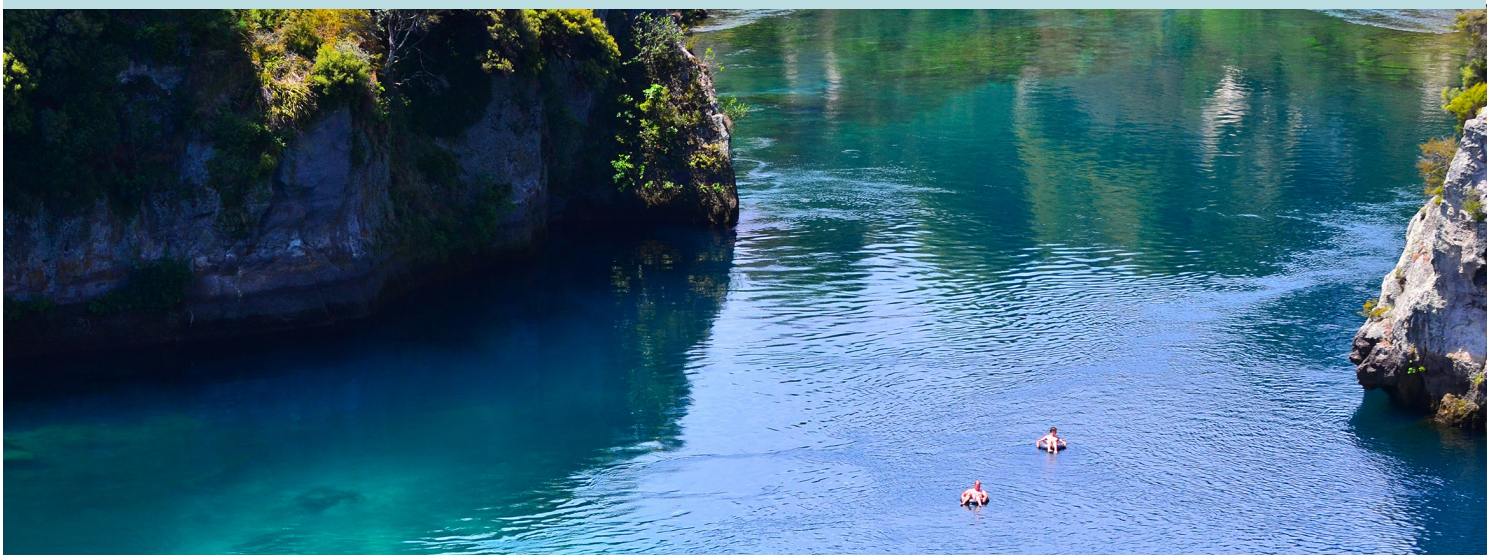
National SCIENCE Challenges

OUR LAND AND WATER

Toitū te Whenua, Toiora te Wai

Designing Freshwater Monitoring Programmes to Detect Early Improvement

Guidance for: regional councils, government, multi-agency catchment groups



New Zealanders share an understanding that, like people, our rivers have the right to be healthy and safe (te mana o te wai). We all want rivers our children and grandchildren can grow up swimming in, like our ancestors did.

Many people who farm, community and iwi groups, and people working as part of the Jobs for Nature programme are taking action to improve freshwater quality, through activities such as stream fencing and planting, wetland restoration, and changes in farming practice.

Monitoring the collective effect of these activities on water quality has not been standard practice in New Zealand – but it is now urgently required. In 2020, the government introduced regulations that aim to improve the quality of New Zealand's fresh water within five years and restore freshwater ecosystems to a healthy state within a generation. The policy package requires water quality trends to be monitored over time, and tasks regional councils with establishing monitoring methods.

For this to happen, we need to fill some critical gaps and shortcomings in our current monitoring methods and networks. People in regional councils need a framework to help them design monitoring programmes that will measure the effectiveness of actions to improve freshwater, and to help them select appropriate monitoring technologies that enable early detection of improvement.

These monitoring programmes will give people taking action on the ground information on successes and failures of past actions, helping them prioritise the most effective actions to improve freshwater quality, so our rivers more quickly return to good health.

The following guidance on designing freshwater monitoring programmes to detect early improvement summarises the work of two working groups convened by the Our Land and Water National Science Challenge. The Monitoring Design and Monitoring Technologies working groups developed proof-of-concept resources to help regional councils decide what should be measured, where and when. Input was provided by a third working group, Enacting te Mana o te Wai (still in progress).

Monitoring programmes must detect early improvement

The people working to improve water quality need more immediate feedback about the effectiveness of their actions. This feedback can become part of a cycle where successes and failures are understood, increasingly effective plans are then developed, and this greater confidence leads to increased implementation.

The current absence of feedback risks encouraging ineffective restoration projects and plans, or uninformative evaluations. Some plans may contain no specific, measurable water quality goals, and the time frames and intervals for monitoring vary greatly. Monitoring and evaluation for restoration projects is often not required, not funded, or not formally reported.

We need more than 'State of the Environment' monitoring

In New Zealand we tend to rely on existing monitoring networks, such as 'state of the environment' monitoring, that provide long-term datasets. These networks were not designed to detect early change or measure the effectiveness of a specific mitigation or restoration activity, and are often at a spatial scale that cannot establish whether a change was caused by an intervention.

Mitigation and restoration activities take place at multiple scales (from paddock to stream to catchment), by a diverse range of people (farmers, community groups, iwi, hapū, regional councils, catchment groups) who are often interested in a wider range of outcomes and attributes than are measured by 'status quo' monitoring. People taking action to improve water quality therefore have different interpretations of success. A digital survey conducted as part of this research found that although respondents collectively prioritised nitrogen as the most important attribute to monitor, people who identified as 'member of the public' prioritised algal bloom, and members of iwi and hapū prioritised mauri and mahinga kai.

Regional councils need to adopt new technologies

People in regional councils generally have ample knowledge about the monitoring technologies available and are enthusiastic about possible novel technologies, though this varies by council.

Novel technologies are needed to enable earlier detection of freshwater improvement. For example, in some places discrete monitoring (such as grab samples) will not detect changes that could be picked up by continuous sensor technology (such as telemetered nitrate sensor). This research developed a 'proof-of-concept' comprehensive inventory of freshwater improvement monitoring technologies that linked a total of 47 attributes to 171 current and emerging monitoring technologies (access available on request).

New technologies must have high-quality guidelines for use

To be adopted for use by regional councils, new technologies must be proven, be economical, and have guidelines or standards for their use. Crucially, they must also be defensible for long-term planning and must be acceptable as evidence in statutory resource management processes. Until novel technologies can reach those benchmarks, councils will tend to stick to traditional approaches.

1 Define the monitoring purpose

Specific and measurable goals make it easier to evaluate the success of restoration actions. A mitigation plan should have a clearly stated objective or objectives, which should be the starting point for a monitoring plan.

2 Identify the catchment's values and natural characteristics

This step requires assembling data and information to build a "state of knowledge" picture of the catchment or waterbody.

3 Quantify the potential effects of mitigation

Monitoring should be targeted at restoration actions. This step assumes the mitigation plan contains a set of spatially explicit management actions and improvement objectives. Wherever possible, this step should be based on information contained in Farm Environmental Plans (FEPs).

4 Determine the likelihood of detecting change

Use information and analysis gathered in the first three steps to determine the likelihood of detecting a change, and the time required to detect it, using freshwater attributes and indicators at various locations in the waterbody and/or catchment.

5 Develop the monitoring plan

The final output of the framework is a plan to monitor the effectiveness of mitigations, including what to monitor, where and when. A general 3-tier structure for monitoring plans is proposed:

Tier 1: Monitoring and detecting early response

This component of the monitoring plan focuses on verifying that the mitigation has worked as expected, and on monitoring the locations and indicators most likely to show an early response. This can identify progress towards the short-term objective of the Essential Freshwater policy package: "Stop further degradation of New Zealand's freshwater resources and improve water quality within five years".

Tier 2: Monitoring medium- to long-term freshwater outcomes

This component of the monitoring plan focuses on whether the mitigation plan's objectives have been met at the locations and to the extent specified in the mitigation plan. It may be used to assess progress towards the Essential Freshwater long-term objective: "Reverse past damage and bring New Zealand's freshwater resources, waterways and ecosystems to a healthy state within a generation".

Tier 3: Mitigation longevity and sustainability

This component of the monitoring plan focuses on medium to long-term monitoring of the longevity and sustainability of the mitigation plan, including monitoring the lifespan performance of mitigation devices/actions and monitoring risks or potential side effects.

Key elements of the Mitigation Effectiveness Monitoring Design Framework

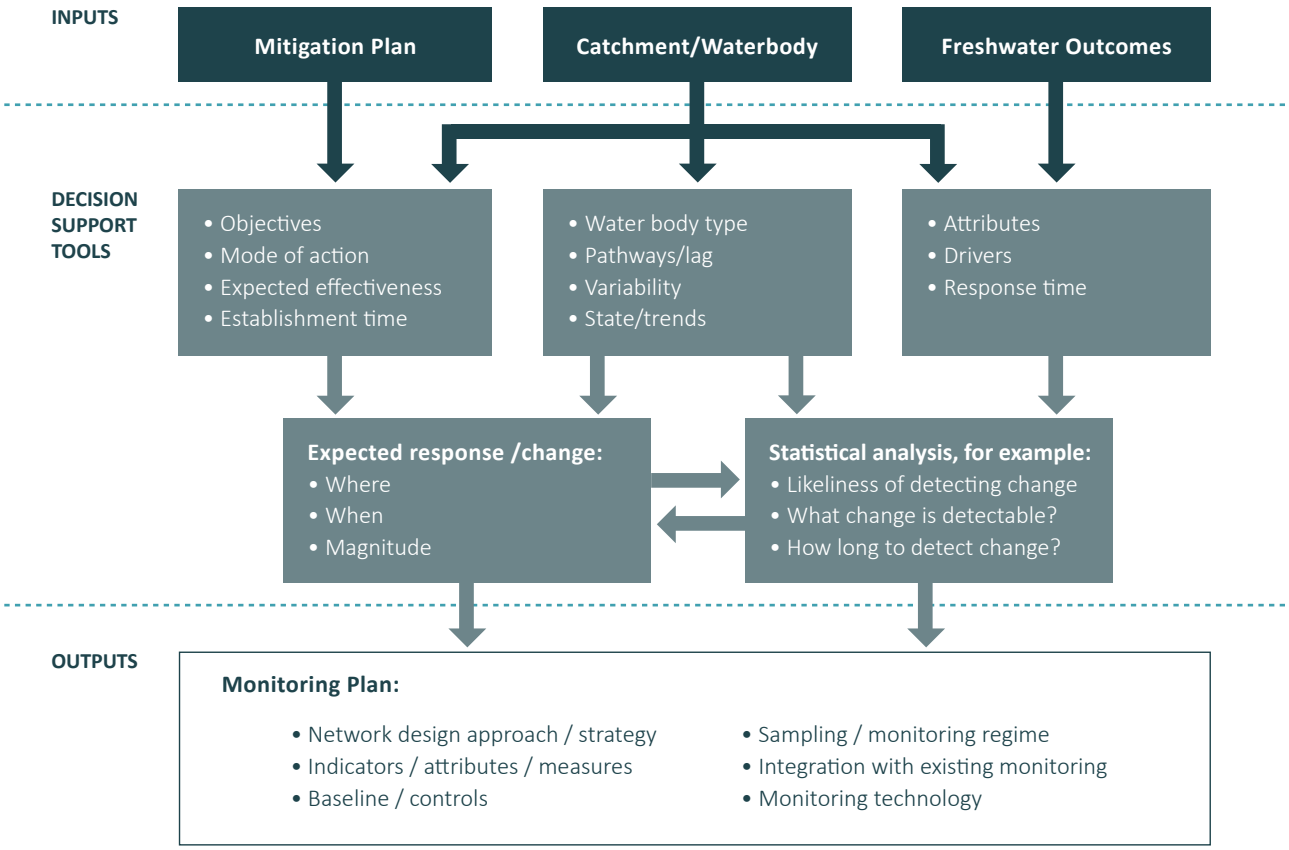


Figure 1: *Key elements of the Mitigation Effectiveness Monitoring Design Framework*

The two working groups identified requirements for further work that will be necessary to develop a fully functioning tool to guide the development of freshwater monitoring programme that enable regional councils (and others with responsibility for Aotearoa's fresh water) to detect early improvement in water quality.

Ensuring the Integrity of Te Mana o Te Wai

Improvements in the freshwater monitoring programmes and technology must ensure the integrity of Te Mana o te Wai (our obligation to prioritise the health and well-being of water) is upheld. Another Our Land and Water working group, Enacting Te Mana O Te Wai, is developing a suite of processes, tools and resources to support the upskilling of mana whenua practitioners and regional authority staff in understanding and operationalising Te Mana o te Wai. That group is working in case study catchments to support strong partnerships and defined freshwater management roles and responsibilities to fulfil Te Mana o te Wai. Tools and resources will be released by September 2021.

Simplified Interface for End-Users

A reasonably high level of end-user technical proficiency was assumed for the initial phase of this research. A simplified interface is necessary to enable direct use by a range of users in specific projects, in particular community-led projects. Ideally, an interface will be developed where users can directly input the anticipated mitigation actions (in particular riparian management) and produce colour-coded maps to guide the development of a monitoring plan. Funding is being sought for this interface development.

End-user engagement has also highlighted significant interest in extending this interface to urban and/or estuarine environments.

The interface to the monitoring technologies inventory also developed by this research is currently considered proof-of-concept, with a large list of recommendations to be fulfilled to make it publicly available.

Mātauranga Māori Monitoring

The two working groups that produced this research initiated preliminary and exploratory work on how mātauranga Māori may be used to monitor the effectiveness of freshwater mitigation or restoration, and how to incorporate important mātauranga Māori attributes and indicators, such and mauri and mahinga kai. This will be an important contributor to further work, and will be guided by the Enacting Te Mana O Te Wai working group.

We recognise the fundamental importance of whakapapa and the need for mana whenua to undertake monitoring within their rohe, using tools they feel comfortable with. The sensitive nature of some of the information forming part of kaupapa Māori assessment frameworks (eg wahi tapu) means that matters of confidentiality and access to the data must be considered further.

Integration with FEPs

Further consideration is required on how mitigation plans, actions and monitoring can be integrated within the Farm Environmental Plan process. It would be useful to link the methods and outputs of the Our Land and Water-funded Register of Land Management Actions Register as inputs to this monitoring design framework. This could potentially be further developed using a farm typology approach.

Further Guidance on Monitoring Technologies

For novel monitoring technologies to be used, significant investment is needed to speed up the creation of guidelines and standards for these methods.

Further guidance is also required on how continuous or event-based monitoring may influence change detection power, and on how to integrate monitoring technology to minimise costs while optimising the likelihood of detection change within the target timeframe. Cost-benefit analysis to identify 'best bang for buck' technologies over a 10-year-plus timeframe is necessary (see Figure 2).

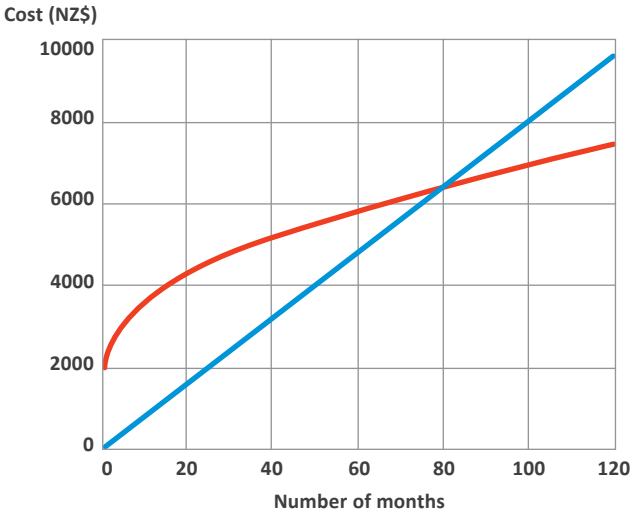


Figure 2:
A novel continuous sensor might require initial investment but will likely save sampling cost compared to traditional grab samples and therefore be cheaper after a number of years.

User-Ready Decision Support Tools

This research developed riparian, lakes and groundwater decision-support tools (see 'Supporting Information', below). These need to be developed from proof-of-concept stage to a user-ready tool, so they can provide useful guidance for the design of mitigation effectiveness mitigation plans.

Integration with Modelling

Given the long-term, sometimes multi-generational, nature of freshwater ecosystem restoration it is sometimes necessary to combine modelling and actual monitoring data to evaluate progress in situations where freshwater outcomes may not be measurable in the short- to medium- term. There may be potential to use the information and frameworks developed by this research to support the development, calibration and validation of catchment and/or lake models.

Supporting information

To assist with the implementation of the five-step process (see page 3) a range of information repositories, decision support tools and modules were created. All are hosted on the Atlassian Confluence online platform. Access can be provided on request.

A comprehensive online inventory of 171 current and emerging monitoring technologies that can be queried by attribute and technology type.

An overall Decision Support Tool (DST) guiding the user through the various components and modules.

Information repositories and resources, including:

- information on freshwater values, attributes and indicators and their interrelationships
- a statistical analysis module, focusing on change detection
- a contaminant load estimation module
- guidance on monitoring edge-of-field mitigation devices
- a database (Excel) compiling information on the potential effectiveness of mitigation actions on contaminant losses, and the expected lifespan of the mitigation (fully populated for riparian buffers only for the proof-of-concept phase of the project)

Three specific Decision Support Tools were developed:

1. A riparian mitigation DST, providing a methodology to estimate the potential benefits of riparian buffers on contaminant losses, shade, and water temperature, with a case study that follows the five-step process in the context of a mitigation plan based on riparian management of a stream network.
2. A Lake Mitigation DST, providing guidance on monitoring the effectiveness of in-lake interventions for combinations of 6 lake types, 6 in-lake interventions and 7 freshwater attributes selected as a representative subset of conditions commonly encountered in New Zealand.
3. A groundwater Nitrate DST, which includes modules on lag time, time series power, Forward-looking Counterfactual Inference (FCI) and spatial distribution analysis and a case study, demonstrating the above analyses in the context of regulatory requirement to reduce on-farm losses of nitrogen via Farm Environmental Plans in the Canterbury Region.

Key Publications

The outputs listed below are available on request.

Ausseil, O., Clapcott J.E., Etheridge Z., Hamilton D., Linke S., Matheson F., Ramsden M., Ruru I., Selbie D., Tanner C., Whitehead A., Bradley A. (2021). **Measuring the benefits of management actions: Mitigation effectiveness Monitoring Design, Proof of Concept development phase.** Our Land and Water National Science Challenge, New Zealand.

Rogier Westerhoff, Richard McDowell, James Brasington, Mark Hamer, Kohji Muraoka, Maryam Alavi, Richard Muirhead, Abigail Lovett, Ian Ruru, Blair Miller, Neale Hudson, Moritz Lehmann, Maiwenn Herpe, James King, Magali Moreau, Olivier Ausseil (in pre-press, 2021). **Towards Implementation of Robust Monitoring Technologies alongside Freshwater Improvement Policy in Aotearoa New Zealand.** Environmental Science and Policy.

Ross Monaghan, Andrew Manderson, Les Basher, Raphael Spiekermann, John Dymond, Chris Smith, Hans Eikaas , Richard Muirhead, David Burger, Richard McDowell (2020). **Quantifying contaminant losses to water from pastoral land uses in New Zealand II. The effects of some farm mitigation actions over the past two decades.** NZ Journal of Agricultural Research.

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National Science Challenges

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Our Land and Water (Toitū te Whenua, Toiora te Wai) is working towards an agri-food and fibre system that enhances the vitality of te Taiao with a diverse mosaic of land uses that improve the health of land, water and people.

Our Land and Water is one of 11 National Science Challenges that focus on defined issues of national importance. Our Land and Water is hosted by AgResearch, funded by the Ministry of Business, Innovation and Employment, and supported by 16 partner research organisations.

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