DEVELOPMENT OF A FRESHWATER MANAGEMENT TOOL TO SUPPORT INTEGRATED WATERSHED PLANNING FOR AUCKLAND WATERWAYS

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ABSTRACT

Auckland Council is responsible for the management of freshwater quality and quantity in the Auckland region. While developing strategies to manage our water resources, the Council will face a number of decisions and the community will be engaged on various options, their cost and benefit. Water resources strategies, particularly around freshwater systems, will primarily be developed and implemented through the Wai Ora – Healthy Waterways programme, including supporting outcomes identified through delivery of the National Policy Statement for Freshwater Management (NPS-FM) and Auckland Unitary Plan. The Council's catchments have been organized into 10 watersheds and Integrated Watershed Plans are being developed for each. In future phases, action plans will be developed for each Integrated Watershed, which could include potential structural and non-structural interventions to improve fresh- and coastal water quality.

To support decision-making and community engagement, the Healthy Waterways programme has begun development of a regionwide dynamic modelling system called a Freshwater Management Tool (FWMT). The FWMT will be an integrated decision support system that represents the current state of the hydrology and water quality of the region's watersheds, and simulates the potential effectiveness and cost-benefit of structural and non-structural interventions that could be implemented over time. The FWMT will provide outputs at varying spatial and temporal scales across Auckland's varied land use types and freshwater bodies (rivers, lakes, wetlands and aquifers). The FWMT will be built using open-source, process-based, continuous simulation models. Continuous simulation is an important component of the approach, as management of freshwater quality requires prediction of the frequency, duration and magnitude of contaminant loads (annualized loads are insufficient in many cases). The FWMT will build upon previous modelling tools developed by Auckland Council, particularly the Contaminant Load Model.

The FWMT will be composed of two components: [1] a baseline hydrology and water quality model and [2] a stormwater management model to simulate the effectiveness of performance of stormwater management devices and non-structural measures. The baseline hydrology and water quality ("current state") model will be used to characterize current catchment conditions; the selected modelling software is Loading Simulation Program – C++ (LSPC). The stormwater management model will be used to simulate the effect of structural and non-structural interventions on instream hydrology and contaminant levels; the selected modelling software is the System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN). The specified models have been selected because they are process-based, continuous simulation models that can handle a wide array of pollutants, catchment conditions and implementation scenarios. At the same time, these models are free, peer-reviewed public-domain models that have been applied in catchments across the world including regulatory programs and case studies by United States Environmental Protection Agency.

The FWMT is being built on a rapid schedule thru 2017/2018 in order to allow for analysis of multiple planning scenarios in 2019. The FWMT will be updated over time as the Integrated Watershed Plans evolve through additional data collection or implementation decisions. At the time of the New Zealand Stormwater Conference, it is anticipated that initial outputs from the current state (LSPC) model will be available. The presentation will have four primary components:

1. Overview of the FWMT and its envisioned role in Integrated Watershed Plans (and thereby for delivering outcomes under the Unitary Plan and NSPFM)

2. Details on the FWMT components (software and datasets)

3. Key datasets used to develop the FWMT including GIS, water quality, weather, and source data. The challenges of compiling these datasets will be described, along with lessons learned and methods to overcome data gaps.

4. Outputs from LSPC that convey key behavior of hydrology and water quality, along with key successes and challenges with model set-up and calibration.

5. Next steps toward development of the FWMT including development of the stormwater management (SUSTAIN) model, along with an illustration of the types of outputs that are expected from the complete system.

With the above vision for the presentation, the remainder of the abstract describes the current state model (LSPC) of the FWMT and its key elements.

The NPS-FM includes objectives to maintain or improve water quality (Objective A1 and A2) and policies that direct regional councils to establish freshwater objectives and implement methods to improve water quality where those objectives are not being attained (Policy A1 and A2). The foundation of water quality planning is characterising and understanding the current state in the drainage catchments. The current state LSPC model of the FWMT represents the flow and the water balance between climate, runoff, groundwater attenuation and storage (including water supply dams) and stream reach hydraulics. LSPC is a catchment modelling platform for simulating catchment hydrology, erosion, and water quality processes including in-stream transport (advection, dilution, attenuation, etc.). LSPC integrates GIS, comprehensive data storage and management capabilities, and a data analysis/post-processing system into a convenient PC-based Windows environment. The algorithms of LSPC are identical to a subset of those in the Hydrologic Simulation Program–FORTRAN (HSPF) model with selected additions, such as algorithms to dynamically address land use change or contaminant build-up over time. USEPA's Watershed and Water Quality Modelling Technical Support Center first made LSPC available as a component of USEPA's National TMDL Toolbox (https://www.epa.gov/tmdl/tmdl-modelling). LSPC has been enhanced with expanded capabilities since its original public release.

A continuous simulation period of at least 15 years based on build up-wash off is being created. The LSPC model for each watershed is being developed and calibrated instream with an emphasis on hourly or finer time series outputs for the following "primary" constituents:

- Flow rate
- Sediment (total suspended solids)
- Bacteria (E. coli)
- Metals (total zinc and copper)

- Nutrients (total nitrogen and phosphorous))

In addition, the LSPC model for each watershed will include outputs for additional "secondary" constituents:

- Temperature
- Nutrient species (nitrate, nitrite, organic nitrogen, ammonia, phosphate and organic phosphorous)
- Dissolved oxygen, biochemical oxygen demand
- Phytoplankton, chlorophyll-a

For both primary and secondary constituents, LSPC will generate an hourly or finer time series for the outlet of each subcatchment. These subcatchment time series are also routed downstream by LSPC to generate a time series for each receiving water stream segment. Through these time series, the current state will be evaluated in terms of percentile exceedance (median, 95th percentile, etc.) for both concentrations and flow rates. Attainment of varying contaminant concentrations and loads, including those specified as Numeric Attribute States by the NPS-FM, will also be evaluated.

The boundary conditions for the LSPC models are based on existing datasets including land use data, impervious cover data, soil classification data, rainfall and evapotranspiration data, data regarding releases and storage by impoundments, groundwater levels, contaminant concentrations in groundwater, and more. The LSPC model will also represent point source discharges to freshwater bodies and point withdrawals/takes. Livestock will be represented using spatially-based livestock density data and per-stock loading rates. On-site wastewater systems will be represented using spatial risk factors and estimated contaminant release rates. The current state model will be calibrated based on several datasets including the following:

- Flow rate and contaminant time series collected by Council at River Water Quality stations
- Other flow and water quality data collected by the Council, including data from stormwater outfalls where available
- Contaminant concentrations from runoff stations in NIWA's Urban Runoff Quality Information System
- Parameters from existing contaminant loading models

The calibration will develop region-wide parameters across the 10 watersheds, while also incorporating specific parameter adjustments for each of the watersheds based on catchment-specific data. Watersheds that are not monitored will be represented using the region-wide parameters. Reporting of calibration/model performance will include quantitative criteria such as the relative error between model predictions and observations for different outputs (flows, volumes, concentrations and loads) and durations (hourly, seasonal and annual) and overall categories of performance such as Very Good, Good, Fair, and Poor.

The data compilation and processing for LSPC model setup has required an intense effort across an array of data types. The data compilation resulted in a data inventory with details of each data source, data processing conducted, notes on data quality and recommendations for future potential improvements. The lessons learned and successes of this phase will be useful to conference attendees who are undertaking watershed planning (i.e., NPS-FM).

By developing the FWMT, Auckland Council will be positioned with the key building blocks to conduct scenario modelling in later stages that will inform policy decisions regarding the cost and benefit of various options for the implementation of the Wai Ora- Healthy Waterways Programme in line with NPS-FM and Unitary Plan provisions. Conference attendees may benefit from learning about Auckland's long-term vision for integrated watershed planning (including the role of the FWMT within that vision).

KEYWORDS

water quality, stormwater, contaminants, modelling, hydrology, national policy statement for freshwater management,