NZHS Technical Workshop

2024 Technical Workshop Abstracts

9th – 12th April 2024 – Queenstown

Managing Expectations: Quality, Quantity, Resources, Resilience

Tuesday 9th April

The role of hydrological data empowering environmental management & decisions.
Lee Boon (Pattle Delamore Partners Limited)

Have you ever wondered how your hydrological data is used? As consultants, we use the Council's hydrological data to inform a variety of projects that go further than just flow measurements and water levels. We use this data to understand and interact with our environment.

Projects are often part of large-scale consents or can help shape decisions in environment court. They influence not only the environment, but also the livelihoods of those in surrounding communities.

This presentation will demonstrate how PDP consultants have used your data, why it is vital for the data to be reliable and accurate, and how improving the quality of data has positive flow on effects for the environment.

PDP consultants have used your data to;

- Determine erosion capability of rivers when designing bridge supports in the Waitotara valley by using the long-term flow record for the Waitotara River to generate flood flow hydrographs.
- Be informed when water levels are low and monitor streams for dead and distressed fish for water take consents.
- Use "surrogate sites" to calculate relationships between catchments in the Karangahake Gorge when hydrological data is not available.

There are limitations to using external sources of hydrological data. We have little insight into what quality control practices are used and we can only assume that the data we receive is accurate. It is vital to have confidence in the quality of the data.

Improving the quality of the collected and reported data with increased clarity into how it was collected improves the accuracy of factors for our calculations, models, and designs. Having further insight in QA/QC practices also adds weight to the data, which is vital when decisions go to court or affects the environment and community. We can use this information to make accurate decisions when protecting and managing our water resources and preserve the health of our ecosystems, creating positive flow on effects on the environment.

Ensuring Monitoring Network Resilience – Opportunities Gained Through Communications Redundancies.
Kirstine Malloch (NIWA)

NIWA is undertaking a multi-year New Zealand-wide monitoring equipment upgrade project, driven in part by communication redundancies. Access to the low Earth orbit satellite system Globalstar, which terminated services at the end of 2023, alongside the upcoming cessation of 2G and 3G cellular network services in 2024 and 2025, will impact over 500 sites. The loss of these communication networks has been used as an opportunity to standardise equipment at sites to reduce installation time, minimise data downtime and future proof monitoring sites. The upgrades incorporate Unidata's 4G Neon remote data logger, wired onto a standardised backing panel that will be used at many NIWA sites throughout the country. These loggers incorporate 4 (8 or 16) analogue channels, Modbus and SDI-12, with data hosted by NIWA's Neon server allowing for remote diagnostics and the ability to set alarms and notifications. Sensors have been upgraded in conjunction with data loggers at many sites to ensure data are fit for purpose and comply with National Environmental Monitoring Standards (NEMS).

NIWA's field teams have incorporated installations alongside business-as-usual activities, dealing with various challenges including short time frames, access to difficult sites and demanding weather conditions. Globalstar replacement impacted over 70 sites in 2023, with teams upgrading all sites within a year, many of which involved helicopters to gain access. Sites were reviewed to assess alternative forms of communications available that ensured network reliability and robustness, with some sites reverting to cellular as telecommunications coverage is now more widespread at remote sites than when Globalstar was originally installed. For sites still requiring satellite, either the geostationary orbit Inmarsat BGAN network was selected if sites had visibility to the northwest, or an alternative low Earth orbit service, Iridium Certus network, was employed.

The logistical challenge ahead is the remaining sites that utilise data loggers that are not 4G capable. One (Vodafone) has announced that 3G services will be terminated at the end of August 2024, with 2G services ending December 2025; Spark has indicated its 3G services will be gone by end of 2025. Given the short timeframe and the number of sites impacted, a variety of strategies will be employed to ensure that sites will be 4G capable before redundant cellular services are terminated, while minimising site data downtime. Roll-out of the 4G upgrade project has commenced, with over 50 sites upgraded either as data logger replacements, site upgrades which include sensor upgrades or modem replacement.

Otago Regional Council's Lake Buoy Monitoring Network

Nick Boyens (Otago regional Council)

The Otago Region is home to over 7000 lakes of many sizes, types and conditions. Otago's lakes exist in a very diverse landscape that has lowland and coastal lakes right through to high alpine tarns and glacial lakes. Included in this are three lakes that sit in the top ten in terms of size and the top 6 in terms of depth. They are Lake Whakatipu (3rd at 291km^2, 4th at 420m deep), Lake Wanaka (4th at 192km^2, 6th at 311m deep), and Lake Hawea (9th at 291km^2, 5th at 420m deep). Many of our lakes are in pristine condition and it is very important to maintain that condition, especially for the large and deep lakes. Unfortunately, this is not the case for all Otago lakes as evidenced by what has happened in Lake Hayes (2.76km^2, 33m deep) which is currently in a poor state. The large deep glacial lakes Whakatipu, Wanaka and Hawea are important not just for the Otago Region, but for all of New Zealand and also many visitors from all over the world. It is critical that they are looked after and the first step in that process is understanding the current state and then being able to continuously monitor for change.

ORC have invested heavily in monitoring programmes targeted specifically at monitoring the state of the water quality in these lakes. This includes a monthly programme of water sampling and CDT sonde casts that has been running since 2016 and more recently investment in continuous monitoring using buoy mounted sensor arrays.
ORC currently has three water quality profiler buoys supplied by Limnotrack Ltd operating on Lakes Hayes, Whakatipu and Wanaka with plans for another for Lake Hawea. These buoys are the platform for a custom designed telemetered profiling sonde that is automatically winched through the water column and a climate station. Operating such sensitive equipment in the sometimes extreme environment of these large deep lakes is difficult. This presentation will discuss the process of designing and implementing the moorings, operating the buoys, issues encountered along the way and present some of the data collected to date.

Searching for Groundwater-Pacific Island Style.

Pete Mason (West Coast Regional Council)

Water resources available in small island developing states are vulnerable to climate extremes and population pressures. Pacific island countries have limited alternate options and only relatively small and finite water resources available to meet increasing water demands. Knowledge on how rivers, aquifers, groundwater and rainwater harvesting respond to increased demands and climate variability is crucial to ensuring sustainable and productive water resources.

From 2004 to 2006, 16 Groundwater investigation bore holes were drilled on the four inhabited islands of the Northern Cook Island Group, Penhryn, Manihiki, Rakahanga and PukaPuka.

This was part of an AusAid water resources programme to assess the potential of groundwater resources for non-potable domestic use, as a supplementary source to rainwater, and to recommend appropriate groundwater supply systems. Other purposes were to assess and recommend improvements to rainwater catchments and storages, and to recommend other water management improvements as appropriate.

The groundwater monitoring programme initiated after the completion of the drilling was to be carried on by local labour but only continued for a short time and eventually ceased for various reasons on all four islands.

This presentation will follow the footsteps of Pete Mason (NIWA) and Wilson Rani (Infrastructure Cook islands) as they take on an epic journey to return to the Northern Cook Island Group, ten years later, to locate, retest and pump out all 16 bore holes to get another complete set of data to compare with the original data, and assess the ongoing" health" of the bores.

The talk will explain the logistics of implementing such a drilling programme in one of the most isolated but most beautiful areas of the Pacific Ocean, how the groundwater bores are built to sample at different depths without contaminating the samples and equipment and sampling techniques used, "Pacific Island Style".

Also covered in the talk (time permitting) will be rain water harvesting data collection, GPS Survey for GIS mapping and automatic rain gauge installation, which were conducted concurrently with the groundwater monitoring programme.
Sounds full on, you bet it was!!

No prizes here for technical detail and data presentation, just a relaxing slideshow to enjoy a trip to a part of the world that time forgot.

Keynote Speaker: Amber S. Jones (USGS)

Amber is an expert on continuous data workflows for the USGS. Her work focuses on streamlining records processing, automated data screening, and data monitoring applications. Amber's background is in watershed hydrology, surface water quality, data science and machine learning, and hydroinformatics. Amber recently completed a PhD focused on data science applications for water including anomaly detection for aquatic sensor data, water data science instruction, and current developments in hydrologic information systems. Amber's degrees are in Civil and Environmental Engineering from Utah State University. Prior to working at the USGS, she was a research engineer at the Utah Water Research Lab. She has also worked as an environmental scientist and as a river guide. She is located in Logan, UT.

Automating Time Series Data Processing at the USGS: Current Approaches and Vision for the Future.

Amber S. Jones (USGS)

The USGS operates a large water data monitoring network and invests significant resources to ensure that data are of high quality and suitable for distribution, analysis, and decision making. Current workflows for processing data from collection to dissemination involve manual steps and significant time and effort from technicians. By incorporating automation in data processing workflows, the USGS aims to improve the value, quality, and consistency of data offerings. Furthermore, removing the burden of tedious steps allows technicians to focus on more complex issues and on robust data collection. In this talk, I will describe priorities and approaches for automating time series processing workflows for USGS data including anomaly detection, field-based correction, model estimation, fouling alerts, and reporting. The status of automation will be covered, including past investigations, current work, and future directions.

Data collaboration across domains and organisations
Paul Sheahan (KISTERS)

Councils collect data in support of many use cases, some internal and some external to the organisation. The use of data in these uses cases is by persons with a broad range of background skills from the public to experts in domains with an equally bread range of expectations.

This presentation will deep dive into current approaches for data collaboration across multiple science domains providing insight on how users of expert systems are able enable effect data sharing for public consumption, operations, expert analysis and reporting.

Bringing Data to Life.
Michael McDonald (Environment Southland)

A recent objective for Environment Southland is "bringing data to life" by enabling the community to view environmental data alongside (near) real-time imagery collected by onsite automated cameras. We now have the first set of sites operating in our region and the supporting systems in place to deliver images to the website. Being one of the later councils to install a live camera network, we were inspired by the groundwork of other organisations and incorporated other ideas from our existing image velocimetry cameras. These sites were then modified to work in with the Data to Life network. Recent events in New Zealand have further demonstrated the benefits of real-time media providing timely context to the data where it may not have otherwise been possible to collect.

Environment Southland has a number of continuous environmental data parameters that are available for members of the public to view and explore through our Environmental Data website (envdata.es.govt.nz). The data available includes air quality, groundwater level, rainfall, soil moisture and temperature, river water quality and hydrology (water level and flow). These parameters are available to view on graphs with the ability to adjust the time period. Hydrological statistics are also available to view for relevant sites.

Outside of context, tabled or graphed data probably does not mean a great deal to the average community member. Installing cameras at environmental monitoring provides an innovative opportunity to bring data to life for the community, where they can view the recorded data in a graph alongside a (near) real-time image. These sites provide the community with a more relatable understanding of what the river conditions look like in a practical sense and may inspire more interest in the environment.

It is not just the community that benefits. There are operational gains with a network of remote cameras across the region. This includes being able to remotely check gauge boards or capture live flow data with image velocimetry. This adds resilience to our network and allows management of staff deployment and minimizes staff exposure to risk. Other benefits are more resource focused like providing insight to weather conditions such as snow and rainfall or looking at historical events when archiving data.

As a part of this project, an internal webserver was created to provide a view of the entire region importing externally operated cameras and grouping relative sites together. The next stage in this project is adding further features over time to enhance the value that this imagery provides.

NEMS River Water Quality Field Regatta and Other Updates

Juliet Milne (Traverse Environmental Ltd)

Around five years ago, the National Environmental Monitoring Standards (NEMS) initiative broadened the scope of its river monitoring standards to include discrete water quality, and periphyton and macroinvertebrate sample collection and processing. At the request of the NEMS Steering Group, two field-based workshops (regatta) were held in November 2023 to support regional and unitary council monitoring staff with implementation of these standards. These workshops were held in Waikato and Canterbury, with in-kind support provided by science staff from Waikato Regional Council, Environmental Canterbury, Bay of Plenty Regional Council and NIWA.

The primary focus of the workshops was on demonstration and checks of field activities in accordance with the NEMS *Discrete Water Quality* (rivers), NEMS *Periphyton* and NEMS *Macroinvertebrates*. However, the scope was expanded to include continuous water temperature and dissolved oxygen monitoring, as well as fish and deposited fine sediment cover assessments to cover more components of council State of the Environment river monitoring programmes. Further, owing to the strong interest in the workshops but a need to limit numbers for logistical reasons, a series of on-line seminar-type sessions were delivered. Over 30 people attended each on-line session, with the periphyton monitoring session attracting the largest audience. A total of 28 and 18 people across 14 councils attended one or both days of the North Island and South Island workshops, respectively. A report has been prepared summarising the on-line sessions and workshops, as well as some additional details of council monitoring activities.

This presentation will summarise the workshop activities and provide updates on several NEMS matters, including proposed changes to the NEMS quality coding matrices and review of the NEMS *Water Temperature* and NEMS *Dissolved Oxygen.*

Homegrown Environmental Monitoring: AquaWatch's Journey to Scalable and Precise Real-Time Water Quality Monitoring.

James Muir (AquaWatch)

The world is looking for innovative solutions that enable continuous and real-time water quality monitoring. But what makes innovation useful? AquaWatch has spent the last seven years addressing this need, developing a cutting-edge monitoring device tailored for scalable deployment in the variety of waterbodies that we find in New Zealand, and therefore, globally. How do we make environmental water monitoring cheap, easy, and useful.

The development journey of our device has faced multiple challenges, electronics and water are not happy together. The work required to achieve effective waterproofing, optimise battery life, address market perceptions, and compete with legacy processes has been a long one. We've worked hard and want to share our journey from a farm in the Wairarapa to being deployed across three countries, and growing.

We want to ensure scalability and accuracy. To do that we've had to work through what accuracy means in the continuous data space. How do we note and log sensor drift? What do we test against to provide validation. Are grab samples actually that useful?

Our deployments in New Zealand have given us some fascinating, and at times challenging, insights into water quality dynamics. Through our continuous real time data collection, we have identified critical environmental trends and provided evidence of illegal contaminants in urban streams. These findings underscore the calls for a shift in how environmental data is collected, analysed, and utilised.

Our development of the world's first Water Quality Index based on multi-parameter continuous data allows us to contextualize our data. We will introduce this score, and the process we went through to build it with Ebi Hussain. By bringing in the pieces of the puzzle around the waterway, we transform raw data into stories of environmental stewardship, drawing fact-based links between outcomes, and activities that. Our approach shows how technological innovation can bridge the gap between scientific research and public engagement, allowing a more informed and proactive response to environmental challenges.

We want to contribute to the broader discourse on enhancing water quality monitoring through technological innovation. Our experiences in building a high-tech solution on a farm in New Zealand show the difficulty in the process, but also the potential of real-time, scalable, and accurate environmental monitoring systems in safeguarding our water resources.

Wednesday 10th April

An Introductory Overview to Hydrologic Information Systems for Aquatic Sensor Data
Amber S. Jones (USGS)

Hydrologic Information Systems (HIS) integrate hardware and software to support collection, management, and sharing of hydrologic observations data. HIS support the day-to-day data operations that are essential to organizations that monitor hydrologic systems. This talk will briefly trace the history of HIS development and describe key HIS components and functions. Examples of current and emerging HIS will be used to illustrate how contemporary challenges for HIS are being tackled and what challenges persist. Opportunities remain for coordinated community efforts to address outstanding barriers, advance HIS, and further enable hydrologic science.

Machine Learning and AI Speed up Data Validation for Quality Assurance
Sean Quereshi (Aquatic Informatics)

Water Scarcity is a serious threat to the health, development, and security of billions of people around the world. According to the United Nations, water use has grown at more than twice the rate of population increase in the last century, and by 2025, an estimated 1.8 billion people will live in areas plagued by water scarcity.

To prevent the global water crisis from spiraling out of control, there is an urgent need for international cooperation and innovation in water management and conservation. Data is essential for monitoring water availability and quality, identifying risks and opportunities, informing policies and practices, and ensuring accountability and transparency among stakeholders.

To organize the world's water information for faster, better decision-making requires accurate quality data. New advancements in data validation using artificial intelligence (AI) and machine learning (ML) are helping to speed up the review and correction of time series data for water managers.

Addressing inconsistencies
Corrections of data can vary based on who is reviewing the information, even when an organization has standards in place, it can still be a matter of subjectivity. This is compounded by the fact that the amount of data is rapidly growing as sensor technology is affordable, accessible, and easy to deploy, and monitoring of systems is expanding. This can result in massive backlogs of data to review, and with limited staff, the process can be rushed and steps for quality assurance missed.

New tools for quicker review of time series data
Using a cloud toolbox to connect to a time-series database, users can select locations and data sets for review and receive recommendations for data corrections. In the initial setup existing

data sets are scanned and the software will use that information to recommend a set of validation rules for each of those data sets. These rules are informed by previous data corrections that have been made by staff as well as validation algorithms. And so, machine learning begins.

Once the recommended rules are set up, users can review the rules, accept them as is, or modify them based on circumstances, perhaps specific to a location. Users can choose what action to take when the conditions for one of those rules are met. For example, if you have a threshold value and you want to see data that is above or below a threshold deleted, you can then set up automatic actions to take. You can also set up rules to not have an automatic action, but instead just alert staff to review that data and make a manual correction to something that may be anomalous.

To help improve the overall ability of data managers to detect anomalous data, a rate of change rule can be applied. If there are rapid changes in a time series values, operators can receive an alert to determine whether something needs to be done at the site or if data needs to be corrected. There are also tools for flatline detection, which can help indicate if a sensor may be offline. Seasonal parameters can be applied at specific times of the year to accommodate variations in supply and demand.

The goal of AI and machine learning in data validation is towards automation so that machines do the routine work and staff focus on decision making. Managers can configure a correction as a suggestion by the machine, in which case it would need to be approved. Or if that suggestion has been successfully approved several times, the managers may decide to let the machine just do it automatically. So, while automation is key to streamlining data validation, data managers can gain confidence in the result before they make the switch from human oversight to automation.

Cloud computing services use a combination of statistical and machine-learning approaches for data validation. Over time, the system will learn what sort of rules may need to be applied or what sort of corrections are being made and may recommend those corrections more frequently in the future. The combination of AI and machine learning is helping to propel water organizations to address the backlog of data to clear for quality assurance. With quality data and the capability of analytics, organizations and policymakers can turn back time on the global water crisis.

National QA framework for community-based monitoring (CBM)

Juliet Milne (Traverse Environmental Ltd)

Through Envirolink Tool funding a national QA framework has been developed to support catchment and community groups to collect fit for purpose stream monitoring data. The framework incorporates 28 indicators across water quality, water quantity, aquatic ecology and stream habitat. This presentation will provide an overview of the framework which includes guidance for CBM support organisations, a Monitoring and Quality Plan template, and electronic Survey123 field forms to facilitate efficient and standardised data collection and exchange.

Interactive Session:
A Python Package for Automating Aquatic Data QA/QC
Amber S. Jones (USGS)

pyhydroqc is a Python package designed for automating QA/QC for aquatic sensor time series data. Functions include rules based algorithms for pre-processing coupled with data-driven regression approaches for detecting anomalies and suggesting replacement values. The techniques were developed and tested on several years of data from multiple aquatic parameters monitored at sites in the Logan River Observatory in northern Utah, USA. Performance was assessed based on labels and corrections applied by trained technicians. The package can be used in any Python environment and applied to other datasets of interest. This session will introduce the package and offer an interactive demonstration using pyhydroqc functions to identify anomalies in water quality time series data.

Participants should have a laptop connected to the internet - watch for additional instructions before the workshop.

How to ~~lower~~ manage expectations and meet annual data targets
Shontelle Milne (Environment Canterbury)

- How do people (internal and external) access our data?
    - Can one method rule them all or do we need a billion ways?
- Is it our responsibility to ensure understanding?
- Can we easily show that we meet our level of service for data quality?
    - Something more scientific than just a simple, "Yes, I promise we did what we said we would, most of the time".
- Current tools and tools for the future.
    - Do all environmental techs/analysts/scientists need to also be statisticians, coders and graphic designers?

What is happening with my data?
Darren Gerretzen & Jas Robb (NIWA)

Methods of data visualisation for presentation to clients, daily telemetry checks, work planning and fault finding.

Groundwater Quality Metadata
Jennifer Tregurtha (Environment Canterbury)

When we have over 200,000 samples in our database, how do we keep track of the purpose each sample was collected for? How can we easily extract the data for our quarterly monitoring wells? What about our annual monitoring wells? These are all questions that the Environment Canterbury groundwater science team has grappled with over the past couple of years. This will be a discussion about the solutions we came up with, how we have implemented them, and the challenges we've faced along the way.

Thursday 11th April

Keynote Speaker: Jono Conway (NIWA)

Jono is a Hydrological Forecasting Scientist at NIWA specialising in snow, mountain climate and flooding. https://niwa.co.nz/people/jono-conway. He leads the curation of snow data from NIWA's Snow and Ice Network https://niwa.co.nz/freshwater-and-estuaries/research-projects/snow-and-ice-network as well leading a new MBIE Endeavour Smart Ideas funded project to develop and national scale snowmelt forecast.

Progress towards quantifying New Zealand's seasonal snow.

Understanding the current and future variability in New Zealand's seasonal snowpack requires a combination of quality observations, modelling and remote sensing. This talk covers progress across a range of initiatives being undertaken by NIWA to improve our ability to detect and predict changes in snowpack including: i) automated measurement of snow variables (snow depth, snow water equivalent, solid precipitation and albedo) at high-elevation Snow and Ice Network (SIN) sites; ii) the use of satellite observations to calculate snow cover duration and snow depth; iii) empirical and physics-based modelling of snowpack conditions at point and catchment scales.

Access Granted: Stepping up our rivers.
Sam Gibbens (West Coast Regional Council)

An issue that underpins our entire industry, is the collection of reliable data. Sometimes, that is a more challenging task than it needs to be. We install and maintain orifice lines, radar brackets, cableways, stilling wells, and staff gauges, presenting building, and civil engineering challenges in remote locations with unique topography.

In terms of site selection, the best option regarding the hydraulics of a particular reach might not also be the site with good communication options, or might be on an eroding riverbank, or be in a nice stable bottomed gorge but with steep, inaccessible and fragmented rocky sides.

Decisions then must be made, to invest in the infrastructure to keep the site running, or to cut our losses and start a new site nearby in the catchment.

We need solutions in which the longevity of the site is foremost as long data records are the most valuable data records. We value stationarity but finding it on an alluvial floodplain within a dynamic river system is easier said than done.

Additionally, our sites since 2015 are afforded the same 'workplace' classification as the desktops and office spaces in the eyes of the Health and Safety Act 2015. If we visit a site regularly, it needs to have the same levels of risk assessment, and hazard mitigation applied. Setting expectations of the managers can be tricky, while they balance the output and value added from staff while doing things correctly and safely within budget.

We still need to find ways as an industry, in 2024 to establish new sites in these areas, and maintain the upkeep of the pre-existing sites in areas that naturally undergo dynamic change and the general wear and tear by exposure to the environment. Part of that longevity and resilience of our sites is to be assessed in a way that highlights the routine and often taken for granted way that safe access can be assured during inspections.

As with many councils, WCRC has inherited several sites over time, with the nature of the site, and technology used to monitor it differing from the original construction. An Aquatel 2 is now an iRIS270, an encoder in a stilling well is now a Vega Radar with SDI-12. Once, physical repairs that might have been easy with a bit of kiwi ingenuity, stand now behind a veritable iron wall of paperwork, protocol, and expense.

Sites deserve a look into what can be done to make things better, so that what is the status quo doesn't become a status woe.

In my talk, I explore the solutions WCRC have found to these challenges with the upgrades we accomplished recently in our different geological areas of the West Coast.

What we have learnt, what is to come, and what still needs inspiration.

Stereoscopic camera station development and installation.

Evan Baddock (NIWA)

NIWA was successful in obtaining a WMO Innovation project to developed stereoscopic camera stations for flood flow measurement. These stereoscopic camera stations are highly innovative, since they can be deployed without needing ground control points, and can be triggered from timelapse, water level (stage), or manually by local residents (citizen science). As promised, three stereoscopic camera stations were delivered to Fiji, with two installed in the headwaters of the RakiRaki catchment (Vatukacevaceva and Narara) at sites with water level recorders but no high flow measurements (very difficult to obtain).

The development of stage-discharge rating curves at these sites is important for the development of flood warnings for the downstream residents in RakiRaki where flooding is an ongoing problem. This means that these stereoscopic camera stations can be used to capture flood events and generate stage-discharge relationships for many catchments and river sites throughout Fiji as they can be easily moved and established where needed.

This presentation will look at the idea behind this, how the installations went and the results to date.

Old Dogs and New Tricks. STIV & Slope Area meet head on at the mighty Orikaka River in the Buller Gorge.

Reuben Stuart and Pete Mason (West Coast Regional Council)

The Orikaka River in the Buller Catchment typifies the rugged and uncompromising landscape of many West Coast rivers and presents unique challenges for hydrometric monitoring. Site access is uncomfortable on a good day and impossible on a bad one. Gaugings can only be done at low to average flow and higher and flood flows are almost impossible to measure.

To make matters worse, the nature of the catchment makes for some staggering rates of rise and fall, as much as 1m rise in 15 minutes. Combining this with the 3 hr drive time from base to site, makes targeted gaugings using our ADCP hardware difficult at best. No bridges, no cableways, no wires and no helicopter access leave us few choices.

Hence the challenge to extend our rating curve to represent reliable data for our Buller Gorge Flood Modelers, as the Orikaka is a valuable indicator for a significant part of the lower Buller catchment.

However, with a combination of both Slope Area from the "Old Dog" Pete Mason and STIV from the" New Tricks Kid" Reuben Stuart, we hope to accurately nail the top end of the rating curve using both techniques.

Pete will take charge in explaining how we set up and surveyed the selected reach, assessed bed material and calculated the discharge using the method described in his coauthored book with Murray Hicks, "Roughness Characteristics of New Zealand Rivers".

The "Young Gun" Reuben will take back the reigns and set about describing the steps required to calculate the discharge using the very latest STIV technology at the same reach. Setup for STIV Gaugings has included the installation of and surveying in of new benchmarks, clearing vegetation for a stationary camera location and scouting drone locations.

The combination of these old and new non-contact methods will allow our field team to record a wide range of flows to satisfy the Buller Modelers. As for whether it's the Old Dog or the New Kid who comes out to take first prize, you'll just have to wait and see.

Guidance on using automated anomaly detection for high-frequency water quality data: A collaborative approach.

David Wood, Jade Arnold, Lucy McKergrow and Alex Vincent (NIWA)

Automated anomaly detection (AAD) is a critical step in ensuring high-quality data for water quality monitoring. We will provide guidance on using existing scripts and tools for automated anomaly detection for the High-Frequency Water Quality Monitoring Guidance Envirolink Tool project. In this paper, we present our approach, which involves workshops with case studies.

The first workshop, in December 2023, brought together 11 members of the AAD Workgroup to gather knowledge and scope the case studies. We discussed the ideal characteristics of AAD tools, evaluating tools, elements of the guidance document, and the case studies. The workshop was preceded by an online survey to identify the tools used and datasets available for case studies and explore what users are looking for in a tool. The survey revealed that the most commonly used tools were QARTOD, Pyhydroqc, and Oddwater, and the overall impression was positive, but there is room for further development of these tools.

The workgroup consensus was that an ideal AAD would be easy to set up, open source, accurate, and able to detect or flag anomalous results. The participants also identified some weaknesses of current tools, including difficulties in setting them up, requiring the tuning or training of models, and their lack of automation. There are also barriers to the uptake of AAD tools, including the challenges in governance and maintenance of tools, lack of high-quality data to train tools, a wide variety of sensors and data sources, and the need to train and combine diverse skill sets to maximise AAD tools in data workflows.

The first case study will explore how well three publicly available open-source tools (Pyhydroqc, Oddwater, and QARTOD) can identify data anomalies. The exploration will begin using a pH, temperature, conductivity, and dissolved oxygen dataset from the Logan River Observatory (Utah, US). A second round of testing will use New Zealand dissolved oxygen datasets. The findings of the first case study will be presented to the workgroup, and with guidance from the project Advisory Group, the second case study will be defined.

Information from the workshops, case studies, and literature will be incorporated into the guidance for delivery in May 2025. The guidance document will provide practitioners with a clear understanding of the advantages and limitations of existing tools and the principles underpinning AAD. It will also guide the effective implementation of AAD and address the challenges that arise during implementation.

Harnessing Data for Water Resource Management: The Otago Regional Council's Innovative Approach.

Nicole Nally (Aquatic Informatics) and Susan Wells (Otago Regional Council)

The Otago Regional Council (ORC) in New Zealand has pioneered a transformative approach to managing its diverse and extensive water resources by implementing a new environmental data portal. This initiative aligns with the themes of Managing Expectations, Quality, Quantity, Resources, and Resilience, crucial for sustainable water management in a region characterized by its varied hydrology.

Otago, encompassing alpine lakes, rivers, and wetlands, faces unique challenges due to its large water volumes and contrasting climatic conditions. The ORC's mandate to sustainably manage freshwater resources is critical, especially considering the region's high rainfall variability and the Clutha River's significant water carriage.

In collaboration with Aquatic Informatics, the ORC developed a user-friendly portal that consolidates data from over 250 water monitoring sites. This system replaces outdated flood and low-flow warning sites, integrating water quality parameters like E-Coli and providing access to historical data, some spanning 80 years. This advancement improves accessibility for a wide range of stakeholders, including farmers, scientists, and policymakers.

The portal's design facilitates efficient management of approximately 1,600 water use consents and 500 discharge consents, addressing individualized area constraints, seasonal variabilities, and contaminant levels. The ORC's environmental data management platform enhances real-time data acquisition, processing, and publication, bolstering regulatory compliance and decision-making.

This presentation underscores the ORC's commitment to leveraging technology for environmental stewardship, ensuring resilience in water quality and availability amidst changing conditions. The portal exemplifies a strategic blend of quality data management and resource optimization, setting a precedent for regional councils globally.

Abstract Evaluating surrogate technologies for river suspended sediment load monitoring.
Andrew Willsman and Arman Haddadchi (NIWA)

NIWA was commissioned by MBIE through the Envirolink scheme to provide guidance on the selection of appropriate surrogate monitoring technologies for robust measurement of the suspended sediment load to support freshwater and coastal management. This talk describes the results from using several technologies that provide surrogate estimates of suspended sediment concentration. This instrumentation was deployed at four representative New Zealand rivers. The surrogate technologies tested in this study include:

- a range of point based optical turbidity instruments, as well as
- point and profiling acoustic back-scatter instruments.

ADCPs and tow tanks – They don't mix.
Mic Clayton (Cooma, Australia)

Have you heard the title (or a variation on it) expressed in the professional circles?

So how do you undertake a logical, and consistent validation or assessment of the performance of the data being generated by your ADCP?

An approach to assessing the performance or validity of an ADCP's calculated measurement reliability could be as described in the Australian National Industry guideline for Hydrometric Monitoring (NI GL 100.08–2019) or NEMs equivalent:

ADCPs should be periodically tested to ensure the validity of the data recorded. These tests may include operating the instrument at a site with a known and stable stage-discharge relationship such as below a control weir and/or conducting comparison measurements between multiple ADCP meters at the same time and location.

In practice though this approach <u>isn't ensuring the validity of the data recorded</u>. It is basically validating a whole process that generates a final discharge output that relies on:

- speed of sound through water to measure velocities and depth (algorithms).
- temperature of the water - to correct the speed of sound through water.
- proprietary algorithms and processing decisions inside equipment to start turning this data into 'velocity results' and depth area computations to get a discharge.
- Oh and don't forget human decisions during deployment and post processing!

Reviewing some of the literature that surrounds the title of this abstract indicates a leaning towards an era when moving boat deployment was the primary deployment for an ADCP stream discharge measurement at a gauging station. This presentation suggests that the stationary mode of an ADCP, if an available option, can provide some sort of acceptable performance validation in a tow tank environment. (and to be honest – Alec Dempster's tow tank presentation in 2021 inspired me to explore the concepts and subsequent trials in this presentation as well!).

It is proposed some level of being able to assess ADCP performance can be achieved in an appropriate tow tank situation, by assessing performance of the depth measurement and the velocity of the ADCP moving through the tank as a surrogate for water flowing past the ADCP as in a flowing stream.

Three separate ADCP performance 'validation' trials were undertaken at the Kisters Velocity Tank facility (Liverpool, New South Wales), over three separate dates, encompassing:

- an initial technical feasibility test out (how are we actually going to do this/will it work?).
- two ADCP assessments with two different ADCP's using lessons learnt from the initial technical feasibility test.

The ADCPs were deployed in:

- moving boat mode – to assess the ability of the tank to effectively reflect the 'bed' surface effectively for bottom tracking measurement, and

- in stationary mode – to assess the ability to 'measure' the relative speed of water past the ADCP head,

with data being assessed using QRevMS to visualise the various depth and velocity performances of the ADCP outputs.

The results from these trials indicate that there is potential for tow tanks to be a potential tool for at least validating some aspects of ADCP data outputs.

Keynote Speaker: Amber S. Jones (USGS)

Amber is an expert on continuous data workflows for the USGS. Her work focuses on streamlining records processing, automated data screening, and data monitoring applications. Amber's background is in watershed hydrology, surface water quality, data science and machine learning, and hydroinformatics. Amber recently completed a PhD focused on data science applications for water including anomaly detection for aquatic sensor data, water data science instruction, and current developments in hydrologic information systems. Amber's degrees are in Civil and Environmental Engineering from Utah State University. Prior to working at the USGS, she was a research engineer at the Utah Water Research Lab. She has also worked as an environmental scientist and as a river guide. She is located in Logan, UT.

Advancements in Automating Aquatic Time Series QA/QC: Research and Applications.
Amber S. Jones (USGS)

Sensors deployed to aquatic environments commonly include data artifacts caused by fouling from adverse ambient conditions, instrument drift and calibration shifts, and erroneous readings related to power, datalogging, or transmission issues. These values are unrepresentative of the targeted environmental phenomena and impact data reliability and usability. High frequency sensor data require robust processes and techniques to support quality assurance and quality control (QAQC). Manual review may be time consuming and subjective, and software based workflows and data driven techniques can improve efficiency and reproducibility by automating anomaly detection, data correction, and estimation. This talk will address some current research approaches and challenges for automating QAQC, including algorithm options, selection, and performance; testing and training data; and data labelling. It will also cover the status of automating QAQC at the USGS including past investigations, current work, and future directions.

Increasing efficiencies and quality of river flow gaugings using autonomous boats.
Michael Rogers (Marlborough District Council)

River flow gaugings are becoming an ever-increasing important part of hydrology as the understanding of water resources, flood forecasting, managing water supplies, and the overall health of river ecosystems comes under greater scrutiny from end users.

River flow gaugings often require multiple people to operate software and the vessel in which the acoustic doppler current profiler (ADCP) is mounted to, requiring more man-hours on the river. The introduction of autonomous vessels has helped to reduce this time on the river by having the boat find its way to river edges/stations, whilst one operator controls the ADCP software. In times when users want more data, having only one operator means more gaugings can be carried out, increasing the accuracy of ratings to our end users.

Marlborough District Council has purchased two of these autonomous vessels from Surfbee Marine Robots in two different sizes to adapt to different flow scenarios. The Flowseeker, the larger of the two vessels can be deployed in velocities up to 4 m/s enabling high flow gaugings without the need of being in contact with the water. The smaller flowfinder uses the Sontek RS5 ADCP to carry out low flow gaugings up to 1.8 m/s where wader gaugings and taglines are not safe or practical to set up. Using RTK software, the Surfbees are able to navigate rivers with ease. They travel the same path, at the same speed, to the same point on every transect reducing the errors of edge measurement and missing data from vessels moving too fast, particularly in more turbulent conditions. It has not only been easy to gauge with these vessels, but they are also light and compact to transport meaning that they can be deflated and transported via helicopter to remote sites for gaugings.

Overall, autonomous methods offer significant potential for increasing the efficiencies of river flow gaugings. They can save time, reduce costs, improve accuracy, increase safety, and provide real-time data for better decision-making. As technology continues to advance, we can expect to see further integration of autonomous methods in river monitoring and management.

Comparison of high frequency nitrate sensors and consequences for data quality.

Alex Vincent (NIWA), Lucy McKergow (NIWA), Stephan Heubeck (NIWA & BPO) & Chris Eager (NIWA & Waikato Regional Council)

In-situ nitrate sensors measure the attenuation of light of specific wavelength as a beam passes through the water – attenuation is proportional to nitrate-N concentration (i.e., measured absorbance will increase). However, light of the target wavelength may also be absorbed by organic material, and/or be scattered by suspended particles. To overcome the influence of these interferences on measurement of nitrate-N, sensor manufacturers utilise on-board algorithms, which account for these interferences to differentiate the nitrate signal from matrix interferences and noise. The algorithms used by manufacturers vary, determined largely by the sophistication of the optical system and on-board data analysis. We tested four commercially available in-situ spectrophotometric sensors (YSI EXO NitraLED, s::can spectrolyser v2, TriOS OPUS and NICO) under laboratory conditions. Test waters spiked with varying amounts of KNO_3 were pumped through flow cells at 20 °C, and mean sensor nitrate values were compared to those measured in discrete samples analysed using conventional methods (APHA 4500, 150 samples). Sensor range, accuracy and linearity were evaluated over a wide concentration range (0-20 mg N/L, >15 test points) using three low nitrate, high visual clarity matrices – ultra-pure deionised water, Lake Taupō water, and Hamilton City potable water. Matrix interference tests were run by adding river silt, kaolinite, or humic-coloured river water to potable water spiked at three concentrations of nitrate-N. All sensors performed well within their stated ranges in high visual clarity waters, with strong linearity and high accuracy. Several sensors were also accurate beyond their stated ranges in the high visual clarity waters. Sensor responses to matrix interferences were varied and within the ranges tested, many sensor algorithms could not accurately calculate nitrate. Despite these measurement difficulties, some of the sensors continued to output numeric values, while others provided metadata that clearly indicated that out-of-range conditions existed ("NaN", and/or a measurement quality code). Our results demonstrate that no "ideal" nitrate sensor exists. Sensor selection should consider: (1) evidence of sensor performance in "real" water conditions, across the required concentration range, (2) the potential for periodic or frequent data loss due to matrix interferences, and (3) metadata requirements.

Managing expectations – A case study comparing two remote flood warning flow monitoring sites in the Bay of Plenty.

Brent Hutchby (Bay of Plenty Regional Council)

Creating reliable and accurate discharge time series in remote flood prone monitoring sites can be challenging. Meeting expectations of data quality often depends on factors outside of your control despite technology and tools for data acquisition in our filed of hydrology having improved significantly over the previous decade or so. This presentation will compare two different flow monitoring sites similar in nature with stable bedrock banks and mobile gravel beds. Both sites utilise ADCP and STIV measurements and Aquarius rating tool development, but with varying success. This success, or lack of, raises questions as to the reliability and accuracy of when to use potentially problematic flow measurements. Is it better to use a suspect measurement over no measurement? Or is it better to use no measurement with theoretical hydrological equations over a potentially suspect measurement?

High frequency visual clarity sensing – low range turbidity sensor tests.

Lucy McKergow (NIWA), Alex Vincent (NIWA), Arman Haddadchi (NIWA), Hamish Carrad (Environment Canterbury), Andrew Hughes (NIWA), Valerio Montemezzani (NIWA)

Visual clarity is a measure of light attenuation due to absorption and scattering by dissolved and suspended particulate material in the water column. Visual clarity is important for ecosystem health (e.g., affecting sighted aquatic animals: predator-prey interactions and other behaviour) and human recreational user safety (e.g., submerged hazards) and aesthetics. Discrete (and infrequent) measurements of visual clarity can be taken (using a black disc, transparency tube or discrete samples analysed for beam attenuation) for status & trend assessment. However, these discrete visual clarity observations are insufficient to support now- or fore-casting of visual clarity and cannot reveal the temporal variability of visual clarity. A beam transmissometer can be used to measure the beam attenuation coefficient (beam-c), which can then be converted to visual clarity with high accuracy (using an established empirical relationship). However, beam transmissometers are challenging to operate *in-situ* and continuously because of high sensitivity to fouling, turbulence and range limits. Turbidity is a useful surrogate for visual clarity, but careful sensor selection is required.

We tested commercially available field turbidity sensors (Hach Solitax, In-situ AquaTroll, Observator Analite, Phathom, Ponsel, Seapoint, WetLabs ECO FLNTU, YSI EXO) under laboratory conditions. Prior to the tests all sensors were validated (or calibrated where required) in a serially diluted formazin suspension.

Test waters were spiked with varying amounts of suspended material and compared to visual clarity measured in the laboratory with a beam transmissometer (WetLabs C-Star). Sensor performance was evaluated at 13 test steps across a visual clarity range from around 3 m to 0.02 m. The test suspensions were river silt (Uawa River <63 µm and <10 µm), kaolinite, and cultured algae (dominated by the green algae *Desmodesmus* and flagellates).

Field sensors were tested in a 170 L recirculation tank at NIWA Hamilton. For the sediment tests we conducted additions; starting with degassed Hamilton tap water and adding a known sediment mass at each test step. For the algal suspension we conducted a dilution test; diluting the initial algal suspension at each step with degassed Hamilton tap water. At each test step at least 5 sensor values were recorded, and samples were collected from the sample port on the tank for beam-c analysis. Particle size analysis was conducted on the lowest visual clarity sample for each test suspension and microscopic analysis of the algal suspension was undertaken.

Our findings demonstrate the sensor selection challenges facing users wanting to use low range turbidity measurement to convert to high frequency visual clarity. Turbidity sensors require high sensitivity across a low turbidity range (nominally 1-10 FNU) to be fully useful as a surrogate for visual clarity. Several of the tested turbidity sensors do not have the sensitivity required across the visual clarity range 0.02 to 3.5 m, while some others can only be used for part of this range. We will provide guidance on sensor selection for high frequency visual clarity monitoring.

Application of index velocity method in complex flow conditions.

Daniel Wagenaar, Thomas King & Tim Hawgood (Xylem Water Solutions)

The collection of accurate and reliable flow records in open channel flow is dependent on several factors of which a stable stage-discharge relationship is crucial. Flow monitoring site and hydraulic conditions that can impact a stable stage-discharge relationship comprises of unstable section control, sediment transport, debris, vegetation, off-channel storage, variable backwater effects and unsteady flow conditions. Variable backwater, off-channel storage and unsteady flow conditions are all hydraulic conditions that can have a significant impact on stage-discharge relationship and accurate flow calculations. Flood-wave movement, operation of irrigation canals, tidal effects, stream junctions and flood control measures are some examples of both variable backwater and unsteady flow conditions.

There are number of established methods in defining a stage-discharge rating curve effected by variable backwater, off-channel storage, and unsteady flow conditions. The methods consist of direct measurements, analytical investigation using simplified approaches, modeling using physical-based approaches, index-velocity method and continuous slope are method. This technical note focuses on the application of the index velocity technique using a bank mounted acoustic doppler velocity meter, SonTek SL1500-3G instrument.

Index velocity method

Calculating flow using the index velocity method is different from the traditional stage-discharge rating curve. Index Velocity method consists of two ratings, the index velocity rating and stage-area rating with the output from each rating multiplied to calculate a flow. The index velocity rating is a relationship between the mean-channel velocity and streamwise velocity measured by the SL1500-3G instrument. The stage-area rating is calculated from the cross-section survey of the reference cross section used for the index velocity.

Study case

The flow monitoring site is situated in a stormwater drain (tributary) for the monitoring of total runoff in the upstream catchment. The tributary discharges into the mainstem of the catchment approximately 1.5km downstream of the flow monitoring site.

The site and hydraulic conditions that will affect the development of a traditional stage-discharge relationship at the flow monitoring site consists of variable backwater from the mainstem, off-channel storage on the left bank, backwater due to bridge deck and vegetation.

The proximity of flow monitoring site in relation to the mainstem of the catchment makes it very sensitive to any flow events that may occur in the mainstem. This sensitivity impacts the accuracy of stage-discharge relationship significantly over the entire stage range especially for traditional stage-discharge rating. The flow hydrograph comparison in Figure 1 shows that the traditional stage-discharge rating overestimates the total flow significantly especially during periods of zero velocity when the backwater effects from the mainstem is most significant.

More than Measurement: Balancing Expectations, Data Demands, and Resilience.
Panel Session Facilitated by Joe Gendall (Watercare)

Panel members:

- Rob Davies-Colley (NIWA)
- Emma Chibnall (Marlborough District Council)
- Steph Bowis (Tasman District Council)
- Phil Downes (Environment Canterbury)

This year's theme really lends itself to a discussion approach of some kind - it can be difficult for any one person to get up in front of a crowd and talk about the problems they face on topics like resourcing, stakeholder expectations and resilience. The aim of this session is to unify the group over what problems we share across the country, and what issues we might not. By bringing four well experienced panellists from a variety of backgrounds together, we hope to create a relaxed forum where we can share pain points, innovations, and possible solutions. There will be four to five pre-arranged questions to guide the conversation, and questions/comments from the audience are encouraged. A web-based application may be utilised to help engage the audience. The pre-arranged questions will be finalised by the panel prior to the session, as a starting point, below are some examples of topics:

- Managing Expectations:
  - How do we effectively communicate with stakeholders to align expectations with reality?
  - Experiences managing/meeting conflicting expectations?

- Data:
  - With increasing demands for larger datasets how do we balance the need for quantity without compromising on quality?
  - Is the demand for larger datasets really justified?

- Resourcing:
  - How do we cope with resource limitations whether budget constraints or reduced/insufficient workforce?

- Resilience:
  - Share an experience where resilience was crucial to overcoming a setback in hydrological field work?
  - What practices or mindset do you instil in your team to enhance resilience during challenging times?

- Technological Innovation/Advancement:
  - How have recent technological advancements influenced the way hydrological data is collected, and what challenges have arisen from adopting new technologies?

Friday 12th April

Keynote Speaker: Rob Davies-Colley (NIWA)

Rob is a Principal Scientist (Water Quality) at NIWA-Hamilton. He has worked for NIWA and its predecessors (DSIR; MWD Water & Soil) for 47 years, broadly in water quality and related fields (e.g., riparian management, river suspended sediment). He has published 140 journal articles on diverse waters ranging from wastewater ponds to the deep ocean. His research specialities include optical water quality and the behaviour of light in waters, microbial water quality, water quality monitoring and QA, and stream shading. Recent work has focussed on 'sediment-related water quality' including swimming suitability of rivers and receiving waters. Retirement looms for Rob – who hopes to exchange computer work for (more) kayak and cycle touring, snorkelling, and tramping later this year.

Mutual benefits from integrating river sediment and water quality monitoring.

Sediment monitoring (NEMS 2020) usually involves high-frequency proxy instruments (discharge, turbidity, sometimes also acoustic signals), and automatic sampling over events for laboratory tests (SPM concentration; sediment properties). Water quality survey (for a wide range of variables) typically includes: (1) routine (usually monthly) visits for on-site measurements and sampling for laboratory analysis, (2) automatic sampling to better characterise high-flow events (and estimate loads) and (3) high-frequency monitoring with sensors of several constituents or proxies, turbidity is commonly measured but other variables include CTD, DO, pH, CDOM, and nitrate. Water quality variables that are *not* amenable to instrumental sensing, so must be measured in the laboratory, include major nutrient (N and P) forms other than nitrate, and the faecal indicator bacterium, *E. coli*.

Many aspects of water quality relate to suspended particulate matter (SPM) in rivers and other waters, notably light attenuation, 'total' N and P, and *E. coli*. As a consequence, there are major and mutual benefits from integrating sediment monitoring with water quality survey. Turbidity is a major integrating variable, being a valuable proxy (suitably calibrated) for SPM concentration and certain water quality variables, notably visual clarity and (roughly, but usefully) for *E. coli*. So regional councils and other agencies can improve cost-effectiveness of overall river monitoring effort, including monitoring for swimming water quality (largely controlled by *E. coli* and visual clarity), by *integrating* sediment monitoring with water quality survey. Monitoring of turbidity and perhaps other variables (with sondes) needs to be supported by high-flow auto-sampling as well as routine discrete water quality visits (for regular cleaning of high-frequency sensors as well as validation or calibration of their response). These principles will be illustrated with the examples of recent research campaigns on the Hutt, Haast-Awarua and Manawatu rivers.

Surfbee Application and Findings in Otago.

Bradley Thomas (Otago Regional Council)

Gaugings at higher flows are vital to collect for creating accurate stage-discharge ratings. The Otago Regional Council (ORC) Environmental Monitoring team has always strived to target these key flows, despite the difficulties posed by large weather events. In 2023, ORC acquired a new method to measure flows in strong currents that are not wadable, utilising three Flow Seeker boats from Surfbee.io.

Flow Seeker is an autonomous gauging boat designed for carrying Acoustic Doppler Current Profiler's (ADCPs). The boat is remote-controlled, made of paddleboard material and powered by reusable DeWalt tool batteries. Most importantly, it has the autonomous transect mode which reduces the need for manual control during gaugings. ORC purchased the boats to deploy the previously owned Sontek M9 and RS5 ADCPs.

The boats have changed how the Environmental Monitoring team conducts its gauging programme throughout Otago, especially for targeting the flows above wadable but perhaps not suitable for Heli-gauging.

The teams use of the boats in different river conditions such as standing waves, debris, and changes in surface water velocity offer insight into the boat's capabilities. Although this use has had its fair share of success stories, it has also had the odd failure.

This presentation explores ORC's application and findings with the Flow Seeker across Otago's diverse landscapes. From the steep catchments of the Dart and Rees Rivers to the mighty Clutha Matua-Au and throughout the meandering Taieri River.

Groundwater Sampling - The importance of groundwater monitoring bore design and construction.

Caitlin Frazer and Nic Love (Pattle Delamore Partners Limited)

Groundwater monitoring bores are used for a number of purposes such as groundwater level monitoring, groundwater quality monitoring and aquifer testing. The design of the monitoring bore is dependent on its intended use and can be vastly different depending on the project requirements. For example, a bore screened across the water table for the purposes of sampling for low density contaminants may not necessarily be suitable for hydraulic conductivity testing, which ideally requires a bore to be screened below the water table. As a result, utilising monitoring bores that were not designed for the intended use can present both obvious and more discrete issues that could result in the collection of unfavourable data. During the planning phase certain design parameters can also be overlooked, causing potential issues with both monitoring bore functionality and suitability for the end use.

This presentation covers an overview of ideal monitoring bore design, as well as certain factors that should be included in the scoping and planning phase for the installation of groundwater monitoring bores, including:

- Significance of selecting an appropriate bore diameter and construction material;
- The importance of filter pack sizing, screen slot sizing and consideration of the natural properties of the surrounding strata;
- The use of glues and filter socks and implications for groundwater quality sampling;
- Targeting specific depth zones with screen placement and/or multiple screens;
- Nested bores, clustered bores and use of packers;
- The importance of bore development and appropriate methods for doing so; and
- Communication with drilling contractors to ensure that the correct specifications are followed.

This presentation discusses a number of case studies where appropriate monitoring bore design and/or construction principles were not followed. The presentation investigates the root causes for each of the case studies and the flow-on effects for the use of the bores.

Deep groundwater sampling challenges

Ryan Nicol (Pattle Delamore Partners Limited)

Aims and methods:

Groundwater quality sampling is a primary method for data collection to understand changes in groundwater chemistry from landuse. Collection of high-quality data is paramount for regional authorities to be able to make decisions. Collection of groundwater samples in shallow groundwater monitoring bores is generally straightforward but the complexity of sampling increases with the depth to groundwater level and also with unusual bore design.

Changes in groundwater chemistry (i.e. nutrients) from landuse activities are typically greatest at the water table and therefore monitoring bore designs generally have screened intervals across the water table. This usually does not pose a problem for sampling shallow groundwater but can be difficult if groundwater levels have large fluctuations and often requires long screens or nested monitoring bores to ensure that samples of groundwater at the water table can be obtained at times of lower groundwater levels.

Groundwater sampling is required as part of resource consent compliance monitoring for numerous discharge and landuse activities throughout Canterbury. These activities generally occur in areas that are sited over unconfined to semi-confined alluvial aquifers. In some instances, groundwater levels can fluctuate by up to 29 m, necessitating deep monitoring bores up to 80 metres below ground level (m bgl) with long screen intervals up to 65 m long to ensure that groundwater samples at the water table can be collected year-round.

The type of groundwater sampling methods that can be used for sampling in these areas depend on the bore diameter and the physical lifting capacity of the pump. In many cases, the sampling equipment needs to fit down a monitoring bore with an internal diameter of 50 mm and be capable of lifting water from depths in excess of 60 m bgl, which restricts the type of sampling equipment that can be used. Further to this, long monitoring bore screen intervals within alluvial gravel aquifers can result in unanticipated effects, such as downward drainage of shallower groundwater through the bore screen which can add further complications to groundwater sampling.

In this presentation, the groundwater sampling complications associated with sampling deep groundwater are discussed along with the methods utilised to ensure that reliable and representative groundwater quality data can still be collected.

Predicting low oxygen concentrations in lowland streams using stream metabolism and atmospheric reaeration.

Ben Woodward, Kerry Costly and Lucy McKergow (NIWA)

Dissolved oxygen (DO) is vital to the health of rivers and streams. In aquatic environments oxygen concentrations are determined by; respiration consuming oxygen, photosynthesis producing oxygen and exchanges with the atmosphere (reaeration, mostly an oxygen source).

Lowland streams are susceptible to periods of low DO due to low reaeration rates (low velocities and turbulence) and high rates of respiration (fuelled by high sedimentation supplying organic matter). The flow conditions and "soft-bottom" created by deposited sediment allows macrophytes to establish. Macrophytes produce oxygen during the day via photosynthesis raising DO concentrations. However, macrophytes also decrease flow rates which increases sedimentation, and if the plants emerge from the water are surface reaching, they form a barrier between the atmosphere and water surface restricting reaeration. Macrophyte biomass also respires, and its decaying biomass provides an additional source of organic matter further increasing respiration rates. By understanding rates of gross primary productivity (GPP), environmental respiration (ER) and atmospheric reaeration (K_{600}) across a stream size gradient we aim to improve our understanding of how macrophytes and discharge affect DO concentrations in lowland steams.

We monitored three Waikato lowland streams which experience high macrophyte biomass during summer. DO and temperature concentrations were measured using PME miniDOT DO loggers adjacent to existing stream gauging stations (Toenepi Stream, Topehaehae Stream, Piako River). By combining the DO and temperature data with stream discharge and water level data from the gauging stations, and light and atmospheric pressure data from a local weather station we estimated rates of in-stream gross primary productivity (GPP), environmental respiration (ER) and atmospheric reaeration (K_{600}) using USGS's R package, StreamMetabolizer.

During the summer of 2020, all three streams experienced prolonged periods when daily DO minima were below the 1-day national bottom-line (4 mg L^{-1}). The length and severity of these events decreased with increasing stream discharge, demonstrating that the larger loads of oxygen, smaller percentage of macrophyte cover and higher ratio of water volume to sediment surface area protects larger systems from periods of low DO. Within each system we investigated the relationship between daily DO minima and GPP, ER and K_{600}. We analysed periods with above and below average GPP separately, as high macrophyte productivity has a strong effect on ER and K_{600} which in-turn influence overnight DO minima. During periods of above average GPP (and ordered by increasing stream discharge), K_{600} explained 66%, 87% and 40%, and ER 52%, 23% and 28%, of variation in the daily DO minima. During periods of below average GPP, K_{600} explained 81%, 54% and 46%, and ER 1%, 9% and 42% of the variation in daily DO minima.

Our results demonstrate that (1) understanding rates of K_{600} and ER in lowland streams is useful for predicting the probability of low DO periods, particularly in small to medium sized systems, and (2) StreamMetabolizer is an accessible and reproducible method of estimating GPP, ER and K_{600} for long term, high frequency DO datasets.

Special Guest Presentation from AHA Delegate

Jaymee Woods (Water Corporation, Western Australia)

Abstract to be confirmed.