New policy, new modelling challenges and approaches for New Zealand

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Highlights

- National policy in New Zealand requires regions to set water quality objectives and limits for fresh water.
- Modelling is required to implement policy in the regions, but the approaches followed vary from region to region and there are significant modelling challenges facing councils implementing the policy.

Introduction

Many streams and rivers in New Zealand, including those in urban areas, continue to have poor water quality (Larned *et al.* 2019). The National Policy Statement for Freshwater Management (NPSFM; NZ Government 2014; amended 2017) was initiated to meet public demands for improved freshwater environmental outcomes. Water quality modelling is a cornerstone in the implementation of the NPSFM, however, there is little guidance in New Zealand on which models should be used or how these should be applied and evaluated. This has meant that each region has largely followed its own modelling strategy leading to a range of models with varying levels of sophistication being used around the country. Here we report some of the outcomes of a scoping study undertaken to review what the regions are doing and the challenges they face in order to develop tools and advice they can use to implement the NPSFM.

Models and the NPSFM

There are three main water quality modelling tasks required under the NPSFM:

- Estimating contaminant loads from all sources reaching freshwater-bodies (i.e., freshwater accounting) based on land use, point sources, and catchment characteristics;
- Establishing the relationship between contaminant loads discharged into the freshwater body and concentrations within the water body (i.e., linkage analysis); and
- Establishing and allocating load limits to meet or maintain water quality targets based on the relationships established by catchment characterisation and linkage analysis.

These tasks have parallels in the development of Total Maximum Daily Loads (TMDLs) in the United States (US Environment Protection Agency 2014). An evaluation of 65 models commonly used for preparing TMDLs (Shoemaker *et al.* 2005) found that no-one tool is able to undertake all the tasks identified. It is therefore likely that different models will be needed at different stages of NPSFM implementation. Moreover, the modelling approach taken in a region will depend on the region's freshwater management priorities and available resources including data availability and budget. With this in mind, we overview two different approaches that have been undertaken in Wellington and Auckland, the regions with the highest urban populations in New Zealand. We also look at the challenges facing regions that have lower urban populations with fewer resources for modelling using the MUSIC model as an example of an off-the-shelf proprietary model that could be applied for policy implementation.

Porirua Harbour – collaborative planning process

At the previous ICUD, we presented our early experiences working with the Greater Wellington Regional Council as part of a collective catchment management team for the Porirua Harbour catchment that included regional and local council planners, scientists and policy makers as well external scientific, cultural

and economic advisors, modellers and community representatives (Semadeni-Davies *et al.* 2017). This region is following a sequential catchment by catchment approach where the models chosen for each catchment reflects the community and environmental values placed on the water body; land use; and physical environment. The Porirua Harbour planning process was the second undertaken in the region. The planning process loosely coupled a suite of models run by different providers, including water quality and hydrological models for freshwater, harbour contaminant circulation modelling and social, cultural and economic impact assessments to estimate the environmental, cultural, social and economic effects of a range of planning scenarios developed in consultation with the council and stakeholder group.
Modelling challenges included: sharing data and model outputs between model providers in compatible formats; ensuring parameters that transcend different models were the same; time management to ensure that the transition between each stage in the modelling process went smoothly; communicating the outputs of the models in a form that could easily be understood by other team members and translating community needs and objectives into scenarios and evaluation metrics that could be used within the models. Modelling was undertaken in 2017 and 2018 and was part of a four-year planning process that culminated in an NPSFM implementation strategy released last year (Te Awarua-o-Porirua Whaitua Committee 2019).

Auckland – regional integrated modelling

The Auckland region covers 4900 km^2, roughly 10% of which lies within the boundaries of the City of Auckland (pop 1.6 million). The Auckland modelling strategy is to develop a regional integrated and continuous hydrological and water quality model called the Freshwater Management Tool (FMT; Stephens *et al.* 2019). This is a customised version of the LSPC (Tetra Tech Inc. 2009) catchment contaminant transport model coupled to an optimisation urban drainage model (SUSTAIN; Shoemaker *et al.* 2009). The FMT integration of SUSTAIN enables stormwater management planning and cost-benefit analysis so that the council can not only set water quality limits but also invest in its stormwater and wastewater infrastructure to achieve desired outcomes. Information on the model-build is being presented elsewhere at this conference by Stephens *et al.* (2020).
A number of challenges have arisen in the development of the Auckland model including: novelty of adapting US-EPA modelling frameworks to New Zealand; obtaining representative input data and calibration data at appropriate spatial and temporal resolutions from a range of sources (e.g., urban and rural land cover information that is ever changing due to rapid urbanisation; high-resolution meteorological data; stream profile and habitat data); delineation of stream networks and catchments from LiDar data; integrating the stormwater, wastewater and stream drainage networks; and representing the complex hydrology of both developed and undeveloped parts of the region, including basalt aquifers to the region's south. The Auckland strategy is unique in NZ for progressing an iterative 10-year continuous improvement and model development process (e.g., Stage 1 completed 2020; Stage 2 to be completed 2023; and Stage 3 to be completed 2030).

Proprietary models: example MUSIC

In contrast to the case-studies above, most regions in New Zealand have lower urban populations and have focussed their NPSFM implementation strategies on setting water quality limits for agricultural runoff. Many also have fewer resources available for undertaking sophisticated urban drainage modelling or model development. For this reason, we evaluated a number of proprietary urban drainage models to assess their suitability within the context of the NPSFM. All of these models have been developed outside New Zealand and need some degree of local customisation. Of these, we chose to evaluate MUSIC (eWater 2014), a dynamic surface flow and water quality model designed for urban planning applications that includes modules for stormwater treatment and cost-benefit analysis. The reason we chose MUSIC is that it is widely used for urban planning in Australasia, can be run at a range of scales, is well supported and maintained, and has outputs that are compatible with the needs of NPSFM implementation. We did not calibrate the model or test the model's performance noting that all proprietary models will need local calibration.
We ran MUSIC for a generic town to test how easily MUSIC can be set up and used with existing publicly available data sets. While we found that while the model is fairly intuitive to use, there are some

challenges that will need to be resolved for NPSFM implementation, the key challenges we identified are listed below,:

- MUSIC default outputs are total suspended sediment, nitrogen and phosphorus. The target contaminants in New Zealand urban centres are generally sediment, zinc and copper. While it is possible to swap sediment for another contaminant in MUSIC, it is not possible to run the model at the same time for all three target contaminants;
- MUSIC uses concentration distributions determined for each land use type to characterise the stormwater runoff. These distributions are specific to Australia and the guidance recommends that they be replaced by local distributions where possible. Accordingly, we used data held in NIWA's Urban Runoff Quality Information System (https://urqis.niwa.co.nz) database to create distributions for the target contaminants, but we did not consider how best to incorporate data from different monitoring studies using different sampling and analytical techniques. There were insufficient data in the database to create distributions for some land use types.
- The representation of stormwater treatment devices in MUSIC relates to Australian design criteria and do not necessarily translate to those commonly used in New Zealand.
- MUSIC cannot be run for more than one catchment in a model-build.

These issues are not exclusive to MUSIC and use of other proprietary models will raise similar challenges.

Conclusions

We carried out a scoping study to look at the modelling challenges facing councils in New Zealand as they implement the NPSFM for the urban centres in their region. We looked at two different strategies being undertaken in two regions with high urban populations that have already embarked on the implementation process for urbanised catchments. We also looked the range of proprietary urban modelling tools that are available in New Zealand and evaluated one of these, MUSIC, for its usability within the context of the NPSFM. We found that the model is fairly intuitive to set up and run, but a degree of local optimisation is required. The work was done ahead of providing guidance and tools that can be used by councils.

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