LAKE ROTORUA – WAI ORA MO A MAATAU MOKOPUNA

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Abstract

Lake Rotorua is the largest lake in the Rotorua district at 8,085 hectares. It was returned to Te Arawa through the 2004 Deed of Settlement, and the lakebed is vested in Te Arawa. The management of the Lakes is shared between "the Partners" to the Rotorua Lakes Strategy Group (Te Arawa Lakes Trust, Bay of Plenty Regional Council, Rotorua Lakes Council). The Statutory Acknowledgement acknowledges Te Arawa's cultural, spiritual, historical and traditional association with the Lakes.

The city of Rotorua is on the south-western shore of the lake and covers about eight percent of the 53,789 hectare lake groundwater catchment. The Lake Rotorua catchment is dominated by pastoral farming and forestry but includes around 9,000 hectares of indigenous vegetation. Forestry occupies around 23,129 ha (43%) within the catchment. Dairy farming occurs on 6,590 ha (12%) and dry stock land-use occupies 19,770 ha (37%).

The water quality for Lake Rotorua has been the subject of concern for over 35 years due to weed growth and algal blooms.

Through research and community engagement the water quality of the 1960s was identified as a suitable and achievable target for the lake. This was established as a target Trophic Level Index[1] (TLI) of 4.2.

To achieve the TLI target the concentration of two key nutrients feeding algal populations in the lake need to be reduced. Science research has shown that the sustainable annual nutrient load required to achieve the target is 435tN (nitrogen) and a range of 33.7 to 38.7tP (phosphorus). The peak nitrogen load flowing to Lake Rotorua is predicted by NIWA's catchment nitrogen model (ROTAN) is 755tN/year. A high percentage of phosphorus in the catchment comes from natural sources and the capacity to achieve any required reduction from the catchment's land-uses is likely to be extremely difficult. Phosphorus needs to be reduced by 47% to 64% of the anthropogenic load.

The challenge for "the Partners" and the community is firstly, how to achieve the target and then how to maintain this level for future generations.

A number of proposals have been put forward and tested to achieve the short and long-term reduction in N and P and the council is always looking for the "next best solution". Some of the technologies that have been tested include:

[1] The trophic level index (TLI) is used in New Zealand as a single number used to indicate lake health. The system uses four criteria, phosphorus and nitrogen concentrations, as well as visual clarity and chlorophyll-a (algal biomass) weighted equally.

- Sediment capping
- Phosphorus locking
- On-farm nutrient management/reduction
- Floating wetlands
- Nanobubble technology

The overwhelming conclusion reached by "the Partners" is that the only long-term sustainable solution is to change the land-use, or the management of existing land-uses. This does not give an immediate solution as the average groundwater age[2] in the catchment is about 60 years. The effect of this average ground water age is the water currently flowing into Lake Rotorua left the average farm in the catchment in 1958 and it could take 60 years for changes in land-use today to make a difference to lake water quality.

Achieving the lake water quality target of TLI 4.2 is further complicated by the potential effects of climate change, which may increase the TLI and the effect of Lake Rotorua on the cleaner water quality in Lake Rotoiti (target TLI is 3.5).

Climate change has the potential to increase storm flow frequencies and magnitudes, bringing more nutrients with erosion or increase water temperature, which may result in better conditions for sediment nutrient releases that feed algae, both effects that may increase TLI.

The focus of the Lake Rotorua nutrient strategy is:

- Long term land-use change –implementation of proposed Plan Change 10 to the Regional Water and Land Plan
- Phosphorus locking – short-term change through the removal of free phosphorus from streams and lake by adding alum (aluminium sulphate)
- Diverting water from Lake Rotoiti as it flows out of Lake Rotorua to the Kaituna River

Land-use Change

The BOP Regional Policy Statement set a nitrogen limit to reduce losses from rural land within the Rotorua groundwater catchment to meet the TLI. Council then introduced proposed Plan Change 10 (PPC10) to the Regional Water and Land Plan following consultation. Achieving the TLI target has a range of cultural and economic challenges which makes this an issue for the Rotorua community and the region.

While nitrogen management is a key focus of PPC10 there will be also be a consequential reduction in the discharge of phosphorus associated with land-use change.

Changing land-use, or the management of existing land-use, in the Lake Rotorua catchment is the only sustainable solution that will achieve the reduction in nitrogen needed to meet the limit set by the RPS.

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[2] . Each sub-catchment has multiple flow paths (overland and groundwater) each with various multiple lag times and attenuation rates reflecting different soil and geological conditions.

Table 1 below summarises the 2010 N loss to Lake Rotorua by land-use in the catchment:

Land-use	Total Area (ha)	Nitrogen outflow (tN/yr)
Forestry	23,129	75.4
Dairy farms (26 total)	6,590	273
Dry-stock farms	19,770	236
Urban/residential area	4,300	102.1
Natural		38.5
Rainfall		30
Total	**53,789**	**755**

From the table the obvious answer is to manage nitrogen outflows from the highest contributor (dairy farms) in the direction of the lowest contributor (forestry). However, this has a disproportionate disruptive effect on one sector of the community so it was agreed that a more nuanced approach to land-use change was needed.

PPC10 provides the regulatory framework – objectives, policies and rules under the Resource Management Act – to manage land-use activities. The council also holds incentive funding that can facilitate change to management practices to achieve the RPS nitrogen limits.

The proposed reduction of 320t/N/y is anticipated to be achieved through the following land-use changes:

a) 140 tonnes through regulatory control of land-use via the proposed rules;

b) 50 tonnes through engineering solutions – measures designed to improve lake water quality include sewage reticulation, construction of the Tikitere Geothermal Treatment Plant and alternative wastewater options for the Rotorua Wastewater Treatment Plant;

c) 100 tonnes through the Incentives Scheme – a $40m fund contributed equally by the Crown and the regional council. The scheme enables landowners to "sell" their N discharge allowances to permanently remove this from the catchment; and

d) 30 tonnes through gorse management – a Gorse Conversion Project funds the conversion of this N fixing plant to production forestry, native bush or other low N land-use.

PPC10 provides for the management of N by allocation to each "property" and requires the managed reduction of N so that the allocation is complied with by 2032.This is likely to require some changes in land-use and/or the intensity of farming.

What happens downstream?

Water from Lake Rotorua exits via the Ōhau Channel to Lake Rotoiti. In the mid-2000s the water quality of Lake Rotoiti was severely impacted by the level of nutrients flowing from Lake Rotorua. The Rotorua catchment has significantly higher land-use intensity and consequently the impact of land-use on Rotorua was also flowing through to Rotoiti.

Water quality in the Kaituna River was also affected by the outflow from Lake Rotorua with algal blooms occurring in the river on a regular basis before 2011.

Achieving an improvement in the water quality of Lake Rotorua will take many decades and so the regional council invested in two projects that provide short-term solutions to the problems experienced in Lake Rotoiti and the Kaituna River whilst the longer term land-use changes are implemented and take effect. These are:

1. The construction of the Ohau Channel diversion wall; and
2. The use of alum to lock phosphorus into sediments.

The Ohau Channel Diversion Wall

The diversion wall is 1.3km long extending from the Ohau Channel into the Okere Arm directing the outflow from Lake Rotorua directly to the Kaituna River, eliminating the circulation of this water around Lake Rotoiti.

The diversion wall was consented in 2006 and commissioned in 2008. Significant algal blooms have been absent from the lake since construction (Hamill 2017).

Phosphorus locking

Since 2007/8 the council has held consents to discharge alum to inflows to Lake Rotorua in the Utuhina and Puarenga Streams. These consents are in the process of being renewed and there is discussion around the deliberate introduction of a contaminant into the lake's water.

However, there has been a dramatic improvement in the water quality of Lake Rotorua since the commissioning of the locking plants largely achieving the TLI target This has had a consequential effect on the quality of the water flowing down the Kaituna River where no algal blooms have been experienced in recent times (Hamill 2017).

Initially alum was used to lock phosphorus present in the two streams but it was realised that the stream dosing resulted in responses in the lake and there was a wider benefit to the system than just treating the streams. The dosing rate is now based on lake monitoring and is altered in response to the concentration of phosphorus in the lake. The council is now adjusting the dose in anticipation of changes in in-lake phosphorus through the seasons.

The use of alum to achieve TLI targets does not directly influence the nitrogen inflows to Lake Rotorua so this is part of a coordinated approach to manage nutrient flows into the lake. Alum is part of the short-term strategy to improve water quality that is more "tolerated" rather than "accepted" culturally and that

by using an adaptive response based on monitoring and modelling there will come a time when alum dosing is no longer needed.

Concluding remarks

Achieving water quality targets for Lake Rotorua requires an integrated approach covering environmental, social, cultural and economic values in the catchment. Integration and modification of techniques and technologies is required to ensure multiple interventions are providing the best solutions.

The council has set a nitrogen target in Lake Rotorua that will require ongoing monitoring and adjustments as conditions in the catchment change. Climate change is almost certain to be an additional challenge to meeting water quality goals.

At present the TLI target for Lake Rotorua is being achieved but there is a long way to go to meet the nitrogen limits. Any opportunity to improve water quality in the lakes must be taken. It is likely that emerging practices and technologies for land-use will relied upon.

Key Words

Nutrient Management, Land-use Change, Lake Rotorua