age distribution. For example, one approach is to select a 'fraction' of water (e.g., < 6 months), or alternatively, a second approach is to consider the entire age distribution. Field sampling for age information has been undertaken at many bores in the Heretaunga Plains, and there will be some work required to process the data so that it is suitable to be input to the model.

Coming up next ….

In the next issue, we aim to introduce our student researchers and provide an update of activities in the project. Please get in touch if there is anything else you are interested to see in our project updates. The team is planning to present to councillors at Hawke's Bay Regional Council in September. It is expected that this event will be live broadcast, so check on HBRC Facebook (https://www.facebook.com/HBRegionalCouncil) or website (https://www.hbrc.govt.nz/) for further details.

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. Hawkes 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 modelling (SPZ) are also being developed.