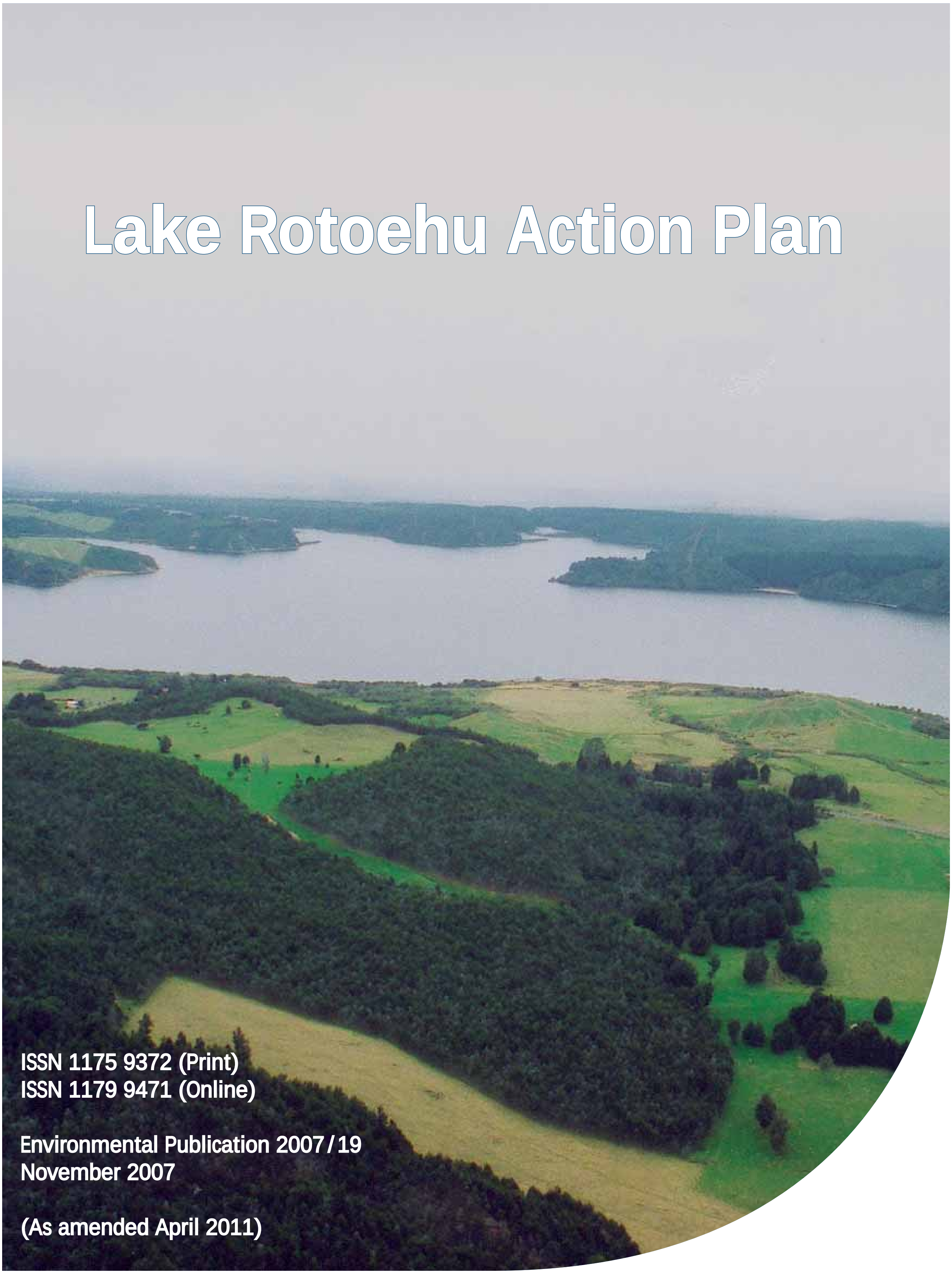
# Lake Rotoehu Action Plan



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THE ROTORUA LAKES

Protection and Restoration Action Programme

A **Bay of Plenty Regional Council, Rotorua District Council** and **Te Arawa Lakes Trust** joint project

# Lake Rotoehu Action Plan

# Hearing Panel Decisions

# 7 November 2007

# Foreword

We are pleased to release the Lake Rotoehu Action Plan, which aims to significantly improve the water quality of Lake Rotoehu through lake restoration actions over the next ten years.

Lake Rotoehu is a relatively quiet lake valued for trout fishing, kayaking and some waterskiing. However since 1993 it has suffered major cyanobacterial blooms, and more recently the spread of hornwort beds through much of the shallow areas.

Te Arawa value the Te Arawa Lakes and the Lakes' resources as taonga and continue to maintain their spiritual, traditional, cultural and historical relationships with their ancestral lakes.

The Action Plan outlines some key actions to improve lake water quality, such as:

Land use and land management changes on pastoral land to meet a nutrient loss reduction target.

Implementation of Environmental Programmes to protect waterways.

- Hornwort biomass harvesting.
- Wetland construction.

Rotorua District Council, Environment Bay of Plenty and Te Arawa Lakes Trust look forward to working with the Lake Rotoehu community and landowners on these actions.

If these actions are achieved, there is a good chance that Lake Rotoehu could be pulled back from its eutrophic state to become a mesotrophic lake again. A key indicator that this has happened will be a decline in the extent of cyanobacterial blooms that infest the lake during the summer months.

**John Cronin**
**Chairman**
**Environment Bay of Plenty**

**Kevin Winters**
**Mayor**
**Rotorua District Council**

**Toby Curtis**
**Chairman**
**Te Arawa Lakes Trust**

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# Chapter 1: Key Recommendations

1 The Rotorua Lakes Strategy Group partners[1] will work with rural landowners and property managers within the Lake Rotoehu catchment to reduce nitrogen and phosphorus loss from their properties through land use and land management changes to meet the land use component of the 2017 nutrient loss reduction targets in section 4.2.

2 Environment Bay of Plenty will work with the Maori Trust lands within the Lake Rotoehu catchment to implement environmental programmes, which include riparian protection works.

3 Environment Bay of Plenty will coordinate hornwort harvesting in Lake Rotoehu to remove nutrients from the lake for ten years, subject to hornwort weed availability, anticipated environmental results, and any contractual agreements with other parties to reduce costs. Hornwort harvesting may continue long-term if it is comparatively cost-effective for EBOP or becomes commercially viable for a business.

4 Environment Bay of Plenty will either:

Construct a wetland to remove 1,650 kg-N dissolved nitrogen from Te Maero Stream, or
Install sufficient floating wetlands to remove 825 kg-N[2] from Lake Rotoehu, or

Subject to the outcome of research and field investigations, resource consents, contractual agreements with any landowners, and cost-effectiveness.

5 Environment Bay of Plenty will continue working with the Waitangi #3 Trust to enhance the wetland area in the vicinity of the Waitangi Soda Springs.

6 Environment Bay of Plenty will continue to investigate other nutrient removal options to improve Lake Rotoehu's water quality, based on cost-effectiveness and anticipated environmental results.

7 Environment Bay of Plenty will develop a fact sheet summarising research on nutrient inputs from aquatic birds/waterfowl to the Rotorua Lakes.

8 Environment Bay of Plenty will review section 9.4 rules[3] in the Regional Water and Land Plan for the Lake Rotoehu catchment, with the Lake Rotoehu Action Plan working party and rural landowners within the Lake Rotoehu catchment.

1 Rotorua Lakes Strategy Group partners: Environment Bay of Plenty, Rotorua District Council, Te Arawa Lakes Trust.
2 This is half the mass removed from a catchment-based wetland, because of the 50% in-lake attenuation rate used to determine the nitrogen reduction target (see Appendix 5).
3 Section 9.4: Discharges of Nitrogen or Phosphorus from Land Use and Discharge Activities in the Rotorua Lakes Catchments.

9 The Rotorua Lakes Strategy Group partners will continue to promote research into Lake Rotoehu, its catchment and land use alternatives to better understand lake and catchment processes and to manage lake quality more effectively.

10 The Rotorua Lakes Strategy Group will commission a review of the Lake Rotoehu Action Plan, ten years after the Group formally adopts the Action Plan.

*Table 1 Comparison of nutrient reduction actions*

| **Nutrient loss reduction targets to 2017: N = 8,880 kg-N/year; P = 708 kg-P/year** | | | | | |
|---|---|---|---|---|---|
| **Action** | **Kg reduction/year** | | **Cost[4]** | | **Timeframe** |
| | **N** | **P** | **$ per year** | **$ per kg** | |
| Constructed wetland/Floating wetland | 1,650 | 0 | $125,000 | $77 (N) | 2007 – 2009 |
| Riparian protection & environmental programmes | 542 | 249 | $100,513 | $185 (N)<br>$404 (P) | 2006 – 2011 |
| Land use/land management changes | 6,688 | 459 | ~ | ~ | 2008 - 2018 |
| **Total** | **8,880** | **708** | | | |
| Hornwort harvesting | 2,400 | 320 | $52,800 | $22 (N)<br>$165 (P) | 10 years to 2017 |
| *N removal from septic tanks (80% N)[5]* | *470* | *0* | *$231,000* | *$491 (N)* | *2010* |

Note that the upgrade of septic tanks in the Lake Rotoehu catchment is required under the On-Site Effluent Treatment Regional Plan. It is not part of the Lake Rotoehu Action Plan and is not combined with Table 1's total as they are private costs and requirements. However, the costs and benefits are included here for comparison with other actions.

Hornwort harvesting is a 10-year programme in this Action Plan. The intention is for hornwort harvesting to achieve some in-lake nutrient reduction until catchment land use and land management changes begin to take effect in the lake. However if hornwort harvesting becomes a long-term action, the land use/land management nutrient loss reduction targets may be reduced by the amount of nutrients removed in the hornwort. But this would be conditional on:

- Lake Rotoehu's TLI trending towards its TLI target.
- Cyanobacterial blooms only happening occasionally.
- Lake Rotoehu re-stabilising as a mesotrophic lake.

4 Estimated public costs only (e.g. Environment Bay of Plenty, Rotorua District Council). These include any capital investment costs, cost of capital (borrowing or opportunity costs), or depreciation costs. Secondary economic benefits that may offset these costs are not included. Refer to the relevant Action Plan sections for more information.
5 Refer to section 8.1.

# Chapter 2: Introduction

## 2.1 History

Lake Rotoehu is a 795 ha lake formed along with Lake Rotoma by the Rotoma eruption approximately 8,500 years ago. Unlike Lake Rotoma, Lake Rotoehu is shallow. Its average depth is 8.2 metres with a maximum depth of 13.5 metres. The lake has no surface outlet. Water exits the lake through a sinkhole in one of the northern lake arms and may have other subsurface outlets.

Lake Rotoehu and its surrounds have been used by Maori groups since descendants from the Arawa canoe entered the area. Ngati Pikiao and associated hapu still own a lot of the land in the catchment. Ngati Awa hapu contested the lake and forests from time to time and also claim it as their rohe.

Rotoehu means “murky water”, implying that the lake was not crystal clear. Geothermal inputs and wind-stirred sediments from the shallow lake bed would have made the lake ‘cloudier’ than nearby Lake Rotoma.

In the 1960s, lake researchers noted that the algal production in the lake was occasionally sufficient to cause algal blooms to develop[6]. This is an indication that Lake Rotoehu was nutrient enriched to probably a mesotrophic state about this time. Water clarity was reduced by about one metre, and the oxygen content in the bottom waters dropped to low levels in summer, into the 1970s[7]. This water quality change reflected the land use changes in the catchment over these decades from native bush and scrub to pasture[8].

The lake water quality remained relatively constant at this mesotrophic state until 1993, when the nutrient levels in the lake doubled and the amount of algae in the lake quadrupled. Since then, Lake Rotoehu has experienced cyanobacteria blooms every summer from 1993-’94 onwards, with an absence during the 2003-’04 summer.

The cause of this massive increase in nutrients and algae is suspected to be from a 4.2 metre drop in lake level combined with a warm summer and low wind speeds. A lake level drop of this amount would subtract about 15 million cubic metres from the 60 million cubic metres of water usually held in the lake. This would increase the concentration of nutrients in the lake. The increased nutrients and warm, calm weather would have caused long periods of deoxygenation of bottom waters, triggering nutrient releases from the lakebed sediment. Since the “event”,

[6] Fish, G.R. (1975) A limnological study of four lakes near Rotorua. NZ Journal of Marine and Freshwater Research 4:165-194.
[7] Richmond, C.J. (1989) Evidence in the Matter of water right application no. 2168 by NSAD for consent to discharge treated sewage near Lake Rotoehu.
[8] Rae, B.J. (1981) Land Use. FORLD, Progress Report No. 5, University of Waikato, Environmental Studies Unit.

phosphorus concentrations have slowly decreased but nitrogen concentrations have remained high.

## 2.2 Ownership and lake use

In 1840 Lakes Ngahewa, Ngapouri/Opouri, Okareka, Okaro, Okataina, Rerewhakaaitu, Rotoehu, Rotoiti, Rotoma, Rotomahana, Rotorua, Tarawera, Tikitapu and Tutaeinanga provided food, shelter, economic resources and primary transport routes for Te Arawa.

The Te Arawa Lakes Settlement Act 2006 has transferred the ownership of the bed of Lake Rotoehu to Te Arawa Lakes Trust along with the beds of other Rotorua Lakes. This gives Te Arawa certain ownership rights:

(a) Public access on the lake is preserved.

(b) Existing commercial operations and lake structures can continue, subject to any resource consent requirements for consultation with Te Arawa Lakes Trust.

(c) New lake structures and new commercial operations that use the lakebed require permission from Te Arawa Lakes Trust as owners, as well as any resource consent process.

(d) New non-recreational activities not using the lakebed need to consult with Te Arawa Lakes Trust if required through the resource consent process.

(e) Te Arawa Lakes Trust has no responsibility for exotic weed management, or the lake quality decline that has occurred during the Crown's management of the lakes.

(f) Te Arawa Lakes Trust are part of a three-way co-management regime for the Rotorua Lakes. This is coordinated by the Rotorua Lakes Strategy Group. The Group is a joint committee under the Local Government Act, made up of the Environment Bay of Plenty chairman and a councillor, the Rotorua District Council mayor and a councillor, and the Te Arawa Lakes Trust Chairman and a senior executive.

The Crown, acting through the Commissioner of Crown Lands, has retained ownership of the space occupied by water and air above each of the lakebeds (Crown Stratum). The land owned by the Crown is administered by Land Information New Zealand (LINZ) in accordance with the Land Act 1948. Environment Bay of Plenty manages the use of water under the Resource Management Act.

The Te Arawa Lakes Fisheries (Regulations) 2006 empowers the Te Arawa Lakes Trust to manage the non-commercial customary fishing within the Te Arawa Lakes. The regulations apply to the following five native fish species: koaro, inanga (smelt), koura (freshwater crayfish), tuna (eel) and kakahi (freshwater mussel). The Trust may make bylaws on the take or sustainable use of these five fish species, which override the amateur fishing regulations.

Te Arawa Lakes Trust and the National Institute of Water and Atmospheric research (NIWA) are currently researching these five species to develop a sustainable management framework for Te Arawa lakes' customary fisheries. Specifically, to develop planning tools, monitoring methods and guidelines based on customary knowledge and sound scientific principles.

Lake Rotoehu has a small residential community, most residing around Otautu Bay and Kennedy Bay. The rural community currently includes one dairy farm and sheep and beef grazing units. Land ownership is predominately Maori trusts, forestry interests and reserves.

The lake is used for boating, trout fishing and wildfowl hunting. The Waitangi Soda Spring beside the lake is a natural geothermal pool used for bathing.

## 2.3 Relationship of the community with the lake

The small communities around Otautu Bay, Kennedy Bay and the rest of the community have a very strong affinity with the lake. Most lake use is by local residents, particularly boating and fishing. These communities are saddened by the algal blooms and hornwort infestations that have plagued the lake since 1993. While local residents are willing to help with restoration of the lake, they believe Environment Bay of Plenty needs to focus and direct efforts to fix up their lake and return it to pre-1993 water quality.

## 2.4 Rotorua Lakes Recreation Strategy

The Rotorua Lakes Recreation Strategy also sits under the Rotorua Lakes Strategy Group. It sets out:

- A vision for recreational management of the Rotorua Lakes
- Zoned lake areas for appropriate activities, infrastructure and management, based on the unique characteristics of each lake. A policy framework applies to each zone.
- Five specific actions to improve lake management.
- A Recreation Forum to guide Strategy implementation and general lake recreation management of specific actions in the Strategy.

## 2.5 Rotorua Lakes Aquatic Pest Management Plan

This Management Plan co-ordinates aquatic pest management efforts within the Rotorua Lakes through an Aquatic Pests Technical Advisory Group. The Plan is a high level, brief plan with set timeframes and responsibilities for specific actions. Environment Bay of Plenty is the lead agency. It is a major step forward in collaboration on aquatic pest fish issues.

## 2.6 Land cover and land use

Lake Rotoehu’s catchment contains a roughly equal mix of livestock, forestry and native bush land uses, shown in Figure 1. Land use is mostly sheep and beef livestock farming, with a dairy farm on flat land to the southeast of the lake.

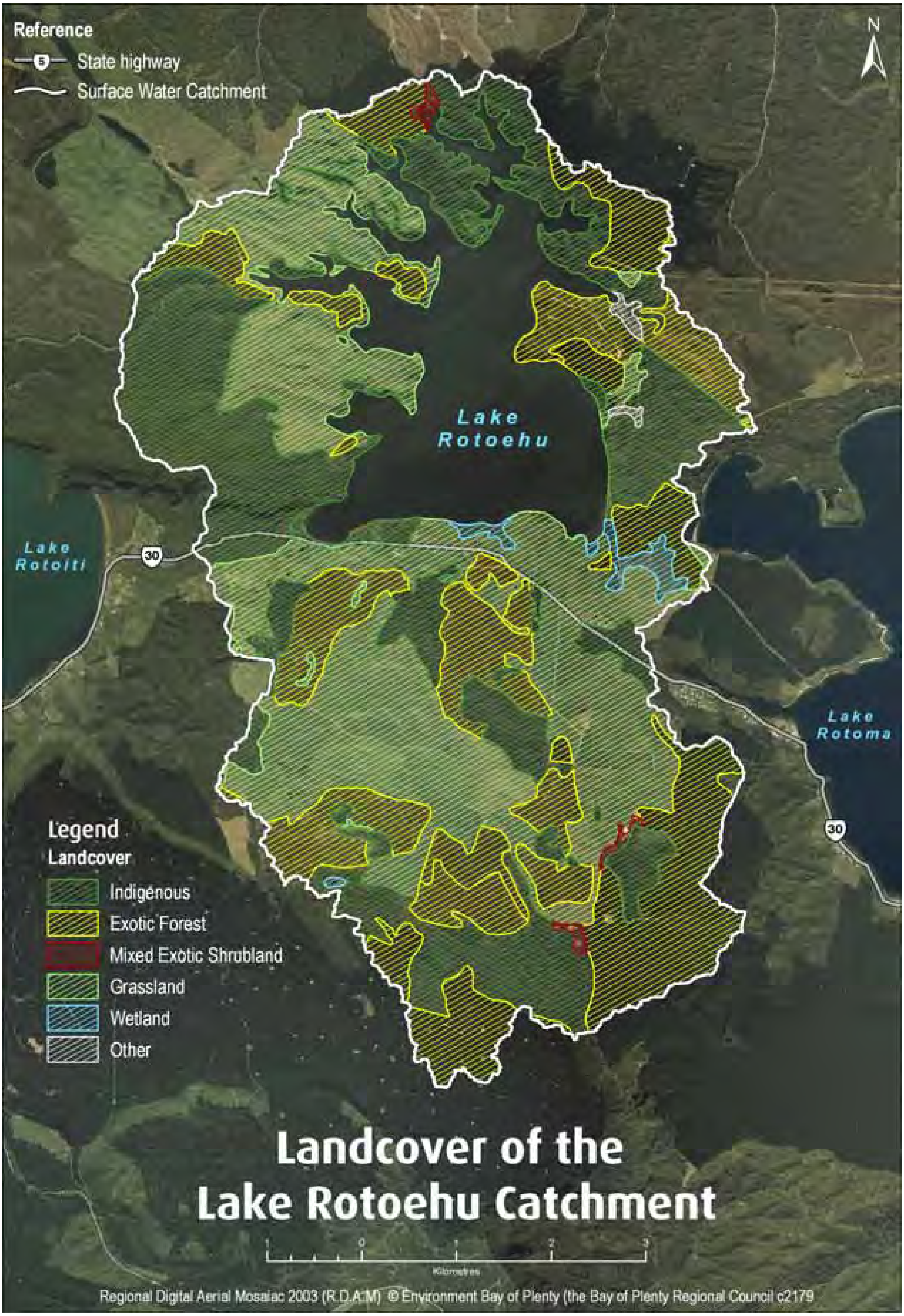


*Figure 1 Land cover of the Lake Rotoehu catchment*

# Chapter 3: Nutrient Sources

Lake Rotoehu's high algae concentration and re-suspension of bottom material by wind and wave action reduce the water clarity in the lake itself. Algal growth is driven predominantly by phosphorus and nitrogen. The more phosphorus and nitrogen that enters a lake, the more algae will grow.

## 3.1 Natural springs

The pumice soils around Lake Rotoehu produce small, clear streams that emerge as springs and in some cases leak back into the ground again. The springs, including the Waitangi Spring, tend to be high in phosphorus dissolved from the underlying volcanic geology and geothermal activity.

## 3.2 Forestry and native bush

Nitrogen is recycled efficiently within forests. Only small amounts are lost to leaching. Phosphorus loss is also low.

## 3.3 Pastoral farming

Nitrogen is incorporated into pasture soils from nitrogen-fixing plants and fertiliser, and recycled through livestock in urine and dung. More nitrogen is lost to run-off and leaching than in forests. Leaching is highest during winter, when soils are saturated and grass growth is low. As a general rule, the higher the intensity of livestock farming, the higher the levels of nitrogen leached. Phosphorus is more dependent on slope, rainfall and land management practices.

Most nutrients into Lake Rotoehu come from pastoral farming. Farming development in the catchment has driven the lake quality decline. To improve the lake again, nutrient loss from farming will need to be cut back.

## 3.4 Wastewater

Wastewater from human communities also contains nitrogen and small amounts of phosphorus. Septic tank effluent disposal leaches nitrogen to the groundwater. Most phosphorus is removed in the tank or bound to the soils.

## 3.5 Aquatic birds

Lake Rotoehu hosts comparatively large numbers of aquatic birds, from the common black swan to the rare dabchick. Estimates of the proportional input of aquatic birds to nitrogen and phosphorus loading vary depending on the source.

Sources of information include:

- Bioresearches (2002): First Order Estimation of the Nutrient and Bacterial Input from Aquatic Birds to Twelve Rotorua Lakes.
- NIWA (1995): Review of the ecological role of Black Swan (*Cygnus atratus*).
- 2001 – 2007 Fish & Game bird counts.

Environment Bay of Plenty staff will work with Fish & Game staff and other researchers to develop a fact sheet about nutrient inputs from aquatic birds/waterfowl to the Rotorua Lakes. The fact sheet will summarise the best available research on the topic.

When aquatic birds graze on aquatic plants within the lake, they are recycling nutrients within the lake. This can increase the levels of soluble nutrients in the water, which are then available for algal growth. Aquatic birds feeding on pasture will add nitrogen and phosphorus to the lake through leaching/runoff of urea. Aquatic birds can also cause bacterial contamination in bays when they gather together in large numbers.

Overall, because most of the aquatic bird species in Lake Rotoehu are native to New Zealand, they should be seen primarily as a ‘natural’ source of nutrients to the lake, and outside the ambit of this Action Plan.

But if research shows that some non-native aquatic birds are contributing significantly to the Lake Rotoehu’s nutrient load, and this can be managed, control measures should be discussed with relevant authorities. Control measures should be pursued for unprotected aquatic birds that have a significant nutrient load to Lake Rotoehu.

## 3.6 Lakebed sediments

A large portion of the nutrient load present in Lake Rotoehu has been recycled from lakebed sediments. As the catchment nutrient load increases, the amount of algae growth increases. The algae eventually die off and settle out to the lakebed. The dead algae de-oxygenate the bottom water as they decompose (high $BOD_5$) during warm, still weather. This is because the warm upper layer stops mixing with the cooler bottom layer and oxygen is not mixed into the bottom waters. Once the bottom water is devoid of oxygen, lakebed sediments can release much greater amounts of nutrients, particularly phosphorus.

Lakebed nutrient release from sediments is measured by testing the nutrient concentrations in the lake before and after the bottom and top lake waters remix. There have been huge variations in lakebed sediment release. A median value from August 1993 to the present is 5.6 tonnes/year of nitrogen and 1.4 tonnes/year phosphorus (see Appendix 3).

Nutrients released from the lakebed drive the cyanobacterial blooms because they are released in a low N:P ratio that favour the cyanobacteria.

## 3.7 In-stream nutrient concentrations

Table 2 below sets out the recorded base flow and nutrient concentrations in the three main streams entering Lake Rotoehu.

*Table 2 Nutrient concentrations in Te Pohue, Te Maero and Rakaumakere Streams, the Waitangi Soda Spring and the Rotoma Springs*

| Stream | Stream Flow (L/s) | Nitrate-N ($g/m^3$) | Total Kjeldahl-N[9] ($g/m^3$) | Dissolved P | Total P |
|---|---|---|---|---|---|
| Te Pohue Stream | 23 | 2.18 | 0.23 | 0.04 | 0.04 |
| Te Maero Stream | 62 | 2.25 | 0.17 | 0.06 | 0.06 |
| Rakaumakere Stream | 93 | 1.29 | 0.23 | 0.07 | 0.08 |
| Waitangi Soda Spring | 162 | 0.35 | 0.29 | 0.09 | 0.15 |
| Rotoma Springs | 318 | 0.24 | 0.14 | 0.04 | 0.06 |

[9] Total Kjeldahl Nitrogen measures the ammonium, ammonia and organic forms of nitrogen in the water.

# Chapter 4: Nutrient Reduction

## 4.1 Long-term lake water quality goal

Lake water quality is measured by a Trophic Level Index (TLI) (see Appendix 1 for an explanation of the TLI). The higher the TLI, the poorer the water quality. Lake Rotoehu's target TLI is 3.9, but its current 3-year average TLI at June 2005 is 4.6. The target was set at a level that equates to the last "good" year for water quality in the lake – 1992/1993.

## 4.2 Nitrogen and phosphorus reduction target

The objective of this Action Plan is to identify some actions that can reduce the annual nitrogen and phosphorus load to Lake Rotoehu. Over time, this should drop the lake TLI back to the target of 3.9[10]. This is equivalent to lake quality before 1993. This lake quality improvement is considered to be achievable.

Table 3 summarises the calculation of the nitrogen and phosphorus reduction target needed for Lake Rotoehu to attain its target TLI.

*Table 3 Nutrient target calculations*

| Symbol | Description | Nitrogen kg/year | Phosphorus kg/year | Notes |
|---|---|---|---|---|
| C | **C**urrent nutrient inputs, using land use nutrient loss coefficients for the catchment (2003). | 53,267 | 2,445.4 | Taken from the nutrient budget in section 4.3 |
| R | Estimated total nutrient **R**eduction needed | 8,800 | 708 | Calculated using lake N and P concentrations needed to reach the target TLI (3.9)[11] |
| T = C - R | Estimated **T**arget nutrient inputs into Lake Rotoehu | 44,467 | 1,737.6 | This nutrient input level, over time, should lower Lake Rotoehu's TLI to 3.9 |
| I | **I**nternal load cycling from lakebed to water column (Appendix 3 average) | 5,597 | 1,399 | These nutrient releases will affect water quality separate to catchment nutrient inflows |

[10] See Appendix 1 for an explanation of the TLI.
[11] See Appendix 5 for these calculations.

**N reduction target: 8,880 kg/yr**

**P reduction target: 708 kg/yr**

Although the catchment reduction target is 8,880 kg-N/year and 708 kg-P/year, if nutrients are taken directly from the lake water column, this target halves to 4,440 kg-N/year and 353.9 kg-P/ha/yr. This is because some of the nitrogen and phosphorus entering the lake settle out to the lake bed, or are lost to the air. A 50% cut in the nutrient load is a conservative estimate of the effects of these natural processes.

## 4.3 Lake Rotoehu nutrient budget, using nutrient loss coefficients

The nutrient budget below is an estimate of nutrient inputs to Lake Rotoehu, based on typical nutrient losses for each land use as at 2003.

*Table 4 Lake Rotoehu nutrient inputs*

| Land use | Area (2003) | Nutrient loss coefficient (kg/ha/yr) | | Nutrient load to lake (kg/year) | | | |
|---|---|---|---|---|---|---|---|
| | (ha) | N | P | Nitrogen | % | Phosphorus | % |
| Bare ground | 2.6 | 5 | 1.00 | 13 | <0.1 | 2.6 | 0.1 |
| Lifestyle lawn | 47.5 | 20 | 0.90 | 950 | 1.8 | 42.8 | 1.7 |
| Septic tanks[12] | 16.8 | | | 588 | 1.1 | 29.4 | 1.2 |
| Bush | 1,373.1 | 4 | 0.12 | 5,492.4 | 10.3 | 164.8 | 6.7 |
| Scrub | 51.6 | 4 | 0.12 | 206.4 | 0.4 | 6.2 | 0.3 |
| Exotic forestry | 1,292.9 | 3 | 0.10 | 3,878.7 | 7.3 | 129.3 | 5.2 |
| Sheep | 2.6 | 16 | 1.00 | 41.6 | 0.1 | 2.6 | 0.1 |
| Sheep/beef | 974.3 | 18 | 0.90 | 17,537.4 | 33.0 | 876.9 | 35.4 |
| Sheep/beef/ dairy | 92.2 | 35 | 0.90 | 3,227 | 6.1 | 83.0 | 3.4 |
| Dairy[13] | 266.4 | 50 | 0.70 | 13,320 | 25.0 | 186.5 | 7.5 |
| Urban[14] | 16.8 | 15 | 1.17 | 252.0 | 0.5 | 19.7 | 0.8 |
| Wetlands | 37.9 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rain[15] | 796.9 | 3.62 | 0.16 | 2,881 | 5.4 | 131.2 | 5.3 |
| Geothermal[16] | | | | 4,700 | 8.9 | 800 | 32.3 |
| **Total Inflows** | **4971.6** | **10.62** | **0.49** | **53,088** | **100** | **2,445.4** | **100** |
| Lake bed sediments | | | | 5,597 | | 1,399 | |

[12] Septic tanks: 16.8 ha urban area = Permanent houses: 13 (Otautu & Kennedy Bays) + 15 (other ares), at 2.5 people per house = 70 people. 63 holiday homes (Otautu & Kennedy Bays) at 3 people for one month/year = ~16 people. Plus 50 people (school est. per year) + 25 people (campground est. per year) = 161 people x 3.65 kg-N per year.
[13] This includes land used for dairy grazing.
[14] Estimate value only.
[15] Pers. Comm. Max Gibbs (NIWA), 2006.
[16] Donovan, C.L. (2003) Estimate of the Geothermal Nutrient Inputs to Twelve Rotorua Lakes. Bioresearches Group Limited, prepared for Environment Bay of Plenty.

Nutrient inputs from aquatic birds are excluded from Table 4 because they are a 'natural' source of nutrients to the lake, and outside the ambit of this Action Plan. Most aquatic birds in Lake Rotoehu are native, protected, and/or partially protected and the majority of their inputs are considered nutrient recycling, from grazing on lake plants.

But if research shows that some non-native aquatic birds are contributing significantly to the Lake Rotoehu's nutrient load, and this can be managed, control measures should be discussed with relevant authorities. Control measures should be pursued for unprotected aquatic birds that have a significant nutrient load to Lake Rotoehu.

# Chapter 5: Working Party Process

Environment Bay of Plenty published a draft working paper for the Lake Rotoehu Action Plan in July 2003. This gave background information on nutrient reduction targets and options to achieve these targets. A working party was established after a public meeting on 8 December 2003, to help consider options to reduce the lake nutrient load.

Previous working party members who have attended meetings are:

- Rosemary Michie – Environment Bay of Plenty Councillor
- Robyn Waimarama-Skerrett – Taumanu/Matawhaura Trusts
- Mana Malcolm – Te Maero Trust
- Joe Malcolm – Rotoma No. 1 block, Matawhaura block, Waitangi No. 3 Trust, Tautara Incorporated, Rotoiti 6 & 7 Trusts
- Grant McComb – Rotoehu Farm Forest Partnership
- Simon Robertson – Morehu block
- Lisa Singfield – Resident
- Mark Jenkins – Resident
- Paul Hakopa – Te Runanga o Ngati Pikiao
- David Marshall – Department of Conservation

Current working party members attending meetings are:

- Tai Eru – Environment Bay of Plenty Councillor
- Jim Koller – Otautu Bay resident
- Catherine Branson – Kennedy Bay Resident
- Jeff Branson – Kennedy Bay resident
- Mark Macintosh – AgFirst Consultants (Taumanu Trust)
- Eben Herbert – Fish & Game Council (Eastern Region) New Zealand
- Phil Alley – Department of Conservation

- Maurice Meha – Tautara/Matawhaura trustee
- Tony Whata – Tautara/Matawhaura trustee
- Nigel McCloud – Tautara/Matawhaura manager

The working party met on: 25 March 2004, 1 June 2004, 28 July 2004, 27 July 2005, 6 October 2005, 6 June 2006[17], 4 October 2006, 21 February 2007, 28 March 2007 and 29 May 2007.

Staff who have contributed to the working party process are:

Environment Bay of Plenty: Paul Dell, John McIntosh, Andrew Wharton, Ben Banks, Richard Mallinson, Andy Bruere, Matthew Bloxham.

Rotorua District Council: Marc Fauvel (former staff), Ian Wallace, Chandran KV, Ana Vidal.

Te Arawa Lakes Trust: Roku Mihinui, Hera Smith.

[17] This meeting was combined with the Lake Rotoma Action Plan working party, with other community members invited.

# Chapter 6: Nutrient Loss Reduction from Land Use

## 6.1 Pastoral land use/management changes

### 6.1.1 Taumanu block

The Taumanu Trust block southeast of Lake Rotoehu is an intensive dairy farm operation. Dairy grazing, including adjacent grazing areas on other farm blocks, covers about 270 ha. It leaches significant levels of nitrogen via shallow groundwater to springs near Lake Rotoehu.

Because of high nutrient inputs and outputs, dairy farms tend to leach around 30-70 kg-N/ha/year. This mostly occurs during wetter winter months when the soils are less able to absorb nitrogen, and grass growth is slow. Nitrate is the main form of nitrogen leached from dairy farms as it is water-soluble and can move through the soil to groundwater.

Nutrient loss from dairy land use comes from:

- Cow urine patches. These contain high concentrations of nitrogen (urea form) over a small area.
- Excess fertiliser application, in particular over 150 kg-N/ha/year, during heavy rain, or when soils are saturated.
- Pasture and stock race runoff.

This does not imply that the Taumanu dairy farm is managed irresponsibly. Instead it recognises that under current farm practice, intensive dairy farms tend to leach high levels of nitrogen.

### 6.1.2 Sheep and beef blocks

The remaining large pastoral blocks in the Lake Rotoehu catchment are moderately-intensive sheep & beef farms. The nutrient loss from sheep & beef farms is approximately 18 kg-N/ha/yr and 0.9 kg-P/ha/yr. This nitrogen loss is lower than dairying, however phosphorus loss can be higher because most sheep & beef grazing is on steeper slopes. This increases soil erosion and P runoff.

Nutrient loss from sheep and beef land use comes from:

- Urine patches. These contain high-concentrations of nitrogen (urea form) over a small area. Beef cattle process less nitrogen-rich feeds than dairy cattle, so tend to leach less nitrogen. Leaching from sheep urine patches is lower again.

- Dung and farm runoff.
- Soil erosion and farm runoff can be major causes of phosphorus loss.

Sheep and beef land use covers a quarter of the catchment's land area. This means sheep and beef farming contributes about a third of all nitrogen and phosphorus entering the lake from the catchment. However sheep and beef farms in the Lake Rotoehu catchment do not appear to contribute more nutrients than the normal range for this land use.

### 6.1.3 Potential nutrient reductions

| | | |
|---|---|---|
| Lake Rotoehu's nutrient reduction target: | 8,880 kg-N | 708 kg-P |
| Minus wetland and Environmental Programmes: | 2,192 kg-N | 249 kg-P |
| **Nutrient reduction goal for catchment land use:** | **6,688 kg-N** | **459 kg-P** |

Hornwort harvesting is not included here, as it is intended as a 10-year stop-gap measure to improve lake quality while catchment land use and land management changes begin to take effect. However, if hornwort harvesting became practically viable and community acceptable, and:

- Cost-efficient for Environment Bay of Plenty to continue long-term, or
- A commercial operation of long-term hornwort harvesting with little or no assistance from Environment Bay of Plenty,

The land use/land management nutrient loss reduction targets could be reduced by the amount of nutrient removed by hornwort harvesting annually. However this would be conditional on the Action Plan achieving its goals, as shown these environmental indicators:

- Lake Rotoehu's TLI is trending towards its TLI target.
- Cyanobacterial blooms are only occasional.
- Lake Rotoehu has re-stabilised as a mesotrophic lake.

If a wetland does not proceed, Environment Bay of Plenty should investigate other nutrient removal options to reduce that nutrient loss.

If a long-term cheap and effective method to remove nutrients from the Lake and waterways is discovered, and was more cost-effective for the community than reducing nutrient loss from land use, these nutrient reduction goals for land use could be smaller.

### 6.1.4 Land use/management change options

The dairy industry at a national level is attempting to significantly reduce nitrogen and phosphorus loss from dairy farming. The industry aims to develop accessible technology, processes and systems that can reduce the dairy industry's impact on the environment. For priority areas (including the Lake Rotoehu catchment), these developments aim to be able to reduce nitrogen loss by 50% and phosphorus loss by 80% from today's benchmark.[18] Based on this industry-led approach, nutrient loss reductions for the Taumanu dairy farm should come from use of these new technologies, processes and systems (e.g. better fertilisers, grazing regimes etc.)

The Taumanu dairy farm has the most management options for nutrient loss reductions. Environment Bay of Plenty staff can assist with these options, but the dairy farm managers should chose which ones to use.

For the Trust Blocks with sheep & beef, significant nutrient loss reductions from land management changes risk the land use becoming economically unviable. Instead, the Rotorua Lakes Strategy Group partners and the Trusts should focus on land use change options that can increase the economic return to the Trusts while decreasing nitrogen and phosphorus loss (with an appropriate Nutrient Discharge Allowance reduction – see section 6.1.7).

### 6.1.5 Action

Environment Bay of Plenty, Rotorua District Council and Te Arawa Lakes Trust staff, in their respective roles, will work with landowners, Trustees and farm managers from the Taumanu dairy farm, the Tautara/Matawhaura blocks, and other rural properties in the Lake Rotoehu catchment, to reduce nitrogen and phosphorus loss from pasture land. This may involve a mixture of:

- Farm management and use of new technology.
- New economically profitable land uses with a low nutrient loss.
- Financial assistance for these land use/management changes.
- A reduction in a property's nutrient discharge allowance under rules in section 9.4 of the Regional Water and Land Plan.

Using the Second Priority in section 6.1.7, Environment Bay of Plenty may provide some initial assistance to the dairy farm to get nutrient reductions happening. But the dairy farm must shoulder the long term cost and responsibility for these management changes – along with an appropriate NDA reduction.

The existing economic returns for the sheep & beef blocks are comparatively low. These blocks have also converted some pastoral land into forestry blocks, and are retiring their stream and lake margins. Recognising this, nutrient loss reductions here should ideally be through land uses that increase long-term profit and decrease nutrient loss to the lake.

Should this collaborative approach fail, the Third Priority applies. Nutrient loss reductions should be specified through rules in section 9.4 of the Regional Water and Land Plan. Any new rules will not come into force until the Action Plan's review in 10 years time, to give farm managers time to make the necessary management changes.

[18] Dairy Environment Review Group (Dairy Insight) (2006).

### 6.1.6 Benefits

At this stage, reducing nutrient loss from catchment land use is the main way to improve Lake Rotoehu's water quality over the long-term. Co-operative relationships between the Rotorua Lakes Strategy Group partners and landowners can work towards sustainable solutions (economic, social, environmental) for catchment land use. These solutions will need to take place within constraints in Regional Water and Land Plan rules.

### 6.1.7 Costs

Evaluation of land use/management changes for permanent nutrient loss reductions should consider costs to the Rotorua Lakes Strategy Group partners (i.e. paid for by the regional community), using these priorities:

First priority: changes that also provide a better economic return to the landowner. The cost to the regional community is minimal. However a corresponding reduction in the property Nutrient Discharge Allowance (NDA)[19] would be needed to protect any gains made for the long-term.

Second priority: changes that require some short-term assistance or financial contributions from the Rotorua Lakes Strategy Group partners, but longer-term can be fully adopted by landowners. Environment Bay of Plenty's Environmental Programmes are an example of this. The long-term cost to the regional community is low – moderate. Environment Bay of Plenty would require a NDA reduction in exchange for any assistance.

Third priority: changes that are required as a result of Regional Water and Land Plan rules. The cost to the regional community is indirect (mostly macro-economic effects), and the cost to the landowners could be significant.

Fourth priority: changes where the costs are fully borne by the community. For example, Environment Bay of Plenty subsidising a new fertiliser that inhibits nitrogen leaching. For these changes, the lower the net cost to the regional community per kg-N removed, the better.

At 2007, most land use/management change options fall into the 'fourth priority'. So staff and landowners should investigate 'first priority' or 'second priority' options to help minimise the overall cost to the regional community. The 'Rule 11' review described in section 8.2 will establish the extent of the 'third priority'.

Environment Bay of Plenty has indicatively estimated that $1 million of the Rotorua Lakes Protection and Restoration Action Programme budget should help facilitate land use/management changes that achieve the Lake Rotoehu Action Plan nutrient reduction targets. This should be regarded as a maximum estimate rather than a budget allocation. Land use/management change proposals (and their associated costs) will be assessed primarily on their comparative cost-efficiency.

### 6.1.8 Timeframes

Allowing for the development of new technology, farm management tools and new land uses to reduce nutrient loss, the land use nutrient loss reductions in this Action Plan should take place over the next 10 years.

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[19] Rules in section 9.4 of the Regional Water and Land Plan limit diffuse nutrient discharges from the Lake Rotoehu catchment. This is done by allocating to each property a Nutrient Discharge Allowance (NDA). Nutrient loss from a property cannot exceed this NDA.

## 6.2 Environmental Programmes

### 6.2.1 Background

Environmental Programmes are negotiated agreements between landowners and Environment Bay of Plenty to provide land management works that benefit the environment, like stream fencing or pest control. Environment Bay of Plenty and Rotorua District Council have been providing a grant rate of 50% – 75% depending on the works, the location, and the priority rating.

The landowner must pay for some of the costs and ongoing maintenance of the works, and this is registered against the property title. Negotiations with Maori land blocks like those in the Lake Rotoehu catchment has been difficult in the past: getting a mandate to approve the works and covenant the blocks.

### 6.2.2 Nutrient source

Nitrogen and phosphorus loss from land use is exacerbated by stock access to streams and the lake, soil erosion, and pasture runoff. Environmental Programme works can minimise these effects.

### 6.2.3 Action

Environment Bay of Plenty staff have prepared environmental programmes for most of the pastoral farm blocks in the Lake Rotoehu catchment. Staff will continue to work on these Environmental Programmes with Maori Trust Block trustees so the environmental programme works can be completed within the next five to ten years.

Works prioritised within the Lake Rotoehu catchment are:

(i) Effective fencing and exclusion of livestock from the lake edge and waterways, with associated alternative water supplies.

(ii) Stock exclusion fencing from important wetland and native bush areas.

(iii) Riparian plants and grasses in lake margins, beside streams, and in ephemeral flowpaths where appropriate.

(iv) Restoration of wetland areas.

(v) Pest plant and pest animal control.

(vi) Native plant species planting in specific areas.

Rule 9 in the Regional Water and Land Plan prohibits stock access to Lake Rotoehu, or the upper bush-covered reaches of the Omahota Bay and Matawhaura Bay streams. Rule 8 and 9A in the Regional Water and Land Plan only allow stock access in any of the other streams in the Lake Rotoehu catchment if it is managed under an Environmental Programme, Property Plan, or resource consent.

Because of this, any remaining works to exclude stock from Lake Rotoehu and its catchment streams should be completed as soon as possible to avoid breaching these rules. Remaining stock access not under an Environmental Programme, Property Plan or resource consent is liable for enforcement action.

### 6.2.4 Benefits

Environmental Programme works reduce sedimentation and also contribute to nutrient reduction. For example, a study of the Ngongotaha catchment in 1990 showed works in this catchment reduced total diffuse N by 8 – 9% and P inputs by 15 – 20%. They are an effective way for landowners and Environment Bay of Plenty to work together to lessen the impact of land use on the lake.

For the Lake Rotoehu catchment, a ballpark estimate generated from NPLAS (a nutrient model), using typical farm stocking rates and fertiliser application for the areas with riparian protection works[20], predicted a nitrogen reduction from riparian protection of about:

N reduction = 542 kg-N/year

P reduction = 249 kg-P/year

Note that this includes existing Environmental Programmes implemented since 2003. The nutrient reduction targets in Chapter 4 are benchmarked at 2003 levels.

Aside from improving water quality, Environmental Programme works help increase biodiversity, reduce erosion, improve livestock health, and can increase land values and sustainability.

Many land blocks, like the Matawhaura Block, already have a large amount of riparian retirement work completed.

### 6.2.5 Costs

If all Environmental Programme works and costs for the next five years are confirmed by the Maori Trust blocks, Rotorua District Council and Environment Bay of Plenty:

**Estimated Capital Investment** = $908,258

| | |
|---|---|
| Environment Bay of Plenty: | 65% |
| Rotorua District Council: | 18% |
| Landowners: | 17% |

**Annual Costs**

| | |
|---|---|
| Annual operating costs (landowner only) | $9,400[21] |
| Cost of capital: | $90,825 |
| Depreciation on capital investment | $30,275 |
| Total | $130,500 |
| **Cost per kg-N (excluding landowner)** | **$185** |
| **Cost per kg-P (excluding landowner)** | **$404** |

**Life of capital investment** **30 years[22]**

[20] Parameters: 153 ha over 4 land trusts. 29% dairy grazing, 71% sheep & beef. Small, poor quality filter strips for grazing areas (before EPs). 180 (dairy) 80 (sheep/beef) kg-N/ha/yr fertiliser. 50 kg-P/ha/yr fertiliser. Stock access to lake/streams 50% of the time. 3 dairy heads/ha & 50,000 kg milk solids, 15 s.u./ha sheep/beef. Note these parameters correlate to approximate land area influenced by the environmental programme works, not discrete land parcel or land use areas.
[21] 1% of total capital works, plus $300 for pest control, per year.
[22] Some components, such as a properly-maintained water supply, will last for longer than this. Fences may only last for up to 25 years. Some upgrades could be made in the future. A 30 year depreciation period is an estimated average.

### 6.2.6 Timeframes

Timeframes are dependent on Environmental Programme sign-off by the Maori Trust blocks before works can begin. Excluding any delays, the nominal timeframes for implementing these works are:

- Tautara Block 2006 – 2011
- Taumanu Block 2007 – 2010
- Waitangi No. 1 Block 2007 – 2010
- Rotoiti 6 and 7 B1 Block 2007 – 2011
- Rotoiti 6 and 7 B2 Block 2007 – 2011

Any remaining lake edge stock fencing within these Environmental Programmes must take priority because of Rule 9 in the Regional Water and Land Plan prohibiting stock access to Lake Rotoehu.

# Chapter 7: Nutrient Removal Actions

## 7.1 Hornwort harvesting

### 7.1.1 Background

Lake Rotoehu has been invaded by large areas of hornwort (Ceratophyllum demersum). This is a recent infestation first recorded in December 2004. Since then it has spread to most arms of the lake. It has established a dense bed of over 60 ha at the south eastern corner of the lake. The shallow nature of the lake (mean depth 8.2 metres) and the numerous lake arms to collect hornwort fragments have favoured their rapid growth.

The hornwort stems are up to seven metres long, and can grow up to 16 metres deep if the water is clear enough. Shallow-rooted hornwort is easily uprooted by wind and wave action. Large rafts of hornwort on the lake surface can build up from this action. If lake water clarity increases, hornwort density and distribution over Lake Rotoehu will also probably increase.

To avoid hornwort spread from Lake Rotoehu to nearby Lake Rotoma or another lake without hornwort, lake users need to be kept aware of the high risk of weed spread, especially by weed fragments on boats and boat trailers. Social responsibility must also come to the fore – mutual encouragement for people to always check and clear weed fragments before they leave and enter lakes.

### 7.1.2 Nutrient source

Hornwort is unlike most other aquatic weeds in that they absorb their essential nutrients from the water column they grow in, not the lakebed sediments. Hornwort uses elongated stems to attach to the lakebed, instead of using roots like most other weeds.

If hornwort material is taken out of the lake and deposited out of the lake catchment, this removes the nutrients that the hornwort has absorbed from the lake water. If hornwort was harvested regularly, the regrowth of the weed would continually take nutrients out of the lake. On a large enough scale, this could help reduce the size and duration of cyanobacterial blooms in Lake Rotoehu.

### 7.1.3 Action

Environment Bay of Plenty will coordinate hornwort harvesting in Lake Rotoehu for the purposes of nutrient removal for ten years, subject to hornwort weed availability, anticipated environmental results, and any contractual agreements with other parties to reduce costs.

If practicable, comparatively cost-effective and accepted by the community, hornwort harvesting may become a permanent fixture at Lake Rotoehu if a long-term commercial operation can be established, or if other long-term funding is found.

If possible, weed harvesting should cover the recreational areas of Otautu Bay and Kennedy Bay areas for improved boat access and visual amenity, and a lower risk of weed spread between lakes from boats.

### 7.1.4 Benefits

If 1,000 tonnes of wet hornwort was harvested each year and disposed outside the lake catchment, this would remove approximately 1,200 kg of dissolved nitrogen and 160 kg of dissolved phosphorus from the lake water. Dissolved nutrients removed from lake water are equivalent to double that amount removed from catchment nutrient inputs. This is because about 50% of the nutrient load to Lake Rotoehu is removed from the lake water column through in-lake processes like sedimentation, volatilisation, plant assimilation and other attenuation. The 50% attenuation factor accounts for a doubling of the nutrient loss reduction targets in Table 3.

Hence the equivalent benefit of removing 1,000 tonnes of wet hornwort from Lake Rotoehu is 2,400 kg-N and 320 kg-P.

However, the hornwort harvesting would need to be done every year to maintain this benefit. Because of this, hornwort harvesting funded through the Rotorua Lakes Protection and Restoration Action Programme should only take place over the 10 years of this Action Plan. Beyond then, long-term catchment-based actions should start lowering nutrient inputs to the lake – unless hornwort harvesting becomes comparatively cost-effective and community acceptable long term, or a long-term commercial operation was set up, in which case the hornwort harvesting could continue removing nutrients sourced from land use.

If hornwort is harvested up to 2 metres depth, this would free up more space for recreational activities like swimming and boating, especially if the harvested areas were in Kennedy Bay or Otautu Bay.

There may be a moderate reduction in risk of weed transfer to other, non-infested lakes by trailers and boats if hornwort was harvested around Lake Rotoehu's boat ramps. Despite this, Lake Rotoehu's boat ramps may still need measures to reduce weed spread.

### 7.1.5 Costs

Harvested wet hornwort contains ~4% dry matter. 3.0% of this is nitrogen, and 0.4% is phosphorus. The following costs and timeframes are based on a two-week hornwort harvesting trial in April 2006.

*Table 5 Hornwort harvesting costs*

| | **50 tonne/day** | |
|---|---|---|
| Cost per day (8 hour average day) | $2,400 | |
| Nutrients removed per day | 60 kg-N | 8 kg-P |
| Cost per kg nutrient removed from the lake | $40 | $300 |
| Cost per kg equivalent nutrient from catchment inputs | $20 | $150 |
| Nutrients removed from lake per month (20 w.d.) | 1,200 kg-N | 160 kg-P |
| Cost for 1,000 tonnes wet hornwort removal per year | $48,000 | |
| Time to harvest 1,000 tonnes wet hornwort | 20 working days (1 month) | |

**Annual Cost**

| | |
|---|---|
| Annual operating cost: | $48,000 |
| Cost of investment: | $4,800 |
| Total: | $52,800 |

**Cost per kg-N (catchment equivalent) $22**
**Cost per kg-P (catchment equivalent) $165**

Hornwort harvesting costs will increase if hornwort is not readily available at the lake surface and close to the harvesting transfer site. Hornwort growth in the southeastern corner of the lake is dependent on water temperature (warmer = quicker growth), water clarity (clearer = quicker growth), and wind speed and direction to the southeastern lake corner (accumulation = denser growth).

### 7.1.6 Timeframes and commercial opportunities

The ideal harvesting period is from February to April. Hornwort starts growing very quickly once the water is warm enough and water clarity gives good sunlight penetration. Harvesting would be dependent on the availability of weed material, and a weed harvester contractor, during this time.

There is potential for hornwort harvesting to be a commercially viable proposition. Business propositions to harvest hornwort commercially, with associated lake nutrient removal, should be encouraged. Encouragement could include scientific advice, assistance with Resource Management Act processes, or financial assistance.

Hornwort harvesting is intended as a 10-year stop-gap measure to improve lake quality while catchment land use and land management changes begin to take effect. However, hornwort harvesting may become practically viable and community acceptable to allow the following:

- Environment Bay of Plenty to continue harvesting long-term, or

- A commercial operation of long-term hornwort harvesting to be established with little or no assistance from Environment Bay of Plenty.

If this occurs and lake water quality has significantly improved, this may affect the land use nutrient loss reduction targets.

## 7.2 Constructed wetland

### 7.2.1 Background

A constructed wetland in this context is a wetland area that is primarily designed and created to remove a substantial amount of nitrogen from water flows. The process relies on the build-up of organic rich sediments, a slow, shallow water flow, abundant denitrifying bacteria, and wetland plants to vent oxygen and nitrogen gases.

Wetlands are also filter areas, removing organic material and settling out some particulate phosphorus. However they will not remove dissolved phosphorus from water flows.

The majority of estimated water flows to Lake Rotoehu are partly or fully subsurface flows. The Maero Stream has some potential for a constructed wetland because:

- The stream has low sediment levels.
- There is a large existing boggy patch of land before the stream enters the lake.
- The stream flow/wetland area ratio is low enough to allow for some denitrification.

However Te Maero Stream is also the most important stream into Lake Rotoehu for trout spawning, recruitment and habitat.

A 3.2 hectare wetland to the east of Te Maero stream, optimised by adding sawdust as a carbon source for bacteria, could remove about 38% of the nitrogen in Te Maero Stream.

*Figure 2 Potential location for a constructed wetland*

Unfortunately below the surface organic layer of the proposed wetland area is porous pumice material. This layer would quickly drain away any surface water. The wetland will need to be engineered with a capping layer, bund or other measure to stop water leaching and allow enough time for denitrification reactions.

Floating wetlands are also being trialled in Otautu Bay. These are made out of recycled soft drink bottles, coconut fibres, and wetland plants on top extending down to the lake water. Biofilms will form on these floating wetlands to enable denitrification. A tank trial will help determine the nitrogen removal rate of these floating wetlands. If the nitrogen removal rate is high enough, it may be more cost-efficient than Te Maero wetland.

The wetland vegetation in the Waitangi Soda Spring trust block is being enhanced to improve lake beauty and wildlife habitat. This enhancement is set out in the Waitangi #3 Trust's iwi management plan for this block.

### 7.2.2 Nutrient source

Te Maero Stream carries 2.25 $g/m^3$ nitrogen, which at average measured flow is 4,400 kg-N/yr. In Lake Rotoehu's case, the elevated nitrate levels are leached from surrounding sheep & beef land use, and possibly also from some shallow groundwater flows from the Taumanu dairy farm. Nitrate is a dissolved, invisible form of nitrogen readily available for lake algae to use.

Table 2 in section 3.7 compares the nutrient concentrations of the major streams into Lake Rotoehu. Te Maero stream and Te Pohue stream (at the southwestern corner of the lake) have significantly higher nitrate concentrations than other flowpaths around the lake; and Te Maero Stream flows are almost three times the flows in Te Pohue Stream.

Floating wetlands remove dissolved nitrogen directly from the lake water. This can have an immediate effect on algal concentration which depends on nitrogen availability.

Streams and springs into the Waitangi Soda Spring carry nutrients leached from the Taumanu Dairy Farm, waste from farm runoff and a stock crossing, as well as geothermal and geology-sourced nutrients.

### 7.2.3 Action

Environment Bay of Plenty will either:

- Construct a wetland to remove 1,650 kg-N dissolved nitrogen from Te Maero Stream, or

- Install sufficient floating wetlands to remove 825 kg-N[23] from Lake Rotoehu.

Environment Bay of Plenty is enhancing the wetland area in the vicinity of the Waitangi Soda Springs, working closely with the Waitangi #3 Block trustees.

Subject to the outcome of research and field investigations, resource consents, contractual agreements with any landowners, and cost-effectiveness.

### 7.2.4 Benefits

A constructed wetland could remove an estimated 38% of Te Maero stream's nitrate load, i.e. about 1,650 kg-N per year.

[23] This is half the mass removed from a catchment-based wetland, because of the 50% in-lake attenuation rate used to determine the nitrogen reduction target (see Appendix 5).

As well as removing nitrogen from water flows, constructed wetlands are a habitat for rare native plants and animals. They provide opportunities for game bird hunting, recreation, education and traditional harvesting, and they improve the aesthetic appearance of land. An enhanced wetland habitat around the Waitangi Soda Spring area will also provide these benefits.

Floating wetlands can be moved to specific areas of the lake for maintenance. They can shade hornwort beds which may limit their growth in certain areas. Some aquatic birds and fish may also find the floating wetlands attractive habitat areas.

### 7.2.5 Costs

**Te Maero Wetland**

| | |
|---|---|
| **Capital Investment** | $1,000,000 |
| **Annual Costs** | |
| Annual operating costs | $5,000 |
| Cost of capital: | $100,000 |
| Depreciation on capital investment | $20,000 |
| Total | $125,000 |
| **Cost per kg-N** | **$77** |
| **Life of capital investment** | **50 years** |

The estimated capital cost for this wetland is $1 million. This is high, because of the wetland's large area and difficulties with the porous substrate material. However once the wetland is established, maintenance costs are minimal.

The land proposed for wetland development is currently boggy and filled with willows. In this state it cannot be used for productive livestock farming. Loss of existing land productivity would be offset by land beautification and potential for tourism and traditional plant harvesting. The main cost to landowners is opportunity cost; Tautara/Matawhaura would not be able to develop that 3.2 ha land area in the future.

Any diversion of Te Maero Stream into a constructed wetland will need to be managed to minimise adverse effects on trout migration, spawning and recruitment.

**Floating Wetland**

Fully planted and operational, floating wetlands cost $300 per $m^2$. The mass of N removed, and the expected lifetime of these structures, is still being determined.

### 7.2.6 Timeframes

If the Matawhaura Block trustees give their approval, construction and planting of the wetland could take place during autumn/winter months of 2008.

New floating wetlands could be commissioned and installed during 2008 and 2009.

Timeframes for enhancing the Waitangi Soda Spring area are reliant on the work programme prepared by the trustees of the Waitangi #3 Trust Block. They expect to begin this work in early 2008.

## 7.3 Other nutrient removal options

There are many other options for lake water quality improvement, such as:

- Use of the Waitangi Stream lagoon to remove dissolved nutrients emerging from the nearby springs.
- Treatment boxes or socks to strip nitrogen or phosphorus from flowing streams.
- Biological products to alter the lake's ecology.
- Chemical and mechanical filtering of algae, phosphates, ammonium and other nutrients from lake water.
- Materials to soak/absorb the algal blooms after the nature of oil slicks on water, applied summer when blooms are thickest and removed for disposal.

Other options are likely to emerge over the duration of this Action Plan. Environment Bay of Plenty should evaluate any potentially viable options to find out their environmental effects (lake water quality and other effects), and their comparative cost-effectiveness.

If a nutrient removal method:

1 helps improve Lake Rotoehu's water quality to its TLI target; and

2 has few adverse environmental effects; and

3 has a comparatively low cost to the local and regional community;

Environment Bay of Plenty will consider trialling and implementing the method.

# Chapter 8: Regulation and Plan Provisions

## 8.1 On-Site Effluent Treatment Regional Plan (OSET Plan)

### 8.1.1 Purpose of the OSET Plan

The purpose of the On-Site Effluent Treatment Regional Plan (OSET Plan) is to reduce the impact of domestic wastewater discharged from on-site effluent treatment systems in the Bay of Plenty. In the Rotorua Lakes area, the main concern with existing septic tank and soak-hole systems is the poor rate of nitrogen removal. In some cases pathogens (disease-causing bacteria) are also an issue.

The plan contains new standards to limit nitrogen leaching from on-site effluent treatment systems into waterways. For the Lake Rotoehu catchment, the new rules state that all on-site effluent treatment systems within the Lake Rotoehu catchment must, by 1 December ~~2010~~ 2014[24], be an advanced system capable of reducing the total nitrogen in the discharge to less than 15 $g/m^3$. Otherwise a resource consent will be needed.

Rotorua District Council is investigating settlement sewage reticulation and treatment options for Lake Rotoma and west Lake Rotoiti, which may include some parts of Lake Rotoehu. However there are no firm plans for reticulation yet because of the smaller settlement area, the topography and the distance between settlement areas.

### 8.1.2 Advanced on-site effluent treatment systems

Environment Bay of Plenty and Rotorua District Council have trialled a number of advanced on-site effluent treatment systems currently on the market, so staff can advise property owners which systems meet the nitrogen discharge limit.

The advanced on-site effluent treatment systems that remove nitrogen can cost $10,000 - $20,000 each. People living around Otautu Bay and Kennedy Bay, especially for temporary accommodation, could consider joining together and sharing an advanced effluent treatment system. This would need agreements between house owners regarding location of structure, cost distribution, maintenance etc.

### 8.1.3 Resource consents under the OSET Plan

If the discharge from a collective advanced system exceeds 2 cubic metres per day (which could happen with three or more households connected), it would need a

[24] Date changed as a consequence of Plan Change 1 to the Operative On-Site Effluent Treatment (OSET) Regional Plan. Plan Change 1 became Operative on the 1 March 2011.

resource consent from Environment Bay of Plenty. However if the collective advanced system met all other conditions in the OSET Plan and was the most efficient option for a group of houses, it may be granted.

As a consequence of Plan Change 1 to the Operative On-Site Effluent Treatment Regional Plan[25], Bay of Plenty Regional Council ~~After consultation with the community, Environment Bay of Plenty has decided to~~ will allow resource consents for existing individual septic tanks to continue until 2017 ~~2018 (a 10 year consent).~~ Houses with slightly undersized tanks can also apply for this resource consent if a solids filter is installed on the septic tank outlet. The resource consent fee will be heavily subsidised.

These resource consents recognise that:

- Nitrogen loss from septic tanks to Lake Rotoehu is minimal compared to other sources. Environment Bay of Plenty's attention should be directed in the first ten years to land use/management changes and lake treatment actions as set out in the Action Plan.
- Rotorua District Council's reticulation of Rotoma and eastern Rotoiti's wastewater is planned to be installed within the next ten years. Some residents in the Rotoehu catchment may be connected to this reticulation scheme.
- Some Rotoehu residents cannot afford an OSET upgrade at this time.

Conditions in each resource consent should specify that the ten year consent will be withdrawn if:

- A new house is constructed.
- The design occupancy of a house is increased by adding new bedrooms.
- The septic tank is not functioning properly and needs to be replaced.

If this occurs, Environment Bay of Plenty staff may specify a period of time available for the homeowner to comply with the OSET Plan.

### 8.1.4 Costs and benefits of septic tank upgrades

Based on an 80% reduction in N loss from septic tanks in the catchment (refer to section 4.3), 470 kg-N would be removed from the Lake.

Estimated costs:

$20,000 per household over a 25 year lifespan
$150,000 for the school and campground OSET system upgrade
+ 10% cost of capital over this time (i.e. interest rate for cost spread over 25 yrs)
= $231,000 p.a. ($491 per kg-N).

If more homes around Lake Rotoehu become permanent residences, the cost per kg-N would decrease as the kg-N removed from the greater wastewater load increases.

[25] Plan Change 1 underwent full consultation with the community and became Operative on 1 March 2011

## 8.2 Regional Water and Land Plan - 'Rule 11' Review

### 8.2.1 Review requirement

Method 35A of the Proposed Regional Water and Land Plan (the Plan) states that Environment Bay of Plenty must review the rules in Section 9.4 of the Plan to individual Rotorua Lakes' catchments. If appropriate, specific rules can be developed for each catchment. The Lake Action Plans and their working parties have a key role to play in the review and any new rules.

Section 9.4 of the Plan contains the rules commonly called 'Rule 11'. 'Rule 11' controls diffuse nitrogen and phosphorus discharges within five lake catchments: Lakes Okareka, Okaro, Rotoehu, Rotorua and Rotoiti. Lake Rotoehu is third in line for the Method 35A rule review. In the Plan, the initiation date for the Lake Rotoehu review is January 2006. New rules must be notified by 31 December 2007. So that the 'Rule 11' property benchmarking information, nutrient model upgrades and Action Plan recommendations can feed into the review, the initiation date for this review has been postponed to June 2008.

### 8.2.2 Working party guidance

The Lake Rotoehu Action Plan working party have some guidance for this Rule 11 review:

- Do not cut back a farm's nutrient benchmark without agreement or considering economic sustainability, as immediate cuts could make the sheep and beef farms economically unviable. They already have comparatively low nutrient benchmarks.
- Voluntary approaches with farm managers and trustees for nutrient reductions are preferred over strict rules.
- Make sure any restrictions in the new rules are clearly defined and effects-based, so farmers can work within the boundaries. This is a strength of the existing Rule 11.
- Requirements to use nutrient management practices are fine as long as the specific practices are listed clearly, and they are generally accepted best practice.
- Nutrient reduction targets for rural land in this Action Plan need to be reflected in any new rules so landowners meet these targets.

### 8.2.3 Consistency with the OSET Regional Plan

As part of the 'Rule 11' review for Lake Rotoehu, and also Lakes Rotorua and Rotoiti, Environment Bay of Plenty will also assess 'Rule 11''s consistency with the OSET Regional Plan. If the review shows a need to change part of the OSET Plan to align it with the 'Rule 11' plan change, both should proceed simultaneously as one process. This minimises extra resourcing requirements, and keeps consistency between the two Plans through the process.

## 8.3 Rotorua District Plan

The Rotoehu catchment is made up of a number of zones including Rural A, Rural E, Reserve A, Reserve B and Water Zone A. The predominant zones are Rural A and Reserve A. Detailed below are the resource management objectives, policies and rules of the Rotorua District Plan which are relevant to water quality and the targets, key recommendations and actions listed in the Rotoehu Action Plan. This section is accurate as at 5 November 2007.

### 8.3.1 Part 10: Rural Resources

There are four resource management objectives in Part 10 of the District Plan, two of which relate to lakes and their water quality:

- Land uses and management systems which do not destroy the amenity and character of rural areas and lakes.
- Maintained quality of the Rotorua Lakes and their catchments.

These objectives are underpinned by specific policies. Policies 2.1.3.3.iii) and iv) aim to mitigate negative environmental and lake water quality effects caused by rural land use:

*2.1.3.3 Policies:*

*iii) To promote a change from animal grazing on pastoral land to indigenous vegetation so as to mitigate the adverse effects of land use activities on lake water quality where additional rural-residential development is contemplated, such as in the Rural B1 Zone.*

*iv) To re-vegetate gullies to assist both in filtering runoff from more elevated rural lands in the catchment behind and in reducing the nutrient level of stormwater before it enters the lakes.*

Policies 2.2.3.1 and 2.2.3.2 aim to improve and enhance water quality through partnerships:

*2.2.3.1 Policy:*

*To improve the quality of water in the lakes by liaising closely with the regional councils and other statutory bodies such as the Department of Conservation and by making special provision for works or operations necessary to improve water quality.*

*2.2.3.2 Policy:*

*To promote, in conjunction with the appropriate regional council, lake, river and stream riparian protection and appropriate management to both protect and enhance natural character values, habitat and ecological values, and water quality.*

The District Plan makes specific reference to methods other than Zoning, including the creation of the Strategy for the Rotorua Lakes that was published in 2000 by The Rotorua Lakes Strategy Joint Committee & Working Group. The Lake Rotoehu Action Plan is part of this broader strategy.

Section 3.4 of the District Plan describes the method of promotion in working with the regional councils and their Environmental Programmes.

The following tables set out the rules for activities in Rural A and Rural E zones that could affect water quality.

*Table 6 Rules for activities in the Rural A and Rural E zones which could be seen as contributing to the enhancement of water quality*

| Activities | Rural A | Rural E |
|---|---|---|
| Agroforestry. | Permitted | |
| Planting for the purposes of amenity improvement, erosion control and riparian management. | Permitted | |
| Plantation forestry including harvesting other than in the covenanted areas along the margins of Lakes Tikitapu and Rotokakahi as shown on DPS 54801. | Permitted | |
| Activities involving the clearance or modification of indigenous vegetation, the drainage or infilling of wetlands, the felling or destruction of any (remnant) indigenous tree, other than provided for as a Permitted Activity. | Discretionary | |
| Buildings not complying with the 25m buffers in R10.2.3:<br><br>…“In the Rural A , B, C, D and E Zones no building, waste disposal facility or structures for confined animal farming may be erected within 25 meters of any river or stream, the bed of which has an average width of 3 meters or more, or from any lake with a surface area in excess of 8 hectares, or within 5 meters of any esplanade reserve or strip.”… | Discretionary | Discretionary |
| Enclosure of livestock. | Discretionary | |
| Activities involving the clearance or modification of indigenous vegetation, the drainage or infilling of wetlands, the felling or destruction of any (remnant) indigenous tree, other than provided for as a Permitted Activity. | | Discretionary |

*Table 7 Rules for activities in the Rural A and Rural E zones which could be seen as being unfavourable to the enhancement of water quality*

| Activities | Rural A | Rural E |
|---|---|---|
| Clearance or modification of indigenous vegetation of up to 500m2 over any 2 year period where the 500m2 is either a total for an individual site or for an individual remnant where that remnant covers more than one site, or the felling of any (remnant) indigenous tree (including for the taking of firewood) of up to 100m3 per year on any one site. | Permitted | Permitted |
| Drainage or infilling in any 2 year period of wetlands of a size up to 100m2 in area. | Permitted | Permitted |
| Liquid organic waste spray irrigation. | Permitted | |

### 8.3.2 Part 11: Reserves, Water Bodies and Heritage

Reserve and Water body zones are addressed in Part Eleven of the District Plan.

Although the policies for the reserves in the district do not directly address the issue of water quality they do address the retention and enhancement of natural heritage. Landscapes and lakes are part of the natural heritage of the district. In addition, lake water quality issues can be addressed in reserve management plans.

Lake water quality issues are addressed in the water bodies zoning where the focus is on the management of water bodies and of the land adjacent to them.

Objectives for the water bodies of the district which relate to water quality are:

- The protection of the natural, cultural and amenity values of water bodies and their margins in the District

- The use of the lakes and other water bodies and their margins in the District, where the use is compatible with the maintenance of natural, cultural and amenity values

Policies 3.2.1.3.1 and 3.2.1.3.3 aim to protect the natural, cultural and amenity values of water bodies and their margins:

*3.2.1.3.1 Policy:*

*To identify and protect, where appropriate, natural, cultural and amenity values of lakes and rivers and other water bodies and their margins in the District.*

*3.2.1.3.3 Policy:*

*To protect natural, cultural and amenity values, and the provision of access to and along water ways by taking esplanade reserves and strips for a variety of purposes (as set out in Section 229 of the Resource Management Act 1991) upon subdivision and development.*

*Policy 3.2.1.3.2 aims to identify areas along lakes and rivers where improved protective management is required:*

*3.2.1.3.2 Policy:*

*To identify those areas where there needs to be improved access to and along water bodies, particularly lakes and rivers, and also those water margins where improved protective management is required.*

The following tables set out the rules for activities in Reserve A, Reserve B and Water Zone A zones that could affect water quality.

*Table 8 Rules for activities in the Reserve A and Reserve B zones which could be seen as contributing to the enhancement of water quality*

| Activities | Reserve A | Reserve B |
|---|---|---|
| Activities involving the clearance or modification of indigenous vegetation, the drainage or infilling of wetlands, the felling or destruction of any (remnant) indigenous tree, other than provided for as a Permitted Activity. | Discretionary | Discretionary |

*Table 9 Rules for activities in the Reserve A and Reserve B zones which could be seen as being unfavourable to the enhancement of water quality*

| Activities | Reserve A | Reserve B |
|---|---|---|
| Clearance or modification of indigenous vegetation of up to 100m2 in any 2 year period where the 100m2 is either a total for an individual site or for an individual remnant where that remnant covers more than one site. | Permitted | Permitted |
| Drainage or infilling in any 2 year period of wetlands of a size up to 100m2 in area. | Permitted | Permitted |
| Felling or destruction of any (remnant) indigenous trees with a height of less than 6m, and having a trunk circumference of less than 90cm at a height of 1.4m above ground level. Where a tree has multiple trunks the trunk circumference shall be the aggregate measurement of all trunks. | Permitted | Permitted |

*Table 10 Rules for activities in the Water Zone A which could be seen as contributing to the enhancement of water quality*

| Activities | Water Zone A |
|---|---|
| Use of craft for aquatic weed management | Permitted |

*Table 11 Rules for activities in the Water Zone A which could be seen as being unfavourable to the enhancement of water quality*

| Activities | Water Zone A |
|---|---|
| Clearance or modification of indigenous vegetation of up to 100m2 in any 2 year period where the 100m2 is either a total for an individual site or for an individual remnant where that remnant covers more than one site. | Permitted |
| Drainage or infilling in any 2 year period of wetlands of a size up to 100m2 in area. | Permitted |
| Drainage or infilling in any 2 year period of wetlands of a size in excess of 100m2 in area carried out under a consent from a regional council provided that Rotorua District Council has been consulted in the consideration of that consent application as an affected party. | Permitted |

# Chapter 9: Review

At 2006, there were a lot of unknowns about Lake Rotoehu, its catchment and how to improve its water quality. Specific unknowns are:

- Groundwater flows within the catchment, especially to the south of Lake Rotoehu.
- Nutrient cycling within the Lake; interactions between the lakebed sediments and the water column.
- The role of lake level fluctuations on lakebed nutrient releases and water quality.
- The ecology of Lake Rotoehu: how it affects and is affected by water quality.

A number of studies will help plug these knowledge gaps over the next 10 years.

- Lake modelling by Waikato University students.
- Monitoring the effects of nutrient removal actions like a constructed wetland, hornwort harvesting, or other actions.
- Collection of more groundwater data to calculate nitrate sources in different streams, and direction and volume of groundwater flows.
- LakeSPI information about hornwort spread and its effect on lake ecology.
- Research commissioned for other Lake Action Plans that can be applied to Lake Rotoehu.

For this reason, Environment Bay of Plenty will review the Lake Rotoehu Action Plan 10 years after the Action Plan is adopted by the Rotorua Lakes Strategy Group.

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# Appendices

# Appendix 1– Trophic Level Index (TLI) and Other Indicators

The Trophic Level Index (TLI) is an indicator of lake water quality. Burns, Rutherford and Clayton[26] developed this index for New Zealand conditions because other international indices were not adequate to deal with NZ lakes. The Ministry for the Environment has adopted the TLI as a national indicator for New Zealand state of the environment reporting, and a TLI goal has been set for each of the Rotorua Lakes in the proposed Regional Water and Land Plan.

Four parameters are combined to construct the TLI: total nitrogen, total phosphorus, clarity and chlorophyll *a*. The parameters reflect the dynamics of the annual lake cycle.

Nitrogen and phosphorus are essential plant nutrients. In large quantities they can encourage the growth of nuisance aquatic plants such as algal blooms. High levels of water-bound nitrogen and phosphorus most often come from agricultural runoff and urban wastewater, but can also come from geothermal inputs and deep springs that leach phosphorus from the rock geology.

Clarity is measured using a Secchi disc attached to a tape measure. The depth at which the disc disappears from sight is recorded by the tape measure.

Chlorophyll *a* is the green pigment in plants used for photosynthesis. It is a good indicator of the total quantity of algae in a lake. Algae are a natural part of any lake system, but large amounts of algae decrease water clarity, make the water look green, can form surface scums, reduce dissolved oxygen levels, can alter pH levels, and can produce unpleasant tastes and smells.

Calculations for the TLI:

- TLn = -3.61 + 3.01log (TN)
- TLp = 0.218 + 2.92log(TP)
- TLs = 5.10 + 2.27log(1/SD – 1/40)
- TLc = 2.22 + 2.54log(Chla)
- **TLI = Σ (TLn + TLp + TLs + TLc)/4**

**Trophic States**

The higher the TLI, the lower the water quality, and the greater risk of environmental ‘problems’ like algal blooms and unusual foams. It can also cause deoxygenation (anoxia) of the bottom water and nutrient release from the sediment. Trophic level bands are grouped into trophic states for quantitative description, microtrophic to hypertrophic as shown below.

[26] Burns, N.M., Rutherford, J.C. and Clayton, J.S. (1999): A monitoring and classification system for New Zealand lakes and reservoirs. Journal of Lake and Reservoir Management 15 (4):255 – 271, 1999.

*Table 12 Trophic states, as determined by the four key variables*

| Trophic state | Nutrient enrichment category | Trophic level | Chla ($mg/m^3$) | Secchi depth (m) | TP ($mg/m^3$) | TN ($mg/m^3$) |
|---|---|---|---|---|---|---|
| Ultra-microtrophic | "Pure" | 0.0 to 1.0 | < 0.33 | > 25 | < 1.8 | < 34 |
| Microtrophic | Very Low | 1.0 to 2.0 | 0.33 – 0.82 | 25 – 15 | 1.8 – 4.1 | 34 –73 |
| Oligotrophic | Low | 2.0 to 3.0 | 0.82 – 2.0 | 15 – 7.0 | 4.1 – 9.0 | 73 – 157 |
| Mesotrophic | Medium | 3.0 to 4.0 | 2 – 5 | 7.0 – 2.8 | 9 – 20 | 157 – 337 |
| Eutrophic | High | 4.0 to 5.0 | 5 – 12 | 2.8 – 1.1 | 20 – 43 | 337 – 725 |
| Supertrophic | Very high | 5.0 to 6.0 | 12 – 31 | 1.1 – 0.4 | 43 – 96 | 725 – 1558 |
| Hypertrophic | Extremely high | 6.0 to 7.0 | > 31 | < 0.4 | > 96 | > 1558 |

**Ultra-microtrophic** lakes are rare. The Pupu Spring in the Abel Tasman National Park is ultra-microtrophic

**Microtrophic** lakes are very clean, and often have snow or glacial sources. Lake Sumner in North Canterbury is a microtrophic lake.

**Oligotrophic** lakes are clear and blue, with low levels of nutrients and algae. Lake Rotoma is an oligotrophic lake.

**Mesotrophic** lakes have moderate levels of nutrients and algae. Lake Rerewhakaaitu is a mesotrophic lake.

**Eutrophic lakes** are green and murky, with higher amounts of nutrients and algae. Lakes Rotorua and Rotoiti are now both eutrophic lakes.

**Supertrophic lakes** are fertile and saturated in phosphorus and nitrogen, and have very high algae growth and blooms during calm sunny periods. Lake Okaro is a supertrophic lake.

**Hypertropic lakes** are highly fertile and supersaturated in phosphorus and nitrogen. They are rarely suitable for recreation and habitat for desirable aquatic species is limited. Many lakes in the Waikato are hypertrophic, like Lakes Hakanoa, Ngaroto, Mangahia, Waahi and Waikare.

**Cyanobacteria (Blue-green algae)**

Cyanobacterial blooms occur more frequently above a certain TLI level. The worst quality waters experience the cyanobacteria blooms e.g. Okawa Bay (TLI 5.3), Lake Okaro (TLI 5.7). Lake Rotoehu began to experience algal blooms in 1994 when the quality of the lake deteriorated and the TLI increased from 3.7 to 4.8. Lake Rotoehu's TLI has fallen slowly since then and in 2004 no blue-green blooms occurred. This could have been due to nutrients absorbed by the spread of hornwort beds in the lake in this year.

Cyanobacterial blooms can form in lakes with good water quality, like Lake Tarawera. Here a large inflow of water with a low nitrogen to phosphorus ratio enters the lake along the shoreline adjacent to Rotomahana. This favours cyanobacteria and when conditions are calm they can assume bloom proportions.

## Other Lake Water Quality Indicators

### Dissolved oxygen

Dissolved oxygen is important for fish and other aquatic life to breathe. Water should be more than 80 percent saturated with dissolved oxygen for aquatic plants and animals to live in it.

In deep lakes, where the waters don't mix for several months over the summer, reduced dissolved oxygen in the stagnant bottom waters is of concern, especially for fish and aquatic animals. Decaying algal material that falls out of the surface water uses up dissolved oxygen in the bottom waters. When this happens, nitrogen and phosphorus are released from the lake bed sediments. When the lake waters re-mix in winter these nutrients are available for plants and algae in the surface waters.

### E-coli

*Escherichia coli* (*E. coli*) is an indicator organism for disease-causing agents in the water. E-coli come from human and animal faeces, so if they are present in water there are likely to be other nasties as well that make the water unsafe for drinking or swimming. Drinking water should have no detectable E-coli bacteria in it at all. Water used for recreation should have less than 126 E-coli colonies per 100 ml of water.

# Appendix 2 – Rotorua Lakes Action Plan Working Parties: Roles and Responsibilities

## A: Planning and Governance

**Method 35:**

Method 35 of the proposed Regional Water and Land Plan requires action plans to be developed for lakes with water quality that exceeds their target TLI (Trophic Level Index). It outlines a four-stage process for action plan development and implementation.

1 Risk assessment and problem evaluation.

2 Action plan prioritisation.

3 Development of action plans for lake catchments.

4 Implementation and monitoring of action plans.

**Action Plan Development:**

1 Define the existing catchment nutrient budget.

2 Determine a sustainable level of nutrient inputs to the lake, based on the lake's TLI target.

3 Identify nutrient reduction targets.

4 Determine actions to achieve targets.

5 Take a holistic approach to planning: sewerage, landscape, climate change, economics, etc.

6 Reach a general agreement and understanding of the scientific principles involved.

7 Meet the other requirements in Method 35 of the proposed Regional Water and Land Plan.

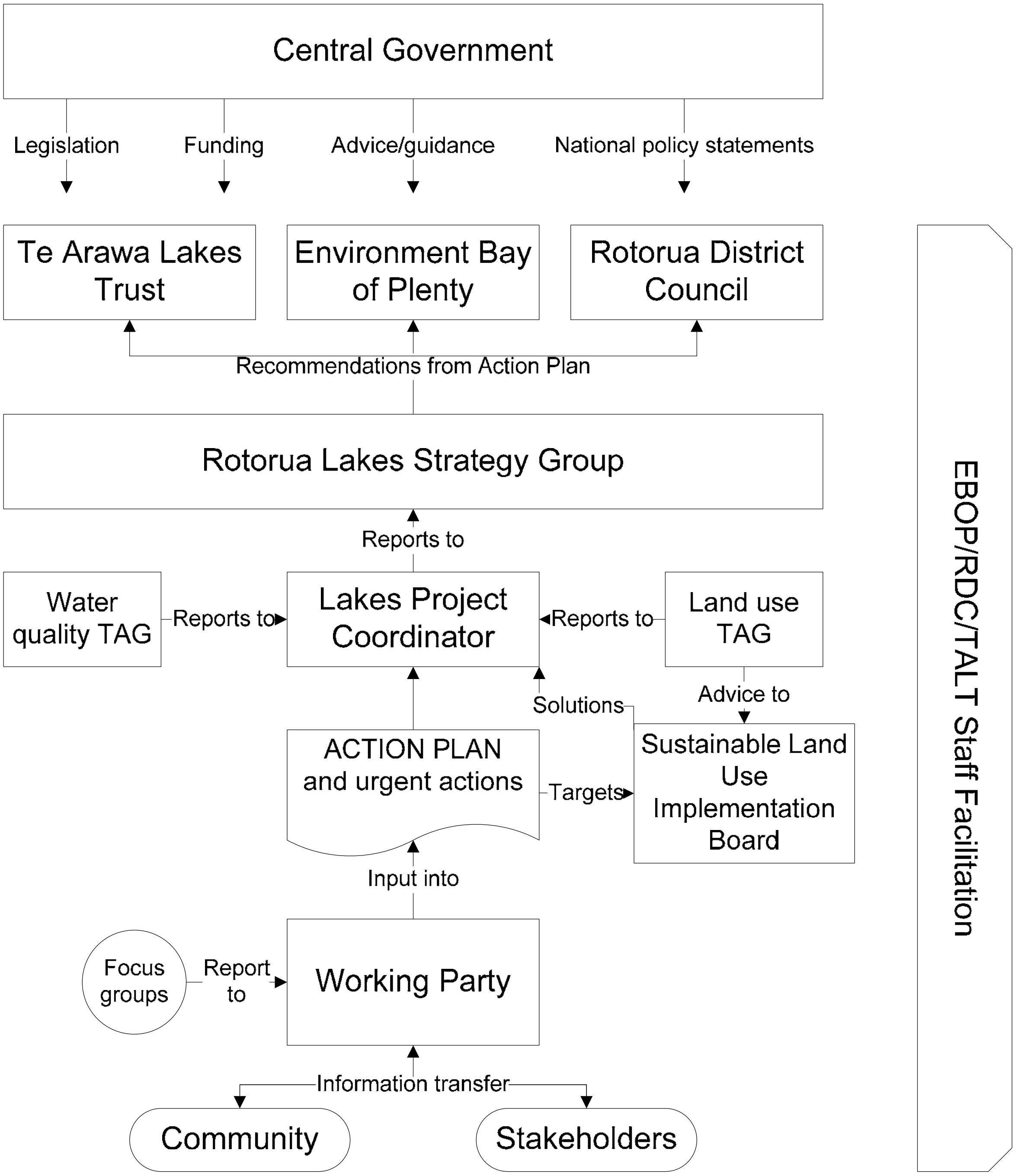


*Figure 3 Agencies involved with Action Plan development*

## B: Roles and Responsibilities of the Project Team (Staff)

1 To administer action plan development and working party process.

2 To ensure minutes and agendas are prepared and circulated.

3 To pre-circulate draft working party meeting agendas where possible.

4 To respond to requests for information.

5 To coordinate research/consultants.

6 To ensure regular reporting to the Rotorua Lakes Strategy Group and Councils.

7 To advise the working party on research/actions in a timely manner.

8 To compile the draft action plan for the working party's consideration before presenting it to the Rotorua Lakes Strategy Group and Councils.

9 To report to their respective Councils on urgent actions to be considered for implementation.

## C: Roles and Responsibilities of an Action Plan Working Party

**Purpose:**

To assist with the development of an action plan containing recommended actions (including urgent actions) to achieve the long term water quality objective specified in the proposed Regional Water and Land Plan for that lake(s).

**Roles of Working Party Members:**

1 To present community/sector group views on lake restoration and specific actions.

2 To evaluate nutrient targets and sources (nutrient budget).

3 To identify possible nutrient reduction options for specific sources.

4 To evaluate these options (similar role for focus groups) with:

(a) Holistic perspective.

(b) Economic implications.

(c) Cost-benefit and effectiveness analysis.

(d) Cultural/community values.

5 To identify issues.

6 To identify research/information gaps.

7 To recommend to the Strategic Partners (Environment Bay of Plenty, Rotorua District Council, Te Arawa Lakes Trust) urgent actions for detailed consideration.

8 To support the Lakes Project Team (staff) in preparing a draft action plan for consideration by the Strategic Partners prior to public consultation.

9 To advise the project team on possible communication options as part of a comprehensive communication plan.

10 To set up focus groups and consider their findings.

11 To identify possible additional participants for the working party or focus groups.

12 To assist in reviewing the nutrient management rules currently in place for that lake catchment.

13 To request additional items on a working party meeting agenda if required.

14 To elect a chairman of the working party.

**Responsibilities of Working Party Members:**

1 Attendance at working party meetings.

2 Attendance at relevant focus group meetings or identify other attendees where appropriate.

3 To listen and respect each other's views.

4 To recognise that individual working party members may hold differing views.

5 To acknowledge that individual working party members may not be able to endorse a specific action.

6 To recognise the timelines for specific actions.

7 To recognise that specific consultative processes exist (e.g. for resource consents, Resource Management Act plans).

8 To try and achieve a consensus view on specific actions.

9 To sign off minutes.

**The Working Party is Not Responsible For:**

1 Budgets and financial expenditure.

2 Statutory processes, such as resource consents and RMA plans.

3 Public consultation, hearing outcome on final plan.

4 Engaging consultants.

5 Directing project team (staff).

# Appendix 3 – Lakebed Sediment Nutrient Release

*Table 13 Lake Rotoehu's internal nutrient load worked out for volume: 795 ha x 8 m average depth*

| Date | [N] ($mg/m^3$) | N load (kg) | [P] ($mg/m^3$) | P load (kg) |
|---|---|---|---|---|
| Nov-90 | 33 | 2099 | 9 | 572 |
| Apr-93 | 51 | 3244 | 43 | 2735 |
| Aug-93 | 235 | 14946 | 22 | 1399 |
| Dec-95 | 45 | 2862 | 22 | 1399 |
| Jan-97 | 136 | 8650 | 40 | 2544 |
| Feb-98 | 315 | 20034 | 43 | 2735 |
| Apr-00 | 57 | 3625 | 9 | 572 |
| Sep-00 | 88 | 5597 | 7 | 445 |
| May-01 | 49 | 3116 | 18 | 1145 |
| Dec-01 | 117 | 7441 | 36 | 2290 |
| Oct-02 | 71 | 4516 | 19 | 1208 |
| **median** | | **4516** | | **1399** |
| **median Aug 93 – present** | | **5597** | | **1399** |

# Appendix 4: Regional Water and Land Plan Method 35

Only the portions of the Method that relate to the Lake Rotoehu Action Plan are given here.

“Develop and implement Action Plans to maintain or improve lake water quality to meet the Trophic Level Index set in Objective 10. Action Plans will be developed according to the following process.

**Action Plan Stages**

1 Stage 1 – Risk Assessment and Problem Evaluation

(a) Identify lakes that exceed the Trophic Level Index (TLI) set in Objective 10, and initiate Stage 3. The timeline to initiate Stage 3 is:
(iii) Lakes Rotorua & Rotoiti – mid 2003

3 Stage 3 – Development of Action Plan for Lake Catchment

(a) Where lake water quality exceeds the TLI:

(i) Identify and quantify the lake water quality problem and any necessary research.
(ii) Identify and quantify the reduction of nitrogen and phosphorus required in the catchment to achieve the TLI in Objective 10.
(iii) Estimate the contributing sources of nitrogen and phosphorus in the catchment, and the effects of existing land uses and activities in the catchment on the lake’s nutrient load.
(iv) Estimate the lag between actual land use change and lake water quality effects.
(v) Establish a timeline for developing an Action Plan for the lake catchment.

(b) Disseminate information and research findings to the community.

(c) Develop and implement Stage 3 and 4 of the Action Plan in conjunction with an Action Plan Working Group comprising appropriate parties from the individual catchment. The Action Plan Working Group will include, but is not limited to, Rotorua District Council, iwi, community groups, landowners, and relevant resource management agencies and industry representative groups. The main aims of Stage 3 of the Action Plan are:

(i) Identify factors that affect lake water quality and any necessary research.
(ii) Include equitable and workable provisions to address effects on existing land uses where it is necessary to restrict land use to maintain or improve water quality. Such provisions include, but are not limited to, criteria for possible financial assistance and land acquisition.
(iii) Identify efficient, cost-effective and equitable measures and options to reduce inputs of nitrogen and phosphorus from the lake catchment to maintain or improve lake water quality.
(iv) Determine if the TLI in Objective 10 can be realistically achieved, and a practicable timeline for achieving the target TLI.

(d) Identify the costs and benefits of different nutrient management and reduction methods. Such methods include, but are not limited to:
   (i) Education on nutrient management;
   (ii) Riparian retirement;
   (iii) Constructed wetlands;
   (iv) Sewage reticulation;
   (v) Review of existing discharge consents in the catchment;
   (vi) Land use changes;
   (vii) Land purchase or lease;
   (viii) Engineering works;
   (ix) Nutrient trading systems.

(e) Take into account the macro-economic and micro-economic effects of lake water quality maintenance or improvement measures, including the value of land use and lake water quality to the catchment, district, region and wider community.

(f) Apply existing funding policies and other funding options for lake water quality maintenance or improvement works, including, but not limited to:

   (i) Differential rating as a means of paying for works within the catchment;
   (ii) Central government funding.
   (iii) User charges.
   (iv) Environmental programmes.

(g) Determine if regulatory measures are necessary to control the discharge of nitrogen or phosphorus, or both, from land use activities in the lake catchment. (Refer to Method 35A.)

(h) Document a timetable for implementing nutrient management and reduction options."

# Appendix 5 – Nutrient Reduction Target Calculation

*Table 14 Calculations for nitrogen and phosphorus reduction targets*

| | | | |
|---|---|---|---|
| Nitrogen | total TLI to drop from 4.6 to 3.9 = | -0.7 | |
| 4.30 | TLn 3 yr median 2005 = | 3.60 | TLn goal |
| 423.07 | mg/m3 2005 | 354.20 | mg/m3 goal |
| | | | |
| | 68.87 | mg/m3 target | |
| | 4439.76 | in-lake kg-N reduction target | |
| | 2.00 | accounting for 50% in-lake attenuation | |
| | 8879.51 | lake catchment reduction target (kg-N/yr) | |

| | | | |
|---|---|---|---|
| Phosphorus | total TLI to drop from 4.6 to 3.9 = | -0.7 | |
| 4.64 | Tlp median 2005 = | 3.94 | TLp goal |
| 36.39 | mg/m3 2005 | 30.90 | mg/m3 goal |
| | | | |
| | 5.49 | mg/m3 target | |
| | 353.90 | in-lake kg-P reduction target | |
| | 2.00 | accounting for 50% in-lake attenuation | |
| | 707.80 | lake catchment reduction target (kg-P/yr) | |

| | | |
|---|---|---|
| Lake volume = | 64464000 | m3 |
| (790 ha x 8.16 m mean depth) | | |