BAY OF PLENTY REGIONAL COUNCIL
TOI MOANA

Rotorua Te Arawa Lakes Asset Management Plan 2021-2031

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Executive summary

The Rotorua Te Arawa Lakes Asset Management Plan (AMP) presents the details of assets associated with the restoration of water quality for the Rotorua Lakes and management of specific lake levels. There are 12 Rotorua lakes in the programme and their target water quality is specified as their Trophic Level index (TLI) targets in the Natural Resources Plan (NRP).

This AMP outlines the assets, how they are managed and funding requirements to ensure they are maintained in a reasonable operational state. It also outlines the authorisations and management plans necessary to guide their operation and maintenance.

Lake operations assets fall into two main categories:

1 In-lake and in-stream interventions which are temporary activities to improve lake water quality while more long-term sustainable land use changes are implemented and take effect, and

2 Lake level management and monitoring assets that deliver service to the local communities to ensure specific lake levels are either managed or cater for future climate change scenarios and long-term data from ground water bores can be collected from key sites.

The key purpose of this plan is to:

- Document key assets in the Rotorua Lakes Programme.
- How these assets will be managed including funding, service delivery, risk and maintenance.
- Document linkages to other documents that are vital to understanding how the assets are managed (management and operation plans, consents etc.).

The Rotorua Lakes Programme is a tripartite programme of lake management and restoration between Bay of Plenty Regional Council (BOPRC), Te Arawa Lakes Trust (TALT) and Rotorua Lakes Council (RLC). The governing group is the Rotorua Te Arawa Lake Strategy Group (RTALSG) and was established out of the Te Arawa Settlement Act 2006.

The basis for this work is outlined in the Vision and Strategy for the Rotorua lakes and described in the vision from that document:

> The lakes of the Rotorua district and their catchments are preserved and protected for the use and enjoyment of present and future generations, while recognising and providing for the traditional relationship of Te Arawa with their ancestral lakes.
>
> E tiakina ana, e manaakitia ana hoki ngā roto o te rohe o Te Arawa hei painga mō tātau me ngā whakatipuranga e ara mai nei, ā, me te aro anō ki te hononga tuku iho o Te Arawa ki ō rātau roto.

The Bay of Plenty Regional Council also manages the Bay of Plenty environment pursuant to the requirements of the Resource Management Act 1991 (RMA). This Act is the basis of the NRP for the Bay of Plenty. The plan has specific outcomes for the 12 Rotorua lakes, specifying water quality outcomes for each of these lakes and a requirement to address water quality issues by development and application of Action Plans where water quality outcomes are not being achieved. More recently the Government has announced a National Policy Standard for Freshwater Management (NPS-FM) that adds to these requirements to protect water quality. There are action plans for 10 lakes in the programme. These will be superseded as the NPS-FM is implemented.

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Part 1:
Introduction

1 Purpose of the Asset Management Plan (AMP)

The Rotorua Lakes Catchment programme is a focused programme of works primarily aimed at addressing water quality issues for the 12 lakes in the programme (see Figure 1). The overall outcome of the programme is to sustainably align catchment land use with long term lake water. The water quality in each lake is a result of catchment nutrient inputs; natural and anthropogenic. Most of the long-term interventions to improve water quality include land use and land management change on private land, and sewage reticulation of lakeside communities. These interventions are not owned by Bay of Plenty Regional Council (BOPRC) and so are not included in this Asset Management Plan (AMP).

This AMP is focused on in-lake and in-stream interventions which are more temporary than the long-term restorations mentioned above. The purpose of these interventions is to improve water quality more quickly, than if catchment land use and nutrient inputs were the only focus of intervention.

This AMP also includes some structures used to manage lake level control and monitor environmental conditions that provide key data for managing the lakes (e.g. Lake Outflow structures and groundwater (GW) monitoring bores).

The key purpose of this plan is to:

- Document key assets in the Rotorua Lakes Programme,
- How these assets will be managed including funding, service delivery, risk and maintenance, and
- Document linkages to other documents that are vital to understanding how the assets are managed. (Management and operation plans, consents.)

Figure 1 Map showing lakes of the Rotorua District

1.1 Overview of services covered

1.1.1 What do we do?

The service that we provide by this AMP is best portrayed by three main groupings:

- Short to medium term in-lake and in-stream interventions to improve water quality (e.g. operation of alum dosing plants and the Ōhau Diversion Wall),
- Management of lake levels in response to environmental conditions and community aspirations, and
- Maintain specific monitoring equipment to ensure targeted monitoring data is available specifically for the lakes programme (e.g. GW monitoring bores).

The interventions to improve water quality and the water level control are of high interest to local communities and attract considerable attention if water quality declines or lakes are outside their "normal" operational range. Staff are committed to responding in two main ways: (a) where appropriate respond to issues and resolve complaints, and (b) provide science based and economic/cost explanations as to why natural environmental conditions may dominate lake conditions and a practical solution may not be appropriate. An example of this is where an algal bloom occurs in a bay of Lake Rotorua. We cannot resolve the short-term issue, but we can provide a science explanation outlining why it may have occurred. Alternatively, where heavy rainfall has pushed Lake Ōkāreka outside of its normal operational range, we can review our management plan to ensure it is still fit for purpose, to minimise out of spec events.

1.1.2 Why do we do it?

The Rotorua Lakes Programme is a tripartite programme of lake management and restoration between BOPRC, Te Arawa Lakes Trust (TALT) and Rotorua Lakes Council (RLC). The governing group is the Rotorua Te Arawa Lake Strategy Group (RTALSG) and was established out of the Te Arawa Settlement Act 2006.The basis for this work is outlined in the Vision and Strategy for the Rotorua lakes and described in the vision from that document:

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The Bay of Plenty Regional Council also manages the Bay of Plenty environment pursuant to the requirements of the Resource Management Act (RMA). This Act is the basis of the Natural Resources Plan (NRP) for the Bay of Plenty. The plan has specific outcomes for the 12 Rotorua lakes, specifying water quality outcomes for each of these lakes and a requirement to address water quality issues by development and application of Action Plans where water quality outcomes are not being achieved. More recently the Government has announced a National Policy Standard for Freshwater Management (NPS-FM) that adds to these requirements to protect water quality. There are action plans for 10 lakes in the programme. See Appendix 1 for a listing of action plans and the review document. These will be superseded as the NPS-FM is implemented.

Long term implementation of the Strategy and RMA plans is provided in the BOPRC Long Term Plan Community Outcomes:

- Water quality and quantity
- Environmental protection
- Resilience and safety
- Regional collaboration and leadership

While the overall expectation of undertaking the work detailed in this AMP is to improve the environment for the Rotorua lakes, there can be occasions when some community members perceive some of the activities as negative. The key activities that can attract negative feedback are alum dosing and the Ōhau Diversion Wall. While alum dosing has been credited with improving the quality of three of our lakes, some iwi are concerned about the ongoing dosing of a chemical product into our lakes. As a result, BOPRC has undertaken considerable research and continues to monitor the water quality and environmental health, to ensure any negative effects are also addressed if they should arise. A second risk with alum dosing is that some members of the community may identify it as a solution to long term land use impacts and see it as an alternative to improving land use.

The Ōhau Diversion Wall is a temporary structure designed to divert the flow of the Ōhau Channel directly down the Kaituna River. This structure was deemed necessary to prevent the nutrient rich water from Lake Rotorua reaching Lake Rotoiti and driving algal blooms in the second lake. It is expected that the wall will need to be in place for about 50 years while the land use improvements in the catchment of Lake Rotorua gradually improve the water quality of Rotorua. Although the wall has consent authorisation (35-year term), there is some resistance to the wall from some iwi groups. The main concern is the effect of interfering with natural flows between the two lakes. In addition, the presence of the wall increases the water residence time in Lake Rotoiti from about1.5 years to 5+ years. Over the time the wall has been in place (since 2008), Lake Rotoiti has not reached its target water quality. There is some concern that changing the lake water dynamics has created some negative side effects that could be preventing the lake reaching its long-term target.

With respect to lake level management in the Rotorua District, BOPRC only actively manages the level of three lakes (Rotorua, Rotoiti and Ōkāreka), and has a more passive level of management of two other lakes (Rerewhakaaitu and Rotomahana). Historic flooding issues and location of infrastructure around lakes has led to the various authorities implementing lake level management structures and regimes. Bay of Plenty Regional Council now takes responsibility for these structures and management operations. Two lake level structures not within this plan are the Ōhau Channel outlet from Lake Rotorua and the Okere control gates on Lake Rotoiti, as they manage flows on the Kaituna River and are operated under a different plan.

The two most prominent issues associated with lake level management are:

- Unrealistic public expectations as to how much influence our management can have on controlling high or low lake levels for differing outcomes, and
- The ongoing effects of climate change which are likely to have impacts on both high and low lake levels.

Public expectations are best addressed by having good linkages with the local community and engaging on management processes. Climate Change impacts are going to influence Council infrastructure decisions. For Lake Ōkāreka, we have already invested heavily in providing for lake outflows of more than double the flow available 20 years ago in 2000.

Part 2:
Assets we own

2 Overview

The below is a listing of our Lake Assets in summary including the book value as at 30 June 2021.

Asset Number	Description	Description	Location	Book value
LAK102512	Bore	Rotorua Dibley	435 Oturoa Rd, Lake Rotorua Asset 10965	$108,000
LAK102514	Bore	Rotorua Jessie Martin Park No 2	79 Ngongotaha Road, Ngongotaha Boring number 10967	$63,000
LAK102515	Bore	Rotorua Gee Road	83 Gee Road, Rotokawa, Rotorua Bore number 10968	$61,000
LAK102516	Bore	Tarawera I Site 1	588 Spencer Road, Lake Tarawera Bore number 1000129	$74,000
LAK102517	Bore	Tarawera I Site 2	Te Miro, Lake Tarawera Boring number 1000131	$74,000
LAK102518	Bore	Tarawera I Site 3 Deep	Lake Tarawera Outlet - DOC Campground Bore number	$79,000
LAK102520	Bore	Tarawera II Site 4	1180 Tarawera Road, Buried Village Bore number 1001051	$75,000
LAK102521	Bore	Tarawera II Site 5 Shallow	757 Ash Pit Road, Waiotapu Bore number 1001052	$65,000
LAK102522	Bore	Tarawera II Site 5 Deep	757 Ash Pit Road, Waiotapu Bore number 1001053	$72,000
LAK102523	Bore	Tarawera II Site 6	1278 Ash Pit Road, Waiotapu Bore number 1001055	$98,000
LAK102524	Bore	Tarawera II Site 7	101 Rerewhakaaitu Road, Waiotapu Bore number 1001056	$87,000

Asset Number	Description	Description	Location	Book value
LAK102525	Bore	Tarawera III Site 8	11 Highland Loop Road, Lake Rotokakahi Bore	$108,000
LAK102526	Bore	Tarawera III Site 10	Tarawera Road, Lake Tikitapu Bore number 1001069	$26,000
LAK102527	Bore	Tarawera III Site 11	171 Millar Road, Lake Ōkāreka Bore number 1001070	$96,000
	Bore	Rotorua	230 Dalbeth Road Bore no. BN-4007	$56,000
	Bore	Rotorua	403 Hamurana Road BN-1561	$54,000
	Bore	Rotorua	89 Hawthornden Road BN-4005	$93,000
LAK102528	Ōhau Channel Diversion	Sheet pile wall	Lake Rotoiti at Ohau Channel	$6,261,230
LAK102529	Utuhina Phos Lock Pl	Dosing and alum store	Depot Street, Rotorua	$197,040
LAK102530	Puarenga Phos Lock	Dosing and alum store	Te Ngae Road, at the Rotorua STP	$241,650
LAK102531	Rotoehu Phos Locking Plant	Waitangi/Soda Springs Phosphorus Locking	Waitangi/Soda Springs Phosphorus Locking Plant	$448,620
LAK102532	Denitrification Plant	Tikitere Denitrification Plant	Tikitere Denitrification Plant	$6,980
LAK102537	Fish Pass, Hamurana	Dam type structure on Tributary of the Hamurana Stream	Hamurana Road	$24,180
LAL102541	Lake Rerewhakaaitu and Ōkāreka monitoring buoys	Monitoring buoy	Lake Rerewhakaaitu and Lake Okareka	$46,500
LAK102542	Ōkaro Wetland Structures	Monitoring location at stream flowing into Lake Ōkaro monitoring weirs and intake pipe	Ōkaro Road	$120,520
LAK104732	Outlet Structure	Lake Ōkāreka Outlet Structure	Lake Ōkāreka Outlet Structure	$869,670

Asset Number	Description	Description	Location	Book value
	Waitangi Stream, Ōkāreka stream works	Spencer Road Lake Tarawera.	Stream protection works	$1,059,920
	Rotomahana outlet control	Culvert and head wall for placement of stoplogs	At outlet between Lakes Rotomahana and Tarawera	$158,250
	Rerewhakaaitu outlet control	Drain and stoplogs at Lake outlet channel	Ashpit Road, Rerewhakaaitu	$67,860
	Total			**$10,791,420**

2.1 Asset detailed information

The following section outlines details of each asset, including expected maintenance costs. Appendix 2 contains specific details and file location of resource consents and management plans for each asset.

2.1.1 Groundwater monitoring bores

Bay of Plenty Regional Council has 14 monitoring bores as listed. These are used to sample groundwater to test for changes in water quality in the BOPRC Natural Environment Regional Monitoring Network (NERMN) Programme. Four of these are located around Rotorua and the remainder around the greater Tarawera Lake catchments. Many are located on private property as these locations have been selected to provide the best monitoring location. While their primary purpose is to monitor groundwater, the landowner can also use the bore to supply deep groundwater for farming and home water supply. Some are located on public land. See Figure 2 below showing the bore at Lake Tikitapu. Sampling involves monthly water sampling and water depth. At that time, other issues regarding maintenance can be undertaken and followed up where necessary.

The gross replacement cost for the groundwater monitoring bores is $1,609,934. The Optimised Depreciated Rate of Cost (ODRC) is $1,289,000. The assets have been valued in total and have not been itemised down to component level.

Figure 2 Groundwater bore at Lake Tikitapu

Asset	Replacement Cost	Sum of ODRC*	Sum of AD**
Groundwater monitoring bores	$1,609,934	$1,289,000	$32,412

**ODRC: Optimised depreciated rate of cost; ** AD: Annual Asset depreciation, 30 June 2021 valuation.*

Asset	Works planned description	Estimate cost (OPEX)	Planned schedule
Groundwater monitoring bores	Monitoring	$1,000	Annual

2.1.2 Ōhau Diversion Wall

The Ōhau Diversion Wall is located in Lake Rotoiti and was built in 2008. The diversion wall has been built to reduce the amount of nutrients reaching Lake Rotoiti from Lake Rotorua via the Ōhau Channel. Water from Lake Rotorua is now diverted down the Kaituna River rather than entering Lake Rotoiti, and due to the reduced nutrient loading has helped to improve the water quality in the lake.

The assets that form the diversion wall include the following:

- King piles (up to 70 m deep)
- Sheet piles (1,300 m long wall)
- Timber facing
- Timber walers
- Mesh
- Navigation equipment

Figure 3 Annual depreciation is approximately $708,000

Corrosion identified on the diversion wall in 2014 has led to the development of a Structural Management Plan to ensure the wall meets its service life of 50 years. Structural components have been installed in 2019/20 to delay major remediation by 10 years. Programmed inspections will determine the degree of corrosion and staged repairs will be programmed as necessary. The Structural Management Plan details inspection frequency as well as repair options.

Resource consent for the wall located in Lake Rotoiti was granted for 35 years pursuant to the conditions of consent RM16-0527.

Asset	Replacement cost	Sum of ODRC	Sum of AD
Ōhau Channel Diversion Wall	$14,583,800	$6,261,230	$708,673

**ODRC: Optimised depreciated rate of cost; ** AD: Annual Asset depreciation, 30 June 2021 valuation.*

Asset	Scheduled works	Estimate cost(OPEX)	Estimate cost(CAPEX)	Schedule dates
Ōhau Channel Diversion Wall	• General monitoring and maintenance	$50,000		Annual
	• Structural management plan inspections	$50,000		2021/22
	• Structural management plan inspections	$50,000		2024/25

Asset	Scheduled works	Estimate cost(OPEX)	Estimate cost(CAPEX)	Schedule dates
	• Structural management plan inspections	$50,000		2027/28
	• Install polymeric screen			
	• Structural management plan inspections	$50,000		2030/31
	• Structural management plan inspections	$50,000		2033/34
	• Structural management plan inspections	$50,000		2036/37
	• Replace polymeric screen, remove sheet piles & encase King Piles		$4,330,000	2038/39
	• Structural management plan inspections			
	• Structural management plan inspections	$50,000		2039/40
	• Structural management plan inspections	$50,000		2042/43
	• Replace polymeric screen		$1,600,000	2045/46
	• Structural management plan inspections	$50,000		2047/48
	• Structural management plan inspections			2048/49
	• Structural management plan inspections	$50,000		2051/52
		$50,000		2054/55
		$50,000		

2.1.3 Phosphorus locking (P-locking) plants

There are currently three phosphorous locking (P-locking) plants in the Rotorua District that are managed by BOPRC. These are:

- Utuhina Stream - Lake Rotorua
- Puarenga Stream - Lake Rotorua
- Waitangi Soda Springs - Lake Rotoehu

P-locking plants are used to reduce available phosphorous from a water body by using a “locking” chemical such as alum. P-locking plants target point sources that are high in phosphorus with the aim of reducing the concentration of phosphorous entering water bodies, i.e. Lake Rotorua or Lake Rotoehu. Various studies have shown that these lakes have degrading water quality due to excess phosphorous. Currently, all three P-locking plants are going through a re-consent process to continue dosing alum. The previous consents remain valid until the decision on the new consents is issued. The current consents are 65321, 65559 and 65966. It is expected that any new consent will be issued for a term of 10 years.

The current operation of the Rotoehu alum dosing is to dose into the Waitangi Stream. Research has shown that at times this dosing location is not the best location. As a result, the new application adds the option of dosing in the centre of the lake and the dosing protocol will provide guidance on the appropriate dose at each location.

These plants have operations manuals, which are upgraded as necessary to take account of any changes in regulations and any change to operations, to improve factors such as safety as well as changes to dosing protocols.

Figure 4 Puarenga phosphorous locking (P-locking) plant

Plant	Replacement cost	Sum of ODRC*	Sum of AD**
Puarenga	$426,100	$241,650	$24,825
Utuhina	$602,300	$197,040	$42,514
Waitangi Soda Springs	$666,200	$448,620	$27,649
	$1,694,600	**$887,310**	**$94,988**

**ODRC: Optimised depreciated rate of cost; ** AD: Annual Asset depreciation, 30 June 2021 valuation.*

Plant	Scheduled works	Estimate cost(OPEX)	Estimate cost(CAPEX)	Schedule dates
Puarenga	• General repairs and maintenance, coating	$20,000		Annual
	• Tank condition review	$5,000		2025/26
	• Coating		$44,000	2025/26
Utuhina	• General repairs and maintenance, coating	$20,000		Annual
	• Tank condition review	$5,000		2025/26
	• Coating		$30,000	2021/22
	• Computer upgrade		$20,000	2021/22
	• Diffuser replace		$30,000	2021/22
	• New tank		$50,000	2021/22
Waitangi Soda Springs	• General repairs and maintenance,	$30,000		Annual
	• Tank condition review	$5,000		2025/26
	• New diffuser (in lake)		$124,000	2021/22

2.1.4 Nitrogen Reduction Plant and Options – Lake Rotorua

The Nitrogen Reduction Plant is located at State Highway 30, Tikitere. The geothermal flows that originate from the Tikitere Hell's Gate thermal field, are high in nitrogen and discharge into Lake Rotorua via the Waiohewa Stream. After a number of years trialling several different techniques for nitrogen reduction from a small geothermal flow at this location, further analysis of the capital cost of constructing has led to the Council mothballing this option. The decision was based on high capital and operational cost. Other options may be available in time and the Council has a long-term lease on the site. The objective is to review alternative options and assess whether they become feasible at a later date.

The site requires some minor maintenance for security and weather proofing the shed.

Figure 5 Nitrogen Reduction (De-nitrification) plant.

Nitrogen reduction options are now being investigated as an alternative to the Tikitere plant. The main target for action here is the development of constructed wetlands to achieve nitrogen removal.

Asset	Replacement cost	Sum of ODRC*	Sum of AD**
Nitrogen Reduction (Tikitere Zeolite Pilot) plant	$458,000	$6,980	$37,096
Engineering options for Nitrogen removal	NA		

**ODRC: Optimised depreciated rate of cost; ** AD: Annual Asset depreciation, 30 June 2021 valuation.*

Asset	Scheduled works	Estimate cost(CAPEX)	Schedule dates
Nitrogen Reduction (Tikitere Zeolite Pilot) plant	Culvert Access	$30,000	2021/22
Engineering options for Nitrogen removal	Evaluation and design	$196,000	2021/22
	Construction works	$2,099,000	2022/23
	Construction works	$2,048,000	2023/24
	Construction works	$2,000,000	2024/25

2.1.5 Koaro Fish Pass/Trout Barrier

The Koaro Fish Pass is located in the Hamurana Stream on the northern edge of Lake Rotorua. It was built in 2012. The aim of the pass/barrier is to protect local koaro fish from predation by trout. The barrier is designed to allow koaro access to the area while excluding trout. Some work is required to perfect the barrier as trout are occasionally caught in the exclusion area.

The assets that form the fish pass include 3 x base slabs and 2 x wing walls. The asset does not require substantial maintenance, but some redesign may be necessary to improve its ability to block the upstream passage of trout into the exclusion area. Resource Consent 67041 was granted in 2012 for a term of 35 years for the structure.

Figure 6 Koaro Fish Pass, Hamurana Stream

Asset	Replacement cost	Sum of ODRC	Sum of AD
Koaro Fish Pass/Trout Barrier	$31,200	$24,180	$780

**ODRC: Optimised depreciated rate of cost; ** AD: Annual Asset depreciation, 30 June 2021 valuation.*

Asset	Scheduled works	Estimate cost (OPEX)	Schedule dates
Koaro Fish Pass/Trout Barrier	General monitoring and adaptions	$5,000	Annual

2.1.6 Monitoring buoys

The Regional Council has developed a small network of lake monitoring buoys since 2007. These were developed in conjunction with the University of Waikato Chair in Lakes Science. Over the period of about 10 years a network of seven buoys was developed. Through the ongoing development of the buoys, a second generation design changed from fixed sensor nodes to a profiling sensor that is winched up and down through the water column to obtain water quality data at any desired location. This has resulted in an improved design that has the ability to take multi water quality measures at variable locations. These buoys enable Council to collect data for day to day management, as well as for long term detailed research such as lake modelling. The data from the network is also available online to the public.

Through the upgrade of the network to profiling buoys, it was decided that the best solution to ongoing monitoring would be to contract out the management of the monitoring network. As a result of contracting out this service, BOPRC requested an upgrade of all the buoys to the profiling mode and so all the older generation buoys owned by BOPRC have now been replaced with the new profiling buoys and they are owned by the service provider. The service provider maintains

them on BOPRC's behalf and output information is available online to the public. Bay of Plenty Regional Council now only owns two buoys located on Lake Rerewhakaaitu and Lake Okareka. All costs associated with the management and maintenance of the buoys is covered by a contract for service.

Lake	Date deployed	Depth
Rerewhakaaitu	February 2016	13.6 m
Okareka	November 2020	

Asset	Replacement cost	Sum of ODRC*	Sum of AD**
Combined assets	$58,000	$46,500	$3,500

**ODRC: Optimised depreciated rate of cost; ** AD: Annual Asset depreciation, 30 June 2021 valuation.*

2.1.7 Ōkaro Wetland Structures and Storm Interception Bunds

Ōkaro Wetland was developed by the programme to aid in the restoration of Lake Ōkaro. This involved the construction of wetland to intercept catchment flows from the main contributing stream. The wetland is located on private farmland as well as partly on a Rotorua Lakes Council reserve. The structures include inlet control and piping, high flow overflow, flow gauging and high flow bunding at two dams 600m and 860m upstream to help mitigate high flows to minimise the activation of the high flow wetland bypass. All these structures are located on private land but BOPRC is involved in maintaining them in working order.

Asset	Replacement cost	Sum of ODRC*	Sum of AD**
Combined assets	$188,000	$120,520	$4,218

**ODRC: Optimised depreciated rate of cost; ** AD: Annual Asset depreciation, 30 June 2021 valuation.*

Asset	Scheduled works	Estimate cost(OPEX)	Schedule dates
Ōkaro wetland structures and interception bunds	General monitoring	$5,000	Annual

2.1.8 Lake Ōkāreka Outlet

Lake Ōkāreka is a 340 Ha lake with no natural surface outlet. It has a small lake side community with some homes close to the lake shore. In the 1960s the water level of the lake increased to such an extent some lakeside homes were flooded and the community pushed for an outlet to be constructed. The outlet is managed by BOPRC, and it consists of about 5 outlet pipes conveying water from the lake into a constructed canal. Water from the canal then flows down a gravity pipeline and discharges into the Waitangi Stream, a tributary of Lake Tarawera.

In 2017, heavy rainfall events led to extremely high lake levels (the highest since the 1960s) and council installed a temporary pipeline and auxiliary pump to provide additional flow capacity to manage lake levels. These works and additional flows were sanctioned by section 330 of the RMA where "emergency works" is allowed where people or property are at risk.

As a result of this need to address this flood BOPRC has now obtained a 35 year consent for additional flow capacity between Lake Ōkāreka to the Waitangi Stream. The flow capacity consented is now 500L/s and is modelled to enable lake level control up to a 1:100 year rainfall event. This is designed to protect homes in the Ōkāreka community.

The following Figure 7 shows the current configuration of outlet structures and pipeline. The outlet structure, pipeline and Waitangi Stream banks have all recently been upgraded to cater for a maximum flow of 500L/s and prevent stream bank erosion as a result of higher flows. Staff have completed an operational management plan that details lake level operation control, inspection frequency, and maintenance programme. The capital budget associated with these works has been to date about $1.8M. Additional work required is to replace the lake outlet arrangement from the five pipes to a simple weir structure and to upgrade the discharge pipe outlet.

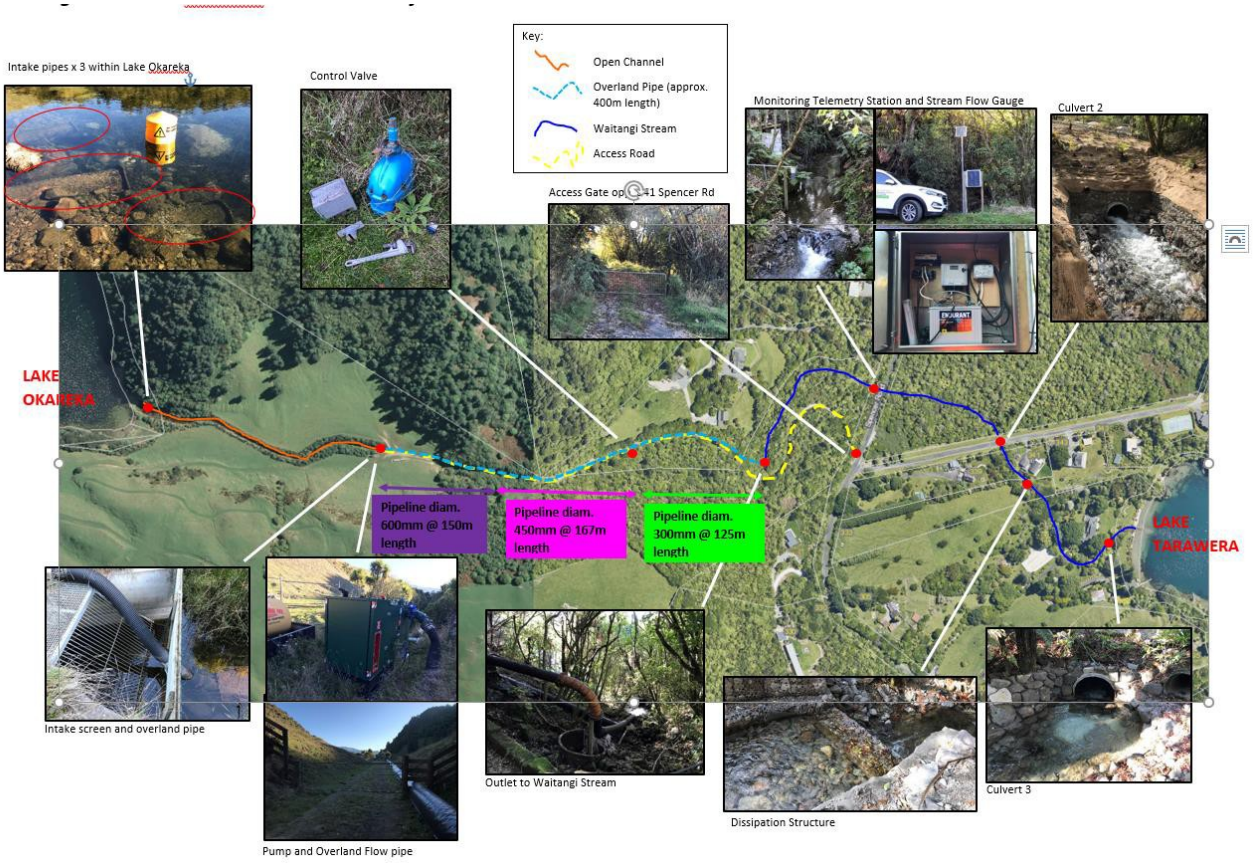

Figure 7 Ōkāreka outlet structures

Asset	Replacement cost	Sum of ODRC*	Sum of AD**
Pipeline and intake	$1,218,800	$869,670	$30,188
Stream protection works	$988,000	$1,021,520	$14,189
Pump	$96,000	$38,400	$9,600

**ODRC: Optimised depreciated rate of cost; ** AD: Annual Asset depreciation, 30 June 2021 valuation.*

Asset	Scheduled works	Estimate cost(OPEX)	Estimate CAPEX)	Schedule dates
Outlet and canal	General maintenance	$5,000		Annual
Pipeline	General maintenance	$2,000		Annual
Stream protection works	General maintenance	$5,000		Annual
Pump	Maintenance	$3,000		Annual
Lake Outlet and Pipeline Outlet	Capital		$65,000	2021/22

2.1.9 Rotomahana Lake Outlet

This is a lake overflow structure built in the 1970s in response to high lake levels. The structure comprises an earth channel leading to a concrete basin and culvert (Figure 8). The structure is important in controlling high lake levels on the Rotomahana isthmus. This is an important structure to ensure management of the lake level, to prevent unnecessary pressure bearing on the isthmus which separates Lake Rotomahana from Lake Tarawera. This is an earth fall formation that fell into place in the 1880 Mount Tarawera eruption. Bay of Plenty Regional Council has a Management Plan for the monitoring and inspection of the structure. These inspections are programmed six monthly as well as being triggered by large rainfall events, large earthquakes and high lake levels. The aim is to identify any evidence of isthmus failure and ensure civil defence is alerted in such an event. The following graph shows the level of Lake Rotomahana since 2011 and the level of the outlet structure is shown by the maximum level of RL 339.400.

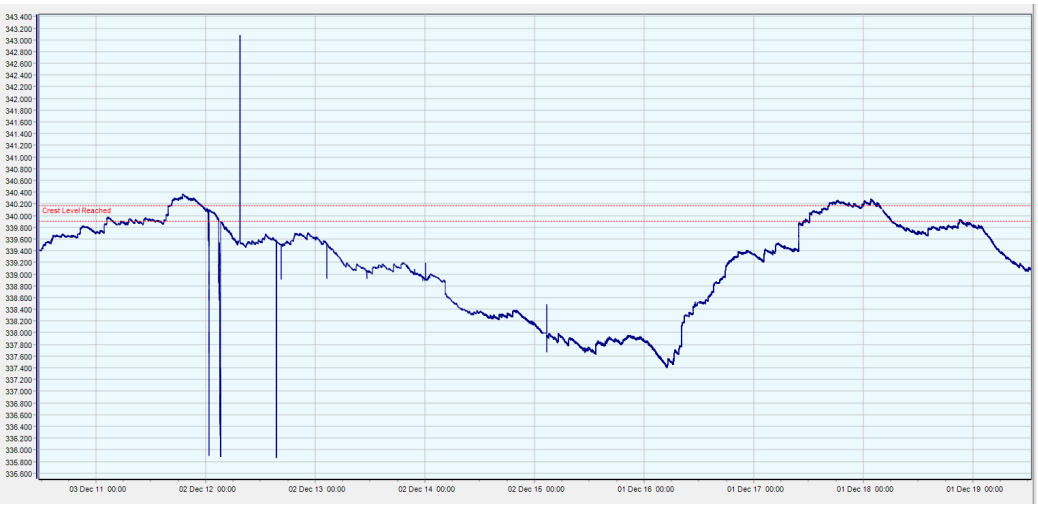

Figure 8 Lake Rotomahana level 2011 to 2020

Asset	Replacement cost	Sum of ODRC*	Sum of AD**
Combined assets	$583,000	$158,250	$8,329

**ODRC: Optimised depreciated rate of cost; ** AD: Annual Asset depreciation, 30 June 2021 valuation.*

Asset	Scheduled works	Estimate cost	Schedule dates
Lake Rotomahana outlet structure	General monitoring and maintenance	$2,000	Annual

Figure 9 Lake Rotomahana outlet control structure

2.1.10 Lake Rerewhakaaitu outlet

Lake Rerewhakaaitu has an outlet drain located at Ash Pit Road. In 2018 the lake level peaked and started to cause flooding of farmland surrounding the lake. Investigations revealed that an outflow control structure had been constructed in the outlet drain to the Mangaharakeke Stream, a tributary of the Rangitāiki River in the 1960s. Responsibility for management of this structure was uncertain and rather than consume additional time trying to understand the ownership of this structure, BOPRC committed to managing the outlet drain. The objective is to keep the drain clear by making regular inspections of the drain, keeping it clear of vegetation occasionally and undertaking excavation of the drain on a regular basis. The drain was cleared by long reach digger in 2019.

Bay of Plenty Regional Council has now developed an outlet management regime that details inspection and maintenance for the outlet. There is no resource consent to manage lake levels. Staff do not see a need to obtain a resource consent as the drain is a modified waterway. Council are not actively managing water levels but ensuring that high lake levels are not exacerbated by keeping the outlet clear. This minimises risks associated with more frequent high rainfall as a result of climate change.

Asset	Replacement cost	Sum of ODRC*	Sum of AD**
Combined assets	$250,000	$67,860	$3,572

**ODRC: Optimised depreciated rate of cost; ** AD: Annual Asset depreciation, 30 June 2021 valuation.*

Asset	Scheduled works	Estimate cost(OPEX)	Schedule dates
Lake Rerewhakaaitu outlet structure	General monitoring Maintenance, long reach digger	$2,000 $10,000	Annual 2022/23

2.2 Overview of issues and risk

The Rotorua Lakes Programme has a unique set of issues to deal with that create community apprehensions and present some potential risk to its ongoing sustainability. The following is a summary of the author's view on many of these issues:

1 The cultural impact of some structures and activities such as alum dosing in our lakes.

2 Concerns around the Ōhau Diversion Wall and alum dosing have already been described in Section 1.2.2. The main concern here is potential and real conflict with iwi values and views. We are often seen as only engaging with iwi when resource consents are required and in between times we just get on with business. Our focus is now to try and develop ongoing relationships around managing these types of structures and operations, which will potentially lead to agreements and contracts which BOPRC will need to pay for, rather than expecting engagement on a "voluntary" basis. Specific agreements will lead to commitment to delivery on both sides.

3 General community expectations are that BOPRC will deliver improved water quality for each lake year on year. There are two issues with respect to this: (a) each lake has a specific Trophic Level Index (TLI) target, they are not all the same and so water quality for each lake will differ, depending upon what is technically feasible and (b) even where some lakes meet their target TLI (say Rotorua at a TLI of 4.2) annual TLIs will vary and algal blooms are possible. This requires some level of communication with the community to understand that lake water quality will continue to vary and that variations in water quality do not indicate programme failure.

4 Our communities now are expecting better access to Council data, especially data from live monitoring sites. Currently data from the monitoring buoys is available online. Keeping access to data provides a useful service for the public, assists in their understanding of lake processes and programme progress and also importantly provides greater trust of Council if we make data accessible. The monitoring bores have not been monitored regularly until 2020. This has led to accusations of lack of transparency and Council drawing conclusions with a lack of data. While the accusations may be incorrect, these perceptions can often only be repaired by providing more transparent monitoring. As a result, the bores are an important part of the BOPRC monitoring programme.

5 The Rotorua Lakes Programme is a high cost investment for the Lake Strategy Group Partners (BOPRC, RLC and TALT, along with MfE investment) of about $240m. As a result, the public are expecting to see a visible improvement in water quality. The programme is based on defining sustainable nutrient inputs to each lake and making these changes through improved land use. The flow on improvements are likely to take many years, even decades, due to the legacy of nutrients in the groundwater as well as nutrients that can recycle from lake sediments. The response to this delay is to invest in short term response projects such as alum dosing and the Ōhau Diversion Wall. Some other interventions while being long term in nature do provide a short response time, such as sewage reticulation of lakeside communities. This is an additional communication issue that requires ongoing attention.

6 Climate Change is an additional issue that has the potential to make reaching water quality targets more challenging, as well as create more frequent lake level issues such as flooding and erosion. The Water Quality Technical Advisory Group (WQTAG) has recently released a Statement on this for Council and public information (see Appendix 3). The potential risk or issue here is that over time nutrient reduction targets may need to be increased as a result.

7 The community and especially landowners' appetite and justification for land use change to improve water quality, is tempered by the water quality they observe in the lakes. If an in-lake intervention is making a big improvement to water quality, this may be counterproductive to our need for long term land use change. A community understanding of the science around short

term interventions as well as the long term land use change is important. The success of alum dosing in Lake Rotorua could lead to this view.

Part 3:
Growth and demand

The Rotorua Lakes Programme is not providing a specific service to customers, it is more providing a wider environmental service. It does connect with the community, specifically iwi because of their special relationship with the lakes and their ownership, specific lake communities who associate with their local lake, as well as other groups with a particular interest in lake water quality and health. It is likely that with time, community expectations to providing good water quality will continue to increase, partly to do with increasing environmental understanding, as well as population growth and development that has led to a decline in environmental health in the past.

3 Overview of drivers

- Regulatory and policy. The BOPRC is responsible for implementation of the RMA to protect water quality and quantity. More recently the release of the NPS-FM has put more requirements on councils to set water quality targets and formulate action plans, to make sure waterways meet minimum standards set by the community. Bay of Plenty Regional Council has been proactive in this area as it has developed policy and set standards of water quality in the Natural Resource Plan (NRP) and has developed action plans for a number of the lakes – see Appendix 1.
- Land use changes. The Rotorua Lakes Programme has relied on policy in the NRP to address land use changes in five of the 12 lake catchments. For these lakes, not only has this stopped land use intensification but it has also led to agreements to reduce land use impacts that support the improvement of water quality for the lakes. The NPS-FM will force the Council to review current policy as well as develop more “action focused “policy for the seven remaining lakes.
- Climate Change has been discussed in Section 2.3. It will be an exacerbating effect on meeting water quality goals as well as having potential to impact lake levels and erosion effects. Climate Change is now a normal part of thinking in the Rotorua Lakes Programme when new projects are being developed, to ensure problems are anticipated and mitigated, if possible, at an early stage.
- The Lakes Programme is highly reliant on new technology and developments. We have strong relationships with University of Waikato (UoW) and fund a Lakes Chair Position. Our other ongoing contacts include a range of science advisors to provide specialist advice. Many of our in-lake interventions have been world leading and New Zealand first applications. This does bring some risk of failure but also has provided major advances such as in-lake monitoring buoys, alum dosing to improve water quality and remote sensing of water quality. It can also bring offers of “untested” interventions which require resource to review and can lead to public perceptions that a “magic bullet “solution is available.
- The programme is ultimately based on sustainable land use in the lake catchments. The in- lake interventions are generally shorter term and so they are assessed against their efficacy, and minimising environmental impacts is part of their assessment before gaining Council support. Often these interventions require resource consent and so they are required to meet the environmental bottom lines set by the RMA and Council policy.

3.1 Impact of and potential risks

The following section brings together the risk level expected as a result of the various issues and sets out the mitigation options.

Issue	Impact	Risk	Mitigation option
Negative connotations of dosing alum into our lakes, iwi and some community.	Could lead to shorter consents and possibly non-approval at consent stage.	Moderate	Continue to undertake impact studies, include taonga species, and include iwi in monitoring programme.
Alum dosing may be seen by some of the community as fixing problem.	Reduce motivation for land use change.	Low	Make sure science for lake decline is available to public and especially landowners, support landowners in BMP and reduce impacts.
Ōhau Wall is seen as negative to iwi in the local area and downstream on Kaituna.	Negativity towards the wall operation and works.	Low	Long term consent achieved, continue to undertake effects monitoring and engage with iwi on effects and possible mitigation.
Community expectations that restoration work will prevent any algal blooms and this will occur immediately.	Complaints when blooms do occur and question the lakes programme spending when blooms occur.	Medium	Continue research around the reason for lake blooms and keep the public informed via media and good one to one response, and working with interested groups.
Access to Council information and data e.g. reports and monitoring.	If information and data is not available, people will draw their own conclusions which may be unhelpful, and lack of transparency.	High	Make live monitoring data available from monitoring buoys and lake level on the Council website. Additional reports are made available on the Council and programme website.
Some restoration actions such as land use change take many years to have a positive impact due to groundwater lags.	The landowners and public may see this as a failure if positive outcomes are not realised quickly.	High	Undertake a number of interventions in parallel with the sustainable land use change that have a more rapid response time, such as alum dosing, the diversion wall and sewage reticulation.
Climate Change is predicted to make meeting lake targets more challenging and may require more work to reduce nutrients.	It may involve going back to landowners in future for additional changes, which may be seen as negative.	High	Release WQTAG statement on Climate Change to make sure community aware of issues. Where the impact has been evaluated, ensure that this is included in future decisions such as flooding at Lake Ōkāreka.
Alum may be needed for longer than initially projected.	There might be difficulty renewing consent in the next 10 years, and loss of confidence in programme.	Medium	Continue research and monitoring around the restoration progress and predictions of recovery.
Ōhau Wall may be required for longer than 50 years.	The wall has corrosion issues and this will add cost keeping it serviceable for longer.	High	Continue to undertake programmed maintenance and regular inspections to ascertain condition and need for upgrades.

Issue	Impact	Risk	Mitigation option
Increased pressure on water courses leading to lakes, e.g. Waitangi Stream due to climate change storm frequency.	More budget may be needed to maintain water courses and minimise erosion.	High	Maintain inspections and monitoring on streams where we actively control flows to ensure we are predicting maintenance needs early.
Changes in legislation and policy that lead to increased need to improve water quality.	May lead to more stringent TLI or water quality standard. More effort and money required to meet the new needs.	High	Consider options in restoration that may over reach targets if cost is marginal.

3.2 Non-asset demand management options

The Rotorua Lakes Programme has always had some investment in this area (non-asset demand). This is basically engaging with the community, with a focus on engaging the “right” local community groups and iwi. There is always opportunity for improvement and thinking about new ways of getting better engagement. For example, we are starting to work with specific iwi groups around using their monitoring to provide impact assessment of parameters that are meaningful to them.

There is also some desire for other community members or groups to undertake monitoring. The advantage of this is that these people and groups then become more engaged, more knowledgeable and can contribute their knowledge and experience to programme knowledge and decisions.

An issue that needs to be considered here is how do we make this work ongoing so that we get good long-term data sets and long-term engagement with enthusiastic people? These people generally need some form of resourcing to ensure they can afford to do the work, which may be monitoring some aspect as well as possibly passing information on to other people. Their information/data needs to be collected by Council or other body to ensure the long-term data is not lost. We have a working example of this with a member of the Lake Tarawera community, where BOPRC pays for their travel costs in monitoring while UoW collects and stores the long term data, which now forms a long term data set used in assessing water quality changes.

More traditional means of engaging with the community around the lakes programme are also prioritised. Communications are managed by various press releases and via the dedicated Rotorua Lakes Programme website. The programme is responsible for the publication of a multitude of science and monitoring reports. These reports are made available to the public via the website. In addition, BOPRC works with the UoW to hold regular science presentations from experts and students on lake research and restoration. Public attendance at these meetings is high.

Some of the challenge in keeping a high public profile with these methods is the effort required to keep the website up to date and relevant. It is important that resourcing and commitment to reviewing the website is a Council priority.

Part 4:
Levels of Service

4 Customers and stakeholders

4.1 Who are our customers and stakeholders?

For the Rotorua Lake Operations Team, our customers are more the public and specific interested groups. Sometimes individuals can be our customers, and stakeholders where lake water quality is impacting on their part of the environment, say if flooding is having a more localised impact or an area of weed growth is impacting their lake access for example.

Our level of service is therefore more general and focused on serving the community needs. Unfortunately our work outcome is heavily influenced by environmental factors that we have no influence on, so in making Levels of Service (LOS) targets we need to be mindful that the outcomes may not be achieved at times, simply due to prevailing weather conditions or ongoing Climate Change. The following table is a listing of key LOS targets that we think we can make an operational difference to and explain why we may not have met the desired LOS if there is a failure.

Asset	Customer/Stakeholders	Values/Expectations	LOS
Lake Ōkāreka level management	Ōkāreka community	Protect homes from flooding, keep lake in operational range, and avoid low levels.	Keep lake in operational range 80%, Prevent homes flooding 100%, Avoid low levels 90%.
Waitangi Stream management	Iwi and other landowners	Minimise erosion, undertake regular inspections, repair identified damage.	Undertake inspections according to LMP frequency 100%. All erosion addressed within 2 months of identifying.
Alum dosing plants	Iwi and community	Maintain plant operation to avoid algal blooms.	Maintain in-lake P levels within protocol targets 70% time.
Ōhau Diversion Wall	Iwi and community	Operation and maintenance of wall to protect Lake Rotoiti.	Undertake 100% of programmed inspections on time. Budget for any necessary repairs in annual plan or long term plan as necessary.

Part 5:
How we manage what we have?

5 Capital planning

This has been a minor part of our plan due to the nature of the programme. Our capital projects to date have been short term interventions to provide an improvement in water quality until catchment land use changes take effect. There are no capital projects in here for the foreseeable future. The main areas of investigation are the Council commitment to reducing 50 t nitrogen from

Lake Rotorua by engineering means. A key project to contribute to the 50 t nitrogen reduction was the Tikitere nitrogen removal. However, this project got shelved as it became too expensive and there was ongoing high risk using a new technology.

Further investigations are progressing into the use of wetlands for nitrogen removal and there are also other options for nitrogen removal at Tikitere. As these projects are reviewed, capital needs will be identified and then included in future Long-Term Plans (LTPs).

5.1 Renewals project planning

The Operations Projects in the Rotorua Lakes Programme are generally short-term projects where they support improvements in water quality. As a result, our initial expectations are they will not require renewal, other than ongoing maintenance until the operation ceases. This is applicable to the Ōhau Diversion Wall and the alum dosing plants. Annual maintenance is planned and budgeted in this AMP.

As outlined in the Impact and Potential Risks Section 3.2, there is a possibility that these assets may be required for longer than initially programmed. At this stage, this is not clear and will only become evident with time as we better understand the impact and timing of land use change on lake water quality.

5.2 Business continuity

The main events that can impact the lake operations projects are climate events that bring either additional rainfall or periods of dry weather. Lake operations are responsible for managing lake level on Lake Ōkāreka and also for managing the outlet levels on Rerewhakaaitu and Rotomahana.

Operational resilience has been catered for on Lake Ōkāreka by modelling potential lake levels as a result of climate change through to 2090, obtaining long term consent to enable the outlet flows to be managed and upgrading the outlet pipeline and stream erosion protection.

The outlet levels on Rerewhakaaitu and Rotomahana are managed more passively where Council undertakes regular inspections of the lake level and outlets to ensure during potential high lake levels the outflows are not obstructed and avoid any potential erosion failure.

Alum dosing plants can be affected by faults at time. For safety reasons they are programmed to shut down automatically and alarm operator who can programme inspection and fault response. These assets are not hour critical and as long as they are inspected, and any fault resolved within two or three days then the impact of a short-term shutdown will not be reflected in water quality decline.

Bulk alum is delivered by IXOM, and they have direct access to our storage data so that they can programme deliveries in advance of tanks getting to critical low points.

5.3 Emergency management

Rerewhakaaitu water level management requires Lake Operations staff to undertake regular programmed inspections of the lake outlet and channel down to Lake Tarawera. This is to ensure that there is no apparent failure of the outlet or natural channel.

Operations staff are aware of the requirement to pass any critical information on to the Regional Council Engineer if any problem is identified. A full management plan on the details of inspection and reporting process is available.

During high rainfall events operations staff will be called upon to ensure Lake Ōkāreka is managed in advance of reaching critical levels to protect property surrounding the lake. A management plan is available for guidance and outlet structures have been recently upgraded to ensure 1:100 year event is catered for.

Part 6:
Financial planning

6 Financial plans

Rotorua Lakes financial estimates 2021 – 2031 (uninflated)

UNINFLATED	2021/22 $000	2022/23 $000	2023/24 $000	2024/25 $000	2025/26 $000	2026/27 $000	2027/28 $000	2028/29 $000	2029/30 $000	2030/31 $000
Operating revenue										
Targeted rates	3,335	3,499	3,620	3,857	3,848	3,927	3,910	3,727	3,712	3,688
General funding	3,248	3,186	3,308	3,616	3,644	3,750	3,834	3,823	3,911	3,975
Operating grants and subsidies	2,167	1,873	1,850	2,859	2,859	3,214	150	150	150	150
Total operating revenue	**8,750**	**8,559**	**8,778**	**10,331**	**10,351**	**10,891**	**7,894**	**7,701**	**7,773**	**7,813**
Operating expenditure										
Other Operating Costs	10,183	7,814	7,787	10,016	9,801	10,509	4,380	4,377	4,376	4,335
Finance costs	359	425	453	497	516	542	504	469	438	407
Depreciation and amortisation	959	984	1,025	1,044	985	986	876	330	330	330
Sub total expenditure	**11,501**	**9,224**	**9,265**	**11,556**	**11,302**	**12,037**	**5,760**	**5,177**	**5,145**	**5,072**
Overhead and corporate charges										
Corporate Costs	1,003	1,027	1,062	1,060	1,076	1,100	1,079	1,083	1,083	1,087
Total expenditure	**12,505**	**10,251**	**10,328**	**12,616**	**12,379**	**13,137**	**6,839**	**6,260**	**6,228**	**6,159**
Net deficit (surplus) to fund	**3,755**	**1,691**	**1,550**	**2,285**	**2,027**	**2,246**	**(1,055)**	**(1,441)**	**(1,545)**	**(1,654)**
Funding required										
(Increase) / decrease in reserves	3,755	1,691	1,550	2,285	2,027	2,246	(1,055)	(1,441)	(1,545)	(1,654)
Total operating funding	**3,755**	**1,691**	**1,550**	**2,285**	**2,027**	**2,246**	**(1,055)**	**(1,441)**	**(1,545)**	**(1,654)**
Capital										
Lake Okareka Pipeline Upgrade	65	-	-	-	-	-	-	-	-	-
Engineering Solution	196	2,099	2,048	2,000	-	-	-	-	-	-
Phosphorus Locking (P Locking) Plant	254	-	-	-	44	-	-	-	-	-
Total capital expenditure	**515**	**2,099**	**2,048**	**2,000**	**44**	**-**	**-**	**-**	**-**	**-**
Capital funding										
Grants, subsidies and insurance revenue	98	1,050	1,050	1,100	-	-	-	-	-	-
Increase in debt	417	1,050	999	900	44	-	-	-	-	-
Total capital funding applied	**515**	**2,099**	**2,048**	**2,000**	**44**	**-**	**-**	**-**	**-**	**-**

Part 7: Assumptions

7 Overview

Statutory financial reporting requires Bay of Plenty Regional Council to revalue its fixed assets at least every five years. Bay of Plenty Regional Council undertakes to value the Rotorua Lakes Programme assets every three years. An asset valuation is to be used for asset management (calculating long-term asset renewal projections, where projects are on-going), identifying loss of service potential (depreciation), and for financial reporting purposes.

New Zealand International Financial Reporting Standard (NZIAS16) applies to all lake operations infrastructure assets considered in the scope of this valuation for the general purpose of financial reports.

All infrastructure assets valued have been done so in accordance with the methodology prescribed in the New Zealand Infrastructure Asset Valuation and Depreciation Guidelines 2006.

The last valuation was undertaken for Bay of Plenty Regional Council on 30 June 2018. The asset will be revalued before 30 June 2021 and builds on valuations undertaken previously.

7.1 Data and input assumptions

This AMP has been prepared based on the following assumptions:

- Currently available information,
- Condition assessments completed to date,
- Existing levels of service,
- Financial forecasts completed for 10 years.

7.2 Financial forecasting assumptions

The following lake operations asset management assumptions have been made in preparing the 10-year expenditure forecasts:

- Asset information is as complete as possible at 30 June 2021. This is based on the valuation data and report compiled by the Lake Operations Team.
- Only lake operations assets have been valued.
- The determination of asset replacement value, depreciated value, and renewal projections are based on the valuation and condition assessment data as at 30 June 2021.
- All projected expenditure is stated in dollar values as at 30 June 2021, with no allowance made for inflation.
- Operational costs are based on historical expenditure, asset maintenance requirements and assessed costs.
- Maintenance and operations allocations are largely based on maintaining current service levels.
- The depreciation has been calculated on a straight-line basis.
- Council staff have developed the AMP. Formal consultation was undertaken during the LTP process.
- It is assumed that regulations relating to lake operations will remain essentially the same over the planning period (i.e. 10 years to June 2031).

Part 8:
Audit and improvement

8 Our approach to this

The Lake Operations approach is to maintain all authorisations for its core activity in one place. These are recorded in Appendix 2 of this AMP. Each authorisation is supported by operational management plans that show how statutory conditions will be achieved and monitored as well as addressing other non-statutory requirements necessary to ensure appropriate management of each asset and maintain necessary data for decision-making and operations.

8.1 Improvement plan

The focus of operational staff falls into four areas:

1 Ensure compliance with statutory consents and be able to demonstrate compliance if audited (this includes maintenance of necessary spread sheets and data bases for data collection),

2 Ensure data is collected that can be analysed and utilised to make informed decisions on operation of lake water quality interventions, such as alum dosing rates to each lake,

3 Aim to optimise operation of all assets to achieve where possible maintenance of RMA Natural Resource Plan water quality targets as TLI,

4 Ensure assets are maintained to a good standard so that breakdowns or faults are avoided.

Appendices

Appendix 1:

List of action plans completed pursuant to Natural Resource Plan

Lake Ōkāreka Catchment Management Action Plan 2004 Lake Ōkaro Action Plan 2006

Lake Rotoehu Action Plan 2007 Lake Rotomā Action Plan 2009

Draft Lake Rotorua and Rotoiti Action Plan 2009 Lake Tikitapu Action Plan 2011

Lake Ōkataina Action Plan 2013

Rerewhakaaitu Catchment Plan 2013 (Completed by Rerewhakaaitu Farmers)

Tarawera Lakes Restoration Plan 2015

Appendix 2

Management plans and resource consents associated with each structure

Each document listed in this appendix is link electronically to a BOPRC file showing the location of each document.

Ōhau wall:

Resource Consent RM16-0527

Structural Management Plan

Ohau Channel Diversion Wall Structural Maintenance Requirements

Alum dosing Plants:

Resource consent Utuhina 65321

Operations and Maintenance Manual Utuhina

Resource Consent Puarenga 65559

Operations and Maintenance Manual Puarenga

Resource Consent Rotoehu 65966

Operations and Maintenance Manual Rotoehu

Trout Barrier:

Resource Consent 67041

Monitoring Buoy:

Contract and specifications for service

***Ōkaro wetland Structures*:**

Resource Consent 62891

Management Plans (In preparation)

Rotomahana Outlet:

Resource Consent 20105

Lake Rotomahana Dam Monitoring Procedure

Rerewhakaaitu Outlet:

Lake Rerewhakaaitu Outlet Inspection and Maintenance Regime

Appendix 3

Statement on climate change, lakes and water resources, Rotorua region – May 2020

Water Quality Technical Advisory Group (Rotorua Lakes)

Statement on climate change, lakes and water resources, Rotorua region May 2020.

1. Increases in concentrations of atmospheric carbon dioxide (CO_2) attributable to human activities are almost certainly responsible for increases in temperature from global climate change. The future climate will manifest as rising air temperature and alterations in the timing and distribution of rainfall.

2. Climate models provide the best quantitative tools to predict the extent of climate warming. Air temperature, averaged across a range of models and for seven locations across New Zealand, is projected to increase by 0.7 to 3.7°C by 2110. The variation represents model outputs from four different CO_2 emission pathways.[1]

3. Rotorua is in a region of moderate rainfall, with climate change projections indicating small increases in annual rainfall intensity based on dry regions of New Zealand becoming drier and wet regions becoming wetter. Seasonality of rainfall is expected to change, reinforcing wet seasons (winter-spring) and dry seasons (summer-autumn), and there will be increased frequency of extreme (e.g., 1-in-100 year return period) rainfall events. The frequency of large-scale climate oscillations like the El Niño-Southern Oscillation (ENSO) may be altered by climate warming.

4. Floods in the Bay of Plenty Region may be most damaging when short-term (hour-to-day) extreme rainfall events are interspersed within periods of more prolonged rainfall leading to saturated soil conditions. These events occur in a setting of different phases of the Interdecadal Pacific Oscillation (IPO) and ENSO. For example, coincidence of the La Niña phase of the ESNO, a negative phase of the IPO, and cyclones could lead to extreme storms.

5. Adaptation to climate change requires a *knowledge-to-action* approach that ensures anticipatory implementation of plans and policies that protect natural capital, infrastructure and assets, as well as human life. Government, NGOs and businesses will need to proactively engage with the community, build shared understanding of issues and the need for action, and allocate resources according to identified risks and the range of possible scenarios.

6. Increased flooding risk is one of the most important potential outcomes of climate change. It may compromise flood stopbanks, inundate built infrastructure around lakes and rivers, and cause agricultural economic losses. Washouts have the potential to destroy restoration actions related to establishment and protection of riparian areas, wetlands and detention bunds. Avoiding such occurrences requires strong alignment of preventative actions amongst property owners, businesses, and local and regional government.

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[1] Scenarios are based on the Intergovernmental Panel on Climate Change Fifth Assessment report. Future climate projections across several different models and for seven stations in New Zealand span a wide range of air temperature increases of 0.3–5.0 °C by 2110 compared with a baseline period of 1995. This variation corresponds to outputs using different representative concentration pathways of CO_2 from several different models. See: https://ccii.org.nz/.

7. Flood mitigation actions may include: optimising grass cover in pastoral systems; establishing well-designed networks of detention bunds and wetlands; provision of forest cover to mitigate rainfall whilst being vigilant with forest harvesting methods and timing; good land use and floodplain management plans including avoiding placement of infrastructure in flood-prone areas; and adoption of green infrastructure (e.g., vegetated swales and stormwater ponds) in preference to hard surfaces. Some of these actions may also be beneficial for water storage provision during drought.

8. Heavy rainfall and associated runoff increase sediment erosion and losses of particulate phosphorus. Their effect on nitrogen delivery is more variable but increased losses are also expected. Complicating factors include: how additional atmospheric CO_2 stimulates plant production and nutrient uptake; increased plant growth and microbial degradation rates from rises in temperature; and interactions of temperature with dissolved organic carbon delivery.

9. The effects of climate change on lake ecosystems may be profound due to increased water temperature and vertical stratification. Shallow polymictic lakes (Rotorua, Rotoehu and Rerewhakaaitu) are most vulnerable because a warmer climate will increase the frequency and duration of intermittent stratification events, which will increase the probability of bottom-water anoxia, nutrient releases from bottom sediments and availability of these nutrients to enhance algal growth upon re-mixing. The deeper monomictic lakes will have longer periods of seasonal stratification, which will also increase the risk of bottom-water anoxia (e.g., Lake Tarawera) or extend the duration of anoxia (e.g., Lake Rotoiti). There is a small probability that some deep lakes may not mix at all in winter, as noted in Lake Taupō in particularly warm winters.

10. Cyanobacteria (blue-green algae) have a number of physiological adaptations that provide them with a competitive advantage over other phytoplankton in a warming climate. For a given nutrient concentration it is likely that there will be increased incidence of blooms and toxin production by cyanobacteria. There are likely to be other 'winners' and 'losers' amongst the flora and fauna of aquatic systems under climate change. Several noxious alien invasive species (catfish, certain weed species, mosquito fish) are native to sub-tropical and tropical regions, and risks of their spread and growth are more likely in a warming climate. Increased surveillance, control and eradication efforts are likely to be necessary for these freshwater invaders. Conversely, habitat of trout, a 'cold-water' fish, may be diminished.

11. The Trophic Level Index (TLI) is used as the primary indicator of water quality for the Rotorua lakes and is linked to Lake Action Plans[2]. Based on model simulations for some lakes, TLI values can be expected to increase by approximately 0.2 units by 2090, more so in polymictic lakes. The Technical Advisory Group recommends a forward-looking approach to adopt emerging science and best-practice frameworks so that nutrient loads are proactively managed as an anticipatory action to ensure that TLI targets are met in the future.

[2] Bay of Plenty Regional Water and Land Plan (2014). Amended as required by National Policy Statement for Freshwater Management 2014.