Recent changes in the water quality of Lake Taupo and its inflowing streams

Bill Vant

More than 10 years ago, the Waikato Regional Council became concerned about the likely effects of changes to land use in the catchment of Lake Taupo on the water quality of the lake. Conversions of sheep and beef farms to dairying and of pine plantations to farms, together with a steady intensification of farming, were all considered to be likely causes of the increases in nitrogen concentrations in rivers and streams in parts of the region and in New Zealand in general.

Previous studies had shown that the algae in Lake Taupo were frequently nitrogen deficient, and that the experimental addition of nitrogen increased the amount of algae present in the lake's water. As a result, increases in the loads of nitrogen entering Lake Taupo were identified as a threat to lake water quality. Calculations showed that over 90 per cent of the manageable nitrogen entering the lake came from areas of pasture in the catchment.

Capping nitrogen levels

Over the following years the Council proposed that the Waikato Regional Plan be changed so that nitrogen loads from the catchment could be managed to ensure that the lake's water quality was protected. A variation to the plan, widely known as RPV5, was developed and finally confirmed by the Environment Court in 2011. The plan aims to maintain the current water quality of Lake Taupo well into the future by managing emissions of nitrogen in the catchment. It aims to do this by –

- Capping all sources of manageable nitrogen at their 2001 levels
- Offsetting much of the load of nitrogen which is still in transit to the lake by reducing some of the manageable sources.

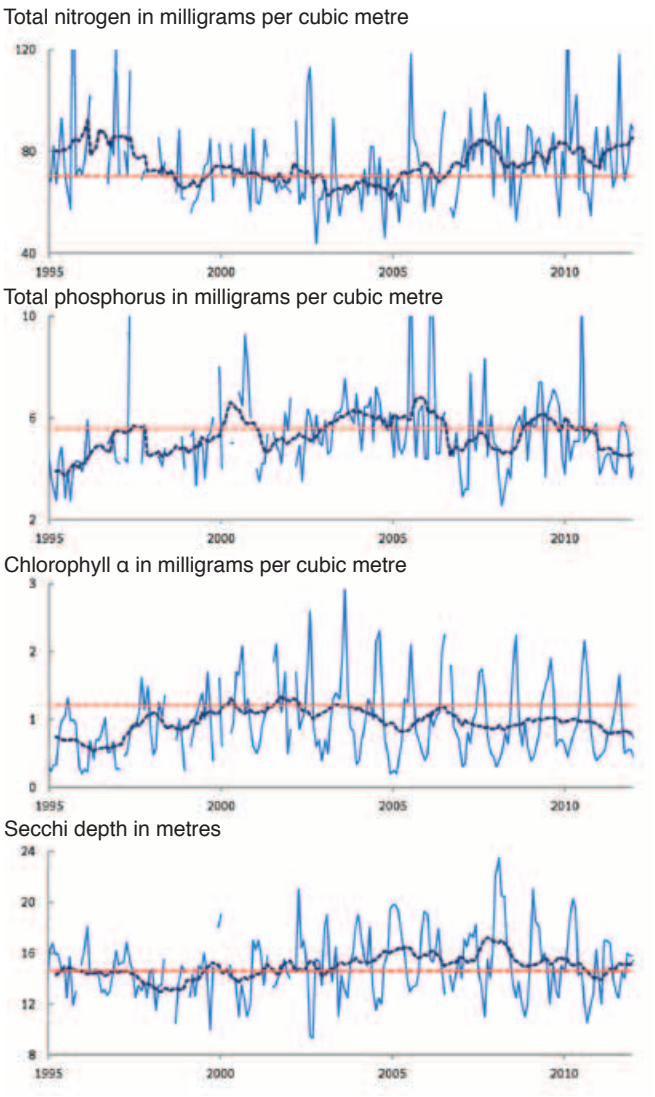
Much of the rain falling on the Taupo catchment area of 2,800 square kilometres percolates through the soil and is stored underground as ground water, in some cases for many years, before finally entering the streams and then the lake. The groundwater therefore contains some of the nitrogen leached from historic land use practices but which has not yet entered the lake.

When the variation to the plan was developed it was anticipated that, despite capping, the loads of nitrogen entering the lake in its inflows would continue to increase until the offsetting began to take effect. It was expected that it would take several decades or more before the full effects of intervention would be seen in the lake.

While emissions of nitrogen are regarded as being of the greatest importance to the current condition of the lake, phosphorus is also important. The plan therefore requires that the amount of phosphorus entering the lake be closely watched. It aims to manage the nitrogen, and to monitor the phosphorus.

Current lake water quality

The Council has operated a water-quality monitoring programme at Lake Taupo since 1994. A deep water site near the middle of the lake is visited every two to four weeks, and water samples are collected and field measurements made. The graphs show the monthly changes in water quality between 1995 and 2011.



Changes in water quality in Lake Taupo, 1995-2011. Dashed blue line is the 12-month running-average, the dashed red line is the Waikato Regional Plan water quality objective.

The water quality of Lake Taupo is generally excellent. Concentrations of the plant nutrients nitrogen and phosphorus are low, and so are the levels of microscopic algae whose growth they support, as indicated by the low concentrations of the plant pigment chlorophyll *a*. As a result, the water is clear and blue. In addition the bottom waters of the lake are mostly well oxygenated.

Although blooms of potentially harmful blue-green algae have occasionally been observed in the lake, for example in March 2003, so far these have not been common. The table below lists the Waikato Regional Plan water quality objectives for Lake Taupo. These were the average values which occurred in the lake between 1999 and 2003.

The table also shows the average water quality during the five years from 2007 to 2011. Average values for total phosphorus, chlorophyll *a* and Secchi depth were all slightly better than the plan's objectives, while

the average value for total nitrogen was somewhat poorer. The results of our analysis of changes in water quality over the past 10 years show that –

- Average concentrations of total nitrogen have increased at a rate of 2.6 per cent a year
- Concentrations of total phosphorus and chlorophyll *a* have decreased at rates of 1.5 per cent a year and 2.8 per cent a year, respectively
- Average water clarity – Secchi disc depth – has been stable.

These changes are apparent in the graphs on the previous page where the dark dashed line is the 12-month moving average in each case. The horizontal red line shows the position of the Waikato Regional Plan objective.

Nutrient loads in inflowing streams

Concentrations of nitrogen and phosphorus are currently routinely monitored in 14 streams

Water quality of Lake Taupo where the average values of indicators are shown, red indicates a deterioration

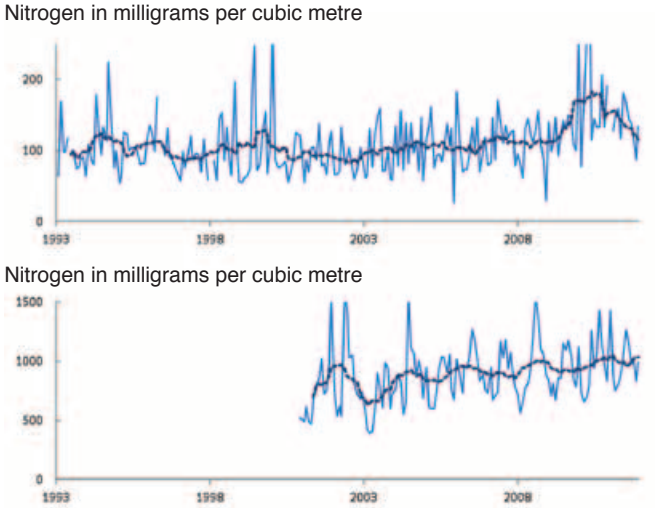
	Total nitrogen mg per cubic metre	Total phosphorus mg per cubic metre	Chlorophyll α mg per cubic metre	Secchi depth metres
Objectives for 2080	<70.3	<5.6	<1.2	>14.6
Currently 2007-2011	79.8	5.2	0.9	15.6
Changes, 2002-2011 percentage per year	*+2.6*	–1.5	–2.8	Stable

Nitrogen and phosphorus transported by 14 inflows to Lake Taupo showing the changes between 2002 and 2011, red indicates a deterioration

	Total nitrogen		Total phosphorus	
	Proportion of combined load	Change Per cent each year	Proportion of combined load	Change Per cent each year
Tokaanu Tailrace	27.5%	0	19.1%	0
Tongariro River	11.3%	0	10.6%	0
Kuratau River	8.8%	*+2.8*	7.0%	0
Waihaha River	6.9%	0	5.0%	0
Tauranga-Taupo River	6.0%	*+5.6*	6.3%	–2.6
Waitahanui River	5.4%	*+2.7*	17.1%	–2.0
Hinemaiaia River	3.4%	*+2.4*	3.1%	0
Whareroa Stream	3.4%	*+2.9*	2.1%	–2.8
Tokaanu Stream	2.9%	*+1.3*	2.2%	–1.3
Whanganui Stream	2.5%	–2.7	2.6%	0
Waimarino River	1.6%	*+8.7*	1.5%	–3.3
Whangamata Stream	1.1%	*+4.9*	2.1%	–2.2
Omori Stream	1.1%	*+4.0*	–	–
Mapara Stream	0.1%	*+0.8*	0.2%	–1.9
All 14 inflows	**82%**	**+1.4**	**79%**	**–0.9**

that flow into Lake Taupo. The Regional Council monitors conditions in 11 of these, while the others are monitored by NIWA, NZ Forest Managers and the Taupo District Council. The table above lists the contribution of each of the inflows to the combined nutrient loads from surface streams in the Taupo catchment.

It also shows the results of our analysis of the changes in the loads transported by each of these streams over the past 10 years. The graphs below show the monthly changes in nitrogen concentration in two of the streams. One of these, Tauranga-Taupo, has been monitored since 1993 while in the Whareroa records did not begin until the end of 2000.



Changes in total nitrogen concentration in the Tauranga-Taupo River and the Whareroa Stream, 1993 to 201, the dashed line is the 12-month running-average.

Altogether the 14 inflows carry about 80 per cent of the riverine loads of nitrogen and phosphorus which enter Lake Taupo. They therefore provide a reasonably good indication of the combined loads from all the surface inflows. Over the past 10 years the combined load of nitrogen carried by the 14 inflows has increased by more than one per cent a year, while the combined load of phosphorus has decreased by slightly less than one per cent.

During this period there has been a moderate-sized increase in the amount of nitrogen entering the lake and a moderate-sized decrease in the amount of phosphorus. These changes are consistent with those described above for the lake itself, namely the increase in nitrogen and decrease in phosphorus over the past 10 years.

Historic land use and old water

Some of the changes shown are somewhat unexpected. In particular, more than half of the overall increase in nitrogen between 2002 and 2011 was carried by four inflows which drain undeveloped and pine catchments on the eastern side of the lake, the Hinemaiaia, Tauranga-Taupo, Waimarino and Waitahanui Rivers. When the variation to the Waikato Regional Plan was being developed, it was assumed that the nitrogen loads from undeveloped and forested catchments would remain stable.

Recently we commissioned a preliminary analysis of historic 1958 to 1965 aerial photographs of the south-eastern part of the Taupo catchment including part of the Tauranga-Taupo sub-catchment. The area photographed currently contains about 159 square kilometres of pine plantation, or about a third of the combined area of plantation in this part of the lake's catchment.

Of this area of pine forest, nearly half is growing on land where pasture was present during the period 1958 to 1965. It is probable that the pre-plantation history of land use in this area is at least partly responsible for the recently observed increases in the nitrogen concentration in the streams that drain from it.

As noted above, the plan anticipated that there would be a delay between the capping of manageable sources of nitrogen in the catchment and the levelling-off of the nitrogen loads entering the lake. This was based on our findings that the water in some of the inflows to the lake had an average age of several decades. It is probably the resulting storage and release of pre-Waikato Regional Plan nitrogen in groundwater which is responsible for the increases shown.

Old water carrying nitrogen

We have recently undertaken a further survey of the age of the water in some of the streams entering the lake, including the Waitahanui River where about 80 per cent of the 197 square kilometre catchment is currently in pine forest. In this case, the average age of the water in the stream was found to be 38 years. It now seems reasonable to conclude that the nearby Hinemaiaia, Tauranga-Taupo and Waimarino Rivers also contain similarly old water, and that their land use before planting in pine forest 30 to 40 years ago partly determines the nitrogen they carry into Lake Taupo.

The reduction in the phosphorus carried by the streams between 2002 and 2011 is also interesting. A major soil conservation programme was initiated in the Taupo catchment in the 1970s, involving fencing and planting sensitive riparian areas and eroding hillsides. Implemented between 1976 and 1989, this means most of the main tributaries of the streams in pastoral areas have now been fenced and planted.

Regular monitoring of the Whangamata sub-catchment to the north of the lake since the 1970s has documented the development of dense vegetation on the streambanks, covering the previous scars of erosion of the pumice soils. The reduction in erosion in such areas may mean that particulate forms of phosphorus associated with soils carried by the streams have also reduced, as seen during the period 2002 to 2011 in the Whangamata Stream.

Conclusions

The water quality of the open waters of Lake Taupo is currently excellent. Over the past 10 years there has been a moderate-sized increase in the concentration of nitrogen in the lake, and moderate-sized decreases in the concentrations of phosphorus and algae. Over the same period there has been a moderate increase in the amount of nitrogen entering the lake from the catchment and a moderate decrease in the amount of phosphorus. These changes are unlikely to be connected with the recent implementation of the variation to the Waikato Regional Plan.

Initial increases in the nitrogen were anticipated in the variation and are consistent with our understanding of the storage of pre-Waikato Regional Plan nitrogen in groundwater in the catchment. However, the recently-observed increases in nitrogen concentrations in streams draining areas in native and pine forest were not anticipated during the development of the variation. These increases suggest that the nitrogen which was leached from historic land use practices and has been stored underground is likely to be larger than previously predicted.

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