ROTORUA
TE ARAWA
LAKES
PROGRAMME

Lake Ōkataina Action Plan

for better water quality

Te kaupapa mo ngā taonga o Rotorua

This is a non-statutory document to improve water quality in Lake Ōkataina.

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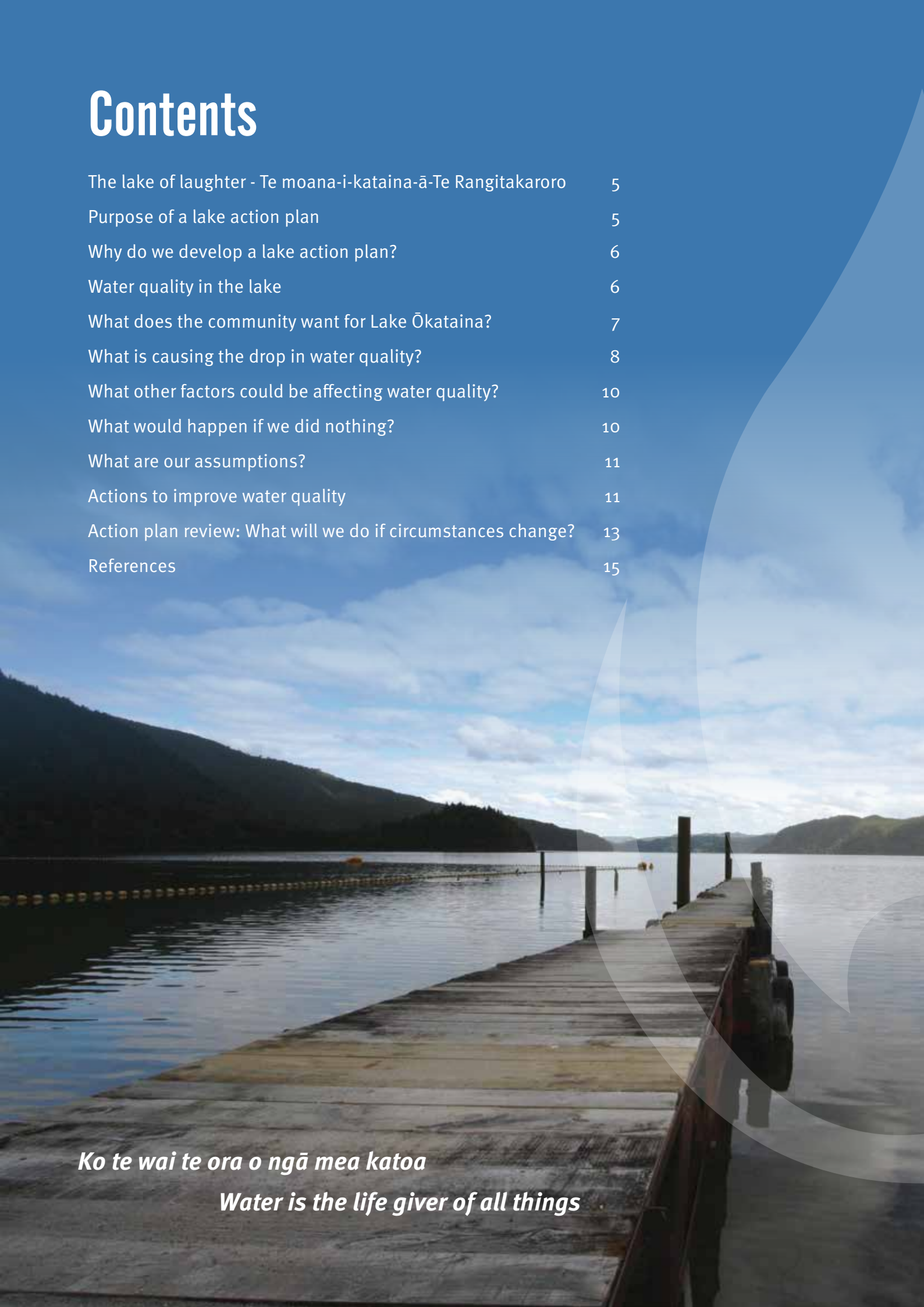
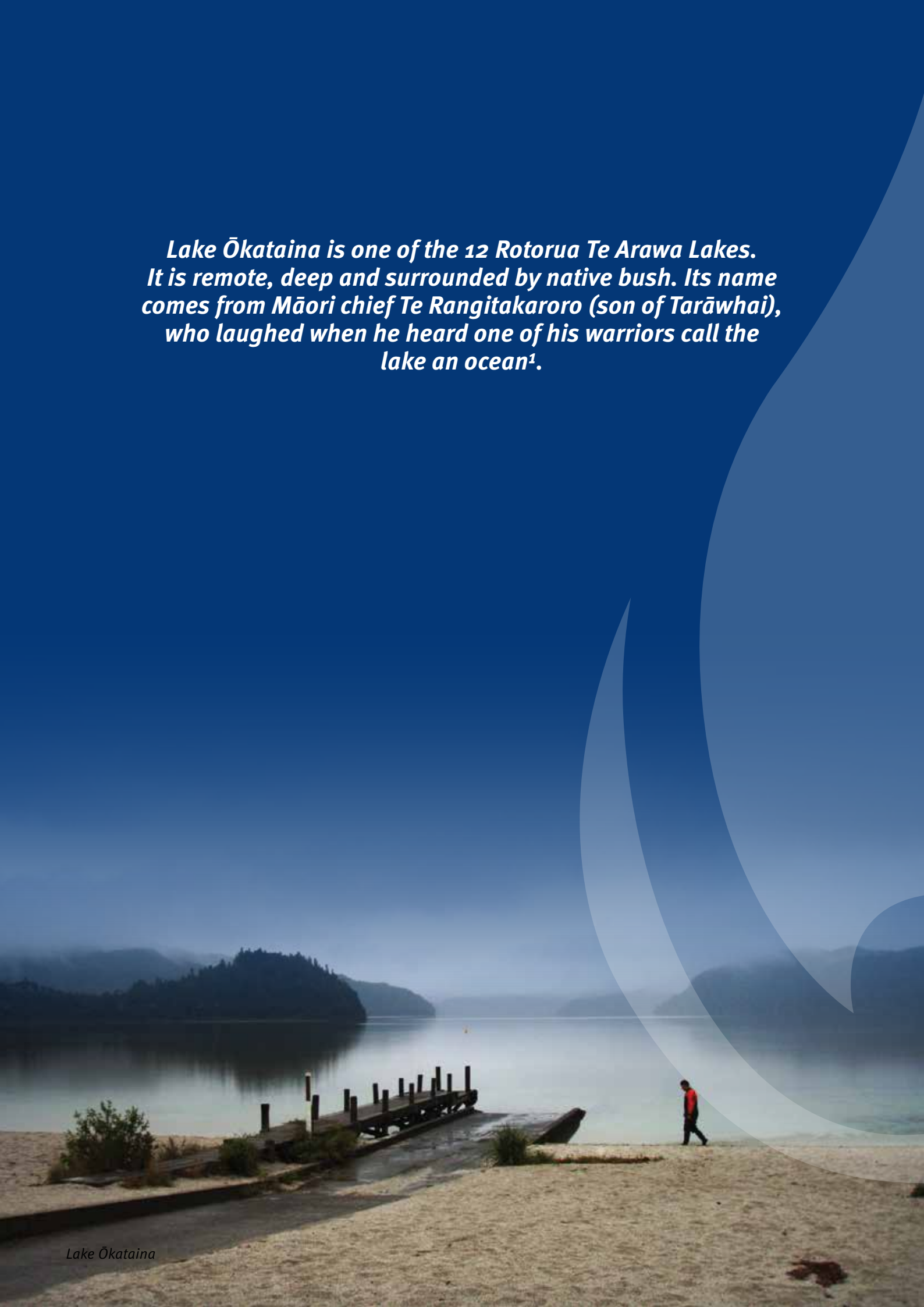


Ko te wai te ora o ngā mea katoa

Water is the life giver of all things

Lake Ōkataina is one of the 12 Rotorua Te Arawa Lakes. It is remote, deep and surrounded by native bush. Its name comes from Māori chief Te Rangitakaroro (son of Tarāwhai), who laughed when he heard one of his warriors call the lake an ocean[1].



Lake Ōkataina

The lake of laughter

Te moana-i-kataina-ā-Te Rangitakaroro

Lake Ōkataina was formed 7,000 years ago by volcanic activity.

It is 1,080 hectares in size and has a catchment area of 62.9 square kilometres. Nearly 81 percent of the catchment is in the surrounding scenic reserve. In 1921, the Chief of Ngāti Tarāwhai gifted the lake shore to be protected as reserve. Other than the reserve area, about 10 percent of the catchment is pasture, eight percent is in exotic forest and the remainder is wetland, buildings and bare ground.

Lake Ōkataina is 79 metres at its deepest point, with an average depth of 39 metres. While the lake level rises and falls, Lake Ōkataina has no surface outlets. Subsurface flow is thought to drain towards Lake Tarawera – a nearby larger lake that is about 13 metres lower than Lake Ōkataina in elevation.

The steep inclines along the lake edge and the pumice soils in the catchment cause fast run-off of rainwater into the lake, increasing the risk of erosion. Occasionally, landslides leave scars on the landscape.

Lake Ōkataina's water quality is good and reasonably stable compared to some of the other 12 Rotorua Te Arawa Lakes[2]. The lake is also safe for swimming. However, its trophic level (the indicator that measures overall lake health) is not quite as good as we would like it to be.

Waharia o Te Koutū Pā

Purpose of a lake action plan

A lake action plan describes what we know and don't know about a particular lake, and what we need to do to improve lake water quality.

The intention of developing actions is to meet the lake health target or trophic level index (TLI) target. Lake Ōkataina's target trophic level index is set at the 1994 level of 2.6.

As a key partner of the Rotorua Te Arawa Lakes Programme, Bay of Plenty Regional Council has led the task of developing an action plan for Lake Ōkataina.

Trophic Level Index

The trophic level index (TLI) is a number used to indicate the overall health of lakes. The number is calculated using four separate water quality measurements: total nitrogen, total phosphorus, water clarity and chlorophyll-*a*. The worse the water quality, the higher the number.

Nitrogen and phosphorus are nutrients that plants thrive on. Large amounts of these nutrients in lakes encourage the growth of algae, which can lead to poor water quality. Water clarity is how clear the water in the lake is. Clear water usually means better water quality. Chlorophyll-*a* is the green colour in plants. Knowing how much chlorophyll-*a* is in a lake gives us a good idea of how concentrated algae biomass is in the lake. More algae means poorer water quality.

These four measurements are combined into one number – the Trophic Level Index.

[1]Gosling (2002) Lake Ōkataina Scenic Reserve, Super Site Resource 4, Department of Conservation.

[2]Scholes (2009) Rotorua Lakes Water Quality Report, Bay of Plenty Regional Council.

Why do we develop a lake action plan?

To improve lake water quality, one of the tasks in the Rotorua Te Arawa Lakes Programme is to develop action plans for the Rotorua Te Arawa lakes.

The Regional Water and Land Plan also stipulates that an action plan is required if the water quality (defined by the three-year average of TLI) of a lake is higher than its target TLI by 0.2 or more for two years in a row.

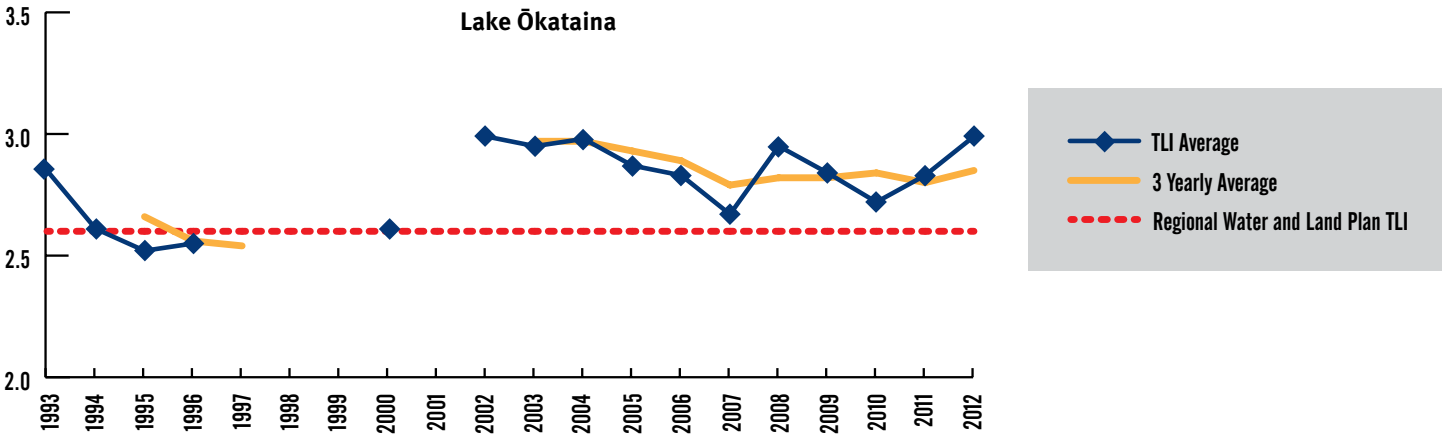
Lake Ōkataina has a Trophic Level Index target of 2.6 that has been set in the Plan. The lake's current (2012) three year average TLI is 2.9.

In developing this action plan we have:

- Examined what we know about the lake, its characteristics and its surroundings
- Researched lake water quality trends
- Talked with the local community and iwi about the water quality trend of the lake
- Asked the local community and iwi what they want for the lake
- Considered potential actions.

This process has helped us understand what is happening at Lake Ōkataina, what the community's expectations are and how we can improve water quality.

For more details and information about the research behind the Lake Ōkataina Action Plan, please see the background document "Lake Ōkataina Water Quality Background Information 2012".



Lake Ōkataina's water quality trend measured by the TLI

Water quality in the lake

Lake Ōkataina has good water quality - but not as good as it was in 1994 (the target level).

The current TLI at Lake Ōkataina is 2.9. The trend over the last 10 years shows this lake's TLI is steady compared with other lakes, and more detailed analysis shows that nitrogen has been declining and phosphorus has been increasing.

While phosphorus and nitrogen are the key nutrients we focus on for improving water quality, scientists are also concerned about low oxygen levels in the deep water in autumn. This could lead to higher levels of nitrogen and phosphorus in the winter and prompt algal blooms.

There is also some concern that the underwater ecology is threatened by invasive aquatic weeds, such as hornwort. The hornwort infestation discovered in the lake several years ago is controlled. To date the control programme has had good results. A plan aiming to eradicate hornwort is currently being implemented. Progress will be reviewed annually.

For more details about water quality in Lake Ōkataina, please see the background document "Lake Ōkataina Water Quality Background Information 2012".

What does the community want for Lake Ōkataina?

Lake Ōkataina is a unique, tranquil and unspoilt wilderness. This lake is highly valued for its historical and cultural significance, as well as its prized fishing opportunities.

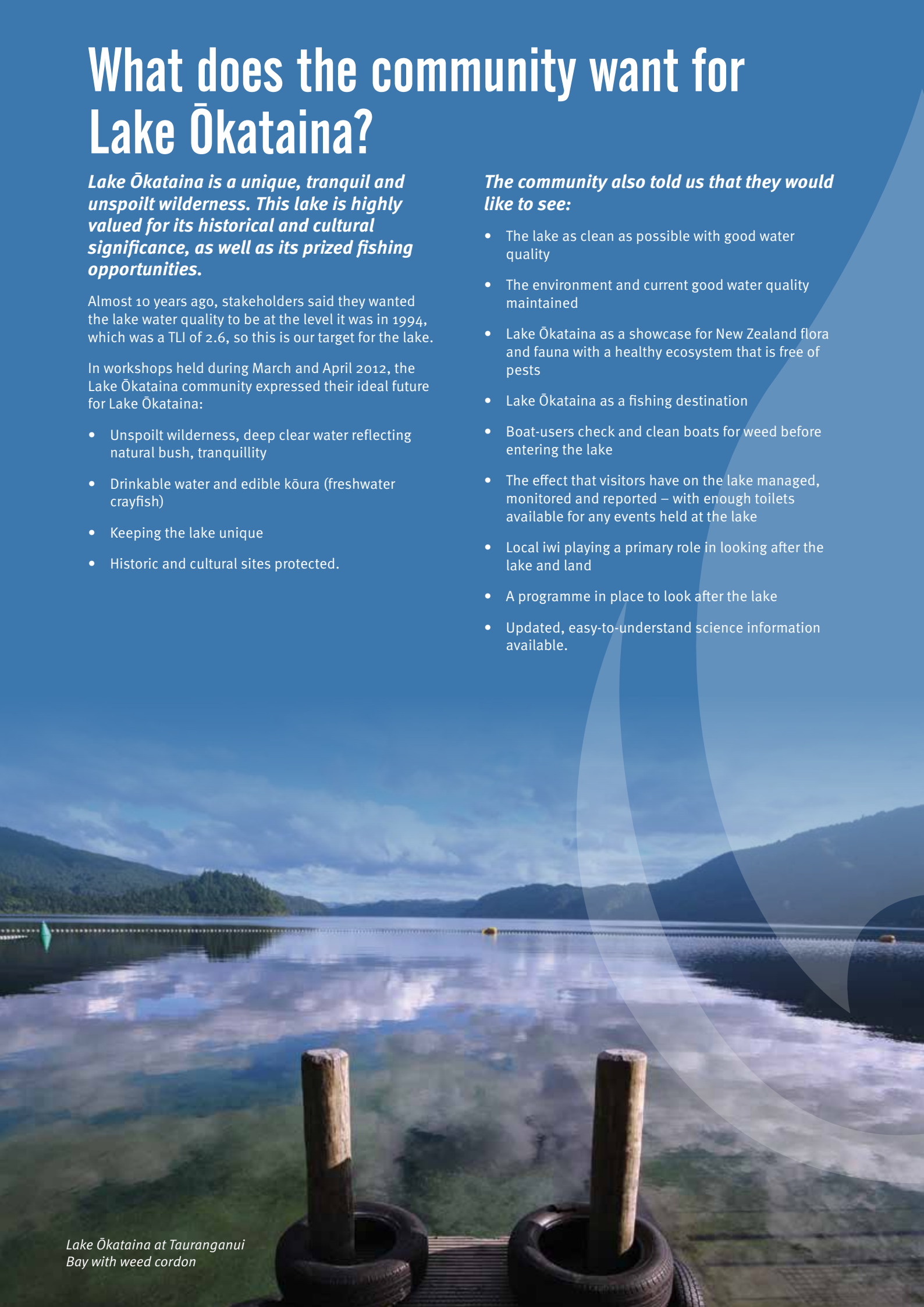
Almost 10 years ago, stakeholders said they wanted the lake water quality to be at the level it was in 1994, which was a TLI of 2.6, so this is our target for the lake.

In workshops held during March and April 2012, the Lake Ōkataina community expressed their ideal future for Lake Ōkataina:

- Unspoilt wilderness, deep clear water reflecting natural bush, tranquillity
- Drinkable water and edible kōura (freshwater crayfish)
- Keeping the lake unique
- Historic and cultural sites protected.

The community also told us that they would like to see:

- The lake as clean as possible with good water quality
- The environment and current good water quality maintained
- Lake Ōkataina as a showcase for New Zealand flora and fauna with a healthy ecosystem that is free of pests
- Lake Ōkataina as a fishing destination
- Boat-users check and clean boats for weed before entering the lake
- The effect that visitors have on the lake managed, monitored and reported – with enough toilets available for any events held at the lake
- Local iwi playing a primary role in looking after the lake and land
- A programme in place to look after the lake
- Updated, easy-to-understand science information available.



Lake Ōkataina at Tauranganui Bay with weed cordon

What is causing the drop in water quality?

Lake Ōkataina is somewhat of a unique case. The lake has many characteristics that would normally ensure good water quality:

- It is a deep lake surrounded by native bush
- It is reasonably isolated
- Most of its surface catchment is covered by native bush
- Little wastewater is released in the catchment.

Based on the data available, the Lake Ōkataina catchment has not significantly changed since the TLI was first recorded. Changes would have most likely led to higher nutrient levels. The catchment is still mostly covered in native bush, farming remains stable and while visitors numbers have varied over the years, the scale is still small.

The combination of these factors leaves us uncertain about what has caused the water quality to drop.

What we do know is that this catchment is vulnerable to water pollution because of its natural characteristics. The steep surroundings and loose volcanic soils make it sensitive to erosion. It is important for Lake Ōkataina that we keep nutrients on land and in the soil as much as possible.

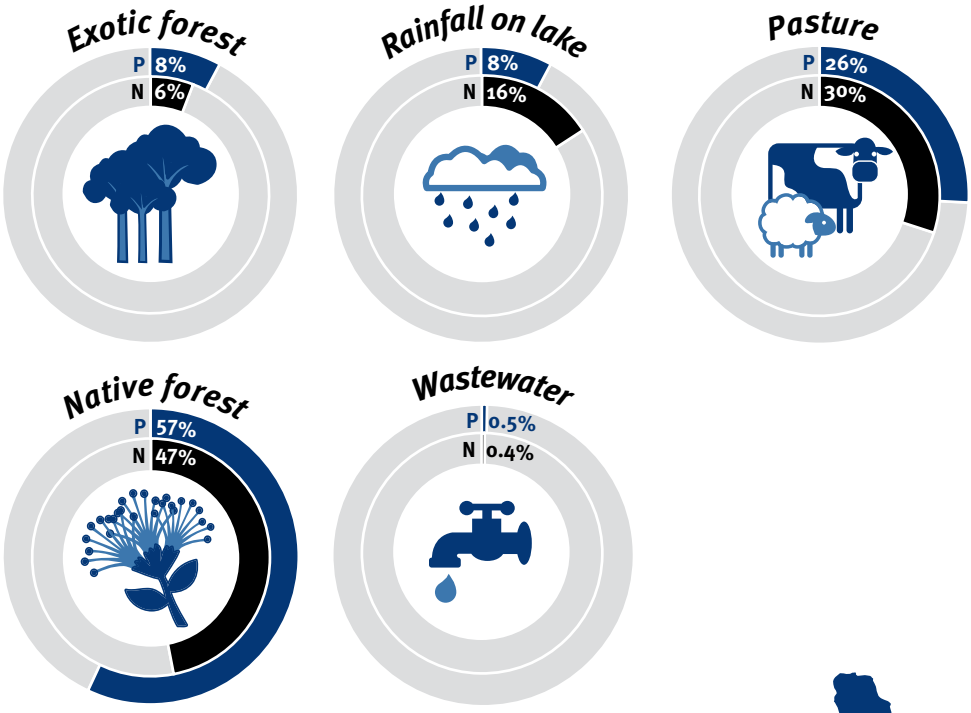
Scientists estimate the levels of nutrients entering the lake annually are:

- Nitrogen: 27,112 kilograms per year
- Phosphorus: 2,079 kilograms per year

The amount of nutrients going into the lake has resulted in the current lake trophic level of 2.9. Work has been done to identify where the nutrients are coming from[3].

[3]McIntosh (2011) nutrient budget for Lake Ōkataina

Where are the nutrients coming from?



Target
2.6
Nutrient reduction:
Phosphorus 380 kg/yr
Nitrogen 860 kg/yr
trophic level

Land Use	% area (including lake)	% N entering lake	% P entering lake
Native bush	67%	47%	57%
Grassland (pasture)	9%	30%	26%
Rainfall on lake	17%	16%	8%
Exotic forest	7%	6%	8%
Stormwater	<0.1%	0.3%	<0.1%
Septic Tanks	-	0.4%	0.5%

N = Nitrogen, P = Phosphorus

More information about land cover and nutrient source estimation can be found in Appendix One, or in the supporting document "Lake Ōkataina Water Quality Background information 2012".

To achieve a TLI of 2.6, the amount of nitrogen and phosphorus going into Lake Ōkataina needs to be reduced by 860 kg of nitrogen and 380 kg of phosphorus each year. While it is important to reduce both nutrients going into the lake, it appears that removing a large proportion of the phosphorus entering the lake will help us meet the desired water quality.

What other factors could be affecting water quality?

The community identified other factors that could be causing a drop in the water quality in Lake Ōkataina[4]:

- Animal pests damaging the native bush could cause higher levels of nutrients going into the lake
- Aquatic pests could upset the balance of the lake
- A need for more facilities (toilets) for visitors and events around the lake.

We don't know to what degree the water quality is affected by pest animals degrading the native bush. The community has observed a significant impact on the native bush and scientists recognise that it is an area that requires further investigation.

The community is also concerned about having enough public toilets available, particularly during events. The presence of *E. coli*[5] usually means that faeces has entered the water. The good news is that the Lake Ōkataina swimming area has consistently low levels of *E. coli* in the water, and it is safe for swimming.

What would happen if we did nothing?

If current actions continue and the environment (for example, the climate or the land use) stays the same, it is likely that Lake Ōkataina's water quality will remain steady. Current actions are listed as "ongoing" actions in Table 1 and 2.

We don't know the risk of more phosphorus entering the lake. There is a risk around the high oxygen depletion rates, where the amount of oxygen diminishes more quickly in the deep parts of the lake.

Once oxygen levels drop to a certain point, nutrients would increasingly be released from the bottom of the lake. Once this process has started, it is very difficult to reverse. Nutrients from lakebed sediments would have a significant effect on the lake water quality, leading to rapid growth of unwanted algae and a reduction in the clarity and visibility of the lake water. Low oxygen levels also increase the risk to the health of fish in the lake. Oxygen levels are currently being monitored monthly by the Bay of Plenty Regional Council.

[4]Bay of Plenty Regional Council, Te Arawa Lakes Trust, Rotorua District Council and key lake stakeholders (2012) Lake Ōkataina Water Quality Workshop

[5]Esherischia coli, a type of human and animal gut bacteria.

Differences in native bush when animal pests are excluded

The community is concerned about damage to native bush from pests. Understory vegetation is important for the forest ecosystem. The photos shows the difference 10 years after the animal pest exclusion area (near Oruaruoa) was installed – the photo above shows outside of the pest animal exclusion area, and the photo below shows inside of the pest animal exclusion area.

What are our assumptions?

Scientists have had to make certain assumptions to undertake the difficult task of estimating the nutrient budget for Lake Ōkataina[6].

These assumptions include:

- The lake level will remain stable
- The water flow of the Lake Ōkataina catchment is similar to other Rotorua lake catchments
- Nutrients entering the lake as a result of land use occurs at a similar rate as recorded in other Rotorua lakes
- No significant land use change has occurred in the last 10 years.

Scientists also make estimates around the nutrient budget. These estimates include:

- The amount of nutrient that stays in the lake
- The amount of nutrients coming from sewage and stormwater
- The accuracy of the nutrient budget is affected by data availability.

Actions to improve water quality

Lake Ōkataina is somewhat of a unique situation – a lake with good water quality, where the activities in its catchment suggest the lake should have a low trophic level index.

However, we need to reduce the nutrients entering the lake by 860 kg of nitrogen and 380 kg of phosphorus every year for Lake Ōkataina to achieve its water quality target.

We are reasonably confident that the nitrogen target could be achieved by land use change from agriculture to forestry. However, this would only happen if the landowners are supported by financial conditions.

To assist landowner decision making, the Regional Council will provide support for a one-off land use change to help Lake Ōkataina meet its nitrogen reduction target.

At this stage, we do not have enough information about how the phosphorus target can be achieved. Approximately 57 percent of the phosphorus entering the lake comes from native bush. As yet, we know very little about how to reduce nutrients entering the lake from native bush.

One of the key actions proposed in this plan is to investigate how the water quality is affected by the state of the native bush. This would provide us with new evidence on whether animal pest control will significantly reduce the nutrient input.

As new evidence becomes available, we will take an adaptive approach – that is to act (and consult) on the most effective, efficient and appropriate options available for improving water quality in Lake Ōkataina.

In the meantime, there are still actions that can be taken to protect and restore this sensitive and vulnerable lake catchment. We know that further land use change can help lowering the level of phosphorus. In the future, the Regional Council will consider supporting land use change proposals that clearly contribute to lake water quality improvement.

While many of the on-going actions are funded through current work programmes (for example, the Sustainable Land Use Programme), no specific funding was allocated to the Lake Ōkataina catchment.

Table 1 and 2 over the page outline what work is being done and will be done to help protect the water quality of Lake Ōkataina.

[6]McIntosh prepared a Lake Ōkataina Nutrient Budget in 2011.

Table 1. Actions for reducing nutrient input and improving water quality

Actions	Timeframe	Led by	Effectiveness in reducing nitrogen and phosphorus
Voluntary change to less nutrient-leaching land use	Ongoing	Landowners, if supported by financial conditions	A recent voluntary land use change is estimated to have met 78 % (671 kg out of 860 kg per year) of the nitrogen reduction target, and nearly 10 % (37 kg out of 380 kg per year) of the phosphorus reduction target.
Provide support for meeting the nitrogen reduction target by converting some pastures to forestry	2013 – 2018	Bay of Plenty Regional Council	A one-off support aiming to reduce 189 kg of nitrogen (meeting the target) and 10 kg of phosphorus.
Consider opportunities and methods to further reduce phosphorus by supporting large scale land use change	2017 – 2023	Bay of Plenty Regional Council	An action aiming to reduce 120 kg of phosphorus and further reduce 2,200 kg of nitrogen.
Looking into pest control options in the catchment	Initiated, and will continue if funding is available	Department of Conservation, assisted by local iwi and lake community	Effectiveness is being investigated. If new evidence suggests this is highly effective it will become a priority.
Voluntary land and farm management practice that reduces the potential for erosion, sediment loss or nutrient loss into waterways (stewardship management approach)	Ongoing	Landowners, assisted by Bay of Plenty Regional Council (advice and possible subsidy)	Relatively effective depending on farm conditions.
An effluent treatment rule: septic tanks within 200m of lakes are required to install an Aerated Wastewater Treatment System with nutrient reduction capabilities or obtain a resource consent	Rule is enforceable from 1 December 2013	Bay of Plenty Regional Council	Effect will be minor due to the small population around the lake.
A policy that sets nutrient discharge limits in the Regional Water and Land Plan for all Rotorua Te Arawa Lakes	Proposed Regional Policy Statement requirement	Bay of Plenty Regional Council	Yet to be determined.
Review regulatory interventions for all Rotorua Te Arawa Lake catchments	Ongoing	Bay of Plenty Regional Council and Rotorua District Council	Yet to be determined.

Table 2. Other actions for reducing nutrient input and improving water quality

Actions	Timeframe	Led by
Building awareness and knowledge about nutrient sources		
Investigate and measure the impacts of native bush understory health to lake water quality	2013 - 2016	University of Waikato, led by Chair in Lakes Management and Restoration
Update community on Lake Ōkataina's water quality trends, including Lake Ōkataina Scenic Reserve Board, Ngāti Tarāwhai Iwi Trust and Ngāti Rongomai Iwi Trust	Starting from 2013	Bay of Plenty Regional Council
Invite interested Lake Ōkataina stakeholders to forums presenting lake science	Ongoing	Bay of Plenty Regional Council
Monitor Trophic Level Index and de-oxygenation rates	Ongoing, monthly	Bay of Plenty Regional Council
Report to the Lake Ōkataina community on water quality	Ongoing, annually	Bay of Plenty Regional Council
Provide sustainable land-use information through workshops, field days and discussion groups. Workshops have been held with the forestry sector about earthworks and harvest practices	Ongoing	Bay of Plenty Regional Council and partners
On-farm benchmarking	Ongoing	Farmers across border between Lake Ōkataina and Lake Rotorua catchments, supported by Bay of Plenty Regional Council
Ensuring the amenity of the lake		
A rule to ban jet-skis and water-skiing on the lake. Other boats must travel 5 knots within 200m of the shore	Completed	Rotorua District Council and Bay of Plenty Regional Council
Control aquatic weed. A hornwort incursion response plan was formulated in response to a 2010 hornwort incursion	Completed with on-going observation	Bay of Plenty Regional Council

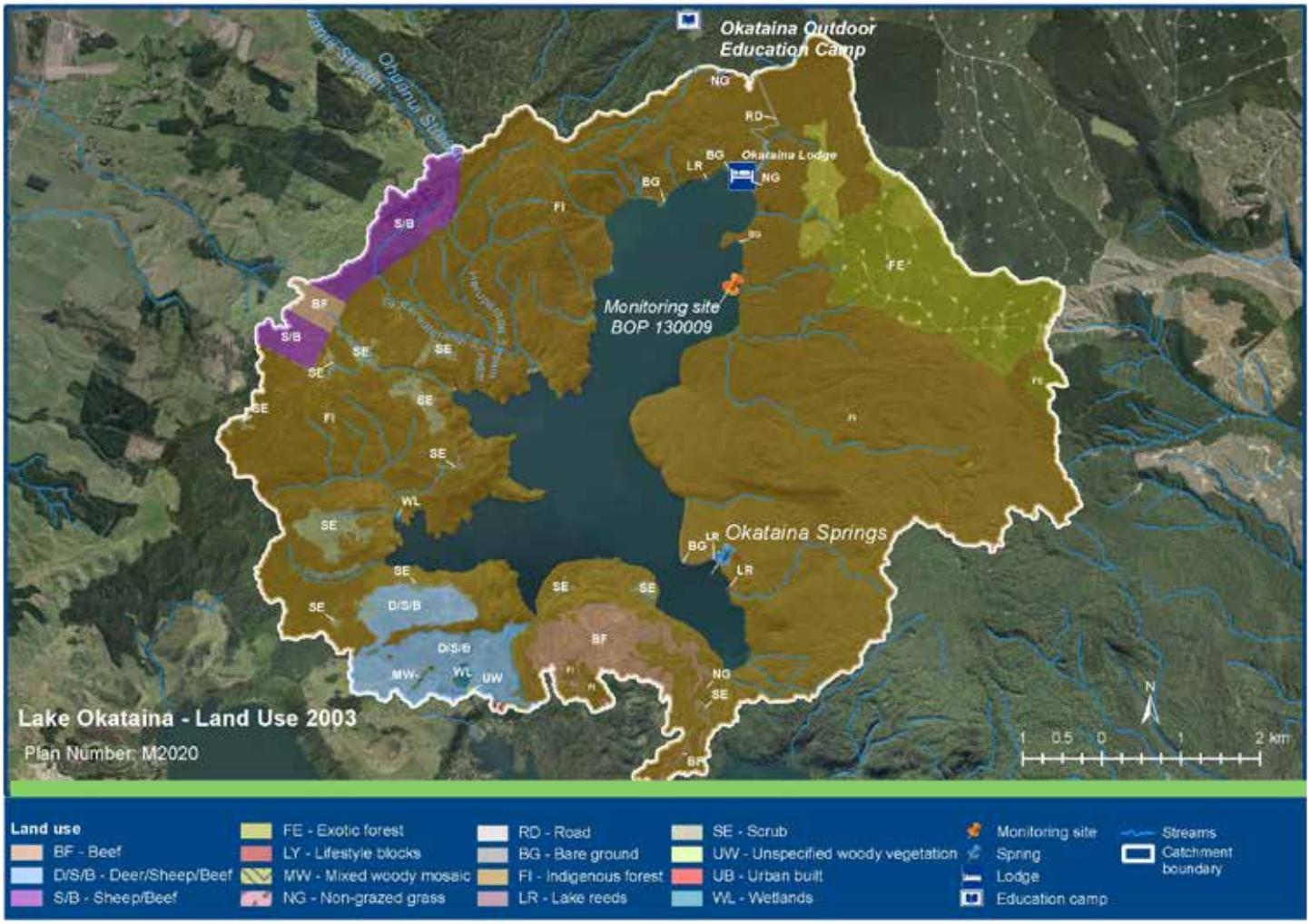
Action plan review: What will we do if circumstances change?

This Plan has been developed based on our current knowledge.

In the case of Lake Ōkataina, there are things we know, and some things we are yet to learn. For example, we don't know what specifically caused the water quality to change, and to what degree restoring the native bush will help improve the lake's water quality.

Sometimes new information or evidence becomes available, and this provides us with more opportunities for new action. We will be alert to the possibility of new information and will review our options if and when new evidence emerges. We will focus our efforts on the most effective and suitable actions to protect and improve the water quality of Lake Ōkataina.

Appendix one



Map: Lake Ōkataina surface catchment (2006) and land-use (2003) indicative map
Table: Estimated nutrient budget based on land-use loss estimates (data extract from Lake Ōkataina Nutrient Budget)

	Area (ha)	Rate of P loss (kg/ha/yr)	Rate of N loss (kg/ha/yr)	P load (kg/yr)	N load (kg/yr)
Bare ground	2.7	0.15	4	0.4	10.8
Exotic forest	436.0	0.40	4	174.4	1744.0
Indigenous forest	4224.8	0.28	3	1182.9	12674.4
Pastoral land	548.7	1.00	15	548.7	8230.5
Reserve, buildings, parking	2.8	-	-	0.9	71.0
Wetlands	7.6	-	-	0.0	0.0
Sewage, septic waste (30 persons/d; 3.65 kgN/p/yr, 0.37 kgP/p/yr)	-	-	-	11.00	110.00
Rainfall on lake*	1067.9	0.15	4	160.2	4271.6
Total	**6291**			**2079**	**27112**

Stormwater (reserve and parking area) estimates are from Williamson (1985), Rainfall nutrients to lake (Hoare, 1987)
**Rainfall on lake is not a loss from the land catchment.*

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