ROTORUA TE ARAWA LAKES PROGRAMME

Science Plan 2015

Proud Partners

DESTINATION ROTORUA ROTORUA DISTRICT COUNCIL

Bay of Plenty REGIONAL COUNCIL

TE ARAWA LAKES TRUST

Document Control

Document Information

Document Name:	Science Plan – Rotorua Lakes Protection and Restoration Programme
Contact Person:	Andy Bruere and Marcus Bloor
Status:	Draft

Document Review

Review Timeframe:	This document will be reviewed and updated annually. Key changes will be noted and highlighted for the approvers. This will only go through formal approval on an annual basis – using the May update.
Reviewers and Contribution Acknowledgement :	WQTAG team and Science Workshop Attendees

Document History

Author	Description of Change	Date	Version
Andy Bruere			
Gloria Zamora			
Paula Johnston	Updated into Programme Template	17/12/13	0.1
Gloria Zamora / Andy Bruere	Additional changes to Plan	28/02/14	
Paula Johnston	Update to Graphs and formatting	04/04/14	0.2
Gloria Zamora / Andy Bruere	Additional changes to Plan	08/04/14	0.3
Marcus Bloor	Update relating to LandTAG establishment and land science priorities	08/07/2015	0.4

Distribution Control

Person	Role	Date of Issue	Version
Paula Johnston	Programme Co-ordinator	17/12/13	V0.1
Paula Johnston	Programme Co-ordinator	02/05/14	V0.2

This approved document will be distributed to the Workstream Leads and Partnership Steering Group.

Table of Contents

1. Introduction and Background

The Rotorua Te Arawa Lakes Programme (RTALP) is a $230M programme of protection and restoration for twelve lakes in the Rotorua District. The programme was initiated in 2000 with the development of the Strategy for the lakes of the Rotorua District. The priorities to date have been the most degraded lakes: Ōkaro, Rotoehu, Rotorua, and Ōkāreka. The focus is now gradually moving to other less degraded lakes; the impact of land use change and defining the science behind some of our successes such as alum dosing.

Science monitoring initially commenced in the early 1960s particularly for lakes Rotorua and Rotoiti, as water quality deterioration was recognised at that time by the community for Lake Rotorua. Since the 1960's, a significant science effort has been undertaken to monitor the quality of the twelve lakes in the district. A step change in water quality for many of the lakes in the 1990 prompted more regular monitoring. The Bay of Plenty Regional Council (BOPRC) has been undertaking intensive monitoring of lakes since 1990 under the regional Natural Environment Regional Monitoring Network (NERMN) Programme.

In 2000, the S*trategy for the Lakes of the Rotorua District* was initiated by BOPRC, Rotorua District Council (RDC), and the Te Arawa Māori Trust Board, as a response to the decline in water quality of many of the lakes. It initiated a programme of coordination and co-operation between the three parties and this is acknowledged in the Te Arawa Lakes Settlement Act (2006). The strategy was reviewed in 2013 with the input of the community, iwi members, and stakeholders. Soon after the development of the 2000 strategy, it was recognised that the Rotorua Te Arawa Lakes Programme (RTALP) would benefit from a focused research effort and an agreement to fund a Chair in Lakes Management and Restoration at the University of Waikato, was signed in 2002. The success of this agreement has resulted in the continuation for a further five (5) year period in 2007, and again in 2012.

A number of other science providers are engaged in the programme, including scientists from BOPRC, Crown Research Institutes and various independent consultants. These providers form the Water Quality Technical Advisory Group (WQTAG), which convenes 3 - 4 times per year to provide science advice, critique, and direction for the programme. Details on this group are provided in section 5, Science Groups. It is of value to note that some of the scientists involved have been associated with the research and advice on the Rotorua lakes since the 1980s and so there is a valuable source of knowledge and continuity since that time.

Although the strategy for the lakes of the Rotorua district was initiated in 2000 in response to declining water quality, the quality of the lakes ranges from very high quality (oligotrophic) to somewhat degraded eutrophic and super-trophic lakes. The objectives of the strategy were not only to improve water quality in degraded lakes but also to halt the decline of those still in a good state. The vision of the strategy is the following:

> ***"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."***

The vision is an important focus of the science plan. It is considerably more encompassing than simply addressing the quality concerns. It is also of merit to note that various parts of the groups within our community identify different values for the lakes. Initially the focus of the science work has been on the water quality; however, in recognition of these other values, the science focus is widening, to include a larger range of science, monitoring, research, and advice.

The science work now encompasses:

- Lakes water quality, monitoring and restoration
- Ecological monitoring and restoration
- Land use monitoring and restoration

- Water and land modelling and interventions for improvement
- Development of cultural health framework and associated indicators

The quality of the science effort is well demonstrated with results that have been spectacular for the programme. Water quality targets have been defined by the community and reside in the Regional Water and Land Plan. These targets refer to the lakes Trophic Level Index (TLI). The TLI was developed by NIWA as a robust tool that is used on the lakes and is a single number representing water quality in each lake, derived from four water quality parameters: water clarity, chlorophyll-α, total nitrogen and total phosphorus. The use of a single annual indicator number assists in portraying lake restoration progress in a community friendly average. Over the last three years a number of lakes have reached their TLI target, although there is some "noise" in the annual result until they stabilise.

The science needs and resources are managed by setting priority lakes and projects. As lake restoration has achieved success, attention has moved to the next set of lakes while still protecting the gains made.

2. Science Plan Objective

The objectives of the science plan are:

- To provide science directions for monitoring, research, and advice for the programme for the next 12 months to 5 years;
- To provide an opportunity for team members to identify science gaps within the programme and help set the science direction for the plan; and
- To provide a transparent and visible science plan for the RTALP partners and public, so that science direction and priorities are understood
- To provide science that is a foundation for clear lake restoration and protective action, monitor the progress and identify where action and science needs to adapt in response to the results observed.
- To provide science that will underpin policy and plans required to manage lake catchments sustainably in line with community objectives. The community objectives are for each lake are set as TLIs in the Regional Water and Land Plan.

It should be recognised that although a formal science plan had not been written previously, the science has been most recently directed by the WQTAG and relationship with the University of Waikato (UoW). This has provided a good foundation for the restoration work that has already taken place.

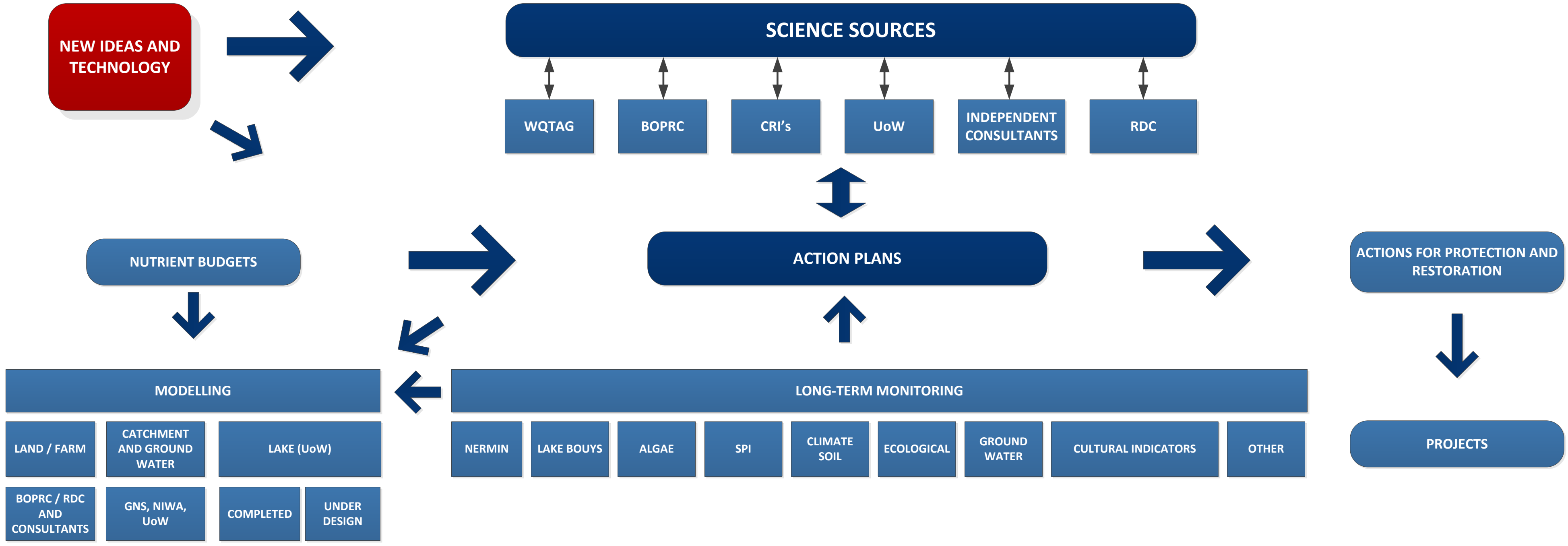
3. Science Structure

Science input is a vital component of the RTALP. It sets the foundation for restoration and management actions by providing monitoring information and advice on potential impacts: including lake and catchment modelling. This advice in turn, helps inform potential solutions and risks and inform planning of lake and catchment parameters pertinent to development of responsive framework, policies, rules and incentives for lake management.

Initially, the programme focused on interventions that would provide rapid improvement in water quality. In some cases, these have been short-term interventions such as the Ōhau Diversion Wall, alum dosing, and weed harvesting. Some longer-term interventions have also been applied, such as sewage reticulation and treatment. It has always been intended to implement long-term sustainable interventions, such as matching catchment land use with sustainable lake loads. Science advice is needed to support these decisions. The restoration effort has generally focused on undertaking actions on the lakes with poorer water quality, leaving the protection work on the better lakes until later. Consequently, as each lake improves, the focus of actions is transitioning from generally short-term interventions to longer-term interventions, such as catchment land use. As a result, there is an increasing demand for land-use science advice for planning decisions as well as for identification of restoration actions. This change in focus is reflected in the science plan, but it must be recognised that the water/lake science underpinning the programme will not be weakened because of an additional element of the science focus.

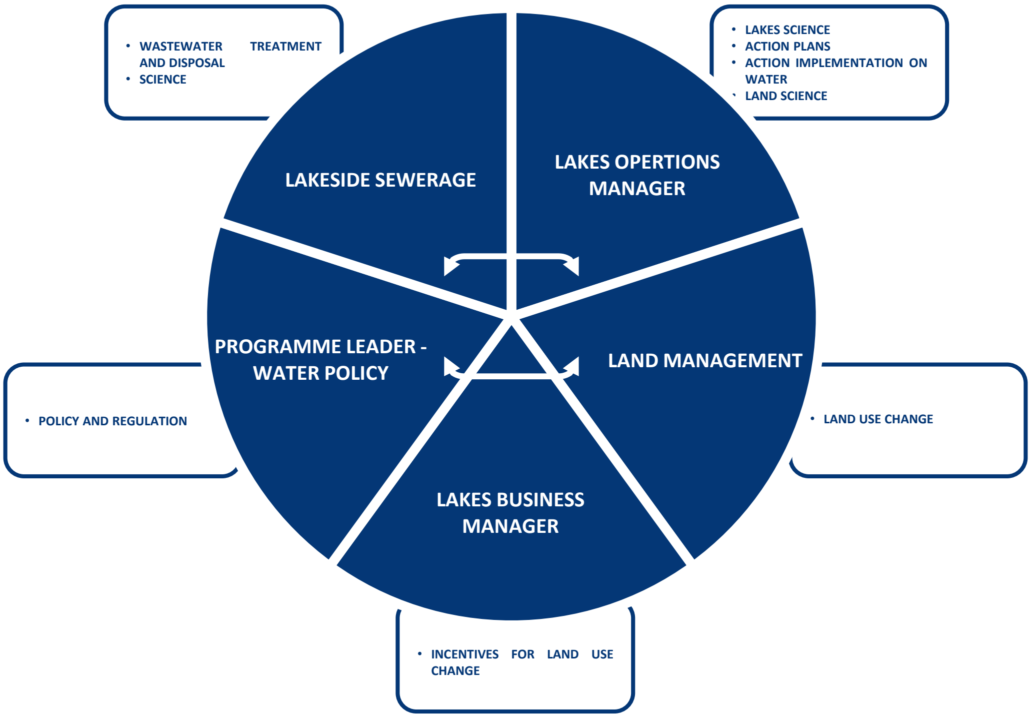
The structure of the science programme is not particularly complicated, but it does have a number of elements working together at any one time that makes precise definition more difficult. In addition, due to the new and innovative approach of the programme, the structure needs flexibility to allow science innovation and application down new paths as they emerge. The science programme for the lakes is the responsibility of the Lakes Operations Manager.

Diagram 1 – Programme Science Structure



The Programme Science Structure diagram is centred on the Action Plans (Diagram 1 – Programme Science Structure). This is a clear signal that the science effort is aimed at actions to restore lakes.

Diagram 2 – Programme Workstream Leads and the Relationship with Science



Generally, our RTALP science advisors initiate lake research opportunities and interventions for in-stream and in-lake restoration in response to BOPRC, the public and the research community. They provide comment commonly through the TAGs. This is then communicated to the RTALP via the Action Plan process where the science advisors and managers advise the community and Rotorua Te Arawa Lakes Strategy Group (RTALSG) about the benefits and disadvantages of a specific intervention or research opportunity. These can then be included in actions in the action plan process and implemented through that process.

The agreement with the UoW enables high level thinking on potential projects and the outcomes to date have been highly successful in closing the gaps in water science. It is recognised that:

Lake hydrology and ecological models will be progressively set up for each lake

Catchment nutrient budgets will be prepared as required for each action plan or review process

Monitoring and research will accompany lake intervention and the outcomes will be discussed at regular TAG meetings

New ideas for research, monitoring, restoration are brought to WQTAG for discussion and decisions are made as to any further action.[1]

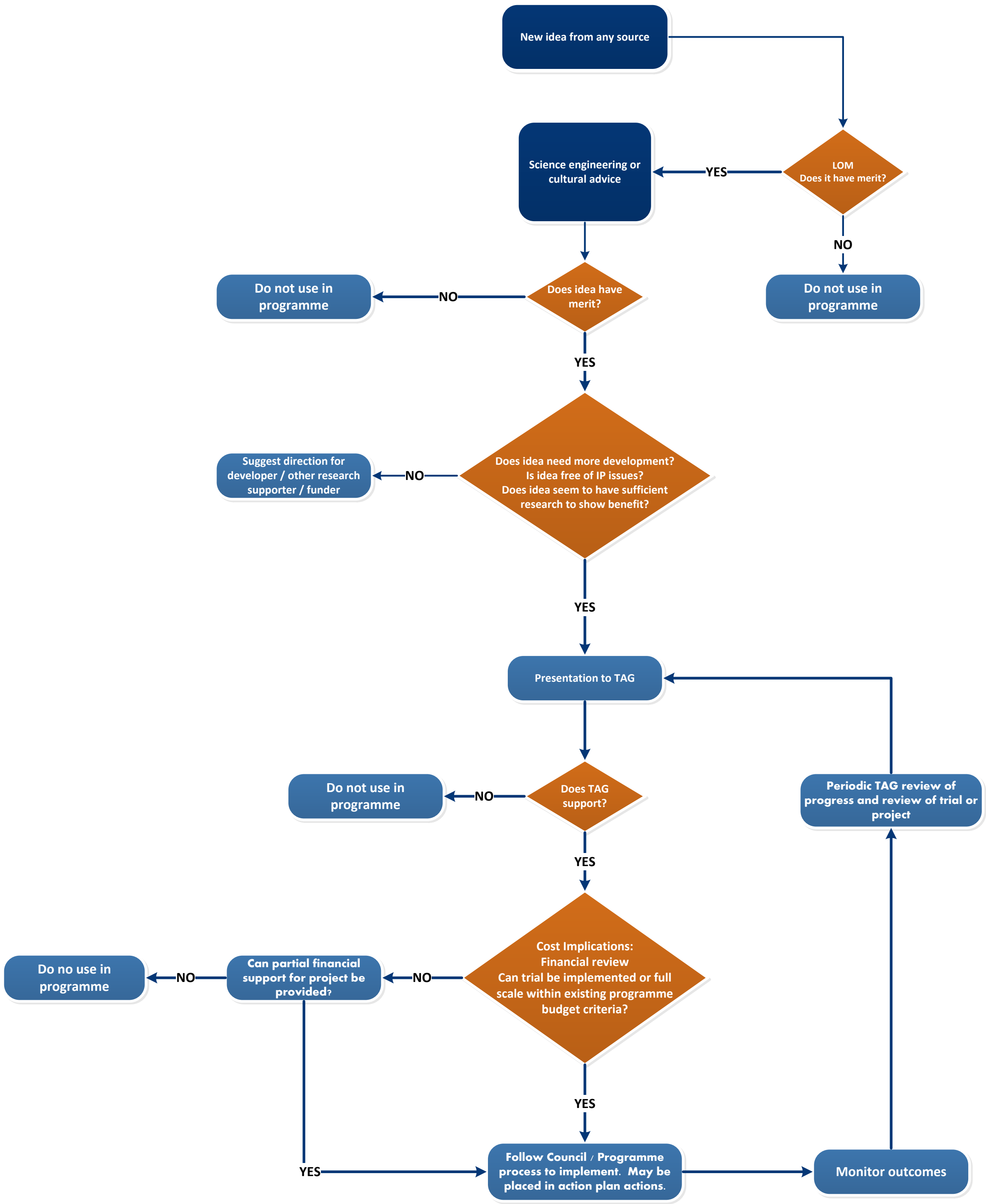
The Lakes Operations Manager and the Lakes Chair meet regularly to agree on short-term priorities to achieve the outcomes listed above and long-term research needs to be proactive in providing research on potential management strategies prior to their implementation.

[1] Preliminary screening of new ideas precedes any information presented to WQTAG to avoid irrelevant proposals being presented.

4. New Ideas and Innovation

Frequently, external sources request opportunity to present new ideas and innovations of lake restoration prototypes. The BOPRC is pleased to receive ideas and innovations; however, these presentations are not always supported by science research suitable to demonstrate applicability to the programme. To allow new ideas to progress into our programme, while avoiding resources being wasted, all submitted ideas follow the process set out in the flowchart below (Diagram 3 – New Ideas and Innovation Flowchart) to assess the ideas viability for the programme.

Diagram 3 – New Ideas and Innovation Flowchart



Note: The process for initiation of action to undertake new science work is detailed above. The areas identified are:

- New technical ideas that may have anecdotal evidence of success,
- New technical ideas that have research results to support them, or
- New technical ideas that have been applied in other environments, but not in the programme.

The Lake Operations Manager undertakes a preliminary review of new ideas, often with advice from one or more scientists. Frequently, the proponents are looking for research support and funding to prove their ideas. These types of projects typically would not be discussed at TAG. It is likely the applicants would be referred to alternative national funding sources.

Note: A similar flow diagram will be required to assess land research innovation once Land TAG is established.

5. Science Groups within Programme

GROUP	Function	Frequency	BOPRC / Facilitator
WQTAG **(Water Quality Technical Advisory Group)**	Provide science advice and critique for the RTALP. See Terms of Reference for WQTAG (Appendix 1 – Final Terms of Reference (ToR) Lakes Technical Advisory Group)	3 - 4 times Annually	Lakes Operations Manager
Land TAG (Land Technical Advisory Group)	The Advisory Group is tasked to provide independent technical science and economics advice on existing and new catchment land uses, their effects on water quality and how to mitigate them.	3 – 4 times annually	Lakes Operations Manager
UoW / LERNZ **(University of Waikato) and (Lake Ecosystem Restoration New Zealand)**	To develop a strategy for applied original research to support some of the key knowledge gaps relevant to management, politics, and regulation for the lakes. A series of projects that aim to restore indigenous biodiversity in lakes.	Monthly or as required Bi-Annually	Lakes Operations Manager Professor David Hamilton
APCG **(Aquatic Pests Coordination Group)**	To coordinate a number of different agencies' work on aquatic pests. (Appendix 3 – Terms of Reference (ToR) Aquatic Pest Co-Ordination Group)	3 times Annually	Senior Land Management Officer
SAG **(Sediment Advisory Group)**	To advise on lake sediment research and remediation, reports to WQTAG. Appendix 2 - Terms of Reference (ToR) Sediment Advisory Group (SAG)	3 - 4 times Annually or as requested	Professor David Hamilton

6. Science Providers

ORGANISATON OR GROUP	AREA OF EXPERTISE	RELATIONSHIPS	CURRENT PROJECTS
BOPRC	• Water Quality • Monitoring • New techniques • Research • Lake restoration prototype • Modelling for lakes • Ecology • Project Monitoring • Land use and soil health	• Science Team • Lakes Operations • Land Management • Pollution Prevention Team • Environmental Data Services Team	• RTLAP • Support in all areas • NERMN • Summer cyanobacteria • Lake bathing
UoW	• Water Quality • Monitoring • New techniques • Research • Lake restoration prototypes • Modelling for lakes catchment and lakes modelling • Ecology	• Contract Chair • Post Doc • Technical Support • PhD and Masters projects • Other providers e.g. Nick Ling and Brendan Hicks	• Lake Monitoring Buoys • Puarenga Catchment Modelling- sewerage • Catchment Modelling- Lake Tikitapu • Sediment Survey-Lake Rotorua • Lake Rotoehu destratification • Integrated Ecosystem- Lake Ōkataina • Catchment and lake Modelling of Ōkaro • Detainment Bunds for mitigating diffuse-source losses • Nutrient Concentrations in Puarenga Catchment • Greenhouse gas emissions in Rotorua lakes • Socio-economic contexts and tools for more efficient policies and regulation of diffuse nutrient loads to lakes • Dependence of phytoplankton succession on lake hydrodynamic • Remote sensing of water quality in lakes • Lake bathymetry Rotomā, Ōkatair and Ōkaro. • Phosphorus sources to Lake Rotor catchment • Modelling land use and lake wate quality for Lake Ōkataina

ORGANISATON OR GROUP	AREA OF EXPERTISE	RELATIONSHIPS	CURRENT PROJECTS
			More intensive monitoring of Lake Rotokakahi water and catchment Lake Tarawera nutrient budget update
NIWA	Sediment Water Quality Catchment land use Ecology Project monitoring	TAG contract Max Gibbs Chris Palliser	Catchment boundaries Catchment modelling Ecotoxic study Sediment releases
GNS	Groundwater Monitoring Modelling	Paul White	Tarawera Model Catchment boundaries
NIWA/UoW	Fisheries expert	Ian Kusabs, PhD study	Koura in a context of matauranga Maori
Private Consultants	Fisheries Biology Ecologists Cultural Knowledge Fisheries Management	Ian Kusabs Joe Butterworth TALT Iwi / hapū Lochmiogh consultants River Lake Consultants Schools	Tau Koura Kakahi modelling Intervention monitoring 12 lake koura monitoring

7. Research Funding Support

Through the process of assessment, the BOPRC needs to determine its involvement and local funding. Ultimately, this is reliant on agreement from the RTALSG and subject to some general guidelines:

- The restoration or research process is transparent and the BOPRC will have access to the technology without an unreasonable additional cost (e.g. royalties or fees for IP etc.)
- There is sufficient evidence to suggest the project is technically feasible and likely to have the environmental outcomes that are claimed and "in sync" with the programme objectives.
- That WQTAG supports the project.
- The level of funding support and BOPRC involvement in the project will depend on the potential benefit to the RTALP and the perceived responsibility within the project area. Typically, in-lake and in-stream interventions will be led by BOPRC, as the council has clear RMA responsibilities in that area of the environment. Conversely, land catchment interventions are more likely to be led by other organisations or individuals. However, BOPRC may be a collaborator, including part-funder.
- Where BOPRC is a collaborator or part-funder, without direct control of the project, a clear business case for support must be provided before any funding decision will be made.
- Generally two (2) types of projects will be considered:
    - New science / technical ideas (not applied elsewhere)
    - Existing science / technical applications that have worked elsewhere but need to be tested within the programme and the local Rotorua environment.

Each project will be assessed against general iwi and community expectations and aspirations. Long- term applications require a robust application and that requires the support of iwi and alignment with community expectations. Funding may not be allocated to proposals that do not align with iwi and community expectations.

External funding is regularly made available to Crown Research Institutes (CRI) for science projects through programs administered by MBIE. The Our Land and Water Science Challenges are currently being funded and have significant synergies with BOPRC research priorities. Opportunities to leverage off broader research agendas should be sought whenever possible. Other science programmes include the following:

- Our Land and Water Science Challenges
- Land Monitoring Forum (LMF)
- Land Managers Group (LMG)
- Sustainable Farming Fund (SFF)

8. Current Science Plan

Science is undertaken as a part of a structured programme of research, monitoring, and interventions that have delivered lake restoration outcomes over the past 13 years. Some specific case studies are attached in Appendix 6 – Case Studies, to demonstrate how these have worked.

An important observation from the science monitoring and implementation programme over the past 13 years is that some new ideas have had spectacular outcomes; some have been lake specific only and implementation has enabled identification of issues related to success or failure. In addition, in deciding upon science projects, simple analyses such as "lowest cost" are not likely appropriate, as many interventions have been implemented mainly due to community and hapū/iwi support and not just economics per se.

9. Current Workstreams

Provide science on state of each lake:

a) Maintain a monitoring programme for N&P, Secchi disc, deoxygenation and chlorophyll-a

b) Communicate TLI changes annually in August of each year

c) Lake Submerged Plant Index (SPI)

d) Stream water quality and flow monitoring

e) Meteorology

f) Lake buoys

Support Action Plan Development:

a) Lake nutrient budgets

b) Provide information on in-lake and in-stream interventions

c) Monitor specific projects

Support management and planning of the RTALP:

a) Support science to assist implementation of Action Plans e.g. nutrient budgets, groundwater models, monitoring etc…

b) Modelling of land use and lakes:

   i) On farm

   ii) Catchment

   iii) Progress lake models for each lake

   iv) Specific modelling e.g. in Puarenga catchment in Lake Rotorua

   v) Support the testing of projects for deed funding or other funding e.g. aeration trials for Lake Rotoehu

Support ecological monitoring and restoration projects:

a) Koaro

b) Kakahi (Rotokakahi)

c) Kakahi and koura (Ōhau Diversion Wall)

d) Trout fishing and associated smelt and migration issues – Ōhau Diversion Wall

e) Floating wetlands (all lakes)

Provide other lake science as needed:

a) Ōhau Diversion Wall - impact of adjusting Okere control gate flows and impact opf water flow from a fish pass

b) Ōhau Diversion Wall - impact of removal if Lake Rotorua reaches TLI 4.2 and associated risks

Land use science:

a) Identify opportunities for nutrient footprint reduction e.g. P-Project and engagement opportunities, e.g. gorse

b) Identify opportunities for collaboration and possible joint funding

c) Provide advice on social issues facing land managers including stress, adaption etc.

d) Provide economic analysis of alternative land uses

10. Key Issues

The following is an identification of potential key science issues that could pose significant risk to the RTALP if the prior work streams are not maintained:

1. Specific science monitoring and assessment of alum use in lakes: Alum dosing has now become a key part of the lakes programme, with two alum dosing plants on Lake Rotorua streams, Puarenga and Utuhina; one dosing plant on the Lake Rotoehu geothermal stream and periodic alum dosing directly into Lake Ōkaro. Monitoring involves the following:
   - Alum plant management and dose rate
   - Water quality monitoring, specifically Al and P
   - In-stream and in-lake ecological monitoring annually
   - Lake sediment monitoring – every three years
   - Targeted ecological monitoring as necessary, previously undertaken by NIWA of UoW.

   Alum dosing has proven to be a successful strategy in the restoration of Lake Rotorua. Until land use changes come into effect and a reduction in nutrient inputs is achieved (reaching the lake), then alum dosing is likely to be necessary. A major risk is that any reduction in monitoring here could reduce the ability to assess the environmental safety of alum dosing. An important question is whether recent improvements can be maintained if alum dosing is phased out and whether the land use changes required are being successfully implemented.

2. Many of the lake projects and wastewater disposal are subject to RMA and resource consents. Science monitoring is necessary to ensure legal compliance with resource consent conditions. Performance and environmental monitoring are also necessary to support the resource consent application process in the future, as consents expire and need to be replaced.

   This applies to the alum dosing plants as described above, but is also critical for projects such as the Ōhau Diversion Wall.

   The Ōhau Diversion Wall consent expires in October 2017. It is anticipated that a resource consent replacement will be required. Monitoring of the wall includes:

   - Water quality
   - Water flows and velocity
   - Native and introduced fish species
   - Avifauna
   - Structural integrity of the wall
   - Sediment movement and disposition
   - Modelling of hydrodynamic and ecological impacts

3. There is significant value in long-term continuous monitoring records, for determining lake water quality trends and changes. In the past, where monitoring records have been stopped due to lack of resources or redirection of resources, this has made understanding water quality changes more challenging. Prior to ceasing any long-term monitoring, an assessment of the long-term needs and potential risks need to be undertaken by appropriate science advisors. . Needs of the RTALP require alignment with BOPRC overall science strategy and resourcing, and where gaps are identified; develop methodologies on how these will be resolved.

4. The programme will be active in identifying new monitoring techniques that can be integrated with monitoring outcomes and understanding. Some examples of this type of innovation are high-frequency monitoring buoys, satellite images, and DNA sequencing for identification of algae species. In these types of applications, there can be multiple advantages and potential to lower costs. For example, recent implementation of the pH-monitoring buoy in Lake Ōkaro is now able to identify times suitable for alum dosing applications.

5. Modelling: identifying science requirements to support present and future environmental modelling; identifying uncertainty in models; usefulness of model in the future – will models be resourced for future iterations and uses.

6. Land use change scenarios: there are a number of variables for land use change scenarios, including environmental (N & P reductions), economic (return, supply chain, management), skills and expertise (what level of expertise is required?).

7. The impact of management initiatives (rules) on other nutrients (i.e. phosphorous) need to be understood.

11. Programme Gaps

A workshop was held in November 2013 to review current work and identify science gaps within the current Programme. Three specific areas were identified:

- Current lake water science (including cultural indicators of lake health)
- Land use science
- Wastewater science

The workshop attendees were selected to provide feedback from scientists and end users (Programme Workstream Leads) and to help identify programme science gaps (Appendix 5 – Science Workshop Attendees).

Since the initial science plan development a review of the science plan has focussed specifically on land use science gaps. The LandTAG has met three times and identified land science gaps identified in sections 13 and 14. These gaps identified have been work-shopped with a number of other groups, including staff and some key external experts, as well as a meeting with Rotorua Pastoral Collective farmers to confirm relevance. Their points of discussion have been taken into consideration in finalising the "gaps" analysis for this document.

12. General Water Science Gaps

- Groundwater for Lakes Rotoiti, Rotoehu, Rotorua
- Cultural Framework / indicators / mahinga kai /matauranga
- Other lake health indices (in particular specific monitoring of native fauna in lakes for example extension of the koura monitoring programme)
- Mechanisms to get ideas into Science Programme
- Mechanisms for Action Plan change / review
- In-lake contaminants / environmental health risks
- Science succession for Programme
- Loss of native flora / native fisheries
- Floating wetlands- benefits
- Regular science forum, extension of student presentations
- Modelling of scenarios
- Story of TLI and other targets to communities
- Local and Māori student involvement
- Storage of information - access to public and scientists, other volume of data now being generated.
- Wastewater disposal science

13. Land Use Science Gaps

Bay of Plenty Regional Council formed the Land Technical Advisory Group (Land TAG) in October 2014 to provide independent advice on land-based nutrient management solutions for water quality. Land TAG will provide independent science and economics advice on land uses, their effects on water quality and mitigation measures. The Land TAG's initial geographic focus was the Rotorua Te Arawa Lakes, but BOPRC has identified significant value in expanding the groups focus to wider land management issues across the region.

Through the initial LandTAG meetings a range of knowledge gaps and land science research needs were identified. The TAG and BOPRC staff prioritised these research needs / knowledge gaps. Projects will be undertaken to address the research priorities, which may require more targeted input from specific TAG members.

Opportunities to leverage of current research programs in other regions to address knowledge gaps should be sought wherever possible.

Specifically the Land TAG will meet 3-4 annually and will initially focus on:

- How different land uses and land management practices impact nutrient loss
- The costs of adopting new practices and land uses
- The economic, social and cultural impacts of new land uses, including how to improve uptake and overcome the barriers to adoption
- Identification of information gaps and advice on prioritising investment in land-based science, economic analysis and engagement with rural landowners

The Land TAG and BOPRC have identified the following categories as general land science gaps. A more detailed description is provided in Section 14.2.

- A framework or methodology for assessing the efficacy of alternative land uses for reducing N and P inputs to water bodies.
- Focused identification and monitoring of sources sediments and nutrients (N & P)
    - Knowledge of delivery times and attenuation
    - Identification of high risk areas for targeted management
    - Application to farm scale and catchment scale models
- Identification of the processes that determine amount of attenuation occurring within the vadose zone and groundwater. Determining how different zones perform with nutrients and how these apply to models.
- Improving inputs into Overseer, such as detailed soil physics information will improve confidence that OVERSEER is effective at modelling local conditions including local soils with high rainfalls. A framework for data / software management is required to ensure versions and datasets are appropriately managed within BOPRC.
- Investigate how nutrient reductions impact on operations and land values
- Economic analysis of alternative land uses including forestry and cropping combinations. Supply chain considerations and management structures should be identified
- Collate and review good management practice advice to simplify messaging to land managers. Provide information to LMOs and LMUs on reducing barriers to implementation, including: Land manager stress, practicalities of compliance and land manager behaviour and learning

- Determine how catchment scale models relate to farm scale models i.e. Rotan to Overseer to determine how land managers and regulators can track progress against nutrient budgets and targets.

BOPRC conducted a workshop on 27 August, 2015 with the LandTAG chair, BOPRC program managers and key BOPRC staff to identify research needs for programs outside of the RTALP.

The key science needs identified in this workshop were the following:

- What is the economic value of N and value of low N farms?
- Phosphorous – alum dosing impacts (WaterTAG), attenuation on farm, its role in hydro lakes
- Conduct a review of biological farming systems
- What other contaminants do we need to be addressing? – Cu, Cd, Zn, Antibiotics etc
- Is there an operational role for the TAG? – test draft programs
- Develop a business case for afforestation on small parcels
- Follow up from opportunities symposium with economic business cases
- What are the key drivers of impacts on non-rule 11 lakes?
- Determine the best fit for critical source areas tools – CLUES, SEDNET, Mitagtor
- Conduct an objective assessment of lake nutrient budgets
- How far would good management practice (GMP) get us? Are non-rule based management initiatives more appropriate for other catchment?
- Investigate a natural capital distribution model

Given the high dependency on the Overseer model in the Lake Rotorua catchment the need for a standalone workshop on the model was identified. The purpose of this workshop is to discuss the science and best management / use of the model.

14. Addressing the Gaps

Addressing the gaps is broken into the two component parts:

14.1 Gaps in Water Science

Definition of Gap	Potential Solution	Resource Need High/Moderate/Low
Groundwater for Lakes Rotoiti, Rotoehu and Rotorua	Monitoring bores and model development	High
Cultural Framework / Indicators - mahinga kai, matauranga	Develop framework of Framework, being led by TALT	High
End User Needs	Community engagement	TBC
Other Lake Health Indices	Community input and related to cultural framework	High
Mechanisms to get ideas into Science Programme	Community engagement, science forums, OBI, UoW study opportunities.	Moderate
Mechanisms for Action Plan Change / Review	Science review of intervention success	High
In-lake Contaminants / Risks	Science review and safety mechanisms	High
Science succession for Programme		
Loss of Native Flora	Research on native species and impact of environmental changes	High
Floating Wetlands	Habitat value for native species and others	Moderate
Regular Science Forum, extension of student presentation	Programming of science presentations, field trips and discussions	Low
Modelling of Scenarios	Implementation of Land TAG	High
Lake in-flows	Especially the greater Tarawera catchment, awaiting GW model to progress	High
Quality of Data		
Story of TLI and other Targets to Communities	Identify best ways of reaching interested community members	Low

Definition of Gap	Potential Solution	Resource Need High/Moderate/Low
Local and Maori Student involvement	Identify projects and students and attempt to connect	Moderate
Storage of Information- access to Public and Scientists	Some work being undertaken by UoW and BOPRC developing new data application	High

14.2 Gaps in Land Science

The priorities have been categorised into broad sectors as follows:

- Land research
- Social science
- OVERSEER, and
- Economic

BOPRC and Land TAG members were involved in the process of prioritising the science needs. Each project / gap was ranked according to its significance to lakes programme and the risk of not having such knowledge. The outcome of this prioritisation was to categorise the projects into the following:

- High priority (Table 1) – research is critical to the broader lakes programme or critical to input into another process that relies on such information.
- Medium priority (Table 2) – projects that are important to the lakes programme, but where there are projects underway to address or a longer timeframe is allowable
- Other priorities (Table 3) – includes projects where we currently have a good understanding of the science, projects where we need to stay up to date with other research and low priority projects.

A workshop with the Lake Rotorua Primary Producers Collective, LandTAG members and BOPRC staff was held on 9 November 2015 to determine the collectives priorities moving forward and to discuss BOPRCs science plan. While there was overlap between the priorities, the key outcome form this workshop was that land managers are going to attempt to achieve any required reductions within their existing systems before moving to alternative land uses. Switching to alternative land uses would require significant upskilling / reskilling and would essentially lead to a change in career for the land managers. They have invested significantly in their current skill set and have a desire to continue to utilise it while still achieving the required reduction in nutrients.

Feedback from the collective highlighted that the priorities did not include enough work on farm system enhancements / changes.

It was agreed at the workshop by the LandTAG chairman Dave Clarke that the science plan should reflect these priorities and that it should be included as a high priority.

Table 1: High priority science needs

Definition of Gap	Potential Solution and current work	Risks
Groundwater nutrient attenuation - Nutrient attenuation below the root zone is poorly understood within the catchment yet has significant impacts on how well the models correlate to reality. This project has strong links with localised calibration of Overseer, but is also significant for the ROTAN model.	Studies in NZ (Roland Stenger and Greg Barkle) have found that there is high variability of nitrogen attenuation with environmental conditions. Recent work has found groundwater attenuation to be as high as 50%. BOPRC need to understand the process and where they vary in the landscape. Science advice is currently being sought from UoW on ROTAN N load predictions given Overseer 6.1.3 N loss rates - this will indicate a likely N attenuation rate.	With the reliance on Overseer to model predicted nitrogen loads it is important to understand the nitrogen cycle in Rotorua soils (pumice, recent, allophanic). There is a risk that modelling does not well represent the local conditions.
Farm system improvements to reduce N – Many solutions to reducing N involve changing land uses which means a change in skills for landowners. It is important to investigate changes within existing farming systems that can permanently reduce N without changing land use.	There is a lot of work on various individual components of farm systems and how they relate to N reductions. There is a need to pull this information together and build on it to provide a complete picture for land managers to achieve permanent N reduction within the systems their existing systems. When system changes are not sufficient, land use change may be required.	Land use change has the potential to create disruption to current farming operations and land managers. This disruption would be minimised by achieving outcomes within existing systems where practicable.
How to extend farm scale impacts to catchment - The majority of available research focuses on discrete parcels of land and localised conditions. There is a need to understand how this site-specific information translates into the broader catchment. This needs to address the wide range of farm systems, profitability and nutrient loss rates, particularly in the less studied drystock sector	Catchment models should be developed with a clear line of sight to farm management model e.g. Overseer so that progress towards targets is easily quantified and adapted as necessary. Validation and adaption of models should be highlighted so that the model is more robust.	It is not easy to extrapolate farm studies to a broader area or catchment. Without knowing how well findings relate to a broader area it is not possible to have confidence in catchment wide decisions

Local calibration of Overseer - Overseer has been calibrated on NZ sites with up to 1300mm of rainfall p.a. Significant areas of the Rotorua lakes area exceed this rainfall (>1800mm) and have well drained pumice soils with minimal to no barriers to drainage. There is a need to understand how well Overseer outputs relate to localised conditions	Local calibration trials could be conducted utilising lysimeters or other technologies to determine the leaching rates experienced in local pumice / recent soils. A draft report is due on this issue DairyNZ and BOPRC are co-funding a 12-month extension of the Parekarangi trials (~1500mm RF) which will enable some local Overseer calibration. Options for potential calibration initiatives were canvassed in advice from AgReseach (August 2014)	Given the reliance of Overseer in modelling predicted impacts there is potential for a challenge to the accuracy of the modelling work.
Alternative land uses - Alternative land uses are critical to achieving a meaningful reduction in nutrient loads. a framework needs to be developed to assess the efficacy of such land uses. What are the most beneficial land uses? What are the barriers to entry for those uses? What skill level is required to implement? What are the supply chain considerations? Market considerations, Management structures etc...	Need to develop a framework or methodology for BOPRC / advisors to assess various landuses. Conduct a review of economic and environmental benefits of alternative land uses	BOPRC is encouraging meaningful change towards lower impact land uses and therefore is at risk where there is little confidence in the efficacy of land uses both environmentally and economically.
P loss identification and mitigation - Determine the hot spots and high risk areas for P and determine the mechanisms available and most effective in mitigating phosphorous loss at farm scale. Catchment scale initiatives such as strategically located constructed wetlands should also be investigated	Catchment models should be utilised to identify key sources or high risk areas for P loss. Investigate phosphorous reduction efficacy of various technologies i.e. wetlands, swales, detention ponds. Richard McDowell (Ag Research) has been working with BOPRC on the efficacy of mitigation strategies.	
Practicalities of compliance - The practicalities of compliance should be understood before management initiatives such as rules are decided.	Investigate the efficacy of other regulatory mechanisms and identify compliance issues and opportunities.	If the compliance process is not clear then it may be possible that management initiatives do not achieve what they were intended, or it may be possible that we are simply unaware of what is occurring in reality due to poor reporting mechanisms

Economic analysis of a cleaner lake - Understanding the cost of meeting the TLI of the lakes will have on the local economy is critical to understanding the economics of a cleaner lake. The council is putting significant effort into cleaning up the lakes. Determining the economic 'pay-back' will help communicate the benefits of this work and forge public opinion.	A comprehensive review of tourism and the local economic benefits of the lakes to the Rotorua region will be required. Hannah Mueller (Waikato Uni) has completed a thesis on this. A component of tourism economic activity will be incorporated into the Market Economics district impact section of the pending s32 work	Public opinion may sway given the significant amount of money currently being spent on improving lake water quality. The benefits should be clearly communicated.

Table 2: Medium priority science needs

Definition of Gap	Potential Solution and current work	Risks
P Sub model - The ability of Overseer to estimate P loss is limited as it measures the loss of P from the block as opposed to a waterway. While there is qualitative guidance on the efficacy of different P mitigation options, it is difficult to quantify at catchment scales. Therefore where catchments are P limited (or co-limited with N), it is difficult to set, implement and monitor P reduction measures. Empirical models	Rotorua dairy farmers are keen to explore P mitigation options. This may involve a drystock-focused SFF application (due October 2015). This may have scope for quantitative P monitoring that may support Overseer P submodel work. Lake Rotorua catchment is "data rich" in terms stream monitoring data, P loss estimates (via Rule 11) and UoW post-graduate P loss work, notably Jonathon Abell and Dylan Clarke.	

Develop a framework for nutrient allocation - There is a need to develop a consistent framework for nutrient allocation at catchment scale. The specific approach may vary with each catchment, but the overarching framework should remain constant across catchments. The framework should highlight allocation methods, effectively capturing cultural values etc. The framework is needed to apply the broad set of "principles and considerations" in RPS Policy WL 5B, particularly as some of these will be in conflict to varying degrees.	Conduct a comprehensive review of allocation mechanisms utilised elsewhere in NZ and around the world. Benefits and issues should be provided with a logical rationale for using the WL 5B matters, with appropriate weighting. The Lake Rotorua allocation analysis is well underway, in preparation for rules notification due August 2015. The lessons from this work could be applied to other lake catchments (and other catchments/aquifers beyond Rotorua) which are also "over-allocated" in terms of nutrient inputs.	Without a consistent framework there may be a range of methodologies rolled out that are inconsistent and create inequalities within the region. Time will spent establishing individual frameworks for each catchment.
Land value impacts - Management initiatives such as rule are likely to have impacts on underlying capital value of properties within the catchment. These impacts need to be understood.	Model the likely impacts of various scenarios i.e. a 20% reduction in productivity, a 10% improvement in operations	
Objective forestry value analysis - Provide a comprehensive review of the value of forestry and associated land uses (ginseng etc.).	Produce a detailed business case for conversion of marginal production grassland into forestry.	
Robust data management - This is strongly linked to version management of OVERSEER. Robust data management is crucial to managing the process. A national framework would provide consistency across projects and regional councils.	Investigate best practice data management - strongly linked to OVERSEER version management.	
Land manager stress - It is important to understand how management initiatives are likely to impact on the health and wellbeing of land managers	Managing land manager behaviour links to this project.	

Land manager behaviour and learning - When implementing new policy that has the ability to impact on land managers operations, there needs to be an understanding of how this is likely to impact on them and how they are likely to react. Determining how to manage this process is important.	Complete a review of available literature available on how change impacts on land managers - work should also factor isolation.	

Table 3: Other science needs

Definition of Gap	Potential Solution and current work	Risks
Critical mass for new land uses - value chain - Linked to Alternative land uses - Alternative land uses may have environmental benefits that are well understood, however from an economic perspective these land uses may not be viable in new areas	Conduct economic analysis of critical infrastructure and production levels required to sustain the value chain and remain competitive with other established areas	

Develop a framework for nutrient allocation - There is a need to understand the best methods for allocating nitrogen within a catchment. There are a number of approaches including allocating to natural capital and allocating to existing land uses. A consistent framework is needed on how to apply the broad set of "principles and considerations" in RPS Policy WL 5B, particularly as some of these will be in conflict to varying degrees.	Conduct a comprehensive review of allocation mechanisms utilised elsewhere in NZ and around the world. Benefits and issues should be provided with a logical rationale for using the WL 5B matters, with appropriate weighting. The Lake Rotorua allocation analysis is well underway, in preparation for rules notification due August 2015. The lessons from this work could be applied to other lake catchments (and other catchments/aquifers beyond Rotorua) which are also "over-allocated" in terms of nutrient inputs.	Having an inappropriate allocation methodology has the potential to cause inequity among landowners and redistribute wealth inappropriately. There will be duplication of effort (analysis, process set-up, stakeholder engagement etc) if a consistent region-wide allocation framework is not established
Ecosystem services - Additional benefits such as ecosystem services need to be clearly identified and factored into decision making	Determine the additional benefits of ecosystems services for various land uses. Investigate available information on accounting for ecosystem benefits	
Overseer Version management - Overseer makes regular changes to the underlying model, which in turn alter the outputs obtained from the model. A national framework would ensure the use of the model is consistent between catchments and between regions. Procedures for managing updates to the model should be part of this.	This project would be linked to data management of OVERSEER	
Alum risks - Moderate quantities of alum are pumped into Lake Rotorua to manage nutrient loads within the lakes. The long term effects of alum on the ecology and characteristics of the lakes needs to be investigated.	David Hamilton and Waikato University have conducted a study into the risk of long-term alum dosing. Grant Tempero is conducting a study currently	
Clarify gorse N parameters - 30T has been flagged to manage / remove gorse within the Rotorua catchment. The impacts and benefits of this need to be clearly understood.		Given the significant budget allocation, the risk of not have a complete knowledge of the gorse parameters is significant.

Alternative pasture species - Pasture species have differing demands of nitrogen and interact with the nitrogen cycle in different ways. Some species are more beneficial than others for mitigating excess nitrogen levels.	There is a large amount of literature available on pasture species in New Zealand. This information should be compared to Rotorua specific conditions and an information pack developed for land manager.	
Nitrogen trading - Nitrogen trading is a mechanism to create a market for nitrogen. The nuances of such a system need to be identified.	Conduct a review of trading mechanisms utilised in other regions or countries i.e. Waikato - Taupō	

15. Appendix 1 – Final Terms of Reference (ToR) Lakes Technical Advisory Group (21 May 2012)

1. Purpose of the Lakes TAG

To provide technical advice on lake science and management to BOPRC, RDC and TALT in order to improve the water quality of the 12 Te Arawa Rotorua lakes. The purpose of the Lakes TAG is to operate as an informal forum of experts on lake water quality problems, causes, and solutions.

2. Membership

The membership comprises representatives from the following core organisations: BOPRC, RDC, TALT, NIWA, UoW, GNS, and SCION. Lakes TAG membership can be fluid, reflecting changes to priority issues, the evolving research and operational programmes, staff roles and availability. At the discretion of the Lakes TAG convenor, additional people can be invited to participate on a short or long-term basis.

3. Scope of Work

The Lakes TAG will make considerations of, provide coordination and guidance to, and make recommendations on, the following matters relating to **the water quality of the 12 Te Arawa Rotorua lakes**:

a) Lake, aquifer, catchment and ecological research linked to lake water quality status, trends and potential water quality solutions, including:

   i) Current and future lake nutrient loads and water quality response

   ii) Sediment nutrient release and management options, taking into account advice from the Sediment TAG

   iii) Nutrient load reductions necessary to achieve the water quality targets and other matters relating to water quality as identified in statutory planning documents

   iv) Current and future risks to lake water quality, including climate and land use risks,

   v) Hydrology (surface and groundwater) and land use.

b) Operational matters, including current and proposed in-lake and in-stream mitigation actions

c) Monitoring regimes, results and analysis

d) Input to the development and review of non-statutory documents, including Lake Action Plans.

The lake TAG is not expected to provide technical guidance on practical aspects of land use and land management change except as they impact on overall lake nutrient loads. The Lakes TAG can identify land use knowledge gaps that may be an impediment to progress on achieving water quality targets.

4. Meetings, Reporting, Confidentiality and Financial Support

a) The lakes TAG will meet 3 to 4 times per year and operate by consensus.

b) The lakes TAG convenor is BOPRC's Lake Operations Manager, Andy Bruere, who is responsible for circulating agendas and minutes to all TAG members.

c) Formal reporting of lakes TAG advice is via the convenor of the Rotorua Te Arawa Lakes Strategy Group, and Regional Council, Rotorua District Council and Te Arawa Lakes Trust by their representatives as appropriate. Minutes of the TAG meeting are public documents. Some aspects of items raised at the TAG meeting in confidence, to aid free and frank discussion, may be excluded from the minutes by agreement at the time of the meeting.

d) The lakes TAG does not have authority to initiate projects or incur costs beyond meeting-related costs, with such projects subject to the external approval processes of BOPRC, RDC and other agencies.

16. Appendix 2 - Terms of Reference (ToR) Sediment Advisory Group (SAG)

A Sub-Group of the Rotorua Lakes Water Quality Technical Advisory Group (WQTAG)

1. *Purpose of the SAG:*

To provide scientific advice and operational direction on how to reduce internal lake nutrient loads via lakebed sediment management techniques.

2. *SAG Membership:*

- Prof David Hamilton (Convenor)
- John McIntosh
- Max Gibbs
- Andy Bruere

Plus co-opted experts as required, including specific postgraduate students and staff from the University of Waikato, NIWA, and SCION scientists, and private sector experts with relevant expertise, products, and systems.

3. *Scope of SAG's work*

a) Provide advice on all relevant remediation methods, and potential for ecological and human health effects, of lake bed sediment flux measurement, including, but not limited to:

  - Sediment capping materials
  - Hypolimnetic dosing materials, e.g. with alum
  - Oxygenation and de-stratification
  - Dredging

b) Formulate criteria for recommending research into any particular product or technique.

c) Review sediment treatment proposals and trials brought to WQTAG and BOPRC and make recommendations.

d) Provide input to other related Rotorua lakes research initiatives, including the in-lake modelling of sediment nutrient dynamics and the response of lakes to interventions and climate change effects.

e) The SAG does not have authority to initiate projects or incur costs beyond meeting-related costs. As such, projects/costs will need to go through the normal project approval processes of BOPRC and other agencies. The SAG can, however, recommend projects for approval to BOPRC or make recommendations through the WQTAG (see below).

4. *Meetings, Reporting and Support*

a) Aim to meet 3 to 4 times per year and to operate by consensus.

b) Report to WQTAG as part of WQTAG regular meetings.

c) Financial support will be provided by BOPRC for the actual and reasonable meeting costs of SAG members.

d) Meeting agendas and minutes will be documented and circulated to all SAG members.

17. Appendix 3 – Terms of Reference (ToR) Aquatic Pest Co-Ordination Group

1. Purpose

The purpose of the Aquatic Pest Co-ordination Group (APCG) is for those agencies with a role in the management of aquatic pests to effectively network, pool resources where possible and share information to achieve the integrated planning and management of aquatic pests in the Rotorua Lakes.

This will be achieved through the objectives of the Group set out below.

2. Objectives

2.1 To facilitate communication and liaison regarding aquatic pest issues between the representative organisations.

2.2 To act as a forum to promote further discussion and input on technical issues from relevant organisations.

2.3 To plan, implement and report on operational activities in regard to aquatic pests within the Rotorua Lakes.

2.4 To raise awareness and understanding of aquatic pest issues in the Rotorua Lakes.

2.5 To promote consistency of policy and strategic direction between agencies for the management of aquatic pests within the Rotorua Lakes.

2.6 Regularly review these objectives, how they will be achieved, and the overall effectiveness of the group

3. How the Objectives will be Achieved

3.1 APCG will prepare an annual plan for Rotorua Lakes aquatic pest management by the 1st of July each year. The plan must take into consideration the roles and responsibilities of each organisation and the resources available for aquatic pest management.

3.2 APCG member agencies will implement parts of the annual plan that apply to them and report back to APCG.

3.3 APCG will prepare an annual report on Aquatic pest operational activities carried out by 30th June each year.

3.4 Each member agency will contribute resources as appropriate within their mandate to help achieve the purpose and objectives of the Group. This will include:

- Contributing to issue based working groups where relevant.
- Contributing to planning and policy processes where relevant
- Committing to undertake actions agreed at meetings in the defined timeframe.

3.5 Each member agency will provide a representative at Group meetings at a level sufficient to represent the strategic direction of their organisation. This representative will have the role of disseminating information from the group within their organisations. Agencies may provide other additional representatives as appropriate.

3.6 All agencies will facilitate information sharing and coordination of information where appropriate and relevant. An important principle is maintaining the confidentiality of information shared unless that information is specifically stated as being public.

3.7 The Group will act as an interface for consultation on issues associated with aquatic pest management policy.

3.8 The Group will develop a coordinated approach to community engagement for Aquatic Pest awareness in the Rotorua Lakes.

3.9 The Bay of Plenty Regional Council will provide administrative support to the group.

3.10 Chairing and convening meetings will be by mutual agreement between the member organisations.

Membership

The Aquatic Pest Co-ordination Group members are:

- Department of Conservation
- Eastern Region Fish and Game Council
- Bay of Plenty Regional Council
- Rotorua District Council
- Te Arawa Lakes Trust
- Land Information New Zealand
- National Institute of Water and Atmospheric (Advisory)

18. Appendix 4 – Final Terms of Reference (ToR) Land Technical Advisory Group (6 May 2014)

Purpose and scope of the Land TAG

To provide independent technical science and economics advice to BOPRC and other organisations on catchment land uses, associated contaminant losses to water and landbased methods of mitigating those losses.

The Land TAG's spatial scope will be staged as follows:

- An initial focus within the Rotorua Te Arawa Lakes Programme on meeting prescribed nutrient loss targets from rural land, especially the Lake Rotorua catchment.
- A later expansion to other Bay of Plenty catchments and issues other than nutrient losses from rural land, as policy develops on setting water body and catchment targets.

Functions

The Land TAG will give advice on:

a. Nutrient losses and associated mitigation methods across current and potential future land uses and farm systems. Mitigation includes land use change, novel alternative land uses, developing technology and practices, and land management change.

b. Good nutrient practices associated with major land uses and farm system types.

c. Cost-effectiveness, risks, certainty and barriers to uptake in regard to nutrient mitigation options and good nutrient practice.

d. Identification of gaps and priorities in land-based science, economic impacts and extension (education and engagement) to rural landowners.

e. Technical advice on specific mitigation techniques and proposals.

f. Input to BOPRC project briefs, including technical analyses to underpin statutory land use policy, rules and implementation (including nutrient allocation and trading) and non-statutory incentives and other methods.

g. Drivers for and impacts from conversions to more intensive land uses.

h. Advice on what relevant land research is occurring and how to exploit synergies

i. Options to influence external research and research funding agencies.

j. Interaction with Lakes Water Quality Technical Advisory Group to ensure synergies, including:
   - Integration of mitigation actions and timing
   - Modelling integration across farm, catchment and lake scales
   - Interactions between nitrogen and phosphorus reductions.

Land TAG functions additional to the Rotorua Te Arawa Lakes Programme will be determined by BOPRC at a later date. Meanwhile, it is noted that the above advice functions will be relevant to multiple Bay of Plenty catchment facing potential nutrient constraints.

Membership

The Land TAG membership will comprise:

a. Representatives from the following professional disciplines (members may cover several disciplines):

i. Farm systems analysis

ii. Nutrient dynamics (soil-plant-animal-water-atmosphere-inputs-outputs)

iii. Farm economics and modelling

iv. Catchment economics and modelling

v. Forestry

vi. Horticulture

vii. Matauranga Maori

viii. Knowledge exchange and behaviour change

b. Relevant staff from Bay of Plenty Regional Council

c. Relevant staff from Rotorua District Council and Te Arawa Lakes Trust while the Land TAG is focused on the Rotorua Te Arawa Lakes Programme.

d. A convenor appointed by Bay of Plenty Regional Council management.

e. A representative from the Lakes Water Quality Technical Advisory Group.

f. Land TAG membership can be fluid, reflecting changes to priorities, the evolving research and operational programmes, staff roles and availability. At the Land TAG convenor's discretion, additional people can be invited to participate on a short or long term basis.

Meetings and reporting

The purpose of the Land TAG is to work as an informal forum of experts, as follows:

a. Meet up to four times annually as required

b. Operate by consensus

c. The Land TAG convenor is responsible for:

   i. Circulating agendas and minutes to Land TAG members

   ii. Liaison with other groups e.g. Lake Rotorua Catchment Stakeholder Advisory Group.

d. Formal reporting is to BOPRC on regional issues and RTALSG on lake programme issues.

Confidentiality and financial support

- Minutes of Land TAG meeting are public documents. Agenda items can be raised in confidence, to aid free and frank discussion, and excluded from the minutes by agreement during a meeting.
- Land TAG does not have mandate to initiate projects or incur costs beyond meeting related costs, with any projects subject to external approval processes of BOPRC and others.
- BOPRC will pay actual and reasonable time and expenses for Land TAG members.

Term of reference review

As the work of the Land TAG begins to extend into the wider regional issues these Terms of Reference will be reviewed. This will ensure in particular that the TAG membership and reporting processes reflect the issues under discussion.

Limitations of scope

- The Land TAG cannot commission work or engage consultants in its own right.
- The Land TAG shall not make public statements other than as agreed with BOPRC.

19. Appendix 5 – Science Workshop Attendees

BOPRC	Andy Bruere Gloria Zamora Anna Grayling Alastair MacCormick Rob Donald Paul Scholes Alastair Suren Sarah Omundsen Ian Morton John Paterson Niroy Sumeran John McIntosh
RDC	Alison Lowe
TALT	Hera Smith
UoW	Prof David Hamilton

20. Appendix 6 – Case Studies

Lake Okaro

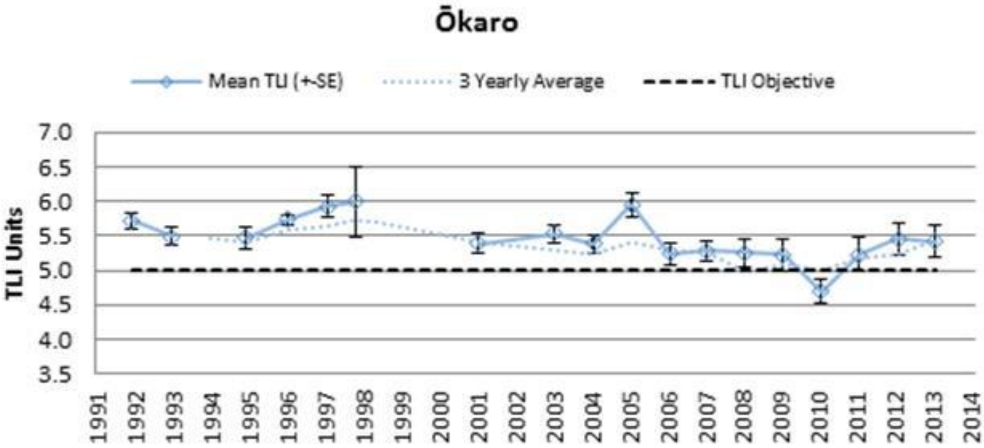
Introduction

Lake Okaro is a small lake situated just to the north of Rainbow Mountain on the Rotorua to Taupō highway. The surface area of the lake is 31 ha and 367 ha of predominantly farmed catchment drains to the lake. The average depth is 12.5m and the deepest part of the lake is 18m. The catchment soils have a high natural fertility due the Rotomahana Mud component spread over the area from old Lake Rotomahana and its surrounds during the 1886 Tarawera eruption. The stream flowing to the lake has a very high background phosphorus concentration because of this.

As part of the Te Arawa Rotorua Lakes Protection and Restoration Programme, an Action Plan was formulated with the community with the primary purpose of reaching the Water and Land Plan trophic level index (TLI) objective of 5.0 TLI units. Okaro had the worst quality of the 12 major lakes of the Te Arawa group. It was unusual in that the internal load was of similar magnitude to the external (catchment) load. This is because the accumulation of organic matter in the lake sediments released more nitrogen and about as much phosphorus into the lake water on an annual basis as flowed into the lake from the land. The internal load of phosphorus could theoretically be reduced by locking with alum or other products but the internal load of nitrogen could only be gradually reduced over time by controlling the outflow of nitrogen from the catchment.

In the Action Plan, the TLI objective was to be achieved by reducing nitrogen by 3.3 Tonne/yr and phosphorus by 0.38 Tonne/yr. Of this, 0.9 Tonne/yr of nitrogen and 0.02 Tonne/yr phosphorus were targeted for reduction from the catchment inflows.

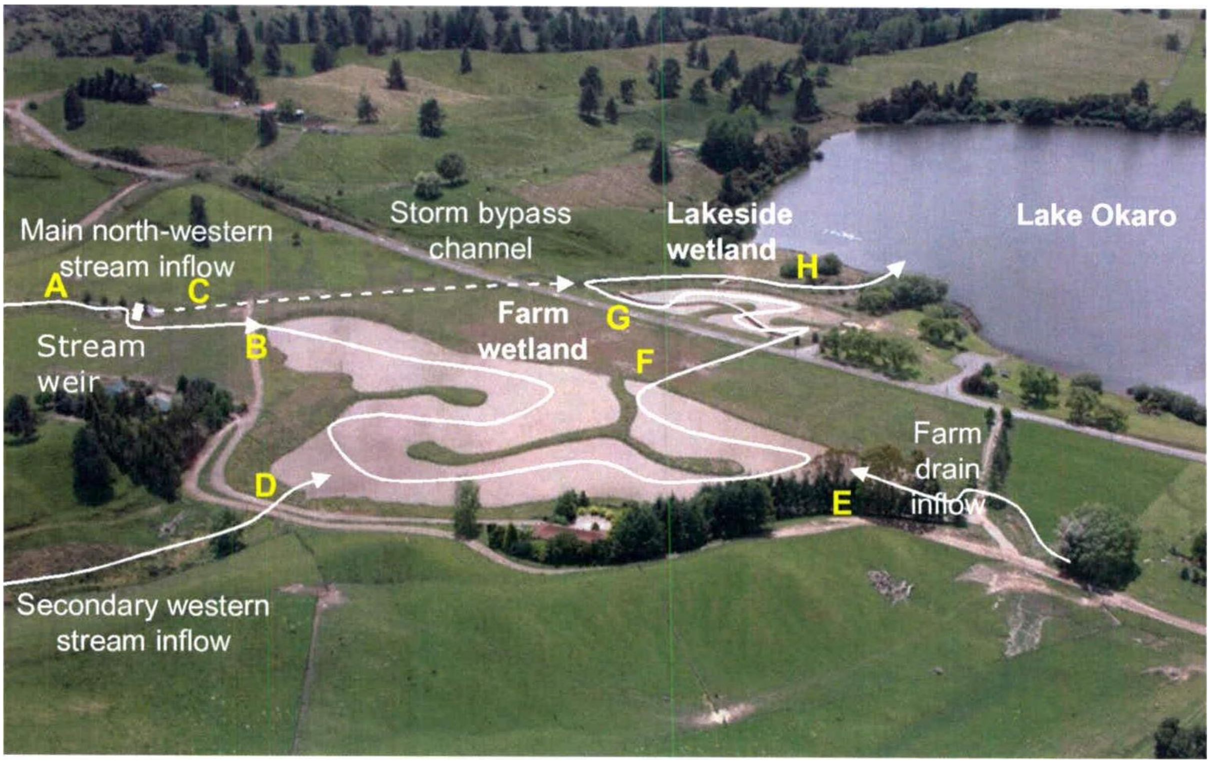
To achieve the objective a range of actions have been undertaken since the Action Plan was put in place in 2006.



The TLI may be lower on average in the last decade than in the 1990s but has only reached the W&LP target once. That may be due to the drought year of 2009 reducing the catchment inflows of nutrients.

Constructed Wetland

The constructed wetland was completed in May 2005 but plants were not fully established for another year and complete flow through from all the waterways was held off for one more year. Wetlands work principally in reducing nitrogen levels through the process of de-nitrification. Some settlement of phosphorus may occur and initially there may be some plant uptake. In the 1970s, cowshed effluent was discharged in the lake catchment but that was diverted to a pond out of the catchment, however, storm flows washed drainage from the cowshed race towards the lake through a planted detention basin until that was diverted to the constructed wetland.



The wetland fluctuates in effectiveness depending on rainfall and in high rainfall years, a large quantity of water passes untreated along the by-pass channel. A NIWA study has recorded a nitrogen reduction to Lake Okaro of 150 - 600 kg/y and a 30 - 300 kg/y in phosphorus as the streams flow through the wetland.

Catchment Management Change

The Okaro Catchment Lake Restoration Group (OCLRG) was established with an objective of establishing farm and environmental accountability. They obtained Sustainable Farming Fund financial support and support from the Bay of Plenty Regional Council and have carried out the following mitigation methods: altering stocking levels and stock classes, altering stocking policies, altering the sheep : cattle ratio, strategic use of fertilisers, retirement of land from grazing, managing critical source areas where nutrient runoff can be high, and installation of a storm water detainment capability to an existing dam to buffer peak flows during run-off events. Between 2008 and 2010, nitrogen loss remained steady but phosphorus loss was reduced by an estimated 34%.

A formalised compliance programme carried out by a specified scientific method remains to be set up and implemented. This would enable the nutrient load discharged from farming properties to be audited.

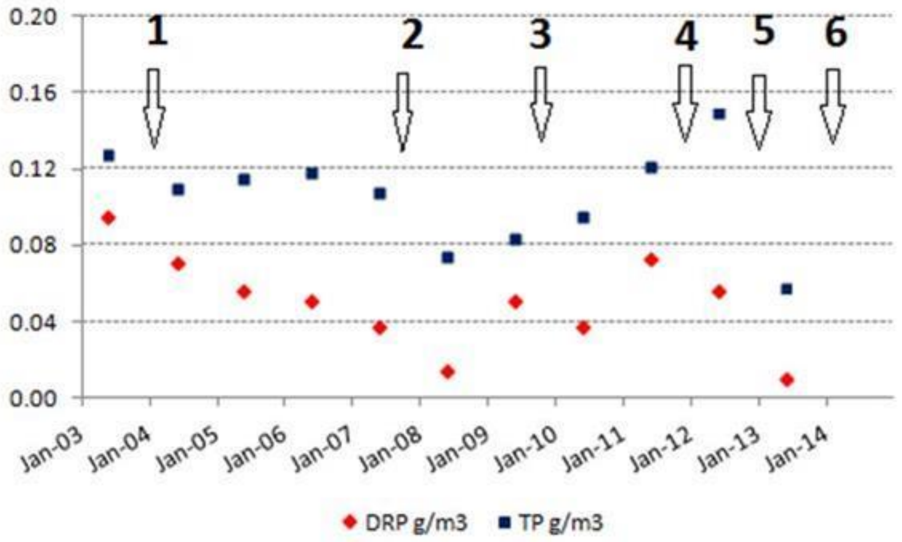
Detainment Bund

A detainment bund (3.9m high and 16,000 m^3) has been constructed (April 2014) to control storm flows in the major portion of the catchment so that the storm water can be channelled through the wetland. Suspended sediment will settle out in the bund removing some nutrients and the delay and attenuation of the storm peak will allow more water to receive additional treatment in the wetland. Storm water by pass of the wetland will be reduced and probably avoided.

Phosphorus Locking

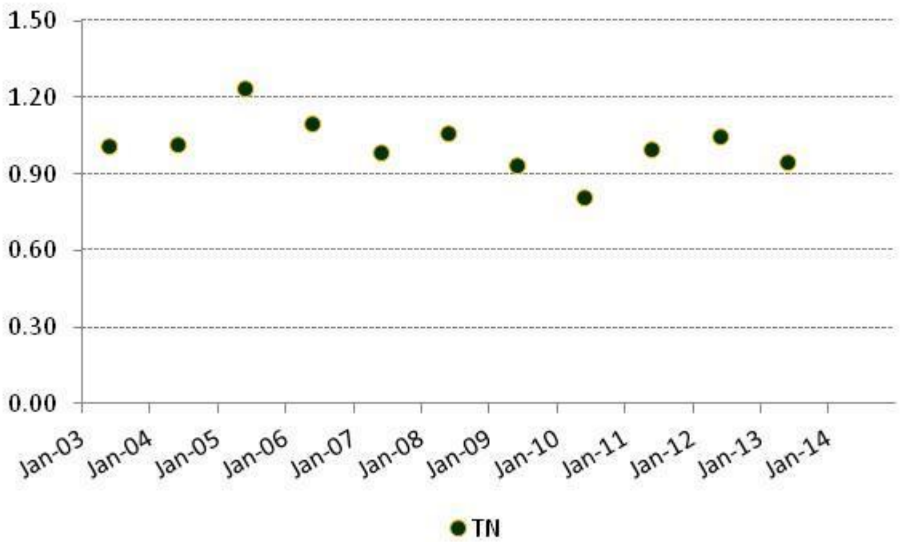
Within the Action Plan the majority of the phosphorus reduction to reach the TLI objective of 5.0, was to be achieved by locking the phosphorus that was re-cycled annually from the bottom sediments of the lake. Two products have been used on Lake Okaro after being trialled either in overseas studies or in New Zealand. Aluminium sulphate (alum) has been used and a locally made zeolite material amended with alum. Alum has been used in recent applications because of cost effectiveness. A resource consent has been obtained for an annual application of 15 tonne of either product.

In June when the lake is completely mixed the phosphorus concentration (g/m^3) is an indicator of the overall nutrient status of the lake.



1: 10 tonne alum, 2: 112 tonne Aqual P, 3: 44 t Aqual P, 4: 5 t Aqual P, 5: 22.6 t alum, 6: 10 t alum

Phosphorus locking has been effective in reducing the in-lake phosphorus concentration (g/m^3) *eg* the 112 T Aqual P drove the concentration down and the after the alum application in 2012 the phosphorus concentration was at its lowest recorded level.



In contrast to the June phosphorus concentration the June nitrogen concentration (g/m^3) has varied around an average of about 1 g/m^3 but has not changed significantly over the last decade.

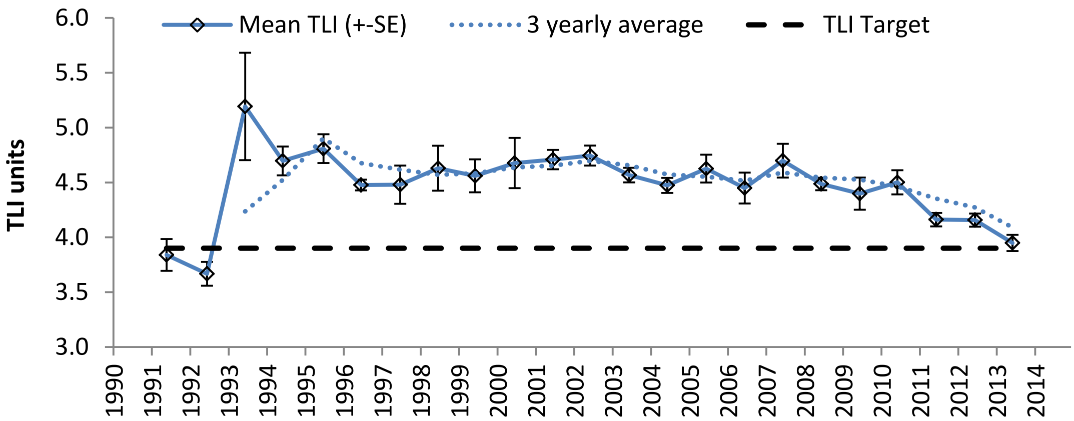
The Action Plan requires a reduction in catchment nitrogen input to Lake Okaro to reduce the in-lake nitrogen concentration and to reduce the internal load of nitrogen, whereas, a reduction in catchment phosphorus input is required but the internal phosphorus load can also be reduced by phosphorus locking.

Lake Rotoehu

Introduction

Formed by lava damming a river valley and surrounded equally by a mix of pasture, exotic and indigenous forestry, Lake Rotoehu water severely declined in the 1990's and has also been impacted by the introduction of the invasive macrophyte *Ceratophyllum demersum* (Hornwort).

As part of the RTALP an Action Plan was formulated with the community with the primary target of reaching the Regional Water and Land Plan trophic level index (TLI) objective of 3.9 TLI units. This would be achieved by reducing nitrogen by 8.88 T/yr and phosphorus by 0.708 T/yr. To achieve this a range of actions have been undertaken since the Action Plan was put in place in 2007 which have seen the TLI, a measure of lake water quality, indicating a marked improvement in lake water quality in recent years. A number of restorative actions have driven this improvement and these are described below.



Science underpins determining not only the extent and potential of many of the restorative actions but also is critical in determining their success.

De-stratifier

Lake science classification defines Lake Rotoehu as a polymictic lake, meaning the lake is too shallow to develop seasonal stratification. Like Lake Rotorua, Lake Rotoehu can intermittently stratify and when the bottom water reach near anoxic conditions phosphorus can be released. De-stratification is a technique that has been employed in other lakes and reservoirs to stop bottom water going anoxic hence preventing phosphorus release, which can fuel toxic algal blooms.

A unique design was proposed for a de-stratifier capitalising on the lessons learnt from other machines with the aim of preventing the lake stratifying. In 2012 two machines were built and installed. An intensive monitoring programme is underway to assess the performance and impact of these machines and will also help in determining the impacts of other restorative actions. Monitoring includes: two (2) live water quality monitoring buoys; zooplankton and phytoplankton monitoring; koura monitoring; monthly water quality monitoring including profiling and longitudinal surveys; current surveys, sediment surveys; and hydrological-ecological lake modelling.

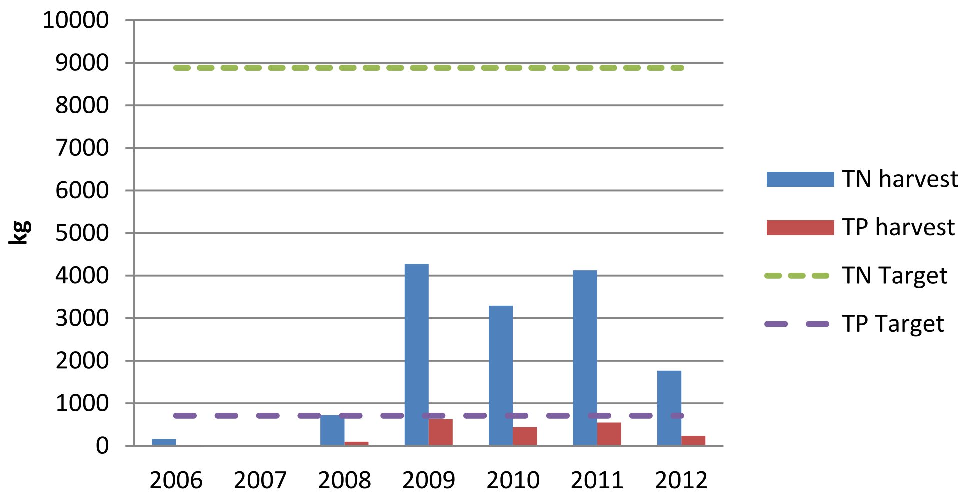
Figure 1: Part of a de-stratification machine being towed into the lake.

Floating Wetlands

Two small floating wetland island were initially trialled on Lake Rotoehu in 2008. Made from buoyant recycled plastic matting and planted with native sedges, the initial success of the wetland islands created the confidence to create a 3000 m^2 floating wetland. To establish the nutrient removal rate from the floating wetland nutrient loads in a tank being treated by a floating wetland were measured. Nutrient removal rates were approximated annually at ~460 kg TN ha^{-1} yr^{-1} and ~73 kg TP ha^{-1} yr^{-1}. Further work and research into the ecological and nutrient reduction benefits of the floating wetlands is ongoing.

Weed Harvesting

Hornwort (*Ceratophyllum demersum*) infestation of Lake Rotoehu likely occurred in the early 2000's, manifesting into large dense surface reaching beds in the southern end of the lake by 2004. Hornwort has been harvested from Lake Rotoehu in large quantities for the last five years after an initial trial began in 2006. The figure below displays the approximate nitrogen and phosphorous removal from the lake over that time in relation to annual lake removal targets. Removal of Hornwort to vermiculture and landfill has achieved almost half of the Rotoehu Action Plan nutrient target for nitrogen in the previous three years of harvesting.



Alum Treatment

The phosphorus load flowing into Lake Rotoehu from Waitangi soda springs is naturally high due to inputs from geothermal springs, which have high levels of phosphorus of geological origin. To address the imbalance of nitrogen to phosphorus in the lake which has occurred due to mans impact on the landscape, an aluminium sulphate (alum) treatment plant doses into the spring waters just before it enters the lake. Alum binds phosphorus, flocculating and settling in the lake sediments removing phosphorus from biological uptake. There is an indication that the present dosing regime may be helping to work towards the TLI target for Lake Rotoehu by providing a strong degree of 'phosphorus locking'. The aim was to remove 0.7 tonne TP yr-1, but like Lake Rotorua there is likely to be further phosphorus locking benefits in the lake waters.

Bio-Treatment

Biodegradation technology has been employed for many years in the wastewater sector. Utilising synergized blends of scientifically selected and adapted bacteria, enzymes, and nutrients, wastes associated with domestic, municipal, commercial, and industrial waste systems are readily transformed to waters of an acceptable standard to be put back into the natural environment. Treatment of Lake Rotoehu with non-pathogenic bacteria and enzymes will help to augment and accelerate nature's own biodegradation process, potentially resulting in the reduction of blue-green algae and improved water quality.

To see if such a technology is applicable to lake restoration problems, BOPRC is trialling this technology in a limited capacity in Otautu Bay, Lake Rotoehu. Initial shock dosing occurred at the end of 2011 and this has been followed up by regular maintenance dosing. Monitoring of sediment-sludge, sediment organic matter, invertebrates and sediment nutrients as well as lake water quality will evaluate the success of this trial. Initial results show that sediment-sludge has reduced in the bay.