Water monitoring and reporting: Overview of the Freshwater Values Monitoring Outcomes Research Programme – Research Aim 2

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Why monitor (and report on) water? *Cause you can't manage what you don't measure'*

It is worth taking a moment to consider why we need to monitor water. At a very basic level there is the 'You can't manage what you don't measure' mantra. We want to manage water (better) so we have to measure it. That's actually quite useful so far as it goes. Of course there are heaps of flow-on questions on what to measure, and when, and where, and how.

The key reasons for state of the environment (SoE) monitoring – of all environmental domains, not just water, are:

1. To define the state of the environment (STATE)
2. To track change in the state of the environment over time (TREND)

These are often referred to as 'state and trend'. (Trend can be mathematically defined and has the units %/yr.)

Note that TREND is much harder to measure than STATE – because the former implies very consistent and accurate measurement over time. If you change ANYTHING about how you monitor, even very subtlety, you risk ruining the ability to detect trends.

Now, although those are undoubtedly the main reasons for SoE monitoring – and reporting on that monitoring – there are many other things that good monitoring data can address or help address. Here are some of them – taken from a report we did in the National Environmental Monitoring and Reporting (NEMaR) project (of which more shortly).

- **Identifying drivers of change.** We might well want to distinguish changes due to global drivers (e.g. global warming) vs catchment-level change. For that we usually need sites in reference catchments where nothing is changing *except* globally.
- **Science.** More generally we want to understand how our waters 'work' – and monitoring data can certainly help with that, although usually other measurements and special investigations and experiments may be needed too.
- **Modelling.** If we achieve a reasonable level of scientific understanding we can develop models – abstractions of reality – that might sometimes be useful for testing understanding or predicting changes – occasionally even useful for management. Modelling and monitoring should be seen as two sides of the same coin: Modelling

needs monitoring data to anchor it to reality, but monitoring also needs modelling – e.g. to fill in the gaps spatially and to make sense of data.

- **Policy.** And we might find monitoring data useful to see if our policies are 'working' – and the ultimate test of that is 'is the water getting better?' (so back up to state and trend!)

> ***Rob's water monitoring principle No. 1!***
>
> **There ain't no such thing as the perfect monitoring network!**
> *OR*
> **No real network can possibly answer all the questions that are likely to be addressed to it.**
>
> That is really rather obvious when you think about it. You can't measure everything, all of the time and everywhere.
>
> However, by addressing the WHAT, WHERE, WHEN, HOW and (above all) WHY of monitoring you can develop a fairly *good* network – that will answer a lot of questions itself, and, moreover, will provide a platform for special investigations that should help answer other questions that arise.
>
> For example suppose we wanted to know about endocrine disrupting biochemicals (EDC) in New Zealand rivers. It would be very onerous to mount a special campaign to monitor EDC. Far cheaper to add measurement of EDCs to existing river monitoring – and far better because the existing monitoring variables (flow? temperature?) might help explain patterns of EDCs.

The National Environmental Monitoring and Reporting (NEMaR) project

Aimed at achieving consistent and dependable monitoring… for national reporting…

I need to talk about the NEMaR project because this started very soon after our research work was planned in Year 1, and took over much of the work we would have otherwise done. So in the VMO programme we concentrated on *adding value* to NEMaR and publishing some research work on monitoring and reporting…

The NEMaR project was a major effort that counts as cofounding to VMO programme on the monitoring and reporting side. A major aim of NEMaR was to achieve 'consistent and dependable' regional water monitoring as a basis for national reporting. 'Consistent' meant that regional councils and other monitoring agencies need to do things the same way (for national reporting); 'dependable' means their monitoring needs to generate accurate numbers… NEMaR also investigated the feasibility of a combined index for reporting at national level, but that's a bit beyond-scope for today.

The actual NEMaR process included workshops with expert panels of regional council staff and Crown Research Institutes and university advisors.

Quite a large number of reports to the Ministry of the Environment were completed in the NEMaR project, and I believe these were going to be made available on the Ministry's

website – as an ongoing resource for regional councils in particular. (At time of press they weren't posted.)

I've outlined the major achievements of NEMaR below.

- Much work was done on **indicators** for reporting. Indicators are the attributes that address VALUES associated with waters.
- In strong relationship to work on indicators, at least to start with, we **defined variables** for consistent measurement (for rivers, variables are identical to National River Water Quality Network (NRWQN).
- **Monthly timing** was recommended for both lakes and rivers (same time-of-day) – not rolling sites or quarterly or other approaches that various councils have used in the past.
- **Protocols were outlined** in broad scope. (For rivers these were mostly the same as NRWQN with small differences.)
- And the **site network was reviewed** – There are about 900 sites over New Zealand, but with some major regional differences in terms of density, and whether integrated over hydrological/water quality/biology. Also, the coverage of environmental categories is somewhat unrepresentative, and in particular, there are insufficient reference sites (reference sites in near pristine conditions are needed to (1) define targets for rehabilitation and (2) distinguish global pressures from catchment changes).

An important finding was that the NEMaR process confirmed the NRWQN as regards variables (identical except for proposed addition of fish) and protocols (very similar), monthly monitoring and monitoring protocols. That is, the NRWQN is a *model* for NEMaR.

Rob's water monitoring principle No. 2!

T**he best check on data quality is if an independent agency gets the same numbers as you!**

The best check on the quality (the Q in QA) of your data is if an independent agency gets the same numbers.

(In NEMaR we recommended as a guideline that perhaps 5% of data points should be independently duplicated.)

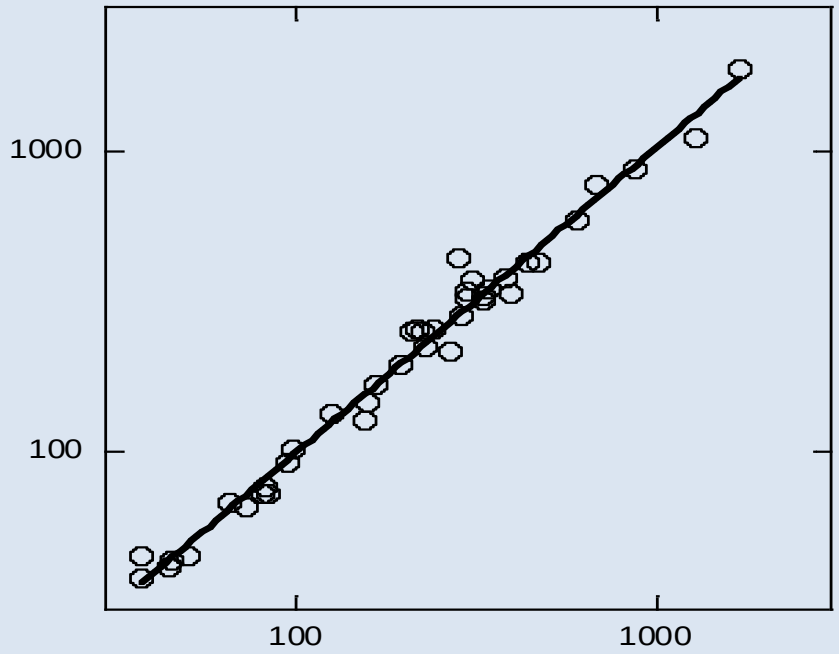

FIGURE. Plot of paired total nitrogen measurements by two independent agencies.

Now, if your data agreed with another agency as well as illustrated here (for total nitrogen), you would be very happy. The data fit bang on the 1:1 line of perfect agreement – with less than 10% RMS error over quite a wide range, and only one (apparent) outlier.

If your data *don't* agree with the other guy's, then you can start thinking about why, and tracking down the source of the discrepancy and what to do about it. That is beyond-scope for today.

VMO monitoring achievements, years 1–3

Here is a list of some of the major outputs and achievements from our main VMO-funded project. Copies of some of the articles mentioned are available on the VMO publications website (http://www.landcareresearch.co.nz/science/portfolios/enhancing-policy-effectiveness/vmo/publications), or alternatively please email me for an electronic copy (r.davies-colley@niwa.co.nz.)

- We published a review article on the NRWQN – which, as I mentioned, is all the more important given that the NRWQN is now recognised as a 'model' for NEMaR. (Davies-Colley et al. 2011*)
- I wrote a chapter for a forthcoming book on ecosystem services, overviewing river water quality in New Zealand. (Davies-Colley 2013*)
- Deborah Ballantine, who was a key researcher in this programme before she left NIWA, completed two articles on technical aspects of water quality monitoring – one on pollution loads in the (dairy-polluted) Sherry River (which has just come out in *New Zealand Journal of Marine and Freshwater Research*; Ballantine & Davies-Colley 2013*), and a second on trends at 77 NRWQN river sites (to be published in the journal *Environmental Monitoring and Assessment*) (Ballantine et al.).

- Graham McBride recently finished a statistical article for *Environmental Monitoring and Assessment* entitled 'Assessing environmentally significant effects: A better weight-of-evidence than a single P value?' This classifies weight of evidence based on a sophisticated use of statistical confidence parameters – and looks likely to be very influential. (McBride et al. 2013)
- Related to that we have upgraded the TimeTrend webtool for supporting workup of environmental monitoring data. (www.niwa.co.nz/our-science/freshwater/tools/time-trends)
- And we have made several conference presentations on the above-published areas of work and some others. For example, I presented an overview of research needs in water quality monitoring and reporting at the 2012 NZFSS conference in Dunedin.
- Richard Storey prepared a Bayesian Belief Network (a kind of numerical model of the interaction between different attributes of a system such as a major water resource) to underpin a pilot study on community collaboration in water planning in Hawke's Bay.

(*) Publications available on e-request

Some principles of good long-term water monitoring

From the work we've done so far, and also the NEMaR project, have come some principles for good long-term water monitoring. These were summarised in the review article on the NRWQN)

- **State objectives** clearly.
- **Design things well.** Learn from others (avoid their mistakes!).
- Be **parsimonious** ('miserly') as regards choice of variables etc. Just measure those attributes that are cost-effective for routine. Don't be too ambitious: many long-term monitoring efforts collapse owing to shifting funding priorities.
- Measure attributes related closely to **values** around water … or other domain (I refer you to the FW reforms … see Ministry for the Environment website.)
- **Report!** Frequent and relevant **outputs** (publish data summaries)
- **QA** – data accuracy (many tasks, but particularly ***independent duplication***)(10% of budget)
- **Consistent operation (over time)** (A national audit and advisory programme is needed.)
- **Integration** (of hydro/WQ/bio monitoring. Water quality and biology must be underpinned by hydrology. Technical difficulties with biomonitoring at the same sites as hydrology, water quality and sediment suggests that rigid integration may not be desirable.

Principles are as given in Davies-Colley et al. (2011) review of the NRWQN; Similar to those of Lindenmeyer & Likens (2010) 'Effective Ecological monitoring', CSIRO

Water monitoring research needs in New Zealand

Here is my personal view of the research challenges for monitoring and reporting on water in New Zealand. Hopefully with some feedback from people at the Symposium, we will be able to turn this list into an action plan for the VMO research programme.

- **Statistical tool development** – tools for turning data on water into information.
    - There are technical issues around the **handling of 'censored' data** (these are data that are reported by labs as '< detection limit' rather than as a best-estimate number. In NEMaR we recommended that practice be avoided by regional councils specifying no < DLs in their contracts with laboratories, but there is resistance to abandoning what has been a standard practice.
    - Another area needing research is the development of statistical methods for **efficient identification of drivers of change** in water quality.

- **Quality assurance (QA) of water monitoring data.** QA is a major area of unfinished business arising from the NEMaR project.
    - In that project we recommended a **national QA programme** in which a team of advisors would visit each regional council on a revolving basis and accompany field staff to duplicate their measurements for assessment of concordance. They would also review council duplicate measurements at NIWA 'benchmark' sites.
    - There are several **other technical issues** in QA of water monitoring that would usefully be researched. This includes **pollution load** estimation (which is hard to do well because it implies flood monitoring and modelling) and **continuous recording** – sensors, especially optical sensors, for a wide range of attributes. (The NEMS project has made considerable progress on **continuous** monitoring, but there is much work still to do – especially on water quality variables using optical sensors.)

- **Community monitoring.** This is a major issue, and seems all the more important because community monitoring seems like a logical extension of community collaboration in water planning. Community groups, notably including iwi, seem likely to want to be involved in the whole policy cycle so that they know and can own the fate of 'their' water. We see this as a win-win for regional councils *and* community groups – the council providing encouragement and technical support to the community group and the community group acting as eyes in the field to extend the council's monitoring coverage.
    - **The concordance** (agreement - or otherwise) of volunteer data versus professional data obtained by regional councils or NIWA is a major issue. Perception is that volunteer data can never achieve the dependability (accuracy if you like) of professional data. I think that is an untested assumption. But even if it were true, surely there is huge potential for improvement of community monitoring over time. Also for extension of regional council monitoring with community involvement?
    - There would seem to be a need for **resources** for councils to encourage and support community monitoring – for example, community members could usefully take flood samples when fluxes of pollutants are very high.
    - We are planning to upgrade and extend the **Stream Health Monitoring and Assessment Kit (SHMAK kit)** – which has been around for more than a decade and has had a fair bit of uptake, but is showing its age. For example it would be very powerful to extend monitoring 'coverage' to include bacterial indicators of water suitability for swimming or shellfish gathering.