Lake Models – Fact Sheet

Linking lake restoration with end users for positive environmental outcomes

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Overview of Lake Models

Models of lakes are used to provide insights into water quality at some future point in time, so that management actions may be targeted and cost-effective. In the past, small-scale physical models were used to simulate lake environments (Figure 1), but nowadays computer models are used to test potential management options. Computer models use a series of mathematical equations to describe the complex interactions amongst physical, chemical and biological processes that affect the water quality of a lake. The equations are stitched together consecutively in a computer program, allowing millions of calculations to take place in a single simulation.

Use of models has become a standard practice to support community decision making for managing lake water quality. These models will increasingly be part of the National Policy Statement for Freshwater Management (2014) which will necessitate that freshwater management units are ’maintained or improved’.

A key part of the strategy to manage water quality in Lakes Rotorua and Rotoiti is the application of lake models. Model simulations of Lake Rotoiti demonstrated how diversion of the Ohau Channel inflow from Lake Rotorua to Lake Rotoiti would lead to a significant reduction in blooms of cyanobacteria (blue-green algae) through reduced nutrient loads. They also showed the length of the wall required to prevent water from the Ohau Channel entering the main basin of Lake Rotoiti. In Lake Okaro, modelling has shown that only major sustained reductions in nutrient loading will shift the lake trophic status from eutrophic to mesotrophic. In Lake Rotorua modelling has shown that recent improvements in water quality are related to alum dosing of two major inflows to the lake, rather than inter-annual variations in climate or composition of inflows.

Figure 1. Waikato University physical model of the Rotorua lakes constructed as part of an exhibition at the Rotorua museum. Photo: Louise Stewart.

Lake Models – Fact Sheet Continued

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Models of Lake Rotorua

Different models are being used to inform the management of water quality in the Rotorua lakes. A climate model is being used to forecast a future climate for the Rotorua region. Projections from the climate model indicate that average air temperature may be around 2.5°C warmer by 2100 than it was in 1990 (Figure 1). It is therefore important to build these projections into lake and catchment modelling .

The catchment model ROTAN (Rotorua and Taupo Nitrogen) was developed by NIWA. It simulates sub-catchments that contribute water to Lake Rotorua (at least 9 major streams, 9 minor streams and 9 geothermal inflows) (Figure 2). It takes time for water to be transferred from rainfall into groundwater and streams that eventually reach the lake. For this reason, a groundwater model has also been an important part of understanding water flow paths, as water can take different lengths of time to reach the lake. Only around 50% of the rainfall that falls in the Rotorua catchment actually reaches the lake; the remainder is lost to evaporation and plant transpiration.

ROTAN is also being used to predict nitrogen loads associated with different land uses and this is also being fed from farm-scale predictions from OVERSEER. The climate and catchment model feed data into the lake model, which is used to predict key water quality indicators such as levels of algae (chlorophyll), nutrients and water transparency. The lake model combines a mixing and transport model (DYRESM or ELCOM) (Figure 3), to represent where water moves within the lake, with an ecological model (CAEDYM) for predictions of a large number of chemical and biological constituents of the water.

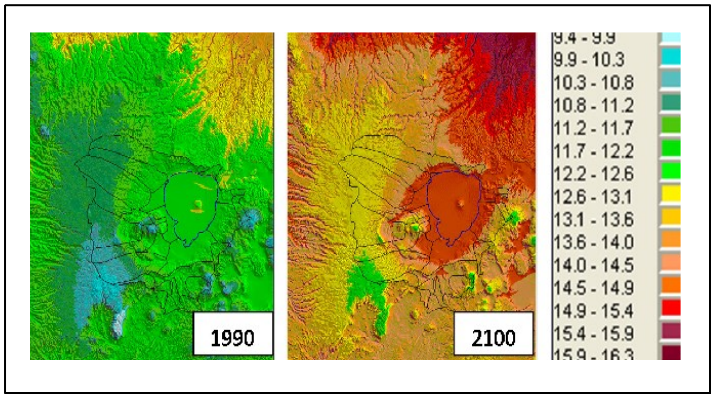

Figure 1. Projected climate (temperature coloured in degrees Celsius; scale on right) for Rotorua region showing sub-catchments and the lake (central circular area).

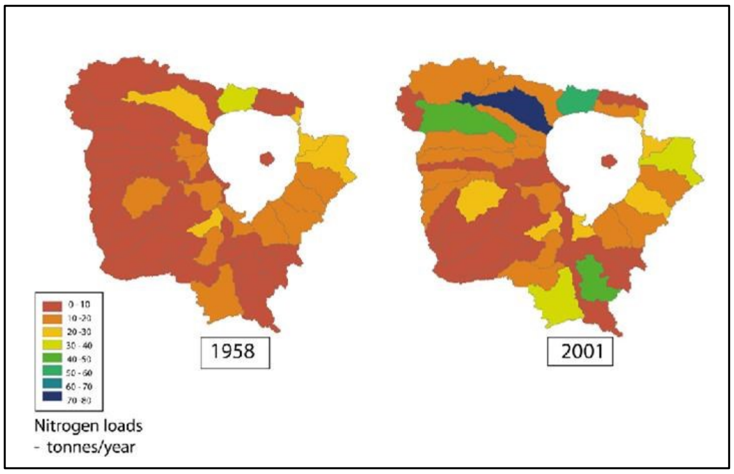

Figure 2. Nitrogen loads from sub-catchments of Lake Rotorua simulated with ROTAN. The total nitrogen load was 427 tonnes/yr in 1958 and 712 tonnes/yr in 2001. Image: Chris Palliser, NIWA.

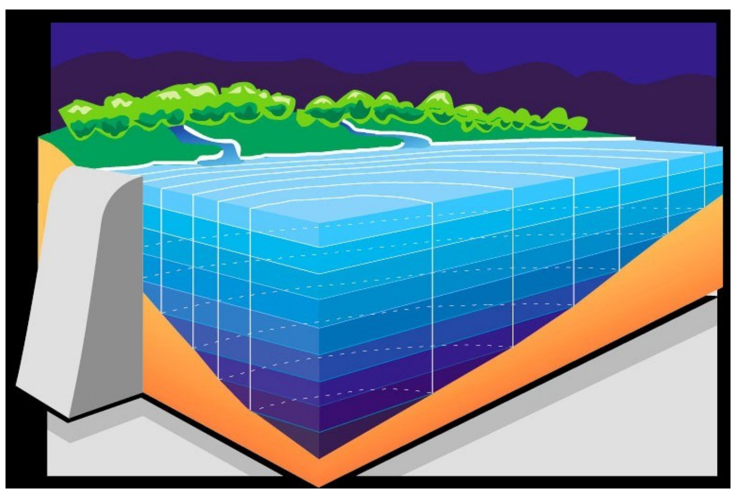

Figure 3. Three-dimensional grid structure used in ELCOM to simulate the transport and mixing of water. Image: Centre for Water Research, University of Western Australia.