Poster Abstracts

SAFE WATER SUPPLY THROUGH THE UTILIZATION OF GROUNDWATER FOR AREAS VULNERABLE TO WATER SUPPLY SHORTAGES DURING DROUGHT

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Ministry of Environment (MoE) and Korea Environment Corporation (K-eco) have been carrying out projects to improve groundwater quality by disinfecting drinking groundwater wells and cleaning up the surrounding tube well for areas vulnerable to water supply shortages since 2012. In addition, through the new development of a public drinking tube well in the village, safe drinking water is supplied to residents who lack drinking water during drought. In South Korea, Area vulnerable to water supply shortages is an area where water supply is not supplied, an area that is vulnerable to drought and needs to secure water resources in case of an emergency, an area where there is no alternative water resource around the area where water pollution is serious. By 2022, MoE and K-eco have completed 2,297 places of tube well disinfection and cleaning up the surrounding tube well, also have completed 39 public drinking tube wells. The effect of the project was to reduce the number of tube wells that exceeded the Total Coliforms-Multiple from 303 to 34 tube wells in 2022. This result means that the use of chlorine disinfectants is effective to improve the water quality at points exceeding the Total Coliforms-Multiple and the improvement efficiency is 88.8%. In addition, an average of 2,300 tons of safe drinking water was provided per day through the development of a public drinking tube well in areas vulnerable to water supply shortages. A supply of safe drinking water allowed local residents to live without water shortages even during drought.

In the near future, the climate crisis is getting worse and residents living in areas vulnerable to water supply shortages may face restrictions on water use, especially during extreme droughts. MoE and K-eco will continue to do our best to provide clean and safe drinking water through support projects for in areas vulnerable to water supply shortages.

COMBINING SUSPENDED SEDIMENT SURROGATES AND EMPIRICAL FISHERIES DATA TO GENERATE SEVERITY INDEX SCENARIOS TO SAFELY SLUICE SEDIMENT FROM A DIVERSION DAM

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Sedimentation is a problem affecting many of the worlds reservoirs. Sedimentation is particularly problematic behind diversion dams, which tend to have smaller storage pools that must occasionally be flushed of sediment to maintain viable operations. But sediment flushing can have damanging effects on the downstream fishery varying from limiting growth and reproduction to mass fish kills. It is thus beneficial to schedule sediment sluicing events such that sediment concentrations and durations are maintained at levels that limit detrimental effects to the downstream fishery. We used acoustic and optical sensors as surrogates for suspended sediment concentration, with the acoustic signal tracking sand-sized particles and the optical signal tracking mud-sized particles. We combined these data with empirically-based sediment fish severity indices to generate release schedule targets for dam managers to maintain fish severity levels that are less harmful to fish during sluicing events. The method uses a rolling average of suspended sediment concentration to implement established and new fish severity indices, and can be used for forecasting and real-time decision making during sluicing events. The method can be applied anywhere surrogate relations have been established with suspended sediment concentrations.

MAPPING THE DURATION AND TREND PATTERNS OF INTEGRATED WATER VAPOR TRANSPORT (IVT) IN NEW ZEALAND

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Integrated Water Vapor Transport (IVT) represents the total amount of water vapor transported horizontally across a vertical column unit area of the atmosphere. While the role of IVTs in weather and climate patterns, hydrological processes, and environmental impacts is acknowledged, spatial exploration and modulation of IVT patterns, particularly in the Southern Hemisphere, has been limited. This study aims to build upon previous works on IVT climatology by focusing on distinct aspects of IVT in New Zealand from 1981–2020 (40 years), using the ERA-5 dataset. Using the classification adopted in Atmospheric Rivers ranking scheme, this work classifies and analyses the IVTs based on magnitude into Weak, Moderate, Strong+ (encompassing Strong, Extreme, Exceptional) IVTs. The decade 2011–20 witnessed positive anomalies in Strong+, Moderate and Weak IVT thresholds in most of South Island in comparison to its previous decade (2001–2010) and base decade (1981–1990). This contrasts with negative anomalies in North Island, aligning with trends that show a strengthening of IVTs in the south and weakening in the north. A key study undertaken is the duration of IVT and results show that the Southland region has a greater number of days with IVTs that persisted relative to other regions. By comparison, the North Island has IVTs that typically last longer and higher IVT inland compared to the South Island. The study of the duration of IVTs at varying thresholds offers a nuanced understanding of how moisture patterns remain stable or change over time in the region. By mapping these trends, this study contributes to long-term water resource management by enhancing predictions of water availability and drought patterns. In the context of climate modelling, it aids in understanding how localized moisture stability may interact with broader climatic trends, and atmospheric contributions to river flows.

SIMULATION OF SEDIMENT LOADS IN LAKE OPUHA USING THE SWAT+ MODEL

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One of the main challenges of sustainable reservoir management is the excess of suspended sediments, which affects a range of functions by reducing their potential for energy generation (hydropower), water supply (drinking or irrigation), and recreational benefits.

This study presents a sediment yield simulation of the Lake Opuha catchment using the Soil and Water Assessment Tool (SWAT+). The primary objective is to use the SWAT+ model to quantify the sediment load that reaches the lake, identify different sediment sources and determine the most efficient measures to reduce suspended sediments in the reservoir. The applicability and suitability of the SWAT+ model in simulating sediment loads will be evaluated. It is planned to in particular improve the model to account for significant point sources of sediment (landslides/mass movements) and for routing sediment loads through the river network.

The methodology employed involves calibration and validation of the SWAT model using data from flow and sediment monitoring stations and observations of landslides/mass movements within the catchment. Subsequently, scenario-based simulations are conducted to assess the effect of a range of land management practices and soil conservation measures on sediment yield dynamics under climate change with a focus on extreme events.

The study will yield insights to establish efficient suspended sediment mitigation strategies both within the catchment area and through specific reservoir operations. By understanding the factors affecting sediment loads, an operational tool will be developed to manage water and sediment releases effectively, optimizing the reservoir's performance while minimizing downstream impacts.

This research contributes to the broader field of sustainable water resource management by providing a comprehensive understanding of sediment dynamics in the catchment, as well as understanding the limitations of SWAT+ regarding the simulations of processes associated with point sources of sediment and sediment routing, with subsequent implementation for improvements.

WETLAND DRAIN SETBACK TOOL (WDST): A PRACTICAL APPROACH FOR ASSESSING THE IMPACT OF DRAINAGE SYSTEMS ON WETLANDS

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Aims

This paper proposes a new drainage model that could be applied to New Zealand's freshwater wetlands, identifies the potential effects of historical and new drains, and provides guidance on appropriate setback distances to ensure the values of wetland ecosystems are not adversely affected by lowered water levels.

The development of this wetland drain setback tool (WDST) will directly support the implementation of the National Environmental Standards for Freshwater (NES-F) that were gazetted in 2020. The NES-F has established rules to protect and restore wetlands. It is now prohibited to undertake earthworks or modify the water cycle within a natural wetland or non-complying within 100m of a wetland if it is likely to lead to partial or complete drainage unless exempted for specific reasons such as wetland restoration.

As there is a lack of national guidance on what an acceptable level is (if any) of water level decline for different wetland types (i.e., marsh, swamp, fen, pakihi or bog), the WDST aims to increase confidence in understanding the effects of drainage on wetland ecosystem health. The tool would support users to make more informed decisions on drainage setbacks, given the challenges with collating data on wetland hydrology and understanding local site settings that are highly variable (for example, changes in soil layers and hydraulic conductivity).

Method

A conceptual model was developed to assess the influence of drain systems on the hydrology, specifically water levels, of natural freshwater wetlands. The conceptual model provided a simplified representation of a wetland hydrological system that summarises the core hydrological principles in wetlands when they are affected by drainage. This aims to reduce the need for complicated modelling or technical drainage assessments at each wetland being considered for drainage-related effects. The conceptual drainage model was represented numerically in the software COMSOL Multiphysics, which allowed the integration of complex governing equations such as the groundwater flow equation. Figure 1 shows a Schematic of the model conceptualisation.

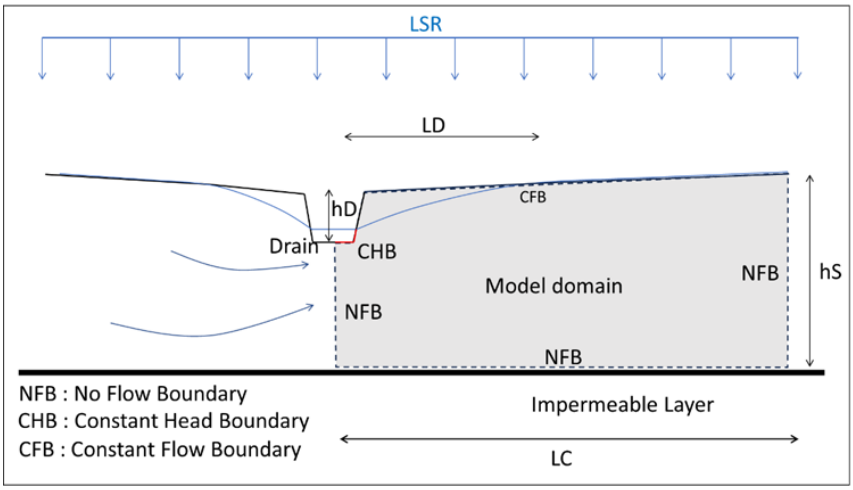

Figure 1. Schematic representation of the model conceptualisation, highlighting important parameters, including the depth to the sealing/low permeability layer (hs), drain depth (hD), drain catchment distance (LC), drain setback distance (LD), and implemented boundary conditions NFB (No Flow Boundary), CHB (Constant Head Boundary), and CFB (Constant Flow Boundary)

Site-specific data was collected and used during modelling, including climate and soil depth and conductivity information, with the models calibrated against water levels measured in wetland monitoring bores in close proximity to existing drains. An acceptable calibration helps prove the suitability of the modelling approach to predict drain effects on water levels (shallow groundwater. drawdown). The sites were Queen Elizabeth Park (QEP) in the Greater Wellington Region, Otakairangi Wetland in the Northland Region, and Moawhitu Wetland in

the Marlborough Region. Site visits were conducted at two of these wetlands to collect additional verification data on saturated hydraulic conductivity (Ksat), drain dimensions, and depth to a low permeability layer.

Results

The transient numerical models for each were simulated for 280 – 900 days, dependent on available water level monitoring records. Satisfactory to strong model calibrations were achieved based on the Nash-Sutcliffe Efficiency (NSE) (ranging from 0.58 – 0.92), with PBIAS ± 1-2%. This indicates the conceptual drainage model was suitable for predicting water level responses at various lateral distances from a drain, and the parameters and theory behind the drainage model have merit for further development.

A hypothetical land development scenario was then tested to consider how the tool may be applied. This considered a single-lot subdivision near a wetland on the Kāpiti Coast, where a boundary drain was proposed to lower the water table. Four scenarios were modelled to indicate the sensitivity of certain parameters on the lateral setback distance. These were the drain depth (at 1.5 m and 2 m) and Ksat (moderate permeability of 72 mm/hr and rapid permeability of 288 mm/hr). Input data was sourced from national maps and local site settings. The lateral setback distance was predicted where there would be minimal drawdown in the long-term water level (~<10 mm), 50 mm and 150 mm.

The results of this simulation are presented in Table 1 and show the importance of site-specific data to help refine model predictions, particularly given the coarse approach for permeability mapping at a national level.

Table 1. Predicted lateral setback distance (m) for a hypothetical drainage scenario on the Kapiti Coast, near a wetland complex. This encompasses four scenarios; two drain depths and two variations of the saturated hydraulic conductivity (moderate and rapid).

Long term average water level drawdown	**Drain depth = 1.5 m**		**Drain depth = 2 m**	
	Ksat – moderate	Ksat – high	Ksat – moderate	Ksat – high
Minimal/no change (<10 mm)	51 m	132.5 m	82.1 m	173.1 m
50 mm	48.6 m	123.7 m	78.7 m	164.2 m
150 mm	42.5 m	103.9 m	70.1 m	144.4 m

Overall, the conceptual drainage model and numerical modelling results provide confidence that a national tool to estimate drainage effects near wetlands is feasible. In all situations where the WDST was applied, it performed suitably.

Further refinement of the WDST is recommended to provide greater confidence in its application for different wetland settings. It is recommended that the drainage model be verified at a further ten wetlands (where monitoring data exists), and additional data collection is undertaken for input parameters such as Ksat.

Our view is that the tool could also be developed into a web-based application where users may enter local site data to predict drainage setback distances for protecting wetland ecosystems. The model and web-based interface could be supported by technical guidance material to ensure the applications and limitations are clear and that its use is appropriate for the scenario.

References

Ministry for the Environment. August 2020. National Policy Statement for Freshwater Management

SUMMER TIME RAINFALL, NOT IRRIGATION, IS THE BIGGEST DRIVER OF NITROGEN LEACHING

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Nitrogen leaching from the majority of NZ's irrigated area must be reduced to meet water quality criteria. The reductions required are being given legal standing through Regional Planning processes and, in some regions, through land-use consents.

There are multiple ways in which a farm's N-loss to water can be reduced, one of which is improving irrigation management practices to reduce the risk of drainage. The "N-Wise Irrigation" strategy seeks to balance the risk of pasture production loss against the risk of N-loss to water. One of the key innovations of the N-Wise irrigation strategy is delaying irrigation until the soil water deficit in the root zone is significantly greater than the Good Management Practice norm of 50% of the root zone water holding capacity, during the margins of the irrigation season.

Plot-scale field trials have been in progress on a commercial dairy farm for two years, the aim of which is to answer the question does N-Wise Irrigation significantly reduce the risk of N-loss to water without significantly raising production loss risks, even when water supplies are unreliable?

Measurements to-date show that regardless of the irrigation strategy applied, the amount and frequency of rainfall has been the main driver for total nitrogen leaching, not the irrigation applications. This challenges the view that increasing irrigated area is the main driver of increased nitrogen leaching in Canterbury. Furthermore, the measured total nitrogen loss has, to-date, been at the lower end of that expected for Canterbury under grazed dairy farming practices.

This paper will present a summary of the field measurements obtained to-date, highlighting the data that indicates that summer-time rainfall is the primary driver of nitrogen leaching. It will also outline the additional field data being collected to further explore these findings.

THE SMALL WATER SUPPLIER GAME

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Aims

With an evolving regulatory system, those supplying drinking water to others are increasingly required to ensure the water is safe, the supply is safe, and that they are aware of all the rules and expectations facing them.

Method

Though the rules introducted by Taumata Arowai were expected to bring clarity to the roles and responsibilites of drinking water suppliers, we have found that small suppliers (that is suppliers providing water to generally less than 100 people, and sometimes less than 25 people) may not easily fit within a Taumata Arowai supplier category.

Adding confusion is how all these new rules interplay with existing ones, such as those set in a Regional Plan regarding small water suppliers, and Building Codes around self supplies.

And on the horizon – a National Environmental Standard for Drinking Water!

So what's a small water supplier to do?

Results

Using the example of a small rural marae and a council-owned community hall we explore the decisions (and their consequences) on the path to achieving regulatory compliance and "safe" drinking water.

RARE EARTH ELEMENTS AND YTTRIUM (REY): TRACING WASTE/ROCK-GROUNDWATER INTERACTIONS

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Increasing concentrations of REY are entering the environment due to human activities. The similar chemical behaviour across the lanthanide series (lanthanum to lutetium) and yttrium, allows their use as tracers, fingerprinting rock-forming processes, and fluid-rock interactions. However, their use in fingerprinting waste and particularly low-level radioactive waste has not received much attention, despite the direct use of REE in the nuclear industry and the traditional use of REE as proxies to understand the environmental mobility of the actinide series (actinium to lawrencium). The highly instrumented low-level radioactive waste site at Little Forest (Australia) allows a detailed REY study, investigating interactions with local strata, neighbouring waste forms and shallow groundwater flows. Groundwater samples and solids from cored materials were recovered from the study site and regional baseline sites in the same geological materials. The REY in water samples were analysed by automated chelation pre-concentration (SeaFast, ESI) followed by ICP-MS determination, while solid samples were analysed using Neutron Activation Analysis (NAA) and X-ray fluorescence scanning (ITRAX). Solid rocks showed no REY departed from typical Upper Crust compositions in either Little Forest or regional background sites. Shallow groundwater from ~4-5 m, at or slightly below waste trench levels, showed water-waste interaction as a marked enrichment, relative to shale-normalised patterns, in samarium, europium and gadolinium, with depleted yttrium. Leachate samples from the neighbouring urban landfill show different REY normalised patterns. REY distribution changes with depth through increased interaction with shales and sandstones. Our study revealed that the Little Forest low-level radioactive waste has a REY fingerprint different to that of groundwater in surrounding land uses. The approach presented can refine source allocation and trace pollutant mobility in current and legacy urban, mixed and radioactive waste sites around the world.

AGILE, ADAPATIVE WATER ALLOCATION, AND RESILIENCE SOLUTIONS FOR WATER USERS

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Lowland streamflows continue to decline in areas such as the Canterbury Plains where there is substantial abstraction of groundwater, despite implementation of current best practice groundwater allocation (i.e. seasonal volume limits on abstraction) for the last decade. Climate change is expected to contribute to further deterioration of stream health if current policy is maintained.

In a project funded by the Ministry for Primary Industries, we developed water allocation policies that enable agile adaptation to climate change and deliver increased flows in groundwater-dependent lowland streams.

We modelled the effects of climate and water allocation policy on water demand, surface water flows and groundwater levels in the central Canterbury Plains. Model simulations were used to iteratively design and test demand management policies, and assess their benefits on instream flows and water supply security. Regional council experts contributed to the policy re-design.

Policies based on annual volume limits are ineffective in most years, while policies that vary the maximum daily rate of take based on aquifer conditions or flowrate in the Selwyn River show the most promise in increasing river flows during summer and autumn. This highlights that integrated management of surface water and groundwater is essential for achieving stream health objectives.

The ability to adapt allocations in response to short-term climate variations is critical for maintaining stream health and enables agile adaption to a changing climate.

Allocation policies that increase stream low flows significantly reduce groundwater supply security. Risk is moved from the environment onto water users.

Further work is underway to explore options for improving water users' resilience to lower groundwater availability. Options include water storage, alternative water sources, and changing the temporal and spatial distribution of groundwater abstraction. This work will include development of an automated method to tune policy parameters for specific catchments, facilitating selection of optimal allocation policies.

USING WATER QUALITY DATA TO DIAGNOSE POTENTIAL ISSUES WITH GROUNDWATER BORE INTEGRITY

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Ensuring groundwater bore integrity is key to obtaining reliable data to characterise groundwater systems, assess potentially contaminated sites, and calibrate groundwater models, among various other applications. Traditional approaches to assessing bore integrity often rely on onsite visual inspections and physical measurements, which can be time consuming, resource intensive and limited in scope. This study explores the use of water quality analysis as a diagnostic tool for identifying signs of compromised bore integrity. By analysing key changes in water quality and shifts in trends, cost effective and proactive assessments can be conducted, facilitating timely interventions and reducing potential impacts to receptors.

A collection of monitoring bores were assessed across multiple hydrogeological environments by selecting data from bores with suspected integrity issues and their replacement or analogous bores within the same aquifer. These bores were selected based on documented issues such as compromised annular seals, tree root intrusion and residual drilling cement. These were subject to analysis through the use of hydrochemical diagrams and statistical methods with the aim of identifying distinct patterns and anomalies associated with compromised bore integrity.

The analysis revealed order of magnitude variations in salinity, metals and major ionic compositions, as well as shifts in pH and distinct trends, when comparing compromised bores to their replacements or to baseline data. These findings form the basis for identifying a robust set of techniques that can be applied to a dataset for identifying bores that may require replacing. These techniques were then tested against an independent dataset to assess their effectiveness.

The utilisation of water quality analysis as a diagnostic tool for bore integrity issues offers valuable insights and practical applications. By incorporating this approach into existing assessment practices, it not only saves time and costs but also reduces potential risks to receptors associated with compromised bores.

DATA: MONITORING, VISUALISATION, AND MANAGEMENT

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To unravel the intricacies of groundwater systems, our efforts hinge on accurate and consistent data collection. The advent of the Internet of Things (IoT) has revolutionised monitoring techniques, allowing us to gather hydrogeological data with great accuracy. Through remote sensing applications, and real-time data acquisition, IoT technology offers a real-time window into groundwater dynamics. Collaboratively, we can address the challenges of data accuracy, tackle gaps, and explore methods to integrate diverse data sources, thereby illuminating a more comprehensive perspective.

The power of visualisation lies in its ability to convert raw data into tangible insights. From Geographic Information Systems (GIS) to 3D modeling and data-driven visualisations, we will uncover how these tools enable us to identify trends, anomalies, and relationships within complex hydrogeological datasets. The incorporation of IoT-generated data enriches visualisation by offering real-time updates, facilitating quicker recognition of critical changes in hydrogeological conditions.

As data accumulates, effective management strategies become paramount. Exploring strategies that streamline data organisation, storage, and sharing is critical. The discussion we must have span data integration, quality assurance, and the importance of establishing standardised databases. IoT-based monitoring generates large datasets, necessitating robust data management techniques to extract valuable insights efficiently. We must understand and work together to ensure best practices that enhance collaboration and lay the foundation for sound decision-making.

Internet of things (IoT) driven monitoring, combined with advanced visualization, empowers stakeholders to make sustainable choices. Our insights, influenced by hydrogeologists, significantly influences policymakers, water resource managers, and industry at large.

Our collective efforts are instrumental in shaping the course of groundwater management, control, and equitable resource allocation. We must exchange experiences and insights on hydrogeological data strategies. As we share our knowledge, we contribute to the ongoing evolution of data practices that underpin effective groundwater resource management.

DATA TO INFORMATION: CONSTRUCTING CONCEPTUAL HYDROGEOLOGICAL MODELS

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Subsurface Drip Irrigation (SDI) is a land discharge method for wastewater disposal that is providing good environmental outcomes for New Zealand communities. To understand how SDI could be utilized within the existing hydrogeological system a broad assessment of publicly available data is undertaken to support the development of a conceptual hydrogeological model. Using lithology data from borehole databases, the regional geology is conceptualized and presented in a geological cross section of the development site and wider area. Nearby groundwater users / boreholes are superimposed on the model to display the separation of their abstraction points from the potential SDI discharge areas. In our example project, this information identified that the majority of nearby bores and consented groundwater users are abstracting water from a fractured basalt rock aquifer underlying the residual volcanic soils intended for SDI discharge. These wells are however at least 2 km from the nearest discharge point. Using GIS to understand the topography of the development site, we were able to infer the shallow groundwater flow paths at a catchment scale. Knowing the general groundwater flux beneath the site, a conceptual understanding of potential contaminant migration was used to refine the list of receptors and to be able to hydraulically isolate a significant municipal water supply spring in the area. The model holistically demonstrated that the groundwater users were abstracting water from a different geological unit than what was being targeted. This information was graphically presented in an accessible manner that would enhance community awareness. Additionally, the model revealed gaps in the current understanding of the on-site geological conditions, which can now be targeted in future site investigations and monitoring. The conceptual hydrogeological model will inform future assessment of environmental effects and also serve as a key document for community engagement and inclusion.

A NOVEL EFFICIENT, DYNAMIC, AND FLEXIBLE RADON SAMPLING METHOD FOR ILLUMINATING GROUNDWATER-SURFACE WATER INTERACTIONS.

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Radon is a radioactive gas arising from Uranium decay series and becomes dissolved in groundwater through subsurface interactions between groundwater and rocks/sediments. Radon has low solubility in water and therefore de-gasses from water at transitional zones between groundwater and surface water i.e. river/lake beds and springs. Down-river sampling for radon can highlight zones of groundwater flux in rivers and is especially useful when combined with other methodology such as flow-gauging and chemical/age tracer data.
Sampling by foot or by helicopter each have their advantages and disadvantages (i.e. accessibility, cost and time constraints). Here we present radon sampling via kayak as an incredibly versatile and efficient sampling method. It is time and cost effective and offers a great deal of flexibility into sampling regimes. Hundreds of samples can be retrieved and processed within short periods of time (ca. 24 hours). This method increases our capability of understanding local and regional hydrological processes and is another layer contributing towards robust hydrological models.

THE DIVERSITY OF GROUND WATER FAUNA AND GENOMIC CHARACTERISATION OF AMPHIPODS

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Aims

1. Broad characterisation of eukaryotic communities across different aquifers and chemically different groundwaters using 18S rRNA, along with metagenomic and meta-transcriptomic data from a subset of sites.
2. Preliminary genomic characterisation of Amphipoda individuals from groundwater.

Methods

There are few investigations using molecular techniques to identify the types of fauna present in ground water systems and those that have attempted classification are being hindered by the absence of detailed reference genomes. Here we report preliminary use of both morphological and molecular techniques to build phylogenetic constructions and evolutionary relationships in groundwater fauna and further focus on amphipods. We collected stygofauna samples from Silverstream bore C4 in December 2022, morphologically characterised and identified stygofauna specimens across the range of stygofauna present in aquifers (Isopoda, Amphipoda, Copepoda, Arthropoda). We then determined and tested DNA extraction protocols for their ability to yield high quality DNA from amphipods for molecular analysis (genomics and PCR amplicons). We also undertake a preliminary analysis of an existing groundwater 18S rRNA amplicon dataset for eukaryotic taxa, including stygofauna.

Results

We will present results on the analysis of existing groundwater genomic and transcriptomic datasets for eukaryotic taxa. We will also discuss protocol optimisation and methods for yielding high quality DNA from amphipods, for whole genome sequencing or amplicon sequencing together with the preliminary analysed genomic sequence data.

MORE DATA, LESS WORK: INTRODUCING THE SYP AUTOMATIC FLUID SAMPLER

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The regular analysis of water samples is central to a range of environmental applications, such as routine water quality monitoring, environmental impact assessments, or scientific research. However, manually maintaining frequent sample collection over extended periods of time quickly becomes unfeasibly expensive and time-consuming, especially when field sites are remote or difficult to access. To aid researchers and professionals to nonetheless achieve the desired sample frequency, we present the novel purpose-built Syp automatic fluid sampler (https://www.waikatoscientific.com/syp).

Designed and manufactured by the University of Waikato in conjunction with Bentech Limited, Kirikiriroa, Syp units allow for the automated collection of up to 58 samples at pre-determined time intervals, with a lifespan of over 12 months per deployment. Samples of up to 15 mL per vial are either collected passively using a funnel (e.g., suitable for cave dripwaters, rainfall) or actively via a pump and tubing (e.g., suitable for standing or flowing water bodies). Self-sealing rubber bungs ensure that samples undergo minimal alteration during storage prior to laboratory analyses, such as a negligible evolution of stable water isotope compositions. Originally tailored for cave research, the modular design allows for easy and protected transport of the instrument even through tight spaces, while programming occurs conveniently through an intuitive browser-based interface via any smartphone or laptop. Syp units are commercially available, and currently facilitate research worldwide with over a dozen units deployed internationally.

HOW WOULD YOU LIKE YOUR DATA? EXPLORING DATA VISUALISATION OF GROUNDWATER MICROBES

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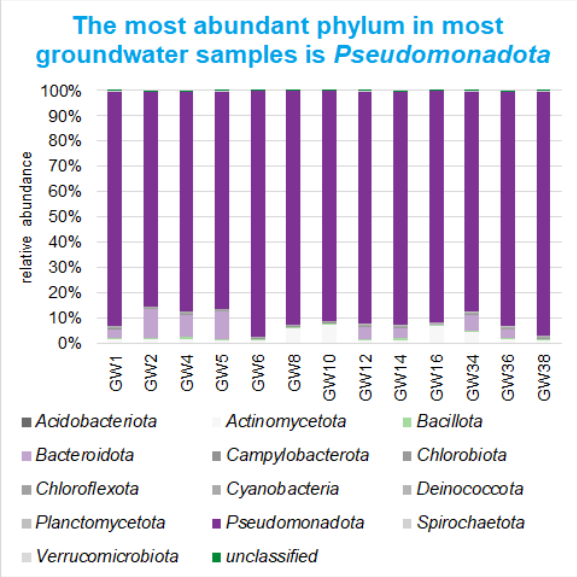
Aims

There is an increasing need for public-funded research organisation to communicate science to a broader audience for a range of purpose, including policy context, provide understandable evidence from observations or experiments and increase transparency (Hajdu and Simoneau, 2020). The GNS Science Ecosystem Monitoring Project was initiated in 2020 and aims to investigate groundwater ecosystem health and identify relationships between microbial diversity and groundwater chemistry. The microbial current dataset includes analysis and interpretation of microbial information (taxonomy, abundance, and potential metabolic functions) collected at 178 groundwater sites nationwide. This dataset is interpreted using complementary data such as groundwater chemistry, well depth, locations, and hydrogeological parameters.
This interactive poster presentation aims to engage with a range of audiences through comments and votes on a range of text and graphics and infographics. This information will be used to review and tailor our reporting to a range of audiences, including but not limited to, national reporting on monitoring activities (Houghton and Santamaria Cerrutti, 2022). If applicable it will also be used to define the format of the datasets for public release.

Methods

Groundwater ecosystem health can be defined in terms of their structure, function and ecosystem services provided (Korbel and Hose, 2011). The first part of the poster will present the national dataset collected to date and the range of information that can be accessed through analysis of microbial DNA sequencing in additional to hydrochemical analyses.
As this information is rich and complex, multiple graphical representations are frequently used to explore the data (Figures 1-3). The second part of the poster will include a series of visualisations of a subset of the dataset, aimed at a selected audience (general public, science and policy teams, microbiologists, and other collaborators). The Conference attendees will be provided with materials (post-it notes, stickers, etc.) to indicate what information is relevant for their needs, and how they would prefer it to be presented. A series of questions will also be asked to determine pertinent information to include in each data category.



Microbial diversity
Figure 1 shows a stacked column chart of the relative abundance of phyla (high level taxonomy) in groundwater samples, which is used to classify microbial diversity. More complex figures can be created which include information on hierarchical levels of taxonomy (phylum, class, genus), or which bacterial groups co-occur. However, these often need to be constructed for individual samples. End-users may request data is displayed on a national, regional or aquifer scale. If relevant, differences within samples (alpha diversity) or across samples (beta diversity) may also be displayed.

Figure 1- Abundant phyla in subset samples

Potential microbial functions

Charts for potential functions can range from graphs indicating the presence/absence of specific traits across many samples, to metabolic pathways with relative abundances of genes from one sample (Figure 2). Which metabolic functions hold significant interest for end-users? Are hierarchical levels of function (metabolism, pathway, gene) important?

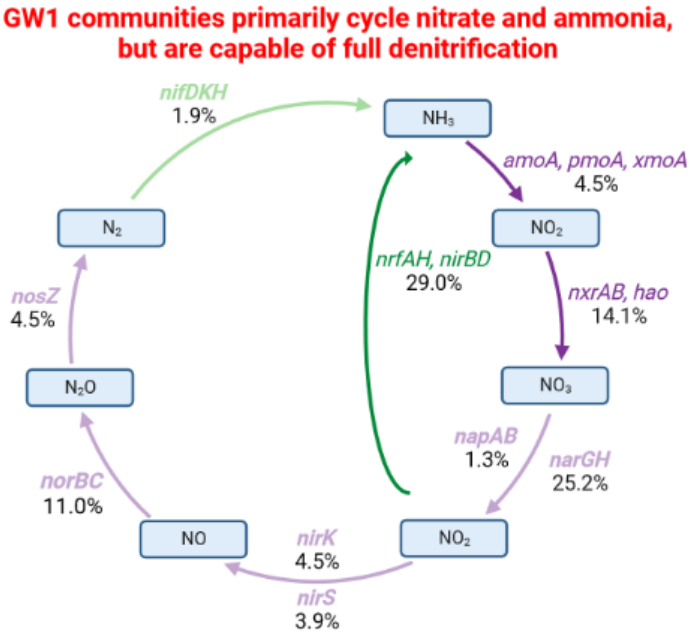
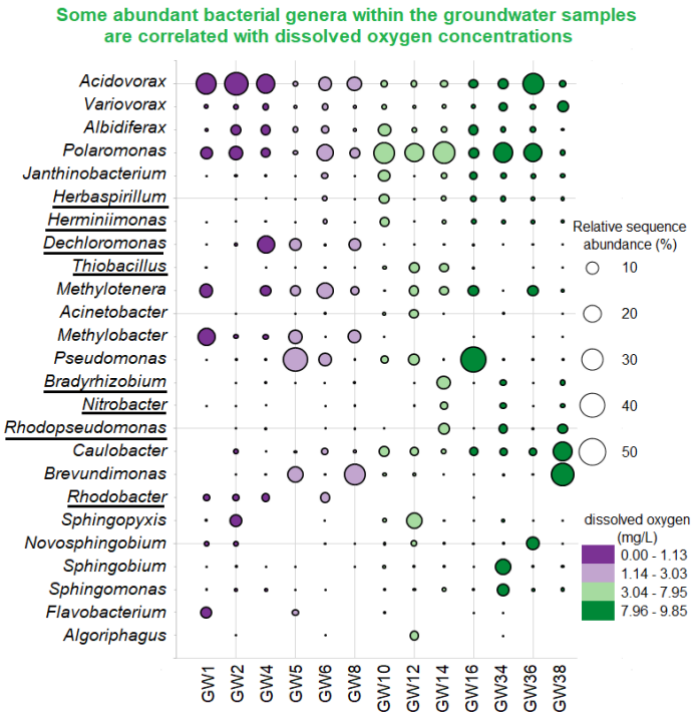


Figure 2: Nitrogen cycle schematic with the abundance of genes in one groundwater sample from the subset.



Relationships

Correlations between data categories can be useful for monitoring and management of ecosystems. Charts may indicate relationships between water chemistry or hydrological parameters and microbial diversity (Figure 3) or microbial functions. Conference attendees are asked to consider which data is useful, and which visualisations are appropriate in order to gain knowledge about specific systems.

Figure 3 – Bubble diagram indicating abundance of genera and dissolved oxygen concentrations within the groundwater subset samples.

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ASSESSING MICROBIAL PATHOGEN TRANSPORT IN GROUNDWATER FROM THE HEKEAO/HINDS MANAGED AQUIFER RECHARGE SCHEME

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[2] Pattle Delamore Partners Limited (PDP)

Aims

Groundwater is the primary source of drinking water for millions of people worldwide, and approximately 40% of New Zealanders (Panckhurst, 2020); yet significant knowledge gaps remain on the fate of microbial pathogens in the groundwater system (Banasiak et al., 2023). Strong links have been made between elevated levels of *Escherichia coli* (*E. coli)* (used as indicator organism for faecal contamination) in drinking water and gastrointestinal disease in humans. As such, further research into the transport of pathogens through groundwater is significant globally. Managed Aquifer Recharge (MAR) can be used to improve groundwater quality by discharging relatively clean water into the receiving aquifer (Guo et al., 2023; PDP, 2022). In South Canterbury, MAR is being implemented by the Hekeao/Hinds Water Enhancement Trust (HHWET) to help reduce elevated nitrate-N in the region, which has occurred as a result of farming in the area. While MAR is intended to have a net positive effect on groundwater quality, pathogens can impact groundwater as a result of the surface water source (the Rangitata River) typically having greater concentrations of pathogens than the groundwater. The aim of this study is to explore the transport and removal rate of *E. coli* through groundwater as a result of MAR, to help improve the understanding of potential impacts on drinking water supplies.

Methods

Water samples from the MAR storage ponds, and from groundwater bores both up- and down-gradient of a MAR site will be collected on a regular basis and analysed for *E. coli* concentrations (MPN/100ml) using *Colilert* testing (IDEXX, 2023). The *E. coli* concentration time series will then be used to assess the correlation and lag between *E. coli* at the MAR site and in surrounding groundwater. They will also be used to inform modelling of *E. Coli* removal at the site and assess the usefulness of different modelling approaches.

Results

This research is currently in the early stages. Progress and preliminary results will be presented in the poster.

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PREDICTION OF GROUNDWATER CONTAMINATION AROUND THE LOADING POINT OF LIVESTOCK RENDERING RESIDUES THROUGH ELECTRICAL RESISTIVITY

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The Ministry of Environment and the Korea Environment Corporation have established an environmental management system to preemptively prevent groundwater pollution caused by leachate runoff around livestock burial sites. Recently, as the disposal of livestock carcasses using rendering increases in the event of a livestock epidemic, rendering residues are often loaded on the open ground, which is feared to cause groundwater pollution. Therefore, we conducted a groundwater monitoring and an electrical resistivity to find out the impact of pollution around the loading point of the rendering residue, which still lacks a management system. The point of investigation is the point where about 120,000 chickens are being loaded and a year after about 40,000 chickens were taken out. The electrical resistivity was performed by setting a side line in consideration of the surrounding site and installing electrodes at approximately 2m intervals to explore the 10m depth section using dipole-dipole. The groundwater monitoring analyzed items used as indicators of leachate in livestock burial sites such as electrical conductivity, ammonia nitrogen, and chlorine ions by collecting the points around and inside the loading point twice. Comparing them, the anomaly zone is highly consistent with the suspected leachate spill point.
This result can be helpful in identifying leachate outflows through electrical resistivity without groundwater monitoring at the loading point of the rendering residue.

EFFECTS OF PROLONGED GROUNDWATER EXTRACTION ON STYGOFAUNA ASSEMBLAGES AND GROUNDWATER QUALITY.

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Groundwater is a vital global freshwater resource. It is particularly important in arid and semi-arid areas where it sustains terrestrial and aquatic ecosystems and is often the primary source of water for communities and industries. Pumping (extraction) of groundwater to meet human needs can result in lowering of water tables, which can impact groundwater ecosystems through chemical, hydrological, and structural changes in the aquifer, with flow-on effects to other ecosystems. The invertebrates in groundwater (stygofauna) provide important ecosystem services and are useful bioindicators of groundwater ecosystem health but have the potential to be impacted by groundwater extraction. There is very limited data on the impact and recovery of stygofauna communities in aquifers subject to groundwater extraction.

To understand the impacts of prolonged groundwater extraction on stygofauna, a 28-day pumping experiment was undertaken in a shallow alluvial aquifer in Maules Creek, NSW, Australia. The experimental hypothesis was that groundwater pumping would cause a change in the stygofauna assemblages in pumping-affected areas. Groundwater samples were collected from 13 bores in impacted and reference locations before and after the pump experiment, as well as throughout a 3-month recovery period. Additionally, water quality parameters and groundwater levels were measured throughout the study. The collected groundwater samples were analysed for stygofauna using traditional (morphological assessment using microscopy) and molecular (eDNA) methods. This presentation will focus on the impact of groundwater pumping on stygofauna assemblages (microscope assessment), water quality and water level and their recovery following the cessation of pumping.

DO NITRATE-CONTAINING WATER SAMPLES DENITRIFY WITHOUT REFRIGERATION?

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Abstract
Greenpeace Aotearoa has been running a free mail-in nitrate testing service for the public since 2021, allowing people to test the nitrate concentration of their drinking water. Generally, it is standard laboratory practice to chill or acid-preserve samples to avoid denitrification, or loss of nitrates by bacterial consumption from the water. However with a community mail-in service, samples arrive at Greenpeace for testing at ambient temperature and may have taken up to a week to be shipped. There are very few studies which describe the effects of temperature on rates of denitrification, so in order to validate our nitrate data, we ran an experiment to assess the potential impact of temperature and time delays on nitrate concentration stability.

We left treated and untreated water samples of different initial nitrate concentrations, plus deionized water as a control, under different light and temperature conditions for 4 weeks. Samples were tested at regular intervals for nitrate, temperature, dissolved oxygen, specific conductivity and pH. Samples showed no change in nitrate concentrations over 4 weeks outside of the parameters of potential instrument error.

These results are in line with those of Delfino (1979) and Stapanian et al. (1989), who found little change in nitrate over time under different temperature conditions. We have worked with other teams to encourage replication of this simple experiment with more sensitive instruments and water from other geographic regions, to better understand whether refrigeration or acid preservation of samples is necessary for accurate measurement of nitrate.

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A UNIVERSE IN A DROP OF WATER

Dino Parisotto[1]

[1]Earth2Water Pty Ltd

Water is an extraordinary molecule containing an abundance of invisible and essential life sustaining elements. Within a single drop of water, an astrologically large number “sextrillion or 1.67 x1021 “ of molecules exists.

Water comprises a vast mixture of elements from the universe. The tiny water molecules are in constant communication with each other and the environment. Water can occur as a nanoscale water droplet, ice crystal, invisible vapour, or be as large as the ocean. Water is as old as the universe and is constantly recycled. Water not only flows around the ocean in conveyor-belt like currents, but also in the microscopic electro-magnetic exchanges between molecules.

Water composition relates to the quality of the natural and built environment. The water molecules can penetrate, erode, dissolve and shape everything like the landscape and built environment. Water is a reactive molecule, a universal solvent and it crosses all boundaries.

With modern analytical instruments, we can understand the intricate and minute physical, chemical and biological imprints in water. From the weathering of rocks, and to the decay of a city, the water erodes and dissolves materials into the groundwater and waterways just like nutrients in a human artery. Most of the harmful pollutants in water are invisible.

Lessons learned with 3 decades with contaminated groundwater investigations is the need for education regarding better waste and chemical management to support ongoing ecological sustainable development. Groundwater quality protection needs to include analyses of current and historical pollution sources and aspects such as community engagement, engineering solutions, and government incentives.

Keeping the tiny water molecule free of harmful pollutants is likely to become the greatest challenge for our generation and the next.

CO_2 WATER ROCK REACTIONS FOR CO_2 STORAGE IN BASALTS

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[1] University of Queensland
[2] University of Newscastle

The transition to net zero requires CO_2 capture and geological storage, and therefore the appraisal of new storage sites. Injection of CO_2 emitted from power plants, blue hydrogen or ammonia production, cement or steel production, or direct air capture may be stored in appropriate reservoirs. Traditionally supercritical CO_2 is structurally trapped under a cap-rock of low porosity and permeability at depths of ~ 1 to 3 km. In shallow formations CO_2 could be injected dissolved in water or as a nano-emulsion for a safer storage option to avoid leakage and accelerate subsequent dissolution and mineral trapping of CO_2 as carbonate minerals to avoid potential leakage to overlying aquifers. Australia and New Zealand have extensive basalt deposits with minerals including olivine and plagioclase that contain Ca, Fe and Mg and are very favourable for CO_2 reaction and mineral trapping as carbonate minerals.

A selection of basalt cores from Queenslands Bowen Basin have been characterised. These include clinopyroxene and olivine phenocryst-rich basalts, veined vesicular basalt, and altered core containing smectite filled vesicles. The basalts also hosted metals such as Ni, Cu, Ba, Zn and rare earth elements (REE). Sequential extractions of drill core material mobilised high concentrations of cations (Ca, Fe, Mg etc.) that can trap CO_2, along with metals and REE. Drill cores were reacted with supercritical CO_2 and formation water at elevated temperature and pressure. The dissolution of CO_2 decreased pH and reaction of minerals resulted in increasing concentrations dissolved elements including Ca, Mg, Mn, Fe, Si, Sr, Cs and Rb over time. Dissolved Pb, As, and Li increased initially and subsequently decreased or varied through precipitation or adsorption. An understanding of the mobilisation and fate of metals to groundwater both informs the CO_2 mineralisation potential, and the potential risks to reservoir or overlying groundwater.

EVERY DROP COUNTS: WATER DATING LABORATORY

Reagan Lithgow,[1] **Reuben Rodricks**[1]
[1]GNS Science

The GNS Science Water Dating Laboratory was first established in the 1950s and analysed its first Tritium sample in 1956. Tritium is a radioactive isotope of hydrogen and is produced naturally in the Earth's upper atmosphere through cosmic ray interaction, as well as anthropogenically through atmospheric thermonuclear bomb testing during the 1960s (Taylor 1966, Morgenstern & Taylor 2009). Once isolated from the atmosphere, tritium decays and can therefore be used to determine as a measure of groundwater residence time. Man-made gases, such as CFCs and SF6, with steadily changing atmospheric concentrations, are used as complimentary age tracers. The use of multiple complimentary techniques enables determination of groundwater mixing parameters and resolves ambiguity in residence times and flow models.

Since 1956, the scientific method and equipment used has been continuously improved leading the way with high accuracy processing and analysis of Tritium via liquid scintillation counting. This is reflected in the 2022 IAEA intercomparison. Over the past 6 months, processing capacity has increased with the new addition of 10 Quantulus counters, generously donated by the University of Waikato. The Water Dating Lab now has the largest collection of liquid scintillation counters in the world.

Applications include mean residence time determination for drinking water supplies, groundwater-surface water interactions such as land use impacts on groundwater quality, nutrient inputs/conceptual groundwater flow models prediction of nitrate loading to lakes, and catchment studies.

References

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WATER QUALITY CHANGES WITH CLIMATE CHANGE – A REVIEW

Hector, R,[1] Rutter, H,[1]
[1] Aqualinc Research Ltd

The potential impacts of climate change on nitrate concentrations in groundwater are complex. In order to understand the nature of climate change impact on groundwater nitrate concentrations, there are three areas to be addressed:

- Source: What are the likely changes to agricultural practices and how may these affect nitrate leaching from the soil zone?
- Pathway: What are the likely changes to groundwater recharge mechanisms and groundwater levels?
- Receptor: What are the likely changes to nitrate concentrations in groundwater and the consequent impact on groundwater receptors?

In terms of the pathway, climate change will affect the hydrological cycle with changes to recharge, groundwater levels and resources and flow processes. Changes to the source, for example in terms of land use and irrigation practices, potentially as a result of climate change, may also be important in controlling the magnitude and timing of nitrate leaching. These are likely to then result in changes in transport, both through the unsaturated and saturated zones.

Recent research has highlighted that nitrates tend to accumulate in soils/unsaturated zone during years of low recharge, and are leached, often rapidly, under wetter years. This complicates the interpretation of changing nitrate concentrations, and the variability could mask the conclusions drawn from improving or worsening land use management. We show some case studies to illustrate the need for conceptual understanding of the whole system when assessing temporal and spatial data.

HARNESSING THE POWER OF MACHINE LEARNING FOR GROUNDWATER LEVEL PREDICTION IN MINING OPERATIONS

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[1]RioTinto, Perth, WA, Australia

Abstract

Planning of Open Cut mining below the water table relies on numerical modelling to predict where the groundwater level is in the future to assure safe and efficient operations. Traditional physically-based models encounter inherent uncertainties and are time-consuming to develop and calibrate. In contrast, machine learning models offer a promising alternative. In this study, we explore the potential benefits of artificial intelligence (AI)-driven approaches in groundwater level prediction for mining. Leveraging advanced algorithms and learning from past historical data from iron ore mines, machine learning models demonstrate high accuracy in predicting groundwater levels and capturing complex relationships. These insights support informed decision-making in mining operations. Furthermore, the integration of machine learning optimizes pumping schedules and reduces unnecessary water extraction, enhancing efficiency and cost-effectiveness. Overall, the use of machine learning in groundwater level prediction holds great promise for sustainable and effective water management in mining and reduces environmental impacts.

SPLITTING STREAMFLOW: EVALUATING THE CONTRIBUTIONS OF SNOWMELT AND RAINFALL TO STREAMFLOW IN A CANTERBURY HEADWATER CATCHMENT

Zane Shadbolt,[1]Shelley MacDonell,[1] Travis Horton[2]
[1] Waterways Centre for Freshwater Management, University of Canterbury and Lincoln University
[2] School of Earth and Environment, University of Canterbury

Cryosphere processes play a pivotal role in regulating seasonal water availability in numerous headwater catchments worldwide, making it increasingly vital to comprehend these processes amidst a changing climate. Seasonal snow cover, acting as a temporary water storage in alpine regions, significantly influences downstream water resources. However, the storage of water in the form of snow is being impacted by climate warming, leading to potential consequences for mountain environments and hydrological processes downstream.

New Zealand's alpine headwater catchments, particularly in the eastern mountain regions, are projected to undergo shifts in precipitation patterns and accelerated warming due to climate change. Among these catchments, Canterbury is of special concern as it heavily relies on precipitation and seasonal snow as key contributors to streamflow, which, in turn, supply critical aquifers serving Christchurch. Understanding the dynamics of alpine streamflow processes and their contributors is crucial for effective downstream water resource management in Canterbury. Estimating the contributions of snowmelt to streamflow in New Zealand is therefore key to address the challenges posed by climate change.

The main aim of this study is to quantify the contributions of snowmelt and rainfall to streamflow in a Canterbury headwater catchment and to determine the implications for water resource management. To address this aim, we used a combination of natural tracers (isotopes), hydro-meteorological measurements and mixing models from the Broken River catchment. As well as enhancing our understanding of streamflow sources this research fills a crucial gap in New Zealand's hydrological knowledge, as it represents one of the first-times isotopic tracers will be used for regular sampling in an alpine stream, further enhancing our understanding of the country's water resources and their response to a changing climate.

PROBABILISTIC GROUNDWATER MODELING AND UNCERTAINTY ANALYSIS FOR DEWATERING IMPACTS IN A REGIONAL AQUIFER SYSTEM: A CASE STUDY OF AN OPERATIONAL MINE IN WESTERN AUSTRALIA

Firman Teuku,[1] Saeed Torkzaban [1]
[1] Rio Tinto Iron Ore (RTIO)

Abstract

Mining of iron ore pits often requires extensive dewatering for safe mining conditions, which can impact groundwater flows supporting dependent ecosystems (GDEs). In this study, we apply a probabilistic approach to estimate parameters and quantify uncertainty in predicted groundwater levels at a specific GDE site. Our methodology enables reproducible parameter estimation and uncertainty analysis, essential for groundwater management decision support in the presence of large-scale uncertainties. We demonstrate the feasibility and efficiency of high-dimensional uncertainty quantification, achieving accurate assessments of dewatering impacts on regional groundwater flow. We estimate the median value and post-calibration variance of groundwater drawdown near the GDE site due to mining-related dewatering operations. Uncertainty in model predictions is predominantly governed by null-parameter combinations. Our findings emphasize the importance of probabilistic approaches for assessing and managing groundwater impacts in mining operations.

EXAMPLES OF GEOPHYSICS APPLIED TO HYDROGEOLOGY / GROUNDWATER

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[1] Umwelt (Australia) Pty Ltd

Geophysics (both borehole and surface) are under-utilised approaches in hydrogeology that can provide a cost-effective and, in the case of surface surveys, a non-intrusive option for collecting key site specific data for groundwater projects. With advancements in digital technology and computing, geophysical equipment and processing software has become simpler to use and in some cases is largely automated. However, automation has not replaced the importance of having qualified and experienced specialists in geophysics to ensure the accuracy of the data collection and interpretation.This presentation will show that when qualifed and experienced personnel are involved in the survey design, field data aquisition, processing and reporting, then geophysics is not only useful and cost effective, but in some circumstances critical to the success of a project. And in other instances geophysics is needed to determine the cause of a problem and to find the way forward. The results can also bring poor designs to light and to raise interesting questions.

GROUNDWATER LEVEL STATE AND TRENDS IN THE GREATER WELLINGTON REGION

Rob van der Raaij[1]
[1] Greater Wellington

Greater Wellington monitors groundwater levels in more than 130 bores covering aquifers in three groundwater sub-regions namely: the Kāpiti Coast, Hutt Valley and Ruamahanga Valley. This paper presents analysis of groundwater level trends covering the period 2011–2022. Median trends for each bore were assessed from average monthly groundwater levels, along with trends in maximum and minimum groundwater levels. Trends in annual minimum groundwater levels provide a long-term view of how groundwater levels decline during the driest parts of the year, giving insight into pressures on the groundwater resource which may be both environmental and anthropogenic. Trends in annual maximum groundwater levels give insight into annual recharge to the aquifers with declining trends in maximum levels indicating non-recovering groundwater levels which may be attributable to climatic effects and/or unsustainable abstraction levels.

Groundwater levels at the majority of sites on the Kāpiti Coast were on average higher over the 2011–2022 period than for previous reporting period of 1994–2011 and most sites exhibited increasing trends in groundwater levels over 2011–2022. In the Hutt Valley and Ruamahanga Valley, the opposite was observed, with the majority of sites being on average lower over the 2011–2022 period than for previous reporting period of 1994–2011, with most sites exhibiting decreasing trends in groundwater levels.
Investigation into the causes of the differences in trends by sub-region is ongoing. A risk classification for declining groundwater levels is being developed to assist in setting appropriate allocation limits for these aquifers.

THE PRACTICALITIES OF GROUNDWATER MODELLING FOR DECISION MAKING

Julian Weir,[1] Nick Dudley Ward[1]
[1] Aqualinc Research Ltd, Christchurch

Introduction

Modelling is the only way to project into the future, or fill in gaps from the past. For those who are not blessed (or cursed!) with the in-depth knowledge of a model tend to either believe it completely as the sole source of truth, or completely reject it. This is particularly the case within legal and/or adversarial processes. In realty, neither position is justified, and the 'truth' is often blurred.

Models are intended to mathematically represent our world, but due to our limited understanding of hydrological systems and our ability to represent them mathematically at a sufficiently detailed scale, simplifications and approximations are essential. As noted by Dudley Ward & Kaipio, (2014) '*mathematical modelling is a compromise between physical insight, good sense and practicality*'. And none more so than models of groundwater systems (which are largely unseen). While there are measures to define model soundness and ever-changing 'best practices', there are still many parts of a model that the modeller will have to decide how to represent. Thus, in practice, modelling is a balance of both science and art.

Some Experiences

For models that are used to inform policy (i.e. to decide rules that directly affect our lives), it is important that the model (and associated results) are both defendable and believable, particularly if they are to undergo public scrutiny. The following thoughts highlight a selection of opinions from the authors' experiences that may be helpful to those endeavouring on a modelling journey.

Develop the model to answer the question(s) at hand. Given the time and cost often invested in model development, it is commonly misunderstood that once a model has been developed, it can be used to answer ANY question in that catchment. However, this is not the case. A model must be built with a particular purpose (or purposes) in mind. Yes, models can be modified and redeveloped later to answer related questions, but this can only stretch so far before the model fails to adequately represent your question.

Develop the right science to provide foundations for your decisions. Careful, thought-out studies to test hypotheses are essential parts of any modelling study. And it is important that modelling is independent. Don't build a model (or 'cherry-pick' parts of a study) to support a pre-defined idea. It may be that model results are counter to the direction expected. Be prepared to change direction.

A sound modelling study is often a long-term investment. This should particularly be the case for publicly-funded studies that feed into plan changes and subsequent revisions. A good example is Tasman District Council (TDC)'s Waimea Plans model (Figure 1), which has been progressively developed over four decades. This long-term vision, with a clear management purpose, has enabled an ongoing cycle of model development that feeds into plan changes, targeted monitoring (to fill gaps and test effectiveness of the plan), subsequent model updates, and review of the plan limits. The cycle continues.

Collect plenty of sound data. This is the foundation of a robust model and requires a dedicated team with a long-term vision. Again, TDC's hydrology team do this very well (Figures 1 and 2, as examples).

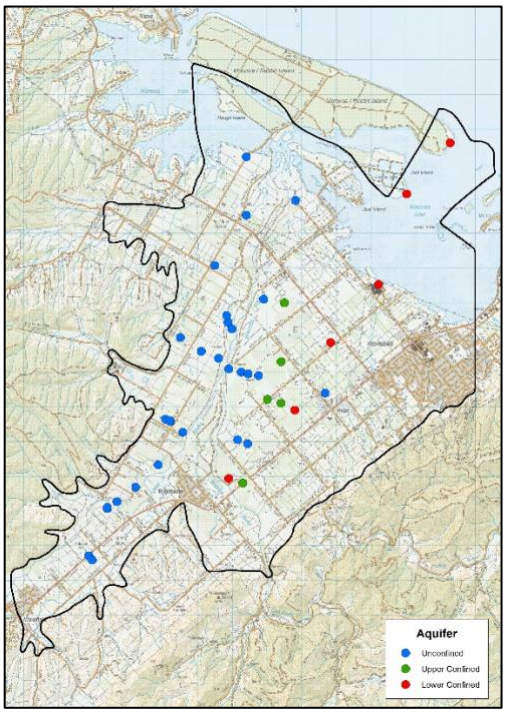

Figure 1: Coverage of monitoring bores, Waimea Plains

Not everything is known, therefore uncertainty exists. And this needs to be quantified (or at least accommodated) and communicated in a practical, honest and useful way.

Even with a sound uncertainty analysis, the results still need to be believable. Particularly so if buy-in is desired from other parties. A poorly-conceptualised model cannot hide for long behind uncertainty analyses.

Even well planned studies can go wrong. Prepare to change course when hurdles arise. Provide plenty of time to do so to prevent rushed development that poorly supports decision making. Ensure that the scenarios trialled are appropriate for the questions being asked of the model.

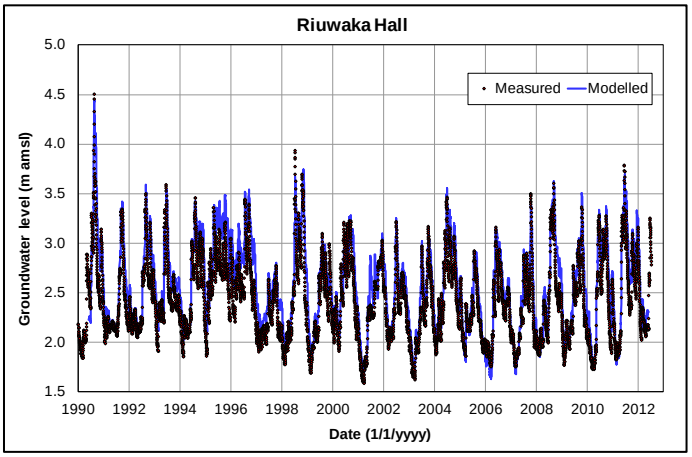

Figure 2: Groundwater level calibration, Motueka-Riuwaka Plains

Work with whatever funding structure is available. However, studies spanning multiple stages spread the funding load, and also enables re-evaluation of the study's direction after each stage. Publicly-funded programmes often require a commercial focus (to ensure the funds are used efficiently), but the best value for money is not necessarily delivered by the lowest tenderer.

Allow time for, and be open to, respected peer review. Independent review from an experienced and trusted peer is invaluable for advancing both the modelling study and the knowledge of the modelling team. This provides a degree of transparency to the results, and where experts agree, also helps decision makers.

Don't model by committee. This is the surest way to burn out your modeller. Yes, seek expert knowledge where essential, but every person will have a different expectation and opinion on what should or should not be done, pulling the modeller in every possible direction and achieving very little. Let the expert modeller make their decisions (with appropriate consultation) – it will be them who has to defend it.

A modeller needs to commit to the long haul. It's a marathon, not a sprint. Choose a modeller who is likely to stay committed and see the work through to completion. One who has been around for a while is likely to stay around for a while.

Uncertainty is a huge and very challenging part of modelling – both conceptually and practically – and even the most thorough interrogation of uncertainties has its limits. No decision should be made without consideration of uncertainty – whether or not it can be usefully quantified. But it is likely that no model of a complex system will give the degree of certainty that a decision-maker would like. It is therefore important to have reasonable expectations about what can be achieved and for the modeller to convey these.

It is important that modelling expectations are reasonable within a practical envelope of uncertainty. However, manged and executed well, a robust model is an invaluable tool for decision making.

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STATE OF ENVIRONMENT UPGRADE IN OTAGO - NORTH OTAGO VOLCANIC AQUIFER

Sam Yeo,[1]
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Background

As part of the Otago Regional Council (ORC) programme of regional upgrade of State of Environment (SoE) monitoring bores, the North Otago Volcanic Aquifer (NOVA) had 2 new bores installed in late 2022. The bores were drilled using sonic drilling methods which offered an excellent opportunity to better understand the volcaniclastic rock that hosts groundwater in this area. Additionally, GNS sampled one of the newly drilled NOVA bores for age tracers and isotopes as part of the nation-wide Te Whakaheke o Te Wai programme.

The NOVA is hosted within the lowland, coastal area south and west of Oamaru township in North Otago. It comprises the Waiareka-Deborah volcanic field, which are marine to sub-aerially deposited volcanics, intermittently active during the Eocene to Early Oligocene (Scott *et al.,* 2020). ORC has monitored groundwater in the NOVA since the mid 1980's (Websters well), however as part of ORC's SoE expansion there is a drive towards installing new, secure bores on publically-owned land and transition away from using private bore less suited to SoE monitoring.

The main groundwater use in the NOVA are for irrigation for farming activity, cropping and market gardening. Groundwater quality sampling in the NOVA shows elevated nitrate nitrogen, with values ranging between 24 – 29g/m^3 from 2009 to present.

Results

The drilling results show a variably consolidated calcareous tuff, lapilli tuff and lapillistone blocks/bombs (Figure 1). Some sections show marine interaction by way of shell fragments, whereas other sections show no apparent marine influence. The material appears visually to have low porosity however showed surprising yields on review of aquifer tests in the area achieving flow rates as high as 30L/s for a seemingly low permeability, consolidated volcanic material. The volcanics are vesicular in places with evidence of solution vugs that are likely creating macro-porosity and conduits for groundwater flow. ORC (2008) also recognises secondary porosity by way of later stage fracture flow.

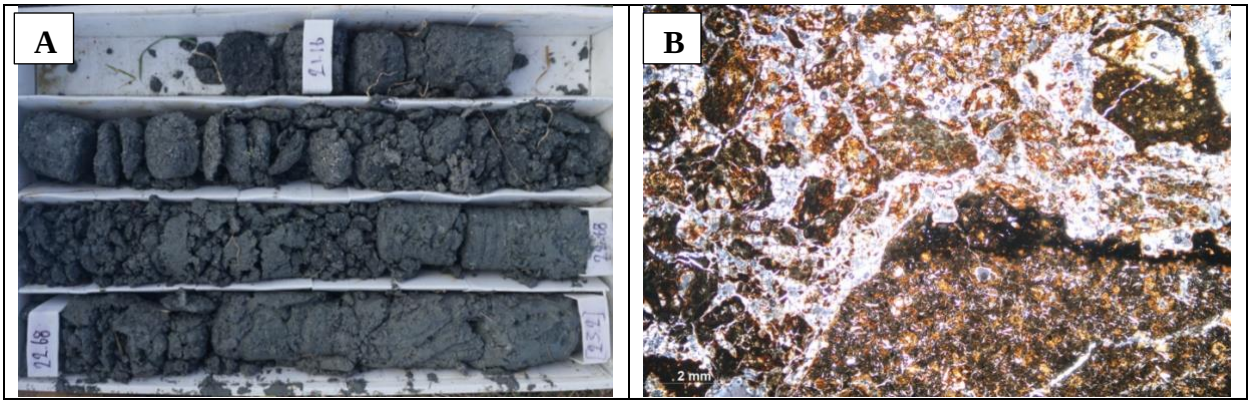

Figure 1: A: Lapillistone with blocks and bombs at 21.1m – 23.2m bgl. B: Thin section taken from 21.9m: Zeolite cemented with variable carbonate-clay infill, hosted within potential dyke fragments. No shell fragments or evidence of biological activity. Images from M. Brenna, Otago University

Preliminary results from the GNS sampling campaign in the NOVA well CC18/0110, indicate tritium concentrations are very low, near baseline, suggesting a mean residence time of >100 years. The long residence time of groundwater within this aquifer represents a challenge in terms of managing high N loads within this catchment area.

References

Scott, J.M., White, J. D. L., le Roux, P.J. 2020. Intraplate volcanism on the Zealandia Eocene-Early Oligocene continental shelf: the Waiareka-Deborah Volcanic Field, North Otago. Inew Zealand Journal of Geology and Geophysics. 63,4

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MONITOR AND MANAGE SURFACE WATER QUALITY FOR INFRASTRUCTURE CONSTRUCTION SITE

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Stantec Australia Pty Ltd (Stantec) was commissioned by a client to undertake quarterly monitoring and reporting of surface water quality of a stormwater channel located downstream of the client's worksite for infrastructure construction between 2021 and 2023. The objective of the monitoring works has been to evaluate whether construction activities have been impacting water quality in the stormwater channel downstream of the project footprint. A brief summary of the work undertaken by Stantec is provided as following:

- Monitoring works including:
    - One round of pre-construction baseline event.
    - Quarterly syn-construction monitoring that included dry- and wet-weather events.
- Potential issues identified:
    - Elevated nutrients were identified from an upstream location to the site discharge point of the stormwater channel based on visual observation of the excessive localised algal growth and lab results.
        - Action: source investigation was undertaken by Stantec to this issue with results that indicated an off-site source for the elevated nutrients identified.
    - Elevated pH was identified from the site discharge point of the stormwater channel based on on-site monitoring results and lab results.
        - Action:
            - Stantec undertook a source investigation upstream to this discharging point and identified two potential sources within the client worksite likely to have been contributing to this issue.
            - Based on the findings, Stantec made recommendations to mitigate the identified potential sources.
            - Stantec undertook validation testing to confirm the effectiveness of the mitigation works conducted by the client.
            - Stantec performed a trend analysis of the long-term pH monitoring results, which indicated that values of pH at the discharge point were reducing and anticipated to fall within the guideline range.