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FRESHWATER MONITORING: CHALLENGES AND NEEDS OF REGIONAL COUNCILS

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EXECUTIVE SUMMARY

Comprehensive and consistent monitoring of Aotearoa New Zealand's freshwater environments is crucial to understand what effects human actions are having on these systems, and what different actions might be required to protect and support the values New Zealanders have for their waterways.

Over the last decade, parallel changes to freshwater policy, resource management legislation, and environmental reporting legislation have altered the obligations of regional councils to monitor their freshwater environments. At the same time, community demand for access to reliable environmental information is increasing. As central government proceeds with reform of the resource management system, it is timely to consider what is needed to build a coherent, rigorous, and effective environmental monitoring system.

This report draws on expert interviews conducted as part of an independent Marsden Fast Start investigation into issues in freshwater monitoring. This report synthesises interview evidence from regional council staff to identify key challenges and needs of regional councils with respect to freshwater monitoring. Interviews with 20 present and former council science staff from all 16 regional councils canvassed six topical areas of implementation challenges and needs. Regional council scientists from the SWIM group provided feedback to strengthen the report, though final responsibility for the report's content lies with the author. Furthermore, while this report highlights the challenges councils are facing, it is important to note that much is also going well in the sector.

Evolution of freshwater monitoring. Under the Resource Management Act 1991, regional councils must monitor and report on the state of the environment, including freshwater bodies. Councils have taken a range of approaches to this, from issuing 5-yearly public reports to issuing annual data updates. Council monitoring designs reflect a prioritising of scarce resources to cover large geographical areas, often focusing on highest-risk areas. Across regions, monitoring network design tends to reflect well-known biases toward monitoring larger waterbodies, more impacted waterbodies, more at-risk waterbodies, using attributes that are easily measurable, and with a tendency toward keeping historical sites rather than changing them. Overall, the increasing pace of legislative change, advances in technology, and the strength of community concern are placing demands on councils for monitoring infrastructure that the Long Term Plan process is not able to keep pace with. Furthermore, the electoral pressure on the LTP process means that council spending on science on monitoring is not often prioritised.

Implementing the National Objectives Framework. The 2020 National Policy Statement for Freshwater Management (NPS-FM) requires councils to monitor 22 specific biophysical attributes for applicable waterbodies in their regions. This requirement is forcing another re-prioritisation process for councils, as they juggle the benefits of measuring some new attributes with the costs and perceived irrelevance of other attributes for their communities. To make resources available to measure these new attributes, some councils are decreasing

the spatial coverage of their monitoring elsewhere. In line with the design of the NPS-FM, Freshwater Management Units are being defined differently by councils and this makes comparison of data across FMUs difficult.

Land Air Water Aotearoa (LAWA). LAWA is a data-sharing platform developed by councils that allows the public to access and explore spatially-referenced environmental data through an interactive web interface. LAWA is considered a positive, bottom-up development that has helped drive harmonisation in council data storage and analysis practices, as well as providing a useful interface for members of the public to access and interact with environmental data. Challenges with developing LAWA include insufficient financing and inconsistent involvement by central government, incommensurate data sources, and trade-offs between offering broad data access versus providing meaningful interpretation of local trends.

Key priorities in freshwater monitoring science. Council staff identified new and continuing needs for science investment in monitoring. These include:

- better quantification of environmental impacts from specific land use practices;
- developing infrastructure to support community monitoring of waterways;
- methods for modelling parameters for which monitoring is difficult or expensive; and
- the development of remote sensing and environmental DNA applications to lower the cost and expand the spatial and temporal reach of monitoring.

These cross-council science needs could benefit from collective investment by regional councils and/or central government, iwi/hapū and industries.

Cultural monitoring. Council staff are enthusiastically embracing new requirements to support cultural monitoring of fresh water driven by tangata whenua. Ambiguities in central policy wording pose a challenge for interpretation, but regardless, councils are proceeding to build relationships with iwi/hapū in ways that are considered appropriate to the context. A particular challenge is that it is unclear to council staff how to analyse and report on cultural monitoring. Resource constraints in many settings mean that relationship-building is slow. Different regions also have different numbers of iwi and hapū, some only a few (1–3), others many (30–50). In addition, Treaty settlements are at different stages throughout New Zealand and this means iwi resourcing for cultural monitoring differs across—and possibly within—regions.

Roles for central government. Interviews explored the existing and ideal relationships between regional councils and central government with respect to freshwater monitoring. Monitoring to produce a national picture of the state of the environment is often at odds with councils' obligations to monitor the effectiveness of regional policies and plans under the RMA, and meet community and tangata whenua aspirations. Additional costs for monitoring in service of national benefit have in the past been met with cost-sharing arrangements between councils and MfE, which are remembered favourably. Two present initiatives—

National Environmental Monitoring Standards and the Environmental Data Management System—provide positive examples of local and central government working together to achieve shared goals. Overall, from the interviews conducted, it appears that relationships between local and central government have been challenged by staff turnover, lack of mutual understanding, and a lack of a coherent central government view on monitoring direction and support.

Conclusions and recommendations. The evidence collected here reveals how ongoing changes to the monitoring system are being experienced and addressed by council staff. The NPS-FM is a major intervention into council science and monitoring activities. Local financing mechanisms limit the pace at which council investments can increase to meet demand. Central government support for the monitoring system has been crucial for getting initiatives such as LAWA and NEMS working, and council staff desire much more involvement and support from central government. It is recommended that:

1. Each regional council ensures that relationships between its monitoring, policy and compliance functions are aligned and effective, and that cultural monitoring investments are situated explicitly within a framework of Treaty-based co-governance.
2. Central government explore mechanisms for financing environmental monitoring that do not rely on local political budgetary processes for coherent implementation.
3. Central government ramp up both in-kind and financial support for council-led and iwi/hapū-led initiatives in the environmental monitoring space, and develop policy that can build upon these initiatives.
4. Regional councils pool their resources and direct environmental research to key priority topics that support the functioning of the resource management system more broadly.
5. MfE and council science staff work together to share information about monitoring needs and challenges, and identify and pursue synergies across the environmental monitoring system.
6. MfE and councils should consider commissioning a follow-up study in three to five years to evaluate how the dynamics in the monitoring system are shifting and why.

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GLOSSARY

DO	Dissolved oxygen
EDMS	Environmental Data Management System. A council-driven initiative to develop a shared portal for handling environmental data.
IBI	Index of Biological Integrity
LAWA	Land Air Water Aotearoa
MCI	Macroinvertebrate Community Index. An indicator of the health of a waterbody based on the presence and abundance of benthic invertebrate species.
MfE	Ministry for the Environment
NEMS	National Environmental Monitoring Standards
NIWA	National Institute for Water and Atmospheric Research
NOF	National Objectives Framework. The NOF is a component of the NPS-FM that, among other things, requires councils to set limits and/or action plans for 22 specified biophysical attributes, and monitor and report progress for these attributes.
NPS-FM	National Policy Statement for Freshwater Management. This policy statement was first gazetted in 2011, then revised versions were gazetted in 2014, 2017, and 2020. The NOF was introduced in the 2014 NPS-FM.
PCE	Parliamentary Commissioner for the Environment
RMA	Resource Management Act 1991
SoE	State of the Environment
SWIM	Surface Water Integrated Management Special Interest Group. A group of freshwater science staff from all regional councils.

1. INTRODUCTION

1.1. Background

Environmental monitoring is an important feature of Aotearoa New Zealand's resource management system. To discover whether environmental policies and actions are protecting and improving the health of the environment, we need to know what the state of the environment is and how it is changing.

Since the enactment of the Resource Management Act 1991, New Zealand's 16 regional authorities (henceforth councils) have established monitoring systems to record and report on the state of fresh water in their regions. Recent national freshwater policy changes have increased the number of attributes that councils have to measure, and in some instances this requires significant changes to councils' freshwater monitoring networks.

In 2019, the Parliamentary Commissioner for the Environment published a review of New Zealand's environmental monitoring and reporting system (PCE 2019). The review highlighted that environmental data are currently collected and reported in inconsistent ways across the country, to the detriment of acquiring a comprehensive understanding of New Zealand's environment.

The PCE recommended that the Ministry for the Environment (MfE) develop a representative national monitoring network to 'ensure systematic, coordinated and consistent monitoring across the country' (PCE 2019: p 86). It was recommended that such a system should include a standardised approach to collecting and analysing data, should have data made publicly available, and be 'properly resourced' (ibid: 86).

Presently, MfE are developing proposals to reform the Resource Management Act 1991 and the Environmental Reporting Act 2015. In part this is to address issues raised by the PCE report, but the aim is also to create a monitoring framework that can support a newly re-designed environmental policy and planning system (RMA Review Panel 2020).

Recent freshwater policy changes have required councils to make significant new investments into freshwater monitoring. Since councils' experiences and challenges with implementing this new monitoring infrastructure have not been analysed or documented, councils are not able to identify issues and solutions that might be in common to multiple councils. Furthermore, without understanding councils' experiences and needs, reform of environmental monitoring legislation risks 'flying blind' to structural problems and common issues that affect councils as they undertake environmental monitoring.

1.2. Purpose and scope of report

This report provides a bottom-up view of challenges and needs for freshwater monitoring from the perspective of council staff. In contrast to the PCE (2019) report, which highlighted important issues facing central government agencies and national-level environmental reporting, this report focuses on the issues councils face when designing, maintaining, and expanding their monitoring networks. The report complements other studies of New Zealand freshwater implementation challenges (Kirk et al. 2020; Beca Limited 2020) by focusing explicitly on issues arising from freshwater monitoring infrastructure and maintenance. Understanding what has helped and hindered councils with freshwater monitoring to date can support the development of appropriate policy design and central government support for monitoring into the future.

This report uses interview evidence collected by the author for an independent research project investigating the use of knowledge in freshwater decision-making (Marsden Fast Start grant CAW-1901). During that research, council scientists reflected that while the issues addressed in this report are often discussed among council scientists, there is a sense that conversations 'go around in circles', likely because the solutions lie with multiple agencies and cannot be solved by one alone. The author therefore identified a need to embed these experiences into a document that can be shared, discussed, and used to prioritise next steps for council and central government investments in the monitoring space.

This report was commissioned by Envirolink on behalf of all councils through the Surface Water and Integrated Management (SWIM) Special Interest Group to synthesise evidence from the author's Marsden-funded research to identify key monitoring-related challenges and needs for the regional sector. The author sought feedback from the SWIM group of council scientists to strengthen the report, but ultimately the research itself was conducted independently and the report's content and organisation reflect decisions by the author. In the process of providing feedback on the draft of this report, SWIM identified important themes that merit further study but which lie beyond the scope of this report, including: documenting initiatives where iwi are taking statutory responsibilities for environmental monitoring, canvassing relationships between research sector and freshwater monitoring, and exploring prospects for government collaboration with industry in the monitoring space.

It is intended for this report to support multi-agency discussions about NPS-FM implementation, specifically around funding monitoring and reporting. Given the systemic issues identified, councils cannot solve these issues alone and the coordination and cooperation of multiple agencies and sectors will be needed, with a shared sense of what issues are at stake and need to be addressed. Regional council staff can use the report in making decisions about how to implement the monitoring and reporting requirements in the NPS-FM (and all other water-related national policy

instruments), and the report can provide an evidentiary basis to make decisions about the future of Land Air Water Aotearoa (LAWA) and other pan-regional council initiatives in the monitoring space.

Because the Marsden research was designed to identify challenges and needs, the report contains more critical comments than positive reflections from council staff on the freshwater monitoring system. As such, it is worth noting that much is also going well in the monitoring space, and that a study with a different design would convey those positive aspects more effectively.

1.3. Methods

This research used 17 semi-structured interviews with 20 regional council science staff to canvas the challenges and needs of regional councils regarding freshwater monitoring. A semi-structured approach meant that four overarching topics were addressed consistently by all interviewees, while the detail of interview questions and discussion points within each topic was tailored to draw on the unique experiences, interests, and knowledge of each interviewee (see King et al. 2019). The four overarching topics addressed through the interviews were:

- the origin and design of the regional freshwater monitoring network
- experiences with implementing the National Objectives Framework from the National Policy Statement for Freshwater Management (2014, 2017, and 2020)
- experiences with and needs for cultural monitoring
- existing and ideal division of responsibilities between regional councils and central government for freshwater monitoring.

Participants were identified by snowball sampling, drawing initially upon the connections of the author and Joanne Clapcott, the project's advisor, and then expanding based on suggestions from interviewees. Interviewees were sought who had a substantial length of term (e.g. > 5 years) at council, and/or a good overview of the freshwater quality monitoring network in their region. Not all interviewees currently work for the council they spoke about. For some councils there was an obvious single person to speak to, but for others where there were multiple teams (e.g. water quality, quantity, ecology), personal recommendations were used to find someone with a holistic perspective who was prepared to reflect openly. This snowballing approach differs from other approaches such as a systematic implementation analysis where council managers might nominate a relevant interviewee to represent each council.

Most interviewees spoke to freshwater quality monitoring, but at least two spoke about freshwater ecology monitoring. The 20 interviewee participants included staff from all 16 regional councils, though interviewees had different expertise and often occupied different roles in councils. As such, the research is intended to provide insight into

different council situations, however, it cannot claim to appropriately represent the challenges of all councils.

Interviews were conducted over Zoom and in person in 2020–2021, and most were approximately 50 minutes in length. Since the elicitation of open and honest opinions was critical for this research, all quotes from participants are anonymised. Unless otherwise stated, all interviewee quotes in this report can be attributed to a generic 'council scientist'. In some cases, it is helpful to attribute quotes from small councils that have less science and research capacity than large councils. I designated as small councils those that (as of January 2022) were eligible for Envirolink funding (see https://www.envirolink.govt.nz/grants/#E). In this report small councils refer to Northland Regional Council, Gisborne District Council, Hawkes Bay Regional Council, Horizons Regional Council, Nelson City Council, Marlborough District Council, Tasman District Council, West Coast Regional Council, and Environment Southland. Large council refers to any other regional council.

All interviews were transcribed and interviewees were given the opportunity to check or revise their transcript. Transcripts were coded initially to the four topics described above, then additional codes for two additional topics were added—LAWA and new frontiers for monitoring. Sub-codes were then created to distinguish key ideas within each code.

This report uses direct quotations to convey the content of statements as well as the tone and context of interviewees' reflections. Direct quotes, in contrast to paraphrasing, help to convey the evaluations, attitudes, and feelings of selected council staff as well as the technical content of scientific monitoring and environmental policy. It also allows readers to understand how a topic is discussed openly—how it is linked to other ideas and issues. Conversational language is typically less formal than technical policy language, so it should be noted that this report prioritises honesty of expression over technical accuracy, grammatical correctness and polite language.

2. EVOLUTION OF FRESHWATER MONITORING

This section provides a high-level summary of how regional councils have implemented their duties to monitor freshwater in their regions. It highlights how local decision-making processes shape and constrain the incorporation of central government requirements into regional freshwater monitoring design and operation.

2.1. Design and evolution of freshwater monitoring networks

Prior to the Resource Management Act 1991 (henceforth RMA), councils monitored various aspects of freshwater quantity and quality across their regions in spatially fragmented and temporally constrained ways. Freshwater monitoring was split between monitoring the effects of specific activities (e.g. wastewater discharges) and developing baseline knowledge using one-off (e.g. 1 or 2-year) field surveys of specific catchments.

From 1991, the RMA enshrined formal requirements for councils to monitor the state of the environment. Section 35 required councils to 'monitor the state of the whole or any part of the environment of its region or district to the extent that is appropriate to enable the local authority to effectively carry out its functions under this Act.'

In the 1990s and 2000s, councils established freshwater monitoring networks to fulfil various statutory requirements of the time. Monitoring and reporting on the state of environment was one of these requirements. Most commonly among councils, physico-chemical variables such as such as dissolved oxygen, pH, temperature, nutrients, and suspended sediment were monitored at the same sites on a quarterly basis. Some councils focused early monitoring efforts on ensuring major waterbodies were represented, while some focused on ensuring key environmental classes were monitored, and others focused on ensuring broad spatial coverage.

As statutory requirements changed, councils undertook reviews of their networks to determine their fitness for purpose. After about 7–10 years, councils commissioned independent scientific reviews of their monitoring networks to identify how to make their network more representative and robust. This review pattern continues into the present: most councils are up to their second or third review.

Over time, freshwater monitoring networks were expanded and refined. In response to independent reviews and local planning needs, new monitoring sites were added, and some were decommissioned. Overall, monitoring networks have become larger and denser, with better representation of the spatial classes designated by the River Environment Classification.

In 2014, the National Policy Statement for Freshwater Management (NPS-FM) 2014 instituted new monitoring requirements for councils. The 2014 NPS-FM required councils to monitor nine biophysical attributes such as nitrates, *Escherichia coli*, and periphyton, and to set numerical limits for these in their regions (New Zealand Government 2014). While the NPS-FM 2014 did not require monthly monitoring for all attributes, several councils report switching to monthly monitoring after this policy came out.

In 2020, a new NPS-FM expanded the total number of attributes requiring monitoring to 22. This includes monitoring suspended fine sediment for rivers (and setting limits for this), as well as monitoring 12 new attributes such as dissolved reactive phosphorus for rivers, macroinvertebrates for rivers, submerged plants for lakes, and fish for wadeable rivers.

Since 2014, councils have been reorganising their networks to effectively monitor the NPS-FM attributes and link them to limit-setting processes, as well meet other new requirements from central government. Several councils report having undertaken independent reviews of their networks specifically for this purpose.

Currently, council freshwater monitoring networks have different coverage and densities across the country. Systematic data collected by the PCE for 2018 shows how many freshwater monitoring sites form the state of environment monitoring networks for each region, as well as how the population, area, and rates revenue vary across regional councils (Table 1).

To give a sense of councils' different conditions for conducting freshwater monitoring, consider two councils with similar land area, such as Bay of Plenty and Hawkes Bay. Bay of Plenty has over 300,000 residents and 2018 rates revenue of $36M, while Hawke's Bay has only 166,000 residents and a rates revenue of $19M. Waikato, West Coast, and Horizons share a similar area (each approximately 9% of New Zealand total), yet Waikato has almost double the population and double the rates revenue of Horizons (469k v 244k residents, $85M v $41M), and Waikato has more than 10 times the population and 20 times the rates revenue of the West Coast region. These examples highlight how rates, land area, and population vary across councils, but it is also important to note that many other factors affect freshwater monitoring networks, such as local land use, political priorities, council structure, and the number and type of freshwater bodies in a region or district.

Table 1. Information about New Zealand's 16 regional councils and their freshwater monitoring networks. Drawn from PCE (2019).

	Population	% NZ pop'n	Land area km^2	% NZ land area	2018 rates revenue $ (000)	# river/stream SoE sites (WQ)	# river/stream SOE sites (ecological)	# lakes monitored	# groundwater quality sites
Northland Regional Council	179,100	4	12498	5	20,915	73	70	27	30
Auckland Council	1,695,900	35	4938	2	1,715,225	42	72	5	141
Waikato Regional Council	468,800	10	23902	9	85,034	120	265	38	151
Bay of Plenty Regional Council	305,700	6	12071	5	39,570	50	118	12	70
Gisborne District Council	49,100	1	8386	3	55,154	47	81	1	0
Hawkes Bay Regional Council	165,900	3	14137	5	19,323	75	75	5	86
Taranaki Regional Council	119,600	2	8254	3	9,478	13	59	1	20
Horizons Regional Council	243,700	5	22220	8	40,648	142	74	15	41
Greater Wellington Regional Council	521,500	11	8049	3	122,788	45	60	5	118
Tasman District Council	52,100	1	9616	4	71,018	26	26	0	11
Nelson City Council	51,900	1	424	0.2	62,163	30	30	1	0
Marlborough District Council	46,600	1	10458	4	62,886	34	50	0	14
Environment Canterbury	624,200	13	44508	17	97,624	141	183	42	329
West Coast Regional Council	32,600	1	23244	9	4,180	37	32	3	28
Otago Regional Council	229,200	5	31209	12	20,909	106	36	8	51
Environment Southland	99,100	2	31195	12	15,682	60	94	7	34

2.2. State of environment reporting

The RMA also requires councils to, 'at intervals of not more than five years, compile and make available to the public a review of the results of its monitoring' (Section 2A). The purpose is to allow the wider community to monitor 'the efficiency and effectiveness of policies, rules, or other methods in [the council's] policy statement or its plan' (Section 2(b)).

Councils have implemented this by publishing regional state of the environment (henceforth SoE) reports every 1–5 years that summarise the state and trends of key freshwater parameters for their region. For example, Auckland Council published SoE reports in 2015 and 2021, and Horizons in 2013 and 2019. In addition, all councils submit certain types of data annually to Land Air Water Aotearoa, which allows members of the public to access available data for 992 river water quality monitoring sites[1], as well as hundreds of lake and groundwater sites.

While councils generally began with a 5-year reporting horizon, most now aim to report their data more frequently as demands for such information have evolved and increased. According to interviewees, Gisborne District Council for example, publishes SoE reports every two years, and Auckland Council aims to publish a SoE synthesis report every 5 years while also publishing a 'basic annual summary' to allow the public to have access to the latest data as analysed by council science teams. Greater Wellington Regional Council and other councils are reportedly also moving toward annual reporting models.

Two key trajectories are apparent with regional SoE reporting amongst councils: fast data access and integrative storytelling.

The first trajectory is that councils are increasingly moving toward a fast model of reporting because "as soon as you publish an SoE report, it's old". Councils such as Auckland Council, Environment Canterbury, Greater Wellington Regional Council and Bay of Plenty Regional Council have invested in developing web portal interfaces for members of the public to access and analyse environmental data for their region (source: SWIM comment).

Currently, all councils transmit several types of freshwater data annually to LAWA, including data on river *E. coli*, water clarity, ammonia (toxicity), nitrate (toxicity), dissolved reactive phosphorus, and MCI, as well as data on lakes and groundwater. LAWA has an interactive map interface allowing people to identify waterbodies and examine the latest available monitoring data for them. However, since LAWA's strict

[1] National river quality data 2006-2020, downloaded from https://www.lawa.org.nz/download-data/. A pivot table can be constructed in the Excel sheet to count the number of unique monitoring sites.

criteria exclude some council data that might be locally relevant, there is a desire by some councils to have greater control over a regional data dashboard.

The second trajectory is toward reporting with integrative indicators and formats. Council staff considered that reporting biophysical attributes without meaningful interpretation for public consumption has limited value, and pointed to the need for greater interpretation of water quality information. To better communicate the significance of water quality attribute levels and trends, some councils are turning to use a Canadian-origin Water Quality Index. The WQI creates a single grade for the whole waterway, informed by the state and trends of multiple biophysical attributes. Each attribute is scored based on the number and magnitude of regulatory exceedances for a waterway. The WQI then adds attribute scores together to create an overall grade for the whole waterway, such as good/poor.

For proponents of the WQI, a key benefit is that it allows straightforward comparison of major waterways. The WQI also indicates what the major cause of a low score is (i.e. which attributes, and whether it is the number or magnitude of exceedance).

2.3. Key tensions and dynamics with freshwater monitoring

Interviewees identified six important dynamics that shape how freshwater monitoring networks have been built and operated. Unless these dynamics are addressed, implementation of new policy directives will likely be constrained by these dynamics as well.

2.3.1. Biases in freshwater monitoring networks

Council staff identified how the selection of sites, driven by local and regional needs and prioritisation has led to systematic biases in regional freshwater monitoring networks.

Size bias. Since larger waterbodies integrate the land use effects of a larger area, they tend to be prioritised for monitoring. This means that small waterbodies such as small streams, which can be heavily impacted by land use change, are often under-represented in freshwater monitoring networks. It also leads to regional differences in monitoring representativeness. For example, since Northland has many small streams whereas Canterbury has fewer large rivers, Canterbury can cover a much larger area with the same number of monitoring stations.

Impact bias. Because of the need to monitor the environmental effects of council policies and plans, councils tend to monitor at the bottom of catchments, and below impactful land uses. This means lowland agricultural, urban, and intensified areas are

well covered, whereas pristine and mountainous areas often are underrepresented in the monitoring network. For council staff:

> When it comes down to it, where do we get our money from as regional councils? Well, we get it from our ratepayers… we ask them. And that's exactly why we don't monitor much in the mountains, because… ratepayers are pretty content with the water quality up there, and it's not a big issue for them.

Since pristine 'reference sites' are costly to monitor and tend to be considered a low priority for local communities, it appears most councils have a lack of reference sites in their monitoring networks (see also PCE 2019).

Measurability bias. Things that are easy to measure get measured, and things that are difficult to measure are measured less. This is certainly the case with reference sites, which tend to be distant or remote. But sometimes suitable reference sites do not exist at all and are therefore unmeasurable; for example, pristine lowland streams or wetlands are rare. In addition to reference sites, council staff also note that certain types of rivers are easier to measure than others, and this affects monitoring site location. For example, braided rivers move laterally across the floodplain so their channel changes often, except for at bridges, which is why monitoring stations are located there. Council scientists also reflected that compared to hard-bottom streams, soft-bottomed streams are more difficult to monitor for some variables, which means "we know less about them."

Risk bias. Councils also tend to focus monitoring effort on the most urgent environmental risks. Monitoring catchments that are the most degraded, for example, helps to generate evidence that can support remedial policies and rules in the next iteration of the regional plan. However, focusing on the greatest risk catchments or land uses also creates blind spots:

> We have done prioritisation based on risk, and at sites essentially across where we've got higher levels of development population, etc. But it doesn't actually show us what's going on in some of our more extensive areas that have got extensive grazing, etc. And from that, a lot of people are making assumptions that "oh yes, the water quality in those waterways is good because it's just low intensity farming." Whereas we know that those streams are impacted, but to what level and how often, we don't… we just haven't got the resources to do that.

Status quo bias. Although council staff readily highlight the biases in regional networks, they are also clear that moving sites to de-bias the network brings a cost of losing many years of valuable data, and a delay of sometimes many years before data

can be reported. Having a long-term record of water quality was cited as important for developing enforceable rules for regional policies and plans, and detecting change over time. Council staff reflected that in general, older sites were valuable and should be kept, where they meet the current requirements for monitoring and monitoring objectives are clearly identified. In a similar way, councils have over time developed multiple ways to use data from a single site, which means that moving or removing sites becomes costly to several parts of the organisation:

> for example, the river flow monitoring that we do is not just about state of the environment monitoring, it's also about flood management. So if we removed that monitoring, how do those other integrated activities that council uses the monitoring for, how do we retain that connectivity between those activities in our monitoring? Our monitoring is not just for state of the environment reporting, it gets used in multiple different ways across the organisation.

2.3.2. Increasing costs

Council scientists are well aware of the biases of their monitoring networks, as this scientist explains:

> Probably my biggest frustration is the inertia in the system. As I say, we get locked into "here's our networks" and a lot of councils, including ourselves, have gone out to consultants and said "can you do us a monitoring network review? Here are all the things that we want the network to tell us." And it will be like: regional state and trends, feed into the national picture, effectiveness of plans and policies, targeted information. And like there's this whole raft of things that we want our networks to tell us, and then, not surprisingly, the consultants come back to us and say "oh yeah, you need 50 more sites."

Adding monitoring sites requires costly instrumentation that needs to be maintained and calibrated regularly, which in turn requires staff time and physical travel. In addition, qualified staff and scientific infrastructures are needed to collect and process chemical and biological samples. For example, one scientist said it costs $45,000 to get their network's ecology samples processed, as well as two staff for three months to do the sampling, bringing the cost to ~$100,000 for ecological monitoring for their network, before the analysis of the data was even included. One scientist said that their council's science budget is "actually the biggest proportion of everything that we spend."

Adding monitoring sites is only one type of additional cost. Councils are also required to measure more attributes at each existing monitoring site to comply with the NPS-

FM, and, to meet trend assessment needs, they also must increase the frequency of monitoring within existing sites. This means *new* instruments and *additional* qualified staff, labour, and expenses are needed to maintain even just the same number of sites as before. This also does not factor in the significant resourcing needed to appropriately analyse and report data at regular frequencies.

Together, these changes make network expansion prohibitively costly despite the fact that most councils report significant increases in their science team capacity and monitoring budget in the past decade. For example, in Nelson City Council in 2009 there were two people in the monitoring team, increasing to 17 by 2021. Until 2017 Nelson City Council had a single freshwater scientist, and in 2022 will have five. The science team of Bay of Plenty Regional Council, a medium-size council, nearly doubled from 8 to 15 over 2011–2021. Yet while councils' science and monitoring budgets are increasing, the requirement for measuring additional attributes at existing sites (and at greater frequencies) means in some cases that "every year we're trying to cut down sites". A scientist from a small council, for example, said that while they obtained a recent 50% increase in the budget for river water quality monitoring, they still had to halve the number of sites historically monitored because the new budget was consumed by increasing the frequency of sampling from quarterly to monthly.

With the new demands for science work outstripping the science capacities of councils, staff are internalising this by working longer hours and expanding their roles. This is especially the case for smaller councils, who may have only one or two staff dedicated to freshwater science or monitoring, and who more often than not spend personal time (after work hours, on weekends) to get the additional work done. An interviewee from a small council reported that work stress-related burnout led one of their science staff colleagues recently to quit.

As this council scientist summarises:

> We have been steadily increasing [in budget] whereas the demands for us have been increasing dramatically. So we're not keeping up with the demand, both legally and from our community.

2.3.3. Political decision making and the Long Term Plan

> Just because something is required, doesn't mean that the resources are readily available there to deliver it.

The procurement of resources for regional freshwater monitoring happens through the Long Term Plan process. In general terms, this involves elected councillors voting on the plan for council revenue and expenditure for the next 3-year cycle. Setting rates—the primary source of council revenue—is part of this process.

According to interviewees, the Long Term Plan process tends to devalue freshwater monitoring and environmental science more generally. As one council scientist puts it, resource monitoring is politically not very interesting or attractive:

> [It's] very hard to get resource for it from elected councillors, and we were certainly always fighting for the stuff that we need to run effective resources.

One scientist said that their (small) council had gone to the community for more money to support the implementation of the NPS-FM, and the result was that "we might get one extra staff member". Yet even this small gain was considered "contentious" and hard-won.

Two interviewees reflected that when they put forward their needs for new staff and resources to councillors, they usually presented smaller numbers that they thought council would agree to, rather than what their needs actually were.

In contrast, another interviewee said that:

> I put up a bit of a case for what we need as a bare minimum to meet both the NPS and the NES for freshwater… I thought we needed 11 FTEs as part of that process. … [We should have] put it out to councillors to make that decision in a way that they are going to need to be warned that "this is going to lead to a significant rate rise. This is going to be put out to the wider community to give them the opportunity to say no, no they don't want it."

But rather than presenting the calculated 11 FTE to councillors, council managers revised the request to councillors down to "two [staff] in the next three years". This council scientist said that "to put it out as a minimum incremental change is just frustrating."

Overall, interviews revealed how the substantial resourcing needs facing councils are minimised and downplayed in the political decision-making process, likely because of the wide range of functions regional councils are responsible for, which collectively can add up to significant resourcing increases. First, some scientists themselves limit their resourcing requests to managers and councillors to what they feel is politically feasible. Second, even when scientists put forward the comprehensive needs for monitoring, these requests may never get communicated to councillors, as council managers can dilute and self-censor the request based on what they feel is politically feasible. Third, even if both scientists and managers propose significant resourcing requests to councillors, these elected officials may reject or minimise proposals for rates rises as a matter of perceived feasibility with their electorate.

2.3.4. State of Environment monitoring link to environmental outcomes

Some council staff considered that increasing investment into SoE monitoring, as required by the NPS-FM, is only a weak pathway for improving waterway health and that other forms of science investment or regulation would help much more.

This scientist reflects positively on new efforts to monitor ecological attributes, for example, but admits that the link from translating SoE trends to policy levers is missing:

> So you've got MCI, you know, a good robust measure of the health of a river system based on the presence or absence of species of different sensitivity. But you know, if I go to any particular waterway and someone says to me "well you know, the MCI score for that particular stretch of water is 80 or whatever… generally poor". There's no magic wand I can wave and say "ok, well I can get that from 80 up to 100 by doing A, B and C."

A scientist from another council elaborates:

> I am totally unaware of any major links between my results where I go off and do all this monitoring and get the MCI score for example… and what our policies and plans are doing. I have never had a policy planner come to me to say "oh that stream is degrading over time," or "it's not showing the MCI score we want, what can we do about that?" … [W]e're doing this sampling annually which is providing information, but that's not being fed in anywhere. So there's a big disconnect going on here between policy planning and making rules and methods, and the monitoring that we're doing.

Council scientists thought that while monitoring could always be expanded and made more representative, and that more attributes, at greater spatial and temporal resolution, would be valuable to know, SoE monitoring was a relatively ineffective mechanism for instigating improvement in water quality outcomes. Interviewees reported feeling demoralised about the disconnect between knowledge of the environment and activities to improve freshwater health:

> I think we're getting a good idea of what is important and what isn't important, it's just a question of is anybody really paying attention to the outputs. I think you'll hear that from a lot of science people. Yeah, there's problems there that have been glaringly obvious for a long time that just seem to have been magically ignored.

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> [A]ctually we do have a pretty good understanding of what's going on out there. That doesn't mean that we have necessarily set the regulations in the right place and set the policy in the right place to stop degradation. But I don't think it's through a lack of monitoring, I think it's more a lack of a will to make those decisions.
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> I've produced three major State of Our River water quality reports since I've been here, and each one basically has the same conclusion. And the last time I did it, I told councillors in a workshop that I'm really getting sick of telling the same thing, and we're really not putting a lot of resources into doing something about it. What's the point in keeping on monitoring?

For some council staff, other types of science would be more useful for making and enforcing environmental policies:

> [I]f you look at the community, they always want us to monitor. I think well, we do know that we lose nutrients - and measure more nutrients. … I think our lack of knowledge sits in the most prioritisation and the most efficient management. So: edge of field mitigations, tile drains, the critical source areas and their mitigation. Sometimes I wonder, why are we pouring more and more money into monitoring? Shouldn't we focus more on mitigation, on management?

While all interviewed scientists would welcome increases in monitoring investment, several of them identified other science areas that they thought were more urgent for improving resource management outcomes (see also Section 5). Council staff expressed the need for targeted investigations, often using modelling, to attribute ecological impacts (e.g. decline in MCI or, increase in *E. coli*) to specific land uses and practices. That way, councils could create plan rules and consent conditions that could survive scrutiny in Environment Court. In addition, council scientists also expressed a need to better quantify the ecological effectiveness of different mitigations (see quote above). This would be different to SoE monitoring because it would be designed to quantify the before/after effect of land use and land management changes on water quality outcomes.

2.4. Summary

Understanding how council monitoring networks have been constructed and evolve provides an essential foundation for developing policies and remedies that target the right issues. The biases that exist in regional freshwater monitoring networks are multiple, but they are also not irrational; there are good scientific, regulatory, and

practical (e.g. cost) reasons for developing monitoring networks in these ways. New requirements for additional or altered monitoring practices will be layered onto these experiences of councils, so it is useful to know how and why council monitoring practices differ. Interviewees highlighted that a key issue affecting monitoring design is a lack of resources. Monitoring is one of many council functions where societal demand is increasing, and resourcing for SoE monitoring has to be balanced against many other needs for council science capacity. Councils are increasing their science capacity across the board, but this is not enough to keep pace with their obligations either nationally or locally. A key bottleneck identified in this research is the importance of the Long Term Plan process, which sees council science resourcing needs filtered through the lens of 'political feasibility' by scientists, managers, and councillors, and resulting consistently in the underfunding of science and monitoring. Furthermore, even while council scientists support and invite additional investment in monitoring, they also highlight that other tools and forms of science are needed to improve outcomes for fresh water.

3. IMPLEMENTING THE NATIONAL OBJECTIVES FRAMEWORK

> The NPS asks a lot of us, and it asks more of us than we're capable of delivering.

Since the first NPS-FM was gazetted in 2011, there now have been three revisions to the national policy—in 2014, 2017, and 2020—with each one including more requirements than the last.

The 2014 NPS-FM added the National Objectives Framework (NOF), which required councils to monitor nine attributes for all relevant waterbodies in their regions (New Zealand Government 2014). Since councils could not be reasonably expected to monitor every single river, lake, estuary or aquifer, the policy required councils to designate Freshwater Management Units (FMUs) for monitoring. FMUs could be large, amalgamated waterbodies (e.g. a large river system with multiple tributaries) or could be a class of river type (e.g. disconnected small coastal streams). Thus, councils did not have to monitor all waterbodies, but they did have to monitor all FMUs, and all waterbodies in their regions needed to be assigned to an FMU.

In 2017 changes to the NPS-FM, new requirements were brought in for *E. coli* and nutrient monitoring, and in 2020 the number of attributes requiring monitoring expanded to 22 (New Zealand Government, 2017, 2020).

During this time, in addition to expanding their freshwater monitoring networks, councils have been undertaking collaborative or consultative processes with their communities to determine freshwater objectives, setting numerical limits for compulsory attributes, and notifying plan changes (see MfE 2017; Beca Limited 2020). Many of the key challenges and issues arising with the implementation of the NPS-FM for regional councils have been described in the report by Beca (2020) and research by Kirk et al. (2020). This report focuses primarily on comments regarding how the implementation of the NPS-FM—and the NOF in particular—intersects with freshwater monitoring design and operation.

3.1. Benefits of the National Objectives Framework

Council scientists expressed wide ranging views on the NOF. On balance, comments were more critical than praising, but even several critics prefaced their criticisms with a general praise of the NOF.

> So, having the NOF: it's clear, it's current, it's got pretty good statutory teeth. I think in terms of something that's toothy and provides leverage, it's quite good. I mean, I've been doing this for 16

> years and yeah, without that sort of thing, I think you're just going to keep going around in circles.
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> I definitely am not against the NPS-FM NOF in general, there are some awesome attributes that we've got in there. I think having more focus on the biology is great, ecosystem health is great, deposited sediment is so good to have that in there. I think it is a great step forward. But… a lot of these attributes aren't there yet, are they?

Council staff highlighted the attributes of the 2020 NOF regarding ecosystem health as a particular strength, as this requires councils to now monitor fish, river metabolism, deposited sediment, and the MCI.

Several scientists said the requirement to monitor wetland extent—as required by the 2020 NPS-FM—was a significant benefit, as this would help them procure resources to undertake this task.

A scientist from a council with a major city said the requirement to monitor fish helped them understand and promote native fish conservation in urban areas:

> Spotlighting for fish in some of our urban streams has proved really, really interesting. We've had, over the last two or three years, a real strong focus on that because it felt like there was a lot that we didn't know, and it turns out that there's all sorts of native fish living up in places you wouldn't necessarily expect. They're going through all these piped streams and getting up into the headwaters, which is amazing, actually. But yeah, it took a bit of a focus for us to actually show that.

3.2. Costs of the National Objectives Framework

The most common issue raised by council staff regarding implementing the NPS-FM was cost:

> We're going to really struggle to meet what we're being asked to do with our existing resources even if we dropped existing programmes and focus solely on [implementing recent] national direction.
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> We can't do everything in the NPS, and some of it will be real token gesture stuff.

For councils, implementing the NOF means building and intensifying monitoring infrastructures for all FMU sites. This includes measuring all 22 compulsory and action plan attributes, which requires staff time, new instrumentation, sample processing, and new analytical capacities. And as one scientist highlighted regarding monitoring for dissolved oxygen, you can't just "plonk your meter to take a meter reading at that point in time, because you need the whole fluctuation over the whole day and then several weeks in the month." Thus, prior to adding instruments to existing monitoring sites, there is a need for scoping analysis and instrument calibration. Even for attributes that are already measured, new instruments are sometimes required, e.g. for new temporal frequencies of observation or for telemetric data transmission. It also means aligning monitoring processes and timing around the FMU sites to make 'efficient runs' for field sampling. Furthermore, as MfE establishes more standards for environmental monitoring through the NEMS process, that requires council resources and staff time to adjust to comply with new standards. For example, councils may need to increase their sampling frequency, or spend more field staff time at each monitoring site to collect more measurements.

For councils this requires increases in science staff, which are difficult to procure through the LTP process. A scientist from a small council said that the calculated costs of NPS-FM implementation for them "can be translated to between 20% to 40% increases in our rate paying; that's a huge amount of increase. We cannot ask the people to do that, simply." Interviewees said that one large council was increasing its science staff by a third, and that another small council was allowing for a 25% increase in science staff to cope with NPS-FM requirements. One council scientist said the scale of change needed in resourcing to deliver the NOF was "ugly" because it caused frustration within council and between council and the community, who resisted rates increases.

3.3. Freshwater Management Units

The definition of FMUs was a key source of uncertainty and frustration for several councils. The intent of the FMU concept was to allow councils to define FMUs in a way that suited their resourcing capacities and environmental conditions. Thus, for example, some councils with large river systems, such as ECan, can use entire river systems as FMUs, and measure all NOF attributes at the bottom of the system. In contrast, several small councils have opted for FMUs that are defined by broad environmental class such as 'small coastal streams'. Marlborough District Council to take another example, uses 62 'water resource units' to organise its own monitoring network, but for NPS-FM implementation it amalgamates these into six FMUs for which all NOF attributes must be measured and reported. This approach means that there are only six sites for which all 22 NOF attributes must be measured, rather than 62 sites.

The designation of FMUs has implications for both scientific understanding and for local political dynamics. One scientist said their council was using FMUs as an engagement tool to foster conversations with its community about what objectives they wanted for their waterways. Another scientist said that while their council wanted to use scientific classifications to designate FMUs, local iwi resisted the implication that two rivers were equivalent and preferred a larger number of spatially-bounded FMUs.

In terms of scientific understanding, a council could monitor a single coastal stream as if it represents a different coastal stream a large distance away. This has implications for how monitoring results can be aggregated and compared:

> every council is creating FMUs differently, which means when we all go off and measure our state and trends in the FMUs and we give that to MfE, there won't be much consistency at that national level when they combine the data.

In these ways, the FMU requirement is forcing a reprioritisation process for regional councils, who are redesigning their monitoring networks into FMU sites. This allows them to minimise the cost of implementation, and it does mean that councils will measure the same attributes in consistent ways, but because of the inconsistent use of FMUs the ability to interpret NOF information across the country will be limited without providing regional specific characteristics and context.

3.4. National Objectives Framework attributes

Several interviewees volunteered reflections on specific attributes required in the NOF that they felt they were either not biophysically relevant to their region, not practical to measure, or ill-configured to render meaningful scientific insight.

> Some of what we're being asked to do is to monitor for things that there is no clear understanding of, so that going forward collectively across the country we can have a set of information we can use to investigate things. For example, river ecosystem metabolism. … So to express back internally to our councils that we should monitor these things because nationally we want to be able to report on them in terms of environmental reporting, that's actually very hard to get that additional monitoring over the line because that's not seen as a regional priority.

Deposited sediment. Some council scientists found this attribute frustrating because, from their perspective:

- The attribute relies on classification of naturally soft- vs hard-bottomed streams, yet the policy classification of streams in several regions is well-known to be inaccurate.
- The method relies on visual observers to accurately detect a 5% difference in sediment composition, which is considered unrealistic.
- Sediment is measured monthly, yet MCI is measured annually, creating a mismatch between the measurements of the pressure-response variables and not allowing meaningful attribution of cause and effect.
- For most regions, high sediment loads come down in < 5% of flow conditions, which for some means that managing to reduce the spikes in high load conditions is more important than monitoring sediment the other 95% of the time.

Fish monitoring. This is a costly attribute to monitor as it requires qualified staff, electric fishing gear, and travel across large distances. Even though a scientist from a large council said they thought it was “a good thing” to monitor because people interact directly with fish, they “haven’t been able to convince council to invest in it” yet. Most councils that already undertake fish monitoring do so through focused studies that look at impacts of specific structures (e.g. dams, fish passage) or discharges (e.g. wastewater). A scientist from a council that was cited by others as having a good level of existing fish monitoring said that the fish Index of Biological Integrity (IBI) protocol enshrined in the NOF “has got some real problems” and “we just don’t have the resources for monitoring that properly, to get a fish IBI for our region.” Other scientists felt the fish attribute was underspecified:

> it says you’re supposed to be electric fishing your rivers annually, but how do you set up a monitoring network that’s representative of the region? It’s a bit of a tricky one: it could be quite intensive or it could be… you just pick a bare bones type approach and try and get that. But then is that going to be useful, is it going to tell you what’s actually going on?

Macroinvertebrates. Council staff generally agree that the MCI is a useful attribute, though they differ on its status as a regulatory attribute, and there is scepticism about the new methods required to monitor the MCI. Before the 2020 NPS-FM, councils who measured MCI often used a *relative* count of different bug species within a small sample, to indicate the composition of invertebrate communities. With the 2020 NPS-FM, absolute counts are now required for a sample of 200 bugs, which increases the labour and analytical costs. One council scientist cited a conversation with a national expert in MCI methods, relating that:

> it doesn’t actually tell you any more information, but it does provide robust statistical information that scientists can make some other judgements and write papers about. It just seems … that council is

> being forced to spend more money on collecting some of this information and using a different method and it's not actually going to help on the ground.

For other council scientists, while the MCI was interesting and valuable to know, it was not clear how councils could create improvement in those scores through plan policies, rules and consent conditions. For example, one council scientist said that:

> even in our most pristine sites we don't have an MCI above 130.… [I]t might be that our reference sites aren't as good as we thought they were, or it might be that they're cold flashy glacial streams so you just don't expect high diversity.

For these reasons, the MCI might provide an indicator of the state of the environment, but its utility for driving change in land use practices remains unclear.

Dissolved oxygen. This attribute was welcomed by some, though it was considered as an attribute that is more meaningful for some environments more than others. Or for some regions, as this scientist explains, dissolved oxygen (DO) monitoring is considered to be a significant expense that doesn't add value back to the local community:

> Our rivers are short, fast flowing, turbulent. We are always going to get basically saturation. We don't have long stretches of rivers… which become stagnant, so why do we have to measure DO when we know the answer is always going to be give or take a few percent at saturation? Yet the NPS requires us to do it.

Periphyton – chlorophyll-*a*. Chlorophyll-*a* was added in the NPS-FM 2020 to improve upon relying on visual assessments of periphyton to measure algae productivity in waterways. However, this council staff highlighted a trade-off that they saw with the change:

> the chlorophyll-*a* attribute is hugely expensive because of the lab costs and how the scraping takes a lot of time. Whereas the periphyton cover, the visuals, you can do sediment at the same time, it's very quick and it informs values better than chlorophyll-*a*. You can actually communicate periphyton cover and proportion much better to the community, saying "30% cover is our threshold for recreation," or "50% is the threshold for ecosystem health." It just makes more sense for them. Apart from that, it is more efficient and cheaper. We can do it more sites. We do it [at] all sites, whereas chlorophyll-a is just a few new sites because we just can't put that into the budget. So things like those, you know, they're the trade-offs.

Another scientist expressed that since periphyton mainly appears during the summer period:

> That's when people are going to get excited or upset about it, and that's when we know we are winning or losing the battle with periphyton. What's the point of doing sampling or monitoring when you know there's no issue? Why can't we just carry on targeting it to the worst-case scenario?

Phosphorus and *E. coli*. Council scientists highlighted that that natural background levels for dissolved reactive phosphorus and for *E. coli* varied significantly across regions, which makes it difficult to attribute failing scores for these attributes to particular land uses. For example:

> one of our sites has a massive gull colony on it, so it will in perpetuity have *E.coli* from now until forever. But we still monitor *E.coli* there because we need to report it for the NPS, and then there's an asterisk on that site that says "hey look, this is a colony of nationally endangered gulls, we're not going to fix this and we don't intend to." And what does happen a little bit is, with things like that you're just diverting money away from other things that you could be monitoring that might be more useful.

Submerged plants. The 2020 NPS-FM attribute for submerged plants (invasive species) requires visual estimates of the degree of impact of invasive weeds in lakes. For some councils this is a significantly costly requirement and two scientists said their councils have no plans to implement this attribute. One scientist highlighted that the different regulatory grades for this are large: the C band goes from 25–90%, meaning that "you could see your number of invasive plants increase dramatically but you're still in the C band. Effectively you've kept the lake in that same condition; it's obviously degrading, but it's still in the C band."

3.5. Summary

Councils have been struggling with various aspects of implementing the NOF. By far the most significant overall issue is the lack of science capacity and resourcing of regional councils. On top of that, and what this research draws into focus, is that this challenge is intensified when major aspects of the policy are vaguely defined (e.g. spatial applicability of fish monitoring, definition of FMUs) and when council staff feel like they have to spend their own organisational capital to fund new monitoring requirements that often to do not feel directly applicable to the region. The trialling of NOF attribute assessment methods reveals how challenging it will be to interpret these attributes in a regulatory setting (e.g. chlorophyll-a). When it is felt that some

NOF attributes are not relevant to a region's specific ecology and land use pressures, it is not surprising that some councils have no plans to implement several attributes required by the NOF.

4. LAND AIR WATER AOTEAROA

Land Air Water Aotearoa (LAWA) is a cross-council data sharing initiative and website platform that provides public access to regional council environmental monitoring data (lawa.org.nz). LAWA uses an interactive map interface to allow members of the public to identify waterbodies for which monitoring data exist, and then LAWA displays that data in a simple way for a lay audience. LAWA thus provides a direct mechanism for the public to access and interpret freshwater monitoring information in a nationally consistent way.

LAWA relies upon regional councils to clean and submit their data in a consistent format, and includes data only for which there is a record of 5 years or more. LAWA was created in the 2010s by council and research scientists, leveraging on philanthropic funds from the Tindall Foundation. It is currently governed by regional councils and funded by regional councils' donations and staff time. MfE had historically been involved in LAWA steering group conversations, but this stopped for a period of time and has now resumed.

Most council scientist interviewees offered reflections on LAWA. Some had deep experience with LAWA whereas some had only arm's length involvement. Here, the report focuses on key uses and benefits of LAWA, limitations, and reflections on governance and resourcing.

4.1. Uses and benefits of LAWA

LAWA was described by interviewees as "a fantastic idea" and "a great tool" that allows people to compare their waterways to others across the country. Several scientists highlighted the "can I swim here?" function as particularly useful, and one that they often directed members of the public to.

More broadly, council scientists said LAWA helps to deliver value back to the community in several ways:

- By increasing the profile of freshwater monitoring data and results, LAWA helps to build the business case for investment in freshwater monitoring.
- By requiring consistent data inputs through a shared server, LAWA has driven consistency in monitoring and reporting methods and formats across the regional council sector.
- For smaller councils who cannot afford to create their own web platforms, they rely on LAWA to provide their communities with access to their monitoring data.
- By having analysis conducted by research scientists, LAWA is considered to benefit from being independent of local and central government.

- By using LAWA data for scientific analysis, councils have an incentive to put their data into LAWA so that such analyses can benefit from their most recent local data.

4.2. Limitations

While council staff generally praised the intent and overall realisation of LAWA, they also identified limitations to LAWA in its current form as a science communication tool.

A key limitation of LAWA is that its data presentation gives the impression that water quality monitoring sites are equally representative of all waterbodies. For example, upon clicking a water quality monitoring site for a river, LAWA will display

- the numerical 5-year medians of available parameters
- indicate the quartile in which each parameter median sits (e.g. top 25% of sites nationally)
- the regulatory grade of that attribute (e.g. 'A band')
- the 10-year trend for that variable (e.g. 'likely improving').

By saying that a given water quality site is in the 'top 25%' of all sites for nitrate, for example, this gives the impression that each site is as representative of New Zealand's waterways as any other site. In fact, monitoring sites can be co-located on the same rivers, and many rivers have no monitoring sites at all. As these council scientists explain:

> actually displaying the information and saying you're in the top 25% of sites… It doesn't actually help a landowner or a person on the ground saying "yeah, top 25% of sites," but does that mean that everything is good, everything is bad? … There's no reference point associated with it.
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> One of my concerns with the likes of LAWA is that it just bundles everything together. Most council monitoring networks aren't necessarily designed to give a representative view of the region as a whole if you chuck everything all in together. … I do feel slightly uneasy with the ability to compare this region versus this region when you're not necessarily comparing like with like. That makes me slightly uncomfortable.

For these reasons, LAWA is "still not something that we would just put all of our data up to there and say "'here, go at it' sort of thing."

The way LAWA reports trends as e.g. ‘likely improving’ or ‘very likely degrading’ was also highlighted as lacking interpretive depth. Council scientists said that while this designation can convey the likelihood of a statistical trend, it does not convey the size or ecological meaningfulness of that trend. A situation that is ‘highly likely improving’ could reflect many measurements of a small, ecologically insignificant change, for example, whereas a situation with a large improvement in ecological condition could be ‘indeterminate’ if there are not as many measurements of that positive change.

Furthermore, council scientists reflected that the local ecological context was very important to understanding trends, but this has yet to be incorporated into LAWA’s presentation of data.

> The whole thing of little arrows going up and going down, that’s providing effectively data but no interpretation of that data. So, sometimes I have… according to LAWA, a strong negative trend of MCI scores in a native bush site. What does that mean? Are we worried about it? Oh it’s probably climatic isn’t it, but LAWA just has an arrow going down: “probable negative trend.” Well it’s native bush; where’s the interpretation guys? I’m worried that they’re providing information as just data with very little big picture interpretation of what it means. And people are going to get hold of it and get confused and use it incorrectly.

The data requirements for LAWA were also cited as a limitation to LAWA’s wider use and utility. For data to be included in LAWA, it must be standardised to meet specified formatting requirements. On the one hand, these requirements have driven efforts by councils toward harmonising their data formatting and storage practices, so that cross-council sharing of data can occur. On the other hand, however, adjusting regional council databases to comply with LAWA standards is also costly and, in some cases, not considered worth it. One scientist, for example, said that their council’s attempts to develop a water accounting data framework that was compatible with LAWA was too difficult. For water accounting, councils need to compile consents information from across their regions, and this information is so variable in format that it is prohibitively costly to translate into LAWA specifications.

In addition to LAWA data standards providing a barrier for certain types of evidence, councils have also found that LAWA data standards have created arbitrary gaps in their existing data. For example, LAWA uses calendar years (January to December) for analysis, rather than hydrological years (October to September). This means that if a council measures water quality in November 2016 (2017 hydrological year) and February 2018 (2018 hydrological year), it contains a consistent record from a hydrological perspective but appears to be ‘missing’ 2017 observations from an annual calendar year perspective.

4.3. Governance and resourcing

Council scientists reflected a broadly consistent view on how they thought LAWA should be resourced and governed. Currently, LAWA is funded by individual council contributions, with some support funding from MfE. For its benefits, and despite its limitations, council scientists see value in LAWA and think it needs much more resourcing to scale up.

> As people have seen the vision and started trying to expand what LAWA does, we're realising that in the real world things take money to set up and to establish and to maintain.
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> LAWA is taking us a long way forward, and I think that that's a model that we just need to put more resources into.
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> I'm just of the opinion that if the appropriate resources were provided, that could be amazing thing. I'm not saying that it's not good, I think it's great. For such a small country, I think it's an amazing tool, an amazing thing that has been pushed on and on by the regional sector.
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> There's a huge amount of work that's gone into getting LAWA to [get it] where it is; it's a lot of work for councils at the moment. And the format that it's in, it isn't appropriately funded. If it is going to be the place where this data is going to be supported, or the seed for a national reporting system, it needs to be properly funded centrally, not just by regional councils… [LAWA] are really struggling to make headway on things because they just don't have the budget. There's some great ideas, really clued-up people, it's got loads and loads of potential, it just doesn't have the funding behind it to get to that next step. … It needs a lot more centralised integration, structured funding programme, a project office, something like that.

Council staff were also clear that they thought MfE should provide this funding:

> I think LAWA is a really great initiative that was born out of regional councils' desire to share nationally consistent data, and it has been partially funded and somewhat supported by the Ministry for the Environment. But basically what LAWA is trying to do really is… it's regional councils trying to do a job that is actually the Ministry for the Environment's job, to do that centralised function.

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> Yes, it's been funded partially by MfE but I would have thought that it's in the best interests of central government to actually support those things to the highest level and long term, this is what you want.

But while council staff thought central government should fund LAWA, they also said it was important that decision-making about LAWA be driven by regional councils. They said that a key strength of LAWA's credibility in both the regional sector and in the general public was that it was responsive to councils' needs and run by independent scientists.

> I think it really also needs to maintain the buy-in of regional councils. So if something like LAWA was taken over by say Ministry for the Environment, I think you would potentially lose a lot of confidence and buy-in from regional councils. I think it really needs to have a strong basis in the regional sector but I don't know, I'm not sure how you put it. For MfE to be a partner in it but to allow regional councils to largely own and drive and set objectives for it.

4.4. Summary

LAWA is a regional council-led initiative that is providing benefit to regional communities and the wider New Zealand public. Council ownership of and investment into LAWA has driven harmonisation in data collection and storage practices across councils, enabling sharing of information and inter-regional comparison. A key limitation of LAWA is in how it treats all monitoring sites as equally representative of all waterbodies, and in how it reports temporal trends. Councils see significant potential in LAWA but see a bottleneck in terms of the resources available to address these limitations and pursue other opportunities. Council scientists see MfE as a major beneficiary of LAWA and hope that central government will support LAWA more substantially into the future, while letting LAWA remain independent and responsive to councils' needs.

5. KEY PRIORITIES IN FRESHWATER MONITORING SCIENCE

Council scientists identified several priority topics for investment into new monitoring science and infrastructure. Some topics help with implementing the NOF, whereas others help with different regulatory functions (such as issuing consents). Here, five major frontiers in monitoring are distilled.

5.1. Impact monitoring

Quantifying the ecological impacts of specific land uses and mitigations was identified as a major frontier for council science that continues to need investment. In addition to understanding the state of the environment for their region's waterways, councils also need clear evidence about the ecological impacts of specific land use practices or mitigations. Several council scientists explain:

> There's definitely a lot of room for improvement at the moment in terms of linking trends in particular to actions. I mean, we have a fairly well-established pattern both regionally and nationally… that broad-scale land cover has very clear impact on water quality state. But you don't see those same clear-cut patterns in terms of trends. You'll have some monitored sites going up and going down, a lot of conflicting things going on that make it a bit more difficult to try to tease that part into "ok, definitely we need to be doing this in this environment." So, getting the more detailed understanding of pressures is really an important point to be able to then link it to those "ok, what do we need to do next? What are the actions to turn this around?"
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> We're at a stage now where we're looking to take all of that monitoring data that we've collected for years and years and move to a more solutions-based approached based on actually making that information work for us and trying to figure out what are the mitigations that need to take place.
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> We plan these actions, and then we don't look back and say "ok, in the last ten years, how have we achieved those actions, how can we evaluate them?" That comes back to section 32 reporting. Another part of council, not us, does that in terms of plan effectiveness. You know: are we achieving the outcomes we set out to achieve by the rules?

In addition to quantifying the impacts of specific land uses or mitigation actions, there is also an outstanding need to identify the source of water quality issues within specific catchments. For example, *E. coli* and phosphorus tend to come from critical source areas, such as feeding troughs or cattle crossings which both concentrate animals and loosen up sediment. Councils need to 'fingerprint' the source of contaminants so that critical source areas can be identified and remedial actions undertaken. This is why most councils have some resources and staff time dedicated to roaming investigations of specific issues across their regions. However, as SoE requirements ramp up and require more budget and staff time, this pulls resources away from catchment-based investigations, despite the ongoing need for such investigations. As one council scientist says, "We need to be allowing more resources for that sort of investigation and not just think 'oh SoE is the be all and end all,' because it's not."

The community demand for catchment-specific knowledge is also increasing:

> people are saying things like "look, I've done all this work on my farm, or our five farms on this bit of the catchment: what impact has that made?" And we might or might not even have a monitoring site on that catchment. Because what we have tried to do is go "well, our hill-fed streams are in *this* condition, or our spring-fed streams are in *this* condition," rather than "your individual stream X is responding in this way to the intervention that you're making." We're getting more and more questioning around that [but] we can't generally get to that level, unless you just happen to be on a stream that we are monitoring.

5.2. Community monitoring

Interviewees from seven councils explicitly identified community monitoring as a key area of current investment and further need for them. Community monitoring or 'citizen science' refers to when members of the local community collect their own observations of freshwater ecosystems, generally using templates and measuring equipment that have been developed by trained scientists. Council scientists reported that initiatives like this were happening across their regions and across the country.

Several benefits of community monitoring were identified. One is that community monitoring at the catchment-scale can generate finer-grained information about ecological change, at scales that are relevant to understanding the effects of changing land use practices in specific catchments.

> The citizen science approach lends itself really well to what I mentioned a while ago about… "on my farm or on these five farms

> we've done in this little stream: what's the impact of it?" It's flexible, it allows people to go out and measure it themselves. … [C]itizen science offers a real opportunity to get a much better spatial extent.

In addition to the added value from higher-resolution data, community monitoring also helps build shared understanding of the local environment and issues it faces.

> The real value of it is that it involves people who are wanting to make change and able to see that change. And it's not relying on us to do it!

One scientist said that while citizen science produces relatively low value scientific information, "in terms of engagement it's valuable."

More broadly, some council scientists think community monitoring could help contribute to a much richer SoE picture for the region.

> I think in the past we've perhaps often used citizen science as a kind of engagement and awareness raising tool, whereas actually, you know, some really cool and useful data can be collected.

For councils facing re-organising their monitoring sites, there is also hope that community groups may be able to continue monitoring where official SoE monitoring sites have to be moved.

> One realistic thing on that is, for example, we are currently right in a middle of environmental monitoring network review. There will be a number of sites that we will be dropping, and I've already heard – and for very good reasons – some questions being raised and saying "well could those sites be picked up by community groups?" and in my head I go like "yeah, of course, why not?"

However, while council scientists largely applaud community monitoring, they also highlight that there are tensions around expanding it and connecting it with council programmes, and they emphasise that supporting it requires proactive investment and action by councils.

One tension is that while community monitoring can provide high resolution information to potentially inform policy making, there needs to be quality assurance processes put in place so that Environment Court and planning commissioners will be able to recognise community monitoring as valid and robust evidence.

> The problem that we have as a regional council is that then people will start citing these data and saying "ok, you should be including this in your analysis of state of the environment" or something like that. We're always a lot more wary at that point, because we're concerned about quality control and quantity assurance. … The problem we always have is: how accurate is it, how well trained are these people who are doing it, what sort of equipment are they using, is it really meaningful data?

To address this, one scientist suggested that citizen science groups could input their data into Hilltop—a shared regional council server for hosting environmental data. Another scientist suggested that using appropriate observational technologies could provide confidence for councils:

> technology now creates also a huge opportunity for community members to be involved because you know, you don't have to worry about some highly complicated laboratory analysis that lies behind grabbing a bottle of water out of a river. You can actually do something in the river itself and measure it with this new technology that gives you a very reliable answer.

Perhaps the largest tension is that supporting community monitoring is a resource-intensive activity. If councils are to provide shared infrastructure, that requires staff time and funding. Sometimes councils are invited to present water quality science to catchment or community groups, and sometimes councils are asked to provide science advice in the design and interpretation of data, all of which require staff time and capacity. One council scientist distilled it this way:

> [I'd love to] set up a really good citizen science, catchment science-based approach, [and] use it to empower the community to do monitoring. … But that takes training, and time, and cups of tea and resources we don't have.

5.3. Modelling

> What do you measure, what do you model? Because you know, measurement in the field is not the only way, and sometimes it's not the most appropriate way to collect information about the state of the environment.

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> the use of models [is] probably the other thing that we're looking at. Again, it's partly getting people used to the idea that

> a dot on a map where you monitor once a month is no more an extrapolation of the real world than a model is. So actually, the use of modelled information is probably going to be more prevalent in the future.

Councils are increasingly turning to modelling as a complement—and in some cases, alternative—to direct freshwater monitoring. As the above quotes highlight, some aspects of the environment aren't suitable to knowing through field sampling. An illustration of this is *E. coli*:

> Because say if my team go out sampling on a Monday to a site, they collect the water on a Monday, it gets to the lab in [named area] on a Tuesday and has the result on a Wednesday evening. So [we] probably get the result on a Thursday because it automatically feeds back into our network. [Since it] needs to go through the curation, we might find out on Thursday afternoon and ideally we know before Friday. So we send an email out and we put it in the newspaper for the weekend. So: we are notifying people on a Friday of what it was like at 10am on Monday morning.
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> I guess it's thinking about… what do people actually want to make decisions about? If they want to say "is it safe to swim here?" they don't want to know what the water quality was like last week, two weeks ago; they want to have a sense of what's it likely to be today, and can I get in.

To provide information about *E. coli* to members of the public within a time frame that they can act on, relying on immediate field observations simply is not viable. Instead, Auckland Council's SafeSwim programme draws on historical data to calibrate its assumptions and then predicts what *E. coli* will be in different places, depending on the timing and size of recent rain events. Over time, the model can be updated with more historical information and its predictions can be tuned to better align with the historical record.

The rationale for modelling extends beyond *E. coli* as well. Attributes like sediment and nitrates can also be modelled, with varying levels of accuracy and precision. For some councils facing the triage of scarce resources, there is discussion about "whether we've got enough [sites] in some areas to stop actually monitoring and start modelling some sites instead."

5.4. Remote sensing

Use of remote sensing technologies—such as satellite imagery, or drones—is becoming increasingly economically viable for councils. Council scientists spotlighted several frontiers where strategic investment in remote sensing is poised to make their jobs cheaper, easier, or more effective.

Remote sensing promises a 'bird's eye' view of the environment that can help gain a synoptic view of a much larger area than field staff could cover themselves visually. Several interviewees cited toxic cyanobacteria as something that remote sensing technologies could assist with monitoring in a more comprehensive way than field sampling can achieve. Normally, with conventional monitoring, "we set our places that we go back to every month," but:

> What you really need to do with cyanobacteria is survey rivers and see where it is in the river. So it's more of a survey technique rather than a rigid monitoring network where you come back and say it's here or it's not. Because the problem being, and we recognise this, is that "yes it's not here, but it might be 200m upstream" and we're not capturing that in any way. … I think things have changed a lot in that space. We recognise that our form of monitoring wouldn't really provide the information you really need.
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> As part of our recreational water quality programme we've been monitoring toxic algae, but we're using drone technology now to try and identify how far and how extensive spread of toxic algae is. So I guess… it's not really monitoring anything different, but it's a different methodology I suppose.

For small councils in particular, remote sensing developments promise the ability to observe large areas, as well as environments for which there exist no monitoring data:

> I'm looking long and hard at a type of spatial analysis of imagery from satellites or drones, which seems to be starting to offer all sorts of exciting possibilities about monitoring in ways that we never thought of before… [Y]ou know, instantaneous, continuous [observations] across the entire landscape, rather than having to go out to one stream somewhere and take one glass of water and pretend it's meaningful in terms of regional representation.
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> Collecting the satellite data and then working with that… to give a picture of: how much wetland we have got in our region? How are we

> really managing our farms in terms of grazing? Are we grazing it in the wintertime, …are we following the best practices, and how [is] our water quality… doing in different lakes where we have got only a few lakes to monitor? Can we harness that for each data source that we can get from the satellite data? Can we use this to show the water quality elsewhere in our region in terms of the lakes or rivers or estuaries?

One council scientist was excited about prospects for using remote sensing to detect wetlands and feed back into the consenting process in an automated way:

> I think we really need to get smart around this with GIS systems. I mean, we've got artificial intelligence now that can read an image and see that certain pixels within a polygon that's marked as a wetland, and they can see that those pixels have turned from… green… to a subsoil brown or whatever. And you could say "ok, send an automated email to our compliance team that there could be some earthworks in a wetland or within the buffer around that wetland." … That would be a serious advancement in terms of our ability to stop wetland loss in our region.

5.5. Environmental DNA

Recent developments in the science of environmental DNA are also poised to be a "game changer" for councils' ability to monitor fish and life in their freshwaters. In essence, environmental DNA approaches involve taking water samples from, for example, a site at the bottom of a stream, and then analysing the DNA in those samples. By comparing the DNA present in the sample with a database of known DNA signatures, it is possible to produce—fairly quickly, and at increasingly affordable cost—a list of species that live in the catchment upstream. However, there is presently considerable uncertainty around the accuracy and robustness of current eDNA detection methodologies.

For councils who are now required to monitor fish as part of the 2020 NPS-FM, the rise of eDNA approaches presents a cost-effective way of gaining wide spatial coverage for understanding what fish live in regional waterbodies.

> Another big exciting one is eDNA which is really starting to just be I think at the start of something incredibly exciting for New Zealand in terms of being able to assess anything and everything that's there. Especially if we can start pushing that into abundance measures as well as just protection measures; that is just going to be just a game

> changer in terms of actually knowing what our streams are supporting in terms of health and wellbeing.

Another council scientist elaborated a more specific vision of eDNA technology:

> I think eDNA could be a huge, huge game changer for us as a council, to help us try and implement some of the NPS. Like for example, we now have to be responsible for the habitats of endangered species according to the NPS, and luckily for us, we've only got two in our region, short-jawed kōkopu and lamprey. But we don't know where the hell they are, and that's where eDNA and these new technologies [come in]… So we try to embrace this new technology. I just hope that the scientific community and more importantly, the regulators can keep up to speed with that and start to embrace it as well. Because if we've got to do fish work, as I said, we can't afford to go and monitor fish communities. But if we can take a water sample and get a species list, can we use that for a fish IBI? To me this is incredibly exciting technology and something I'd like to see embraced more and more and more.

5.6. Summary

Impact monitoring, community monitoring, modelling, remote sensing, and environmental DNA approaches are some of the technological and relational frontiers that extend beyond the status quo of SoE monitoring. For some frontiers, like eDNA and remote sensing, development of these new technologies can help councils to monitor existing attributes with lower cost and greater spatial and temporal coverage than before. For other frontiers, like modelling, there is a potential to generate more relevant knowledge (such as timely *E. coli* projections) for the general public than is possible given current monitoring and sample processing technologies. Impact monitoring, perhaps a long mainstay of council science, endures as a key priority that continues to require investment. Summarising these frontiers here highlights that multiple councils still have needs in these areas, and this suggests that there could be value in 'banding together' to make investments that can benefit many councils. Given that all councils are reallocating scarce resources to comply with the NPS-FM, these scientific frontiers may have resources sapped away. This shortfall could be covered and perhaps reinforced and expanded by central government, as these technologies will benefit all councils' ability to implement the NPS-FM at a lower cost, and in a more systematic manner.

6. CULTURAL MONITORING

Cultural monitoring refers to Indigenous peoples' practices of systematic environmental observation and sensemaking (see Tadaki et al. 2022). In Aotearoa and globally, Indigenous people have developed environmental observation methods that are built out of Indigenous world views and apply to domains as diverse as forests, soils and fresh water. Aotearoa has seen the rise of many such cultural monitoring methods in the freshwater domain (see Rainforth & Harmsworth 2019).

The 2020 NPS-FM has several new requirements for regional councils to support and include mātauranga and cultural methods of monitoring freshwaters (New Zealand Government 2020). These requirements are that:

- 'Every council must… enable the application of a diversity of systems of values and knowledge, such as mātauranga Māori, to the management of fresh water' (section 3.2)
- 'Every local authority must actively involve tangata whenua (to the extent they wish to be involved) in freshwater management… including in… developing and implementing mātauranga Māori and other monitoring.' (section 3.4)
- 'Every regional council must establish methods for monitoring progress towards achieving target attributes states and environmental outcomes. The methods must include measures of… mātauranga Māori.' (section 3.18)

In essence, the NPS-FM requires councils to explicitly hear and support the aspirations of tangata whenua to apply Indigenous knowledge toward monitoring freshwater outcomes. The clearest prescription is laid out in Section 3.18, that councils must establish 'methods for monitoring progress… [that] must include measures of mātauranga Māori.'

6.1. Initial ambiguities

While council scientists overall conveyed a sense of quiet confidence about their councils' approach to implementing these new requirements, they also identified points of confusion and uncertainty:

> What we are not monitoring well is mātauranga Māori. We've never been asked to do that before through the statutory regulatory regime. We can speculate whether we should have been doing it previously and listening to our iwi more than we have, [but we] acknowledge that we need to get into that space far more now than we ever have as a council. We were moving that way as a council even before the 2020 NPS freshwater attributes came out and starting requiring us to get into that space. We find it fascinating and frustrating in equal

> measures that the NPS does not actually explain what Mātauranga Māori is, or mahinga kai. It basically says “go and do it” and we are all looking at each other saying “yeah? Go and do *what*?”

For one scientist’s council, a key uncertainty was around what mātauranga Māori means for the existing monitoring network:

> Particularly with all the national reform saying that we should be looking at the mauri and the health of the river. [We are] really wanting to develop some relationships and understanding… what that means and what practical additions or add-on’s to our monitoring programme could…what form that could take.

For others, questions arise around how to prioritise scarce resources for cultural monitoring in places where there are multiple iwi and different interest and capacity to engage:

> it’s a really challenging area because it’s not actually clear what’s being asked in the NPS other than the word mātauranga, do you know what I mean? So it’s not really specified what level and how often and by who, and *by who* is the really critical question. … In this rohe there are… [number] iwi groups, and some will have an interest in doing it, some may not be resourced to do it, so may not want to do it or see it as a priority here.

6.2. Council-iwi relationship contexts

Strong and positive relationships between councils and local iwi were considered essential to implementing the new requirements. However, council staff readily identified that these relationships differ across space, and that they are uneven even within council.

Placing cultural monitoring within the wider context about co-governance and building the mana [prestige] of iwi partners, council scientists set the scene like this:

> In terms of iwi groups themselves, [it’s about] trying to work out “what this is meant to mean?” and also trying to integrate that with what they want to find out for themselves anyway. So that’s really the big area of discussion, negotiation, reflection, refining for the next few years for us.

> it’s got to be a two-way thing. You can’t just go along to iwi and say “oh, we’re doing cultural monitoring for you, and this is what we’re

> going to measure." You've actually got to go along and say "how can we help you understand what's happening to your resources?" and it's got to be done in a co-design sort of way.

However, the ability of councils and iwi to have frank conversations about these needs differs across the country. Councils are in various states of engagement with their local iwi for freshwater planning, and these relationships vary from strong to weak, positive to negative.

> we've got a lot of iwi groups, and when we consult with iwi, that's even more… slower and contentious… [I]t's challenging, aye.

Some councils have substantive Māori involvement in decision-making structures already, whereas in other areas, council capacity as well as iwi capacity are limited, and relationships between them can be weak. Thus both small and larger councils reported hiring new Māori engagement staff, intended to add capacity between the science teams and local iwi.

In some places, councils already have relationships with iwi relating to monitoring. One council, for example, already contracts a local iwi to undertake recreational water quality monitoring of waterways, and they see cultural monitoring as a logical further step that they can take with that relationship. Another council had recently worked with iwi on cultural mapping, and they thought this work could be extended through mātauranga monitoring to link into how council issues consents in its planning processes. Yet another council had employed iwi members to help undertake sampling for fish in an estuary, which led to a wider collaboration between iwi and the council on cultural assessment for wetlands and fish passage.

However, while building positive relationships between councils and iwi is possible, it is also complicated:

> I work a lot with iwi here, and [we have] a really beautiful relationship built on trust and respect, while then another part of the organisation is in court with the same people, arguing in the Environment Court with lawyers tearing shreds off staff… lawyers pulling us to pieces. It's very bruising on people.

Even interviewees that cited having strong Māori engagement teams in their councils said they experienced difficulty with advancing conversations about mātauranga Māori cultural monitoring.

Council capability with respect to tikanga Māori, mātauranga Māori, and Te Ao Māori is also variable:

> We've all got our ideas on what we think it looks like, but we don't have anyone….we've got a couple of people in our policy team who are our iwi liaison people, but two people is not enough for a region this size, and we don't have anybody really skilled up within our team in that cultural space as to what types of things people want us to be doing and how we want to engage, that kind of thing.

In addition to employing new Māori engagement staff, several councils and their science teams are working to upskill in their understanding of appropriate uses of and needs for cultural monitoring approaches. Scientists from several councils reported that science staff were being trained by iwi on how to understand and interpret specific cultural monitoring methods, such as the Mauri Compass. Someone from a large council reported a council-wide push to upskill their science staff in the knowledge of the Treaty, te reo Māori, and tikanga.

6.3. State of Environment and cultural monitoring as different types of knowledge

Several council scientists expressed concern that the NPS-FM requirements applied a western science frame around cultural monitoring, which they considered a fundamentally different type of knowledge. This concern was also expressed by Māori cultural monitoring practitioners in interviews as part of the wider research project (see Tadaki et al. 2022).

The requirements to 'establish methods for monitoring progress towards achieving target attributes states and environmental outcomes… [including] measures of… mātauranga Māori' for some implied that mātauranga can—and must—take the form of measurable attributes that can be plotted over time like other SoE data.

In contrast, several interviewees reflected that a qualitative understanding of mātauranga Māori is more appropriate:

> Things like mahinga kai, we're talking about… "what did the experience mean to you?" And "was that what it should have been?" Or "was that not what it should have been?" And so we're into almost social science type areas, instead of using my area of expertise.

> The way I refer to it is, using mātauranga to monitor "are we reaching the objectives we've set out to achieve?" So generally it's about improvement and using a mātauranga approach to measure that…. it's not about us going out and monitoring, it's about using the knowledge that's there to report back in, to sit alongside our

> ecological and water quality monitoring and flow assessments and things, to say “are we getting where we need to be?”
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> I remember this conversation with [iwi] around [named areas], where we were saying “well look we’ve been measuring bugs and nutrients in these waters for a long time and you know, there’s no trend of decline,” and they’re saying “but our shellfish beds have gone.” And they said “and look, there’s a sewage discharge over there,” and we’ve said “oh yes, but that’s highly treated that sewage,” and you know, “blah de blah.” In actual fact, what had killed this resource for Māori was the huge inputs of sediment that had come into those harbours when the catchments were deforested in the 19th century. So [we were] talking past each other, I suppose, and not recognising the value and importance of that community knowledge and understanding of their resource. Because there is actually an important historical perspective that we didn’t have; we were measuring things that weren’t important to them.

Council scientists explicitly identified a tension between SoE and cultural monitoring approaches:

> as a rule, it’s a tricky area that requires a bit of conversation, a bit of navigation, and a bit of understanding and respecting te ao Māori, as opposed to placing a western lens on their knowledge and trying to claim knowledge as our own for reporting reasons.
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> The question goes in many ways: are we supposed to take anything up into our SoE monitoring programme that satisfies mātauranga Māori/Te Mana o te Wai needs, or can we report together what we assess separately? Or do we even report separately? There are many ways to start, but I think there are still too few constructive ideas how to do both SoE and cultural monitoring. There are some local concepts, but that doesn’t mean it fits the needs of the neighbouring marae, so the spatial applicability becomes a problem. We have one national/regional dataset for SoE monitoring, we all report on the same core attributes: how does it work if we have a mosaic of different aspects for each catchment, sub-catchment, along main stems? Who is going to manage the data and distribute resources for this, and how can you report on state [of the environment]?

Although the NPS-FM designates councils as responsible for establishing methods for monitoring progress toward freshwater objectives, council staff were clear in their

understanding that cultural monitoring needs to be undertaken by iwi and that it is council's role to support them. As these scientists summarised:

> I don't think we 'western' scientists should own the cultural monitoring, this should be tangata whenua-led."

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> We're a group of Pākeha scientists who can't possibly understand. We can learn and work alongside, but we can't be the one to lead it, it's not right.

However, for that to happen, in addition to having enabling relationship contexts, there needs to be sufficient resourcing and capacity for iwi to drive the monitoring conversation.

6.4. Resourcing for cultural monitoring

Although some councils are hiring new Māori engagement staff, iwi across the country remain extremely under-resourced in terms of qualified staff, labour time, and funding to meaningfully engage with freshwater planning processes (Waitangi Tribunal 2019). Furthermore, increasing council staff is not the same thing as enhancing the skills and available labour and time within iwi and hapū. Iwi/hapū need technically qualified staff of their own, and only rarely do they have the ability to fund them.

These two scientists reflected on how the lack of capacity for Māori to engage with council hinders their ability to progress cultural monitoring:

> where we've started to have some really good conversations is where there's a paid person, and quite often it's been through… some kind of central government fund. But it's only ever been for a fixed term period of time. You end up developing a really good relationship with the person and understanding what it is, but then you always know there's an end date, it's not ongoing. I think that person becomes really important. Quite often they're the volunteer that's unpaid to begin with, but then they find that there's a resource there for a certain amount of time but then that stops but then they just keep volunteering but they've got a day to day job. So just everything slows down a lot.

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> We are trying to put some money forward to allow iwi to engage with us more readily, but on the whole, I think lack of resourcing is going to be a big issue for them. You know, you're asking them to travel to

> meetings and provide their time free of charge, that is going to go down like a cup of cold sick basically. So… [it] can't be expected, it's not realistic.

Interviewees broadly agreed that it is not realistic nor fair to have a system that relies on voluntary contributions of time and knowledge from tangata whenua for environmental management. Further, some said that it should be central government's role to step and help address the issue in a significant way:

> it's not good enough to simply say MfE want it, therefore regional councils have to pay for it. There needs to be a much more reasonable analysis there. And similarly iwi are right to say "just because we now have settlement money, that doesn't mean we should be spending it on monitoring the rivers which has a wider value, and why should we be responsible for discovering which rivers are degraded. Isn't it someone else's responsibility?"
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> There needs to be such a massive investment by the government in that space for iwi, and to trust iwi to do that investment themselves and to train the right people and respect the knowledge.

6.5. Summary

Despite finding the requirements for cultural monitoring in the NPS-FM vague, councils are proceeding in earnest in building relationships with tangata whenua. The specific opportunities for cultural monitoring across the regions are diverse and unique to each place. Cultural monitoring initiatives need to be understood and evaluated within the wider context of Treaty partnership and shared decision making about the environment. Council-iwi relationships are different even across different parts of the same council, and often it is specific individuals in both councils and iwi that allow relationships to be developed in durable ways. A key challenge for council staff is that the NPS-FM requirements imply that mātauranga should be collected and reported like SoE information, yet if mātauranga is qualitative and place-based then it is not clear how it should be handled. This ambiguity is compounded by the fact that councils are required to 'establish methods… including mātauranga measures' for SoE reporting. Councils are seemingly held accountable for establishing these measures, yet council staff observe that i) mātauranga may not take the form of measures and ii) it is tangata whenua who must establish what mātauranga is. Finally, although the inclusion of mātauranga Māori monitoring in the NPS-FM is helping to enhance council capacity in Te Ao Māori, this is not the same as enhancing iwi/hapū capacity to engage in monitoring. Council staff think that central government, which is

free of LTP constraints, can and should help to address these capacity constraints in a systematic way.

7. ROLES FOR CENTRAL GOVERNMENT

Interviewees discussed the existing division of responsibilities between local and central government for freshwater monitoring and reporting, and reflected on what they thought would be more desirable. To set the scene:

> there are a lot of conversations that we're having about... how do we continue with our current monitoring programmes to answer our own regional level questions, and still manage to do what we're actually required to do under the NPS-FM? Some of those questions that we're being asked to answer for the NPS-FM attributes may not actually be things that are really important to the community in our region, and it's quite hard to justify moving resources for that except that we have to.

Council staff are feeling pulled in different directions. On the one hand, councils are held accountable to their local communities for their decisions about expenditure through regional elections, yet on the other hand they also are required to implement national direction. The divergence between these drivers is significant, and has increased in recent years:

> I think lots of changing the mandate to be more on us to do things has happened by stealth in the last five years. So ten years ago, it was dangled in front of us to do more national monitoring, and the answer from the regional sector was: "well, who is paying?"
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> …Since then you've had the NEMS come out to try and raise the bar, which is quite positive, but it still comes at a cost. You've had the NPS come out which has moved towards increasing the monitoring by having to do activity monitoring and limit setting and NOF monitoring, and you had more requirements for reporting, and those requirements are starting to drive or inform what's being collected.
>
> …I still think the piece that's missing is actually….there's only a limited pot of money within the regional sector to deliver these programmes, and the span of them has grown, the cost of them has grown and I feel that there should be a component of that which is centrally funded to deliver on.

In interviews, council scientists explained the differences between regional and national environmental monitoring and reporting, and argued that this difference is why central government needs to step in in a more substantive way to resource national monitoring and reporting. They also identified three key ways in which central government can support councils by making their work easier and less costly: cost-

sharing and direct funding, harmonising data collection methods, and harmonising data storage and analysis. The current and desired roles of MfE in current initiatives in these spaces were also discussed.

7.1. National State of Environment monitoring and reporting: a fundamentally different task

Since council monitoring networks each have their own built-in biases and historical path-dependencies (Section 2), “trying to get a national conversation out of a whole lot of combined data… is not really going to tell the story as it is.” The issues confronting the task of aggregating regional data into a national picture are well covered by the PCE (2019) and are thus only lightly addressed here.

Council monitoring networks are designed to track key local land uses, reflect locally valued ecological objectives, and are constrained and directed by the local political budgetary process. As Section 4.3 showed with FMUs, the monitoring data from an FMU can represent either the cumulative impacts from a large area, or a small spatial area intended to represent other similar areas. FMU monitoring data collected thus can have very different meanings, making their aggregation to the national scale difficult.

For regional councils, telling accurate and meaningful stories about waterbodies in their regions is their key priority. This task can benefit from SoE monitoring data but is not reducible to it; interpretation of SoE data within the regional context of land uses and environments is needed:

> there’s a real tension there, isn’t there, between what’s the best thing to do for the national picture in terms of aggregating all of this data, and what’s the best thing to do for your region and your ratepayers as they stand.
>
> ***
>
> by the time you start to aggregate information at a national scale across all the regional councils… A lot of the information is context-dependent, and it’s been collected for a specific reason, and if you start to say it’s simply to represent state at a national scale, it may in fact be not true for a number of the sites. They may have actually been sites that were monitored to specifically look at whether sediment works are working, or whether things are changing, or there may be a specific catchment-related question. And then you start to aggregate everything together and just talk about it as being a representative picture of the country.

In contrast, national SoE reporting is a task for central government that relies on meaningful statistical representation of land uses and environmental types across the country. While successive NPS-FMs have driven consistency in what councils monitor, the issue of statistical representation across the national freshwater network has not yet been addressed (see also PCE 2019).

Presently, council staff are worried that MfE will compel councils (without providing funding) to monitor sites that will make the national monitoring network more representative. For example, since regional networks can be biased toward impacted sites, the national network needs more pristine and reference sites to be more statistically representative of Aotearoa New Zealand's land area. This could lead to councils being forced to monitor additional pristine sites, which will add cost without adding much specific value to ratepayers.

> when NIWA have done the analysis around "what's missing?" it ends up with "which councils have to do a whole lot more"? Well, it's West Coast, Canterbury, Otago and Southland particularly, … [they] have to go and do a whole lot more monitoring. And we're like "great, so *we'll* do that, just don't expect the poor old West Coast to pick up an extra 50 sites and pay amongst their 10,000 ratepayers" or whatever it is.

Since council staff see regional networks and the national network as having fundamentally different objectives, they think the networks should be operated separately and financed through different mechanisms.

> You'd almost need to maintain multiple monitoring networks. One that's probabilistic and represents [waterbodies] on a national level, as well as… more of an FMU-specific targeted, looking at impacted sites level, as well as a reference site network. So you'd almost need three separate networks.

Interviewees recalled positively that NIWA used to run a National River Water Quality Network (see Davies-Colley et al. 2011) that had its own resourcing and therefore did not require councils to monitor sites that were not a local priority. They noted that responsibility for this network has since been devolved to councils, and this has resulted in a loss of some sites.

7.2. Cost-sharing

> it's really fine for central government to want to report on a greater number of things going forward in time, and I think as people working in the environmental field, we would all want that to be a reality going

> forward. But I think it is difficult… to establish the need to do that within individual councils, especially the small councils. And if that's clearly where we're going, then MfE or central government need to fund councils to collect that information, it's as simple as that.
>
> it does come down to money and capacity at the end of the day. [As] a regional council, our regional responsibilities will always overwhelm any national responsibility that we have *unless* there is capacity coming from somewhere for us to do it. I think it's that simple really.

A common refrain from council scientists was that, since the objectives of national SoE reporting are distinct from—and additional to—regional monitoring, that national monitoring functions should be financed separately. They outlined several mechanisms that could achieve this.

One suggestion was to create "a pot of central government money to fund the national picture." This fund could have as its objective:

> To get a picture of national state, trends, whatever else is required. Potentially that pot could fund regional council scientists to go out and monitor. But it feels like that should come from the government and that it can be consistent, the methods can all be really clearly laid out, the sites can be selected as appropriate for the national picture. And *then* regional councils can focus a bit more on the needs of the region and the needs of their catchments and sub-catchments. It's a lot clearer delineation.

Central funding was considered especially important for smaller councils:

> There should be some funding mechanism where, if we are to develop a national network for the benefit of New Zealand, that for those councils that can't pay for it, they should get some help. That would be $100,000 to the West Coast: is that really going to break the government's coffers? That would be half a day of lockdown in Auckland wouldn't it, not even that.
>
> ***
>
> I think this government is signalling they're trying to be serious about improving our water quality. But I think to do that, we have to get serious about proper network design and funding it for those councils. I mean, I'm sure my council couldn't care less if I was to switch my 130 sites for another 130, they don't care. But the West Coast… or Northland, they might find it hard to do that so they should get some help from central government; I strongly believe that. Because the

> data we collect is useful both for regions but also at the national picture, for our national environmental reporting obligations that we must do.

A second suggested cost-sharing mechanism was to revive an earlier model of cost-sharing between MfE and councils used in the early 2000s.

> MfE… would set up an MOU with each regional council, specifying what information MfE required and cost sharing. Now, it only ever happened in the air space. In the air space, MfE came to [region name] and said "alright, in terms of what information we need from [region] that you're not already generating for your own purposes: we want this bit, and this bit as well. We will pay for all the equipment, if you're happy to provide the staffing to run the equipment." We said "yes, that's fine: mutual benefit."
>
> …So that worked for about two or three years, and that was meant to be the start across all environmental domains, and it never got any further than that. Obviously some chief executive somewhere pulled the plug. It was a pity: it was a good cost-sharing arrangement, mutual benefit, everybody was getting what they needed, or were happy to cooperate to provide it for some other party, and it fell over.

But while one scientist recalled this model positively, another highlighted that the temporary nature of the funding meant it was not appealing for councils:

> as a result of one of their state of environment reporting exercises, MfE looked at all the data they had and they said "well we've got very little information on the headwaters of rivers that are flowing out of the Southern Alps and the ranges in the North Island," and so forth. And I thought well again, that reflects regional council focus, and it's a bias.
>
> …"We need to be telling this good story about how wonderful the water is in Arthur's Pass National Park" and so forth, and regional councils weren't doing this because they said "well we know that water quality is good, and there's very little point in us investing a lot of time and money in continuing to recognise that it's good, but yes: there's no data on it, it's an assumption that we make."
>
> …And MfE went along to regional councils and said "look, we'll pay you to go and collect more data in these high country water bodies," and they had a schedule of the number of sites they wanted in each region based on their understanding of regions, and they said they

> would pay for the sampling or pay for the cost of analyses or whatever, and they'd do that for two years and then regional councils should take it over.
>
> …And regional councils said, "well, why should we do this? We don't have the resource to be racing around the high country collecting water quality samples." And "it's nice of you to offer to pay some money but you know, the net effect of that money drying up in two years' time is we would stop measuring if we were of a mind to."
>
> … I think they were at least going to pay for the cost of analysis, and I think they were going to pay for cost of collection as well. … from their point of view it was quite generous, but regional councils couldn't see much point, and they said "well, if you want us to go and sample say in our national parks, we'll actually have to pay a contractor to do that for us because our guys are busy anyway." So that never really got off the ground.

A third mechanism for cost-sharing with councils is to directly reimburse staff time spent working on national policy implementation and national reporting. Council scientists identified a range of initiatives, from NOF monitoring redesign and biophysical modelling to sitting on central government-convened steering groups, developing national guidance on monitoring methods, or sharing information with central government, that council scientists spend their scarce time working on. These activities primarily benefit the objectives of central government but take time away from activities that primarily benefit the region. As a result, council staff feel stretched thin, and "overloaded." One council scientist suggested that central government could seek to backfill council capacity when they rely on council staff to do central government work like sit on steering committees.

> it would be amazing to have a structure more formalised in some ways, and have people like me as [a major contributor to central government activities], to have an agreement with [my council's] Chief Executive that says "ok well, [name] has become the [working group convenor] as of today… For the next two years, half of their time is going to be dedicated to [working group] and half of their time is going to dedicated to [council name]."

7.3. Harmonising data collection – National Environmental Monitoring Standards

A key role central government plays is in promoting the use of consistent measurements and methods of environmental monitoring.

The National Environmental Monitoring Standards (NEMS) is one initiative supported by MfE that was signalled as useful by council staff (see nems.org.nz). NEMS involves working groups of council scientists and other experts working together to develop standard terms, definitions, and measurement approaches for specific attributes that can be used across all regional councils. The intent of NEMS is to provide a common reference point for how to measure and interpret attributes such as suspended sediment, macroinvertebrates, or dissolved oxygen.

Council staff reflected positively on NEMS, as the 'bottom up' process of creating the standards drew on regional council science expertise and could be informed by councils' needs and priorities. However, one scientist noted that in cases where the NEMS groups were split on a particular topic,

> I think that we are lacking leadership and that MfE needs to show a bit of leadership here and say "we've done this work, *this* [approach] is better. Councils: you do it." But I think they're too scared to, or they don't have the money or resources or whatever, and it becomes a political bun fight.

As with other topics, council staff also felt that NEMS work was seriously underfunded. One scientist reflected:

> one of the concerns that we've discussed about NEMS: we don't get a lot of money. [Name] applied for $1.2 million last year for three years' worth of work for the Ministry for the Environment, and they came back and said "sorry, we can only give you $148,000 for one year." And they're like "how many NEMS can you do for that?" We're like "one and a half." You're sort of looking at $45,000 to $50,000 per NEMS document, just in in-kind time, publishing time, project office time. All up you're probably looking at $150,000 if you count all of the in-kind time that's provided by council working groups and things like that. So I think there is a desire there to have these things but there is no longevity or permanent structure around funding and supporting these things to continue.

7.4. Harmonising data storage and analysis – Environmental Data Management Systems

As councils' experience with LAWA shows (see Section 5), the act of sharing data with each other through a common platform can drive changes toward harmonising environmental data practices.

In addition to LAWA, councils have been progressing work on an Environmental Data Management System (EDMS) that could host all councils' environmental information. The vision is for councils to input environmental data for multiple domains with consistent formats, filenames, and metadata, using consistent protocols, so that desired information can be extracted and compared in a straightforward manner. This scientist articulates the need for work in environmental data management:

> All councils need to have databases and reporting needs that are identical, so we should be working together. I actually think that… probably the biggest area of all is database design. We all have the same needs, and we all are duplicating effort in terms of building databases and managing them.
>
> …There still needs to be custodianship at the council. The party who is collecting the data needs to be responsible for that data and the quality of it. So that's still paramount. But in terms of actually the architecture of the databases and so forth, I think that central government have been a bit woeful in leave councils to [do] it [themselves].
>
> …I know it's a technology question, and I can see why governments are loathe to dictate the technology for the job, and it could stifle innovation and so forth. But I think that councils could bandy together and save millions and millions of dollars on that and have much better products.
>
> …There are some products that we use, like Hilltop. Eleven out of 16 councils use that as a time series database. That's probably the closest thing we've got, in my work area, to an integrated database that's got a really good development programme. There's a Hilltop user group… driving that. But there's nothing like that in the ecology, freshwater ecology area.

Another scientist echoed the point about duplication of effort in data management, observing that MfE appear to be developing a parallel stream of work on the topic:

> There are multiple projects that are being funded nationally at the moment, I believe, all trying to do a similar thing, which is allow the sharing of data between agencies. … I'm aware vaguely that the Ministry for the Environment is trying to create some sort of data warehousing system which I think they think will allow them to hold regional council and other agencies' data for their reporting purposes. I think their efforts would be best placed in working in these other projects to get the best outcome for everybody, rather than trying to

> reproduce something that regional councils just don't have any buy-into and I don't think or believe will work long term.

7.5. MfE role

Interviewees had several perspectives on MfE's role in environmental reporting and freshwater management. One reflection was that MfE seems disconnected with the on-the-ground responsibilities and needs of councils:

> The Ministry for the Environment has downfalls in that, on the whole, and very generally speaking, I don't think they really understand what regional councils do, what drives us to do what we do, how data is collected, stored, analysed.
>
> ***
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> To put it bluntly, MfE—from my perspective, from the regional council's perspective—has floundered for 25 years trying to work out how to do environmental monitoring and reporting, and I'm still not convinced it's actually got itself sorted out. The impression we have is that MfE's monitoring has been driven at least largely by its international reporting obligations. So there are frameworks, conventions, ways of doing things that it's obligated to meet, and it's discovering that the way regional councils do it, which it is relying on for most of its information, doesn't necessarily well integrate with that.

A suggested reason for this disconnection was that MfE are bound into a 'treadmill' of their own obligations which they are focused on implementing:

> Their problem at the moment, which again is what Simon Upton pointed out [in PCE 2019], is that they're bound into this reporting system that just keeps them continually on this treadmill and they don't have a chance to sit back and go "what does this all mean? Are we reporting in the right way?"

Over time, the perceived disconnect between MfE and councils has led to a distrust of MfE by regional councils, although this situation may be improving:

> They also…I mean, I'm thinking back to a number of years [ago] but they had a real view that regional councils needed to be told how to do their jobs, that they didn't know. I think that's changing slightly over time. One of the things I've probably seen change over the last five to ten years is that they're actually starting to come to councils

> and go “can you tell us how you do that?” and “what we can have from you that will help with this reporting that we need to do?”

One council scientist cited the Environmental Reporting Act 2015 as an example of MfE’s disconnect from regional councils. That Act locks MfE and Statistics New Zealand into producing new national SoE reports for freshwater every 3 years, yet regional councils have to report their data to the public every 5 years as per the RMA. This can lead to MfE reporting more often than regional councils update regional data.

Another perspective expressed was a desire for a consistent national perspective on monitoring needs. If MfE are to be custodians of the national interest in freshwater monitoring, interviewees thought they should be prepared to identify with councils what additional monitoring in any given region would help tell the national picture.

> It’ll be helpful to know what their questions are, so when we are designing our network, we can keep those in the back of our mind as well. … And maybe if they don’t change the questions as well, maybe if the questions try and stay similar throughout time, that would be helpful.

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> if only we could get some guidance at a national level about which sites in our network are likely to be critical for national level reporting, when you’re looking at having adequate covering and different types. Apparently every time we have conducted some kind of network review or thought about changing or closing or moving a site, we’ve been in contact with MfE for example, to say we’re thinking about doing something to the site, we’re going to move it upstream, downstream, we might close it: “does that have any bearing on the reporting that you’re looking at doing?” And basically getting no response or they’re just like “I don’t know.”

As this interviewee concludes, but which others also expressed, council staff see a need for greater communication, and development of shared purpose across the environmental monitoring system:

> I don’t think we need to communicate more but I think we need to be more cohesive as a group of environmental practitioners across central and local government, across CRIs and councils. We all are aiming for the same thing, but at the moment the systems, and by that I mean how science is delivered through CRIs, how research or monitoring and science is delivered through regional councils, what we’re aiming to do at a national level – they all seem to be very disjointed.

7.6. Summary

Regional freshwater monitoring and national environmental reporting have different objectives and needs. Council staff argue that the different functions require different mechanisms of finance as well, with regional monitoring addressing local needs and being funded by rates, and with national needs being met by central government financing. Interviewees identified several different forms of cost-sharing between central and local government, including a pot of dedicated funds, Memoranda of understanding with specific councils, and compensating council staff time to contribute to central government activities and objectives. In addition to financial support, central government can also play important roles in harmonising data collection and data storage and analysis. Experience from past central government engagement with monitoring initiatives reveals a desire for more consistency from MfE, and for MfE to take a more proactive role in listening to councils and supporting their agendas.

8. CONCLUSIONS AND RECOMMENDATIONS

Since environmental monitoring is a key part of the resource management system (PCE 2019; RMA Review Panel 2020) and has been spotlighted for reform by central government (MfE 2022), it is crucial that policies designed to improve monitoring outcomes are built on robust understanding of how environmental monitoring works in practice. This research aimed to understand how regional councils are implementing their freshwater monitoring responsibilities, and why.

Drawing on interviews with 20 scientists from all 16 regional councils, it examined how freshwater monitoring networks have been designed, why, and how councils are coping with new monitoring requirements. From across the different topics discussed in this report, three conclusions can be reached.

8.1. NPS-FM implementation requires significant change to freshwater monitoring

A first point is that the requirements of the NPS-FM are substantial for regional councils, and these are laid upon councils whose obligations are many and whose resources are few. Successive revisions to the NPS-FM have increased requirements for councils to monitor and report on i) new attributes, ii) at greater frequencies than before, which requires iii) new analytical capacities such as ecological sampling, iv) increased staff labour for field sampling, analysis, and instrument and databasing work, and v) new skills and competencies within councils, such as mātauranga and Te Ao Māori. These new requirements have been layered onto councils since 2014 with increasing scope and specificity, and while councils have drastically increased their science and monitoring capacity over this time, this has still not kept pace with their obligations.

Furthermore, the magnitude of the implementation cost varies for different councils, as some have monitoring networks that can be easily adapted, and some councils can easily augment their capacity, whereas others cannot. Large and small councils alike are struggling to implement the new requirements, and in multiple cases staff report working overtime to ensure work is completed. The research also shows what trade-offs confront councils when allocating resources to meet NPS-FM requirements. If councils must meet NPS-FM requirements, they may have to reduce or defer investments into much-needed areas such as impact monitoring, modelling, or new science such as remote sensing applications. Or, councils can decrease the number of sites in a monitoring network to allow newly required attributes to be monitored. Overall, councils are navigating their way through imperfect conditions of resourcing and capacity, ‘making do’ with what they have to juggle multiple and sometimes competing demands. They are making these trade-offs in situations where change itself is costly and local community concerns are paramount.

8.2. Local financing mechanisms are a bottleneck

A second conclusion is that the processes for funding local government activities are proving insufficient to deliver on NPS-FM requirements. If it has been assumed that councils would translate necessary NPS-FM implementation costs to ratepayers to ensure full implementation, this is not consistent with reality. Regional electorates can vote against rates increases by voting for politicians with platforms to cap or lower rates. The culture of 'feasibility' at councils means that council scientists, their managers and elected councillors all have incentives to downscale the expression of science capacity needs for monitoring. Council scientists feel that the NPS-FM requires a significant increase in council capacity for monitoring and science, yet the LTP process delivers only incremental increases. Within councils, 'feasibility' is in turn shaped by contextual factors such as the existing size of science and monitoring teams, or the perceived value of monitoring relative to other more politically appealing investments. As a result, councils must reallocate scarce resources to meet new NPS-FM policy requirements and this is stretching their existing staff thin. Notably, Otago Regional Council is often cited as a positive example of making a step change in council capacity to deliver on the NPS-FM. However, this situation was prompted by a Ministerial review requiring the council to make substantive change to deliver on the NPS-FM.

To improve the consistency and comprehensiveness of NPS-FM implementation, monitoring finance may need to be re-organised. One option could be for central government to create policies ensuring that LTP processes provide enough capacity for monitoring and NPS-FM implementation. Another option is funding SoE monitoring from central government. De-linking SoE monitoring from regional budgetary processes could allow more consistency across regions and better coverage of freshwater bodies and environments across the country.

8.3. Central government support: much more needed

Given that central government have primary responsibility for reporting on the state of the environment to the New Zealand public, it behoves government agencies to support efforts to make freshwater monitoring more consistent and comprehensive across all regions. This research illuminates the multiple ways—beyond regulation—that central government has been and might yet be involved in supporting innovation and change in the sector. Central government agencies have provided some financial support for LAWA, funded some NEMS work, and in the past have developed MOUs with councils to share costs of local monitoring for the national interest. These initiatives were all recognised by council staff as important and valuable, while staff also desired an order of magnitude increase in central government contributions toward these efforts. LAWA does not resolve the tensions between local monitoring network design and national reporting needs, but it is a forum for those tensions to be

worked through in a way that councils feel trusted, listened to, and involved. LAWA also provides a platform for cross-council equity, as smaller councils can benefit equally from the infrastructure that LAWA provides. The NEMS model of deciding monitoring standards, as opposed to central government instituting standards through the NPS-FM, allows council scientists to drive the development of standards, taking into account issues of practical feasibility and consistency, while testing the logic of the standards against council experience. Similarly, council investments in the EDMS shows initiative, and councils are concerned that MfE is developing its own plans for data integration separately rather than supporting bottom-up initiatives like EDMS to feed into those roles. In sum, there are several models already in play that are proving effective for driving change in a thoughtful way that can benefit from and be responsive to council experiences and dynamics.

The research also identifies key mechanisms through which central government can support council-led efforts of harmonising and strengthening monitoring practice. Central government could provide project office staffing for council-led initiatives such as LAWA, NEMS, EDMS and others. Government could create a fund for monitoring implementation support that could be dispersed to provide councils a step change in staffing or technology needed to more fully implement the NPS-FM. The MoU arrangements of the early 2000s could be revisited and revised, to allow monitoring of nationally-useful sites that would not be a regional priority. Central government could work with councils to set up secondment arrangements that more directly compensate for the time of council staff spent on national monitoring and reporting workstreams. And last, but not least, central government could make strategic science investments in any of the areas flagged as key priorities for councils such as impact monitoring, community monitoring, remote sensing applications, or environmental DNA. Research and resourcing focused on developing these areas into workable applications that multiple councils can use would help to lead the implementation frontier, reducing the costs of taking up new technologies.

8.4. Recommendations

In light of these conclusions, the recommendations from this study are:

1. Each regional council should ensure that the relationships between their monitoring, policy, consenting and compliance functions are aligned and effective, and that cultural monitoring investments are situated explicitly within a framework of Treaty-based partnerships.
2. As part of resource management reform, central government should explore mechanisms for financing environmental monitoring that do not rely on local political budgetary process for coherent implementation. Potential options could include:
    a. funding from central government,

   b. using Memoranda of Understanding with councils to fund those sites and attributes that are of primarily national benefit,
   c. central government creating and maintaining a national network that complements regional networks, and
   d. policy mechanisms to ensure adequate resource allocation in local budgetary processes.
3. Central government should significantly ramp up both in-kind and financial support for council-led and iwi/hapū-led initiatives in the environmental monitoring space, and develop policy that can build on these rather than create separate central government infrastructures that do not include councils in driving roles.
4. Regional councils should pool their resources and direct environmental research to key priority topics that support the effective functioning of the resource management system more broadly. These can include, but are not limited to, applied scientific research on:
   a. impacts monitoring
   b. community monitoring
   c. modelling parameters that cannot be monitored adequately otherwise
   d. remote sensing applications
   e. environmental DNA.
5. MfE and council science staff should work together to share information about monitoring challenges and needs, and identify and pursue synergies across the environmental monitoring system. This can start with taking local-central government collaborative initiatives that work well—such as NEMS, and LAWA—and deciding how the benefits of these can be strengthened and replicated.
6. To ensure the needs of the monitoring system are being met, MfE and councils should consider commissioning a follow-up study of the sector in three to five years by an independent research provider to evaluate how these dynamics are shifting and why.

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