Environment Waikato Technical Report 2006/46

Nitrogen and Phosphorus in Taupo Rainfall

Prepared by:
Bill Vant (EW) and Max Gibbs (NIWA)

For:
Environment Waikato
PO Box 4010
HAMILTON EAST

October 2006

Document #: 1108685

Environment Waikato
REGIONAL COUNCIL

Reviewed by:
Jeff Smith Initials ____________________ Date 19 October 2006

Approved for release by:
Viv Smith Initials ____________________ Date 19 October 2006

Acknowledgements
The rainfall collectors were constructed at NIWA's workshop in Hamilton. EW staff Ross Jones, Ralph Ostertag and Jeremy Piper installed the collectors at sites that were operated by Roy Carmichael and colleagues (Taupo Airport), Alistair Piper (Kinloch) and Kerry Mackie and colleagues (Kuratau power station). Paul Smith (EW) and colleagues supplied the site operators with clean bottles and transported the full ones to the laboratory. Ross Jones provided edited versions of rainfall quantity for the collection sites. Jeff Smith and Viv Smith made useful comments on a draft of this report.

Summary

During 2004–05 rainfall was collected at three sites near Lake Taupo and analysed for dissolved and particulate forms of nitrogen and phosphorus. Rainfall was retrieved from the collectors every day, and stored frozen as monthly composite samples until analysis.

Some of the samples showed signs of contamination, and were disregarded. In the other samples, about half of the nitrogen and phosphorus was present as dissolved inorganic forms, with the remainder being organic and particulate. The concentrations varied from month-to-month, and the samples from drier months often contained higher concentrations.

The loads of nitrogen and phosphorus in rainfall at Taupo Airport during 2005 were similar to those found there in the early 1980s (and in Taupo town in the 1970s). The loads at the Kuratau site were 40–76% higher than at the Airport site (for N and P, respectively). As also found in previous studies, the loads measured near Lake Taupo in 2005 were lower than those found in more densely-populated and industrialized parts of the world. The load of nitrogen entering Lake Taupo in rainfall in 2005 was estimated to be about 270 t/yr, while the load of phosphorus was about 24 t/yr.

Table of Contents

1 Introduction

Budgets of the loads of nitrogen and phosphorus entering Lake Taupo have been prepared as part of Environment Waikato's plan to protect the water quality of the lake (Vant & Huser 2000; Elliott & Stroud 2001). An important source of nitrogen to the lake is the rain that falls directly on the lake surface. This has been estimated to account for about 20% of the total load. The estimates of the loads of nutrients carried in rainfall were based on previous assessments of the chemistry of rainfall in New Zealand (e.g. total nitrogen load of 3.7 kg/ha/yr, and total phosphorus load of 0.38 kg/ha/yr: Rutherford et al. 1987, table 4; more recently, a global modelling study found that the load of inorganic nitrogen in rainfall in New Zealand is likely to be in the range 1–2 kg/ha/yr, compared to a global average of 3.5 kg/ha/yr: Phoenix et al. 2006, figure 1).

During 1973–74, atmospheric deposition was collected at Taupo town during 9 wet and 9 dry 24-h periods (White & Downes 1977). Concentrations of inorganic nitrogen and reactive phosphorus were determined.[1] From these, loads of about 3.7 kg N/ha/yr and 0.13 kg P/ha/yr were estimated. During 1981–82, and for several weeks in 1983, forms of nitrogen were studied in rainfall collected at two sites at Taupo (Timperley et al. 1985). In that study, rainfall was removed from the collector at weekly intervals, and filtered prior to the determination of inorganic and dissolved organic forms of nitrogen. The loads of total filterable nitrogen were estimated to be in the range 2.5–3.1 kg/ha/yr.

In this study we collected rainfall at daily intervals at three sites near Lake Taupo over a 14-month period (November 2004 to December 2005). Strictly-speaking, the design of the collectors was such that we actually collected "wet and dry deposition". However, for simplicity—and because we did not distinguish between wet and dry forms—we call this "rainfall" in this report. We determined the concentrations of dissolved and particulate forms of nitrogen and phosphorus in the rainfall samples. The quantity of rainfall was also measured. This information was used to make up-to-date estimates of the quantity of nitrogen and phosphorus entering Lake Taupo in direct rainfall.

2 Methods

Rainfall collection sites were established at three locations near Lake Taupo, as follows (see Figure 1):

- Taupo Airport, at the permanent weather station (map reference NZMS260, sheet U18, 779-689)
- near Kinloch, in a paddock at 760 Whangamata Road (T17, 656-804), and
- at the Kuratau hydrolake (T18, 467-551)[2]

A rainfall recorder has been installed at the Airport site since 1976. Temporary rainfall recorders (Davis, 0.2 mm tipping buckets) were installed at the other sites as part of this study. Purpose-built rainfall collectors were also installed at all three sites. These comprised a 150 cm diameter glass funnel feeding into a 1.25 L collection bottle, both enclosed inside a stainless steel housing. The collector was mounted on a post, with the funnel about 1.5 m above the ground.

The details of the rainfall collection and storage procedures are described in Appendix 1. Each site was visited every day at about the same time. If rain had fallen, then the collector bottle was retrieved and replaced with a new, clean bottle. The rainfall

[1] White & Downes (1977) noted (p. 349), "Most of these collections were made in a residential area where the nutrient concentrations might be higher than those expected over the open lake."

[2] The latter two sites are described in EW's databases as "Whangamata Stream @ Ramsey G rainfall, 1300_12" and "Kuratau @ Top of dam, 282_8", respectively.

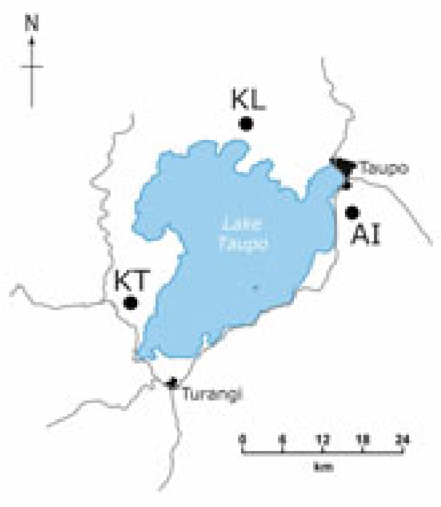

Figure 1: Location of three rainfall collection sites near Lake Taupo. AI, Airport; KL, Kinloch; KT, Kuratau.

sample was added to a 5 L "monthly composite" bottle, and frozen. At the end of each month the frozen composite sample was delivered to NIWA's Hamilton laboratory for nutrient analysis.

Various forms of nitrogen and phosphorus were determined, using high sensitivity methods specially developed for low-concentration samples (see Gibbs 2006, p. 57, for details). The following forms of nitrogen and phosphorus were measured: nitrate and nitrite nitrogen (NNN), ammoniacal nitrogen (NH_4-N), total filterable nitrogen (TFN), particulate nitrogen (PN), dissolved reactive phosphorus (DRP), total filterable phosphorus (TFP) and particulate phosphorus (PP). Dissolved inorganic nitrogen (DIN) was calculated as the sum of NNN and NH_4-N, dissolved organic nitrogen (DON) as TFN minus DIN, and dissolved organic phosphorus (DOP) as TFP minus DRP. Total nitrogen was calculated as TFN plus PN, and total phosphorus as TFP plus PP.

3 Results and Discussion

3.1 Quantity of Rainfall

Figure 2 shows the monthly rainfall totals for the three sites during the study period, with the individual values being listed in Appendix 2. At each of the sites, there was considerable variability over time, with rainfall totals being lowest in January, April and November 2005 and highest in October and December 2005. For most months, the total rainfall at each of the sites was similar, although the total at the Airport site was often lower than at the other two.

Total rainfall during 2005 was highest at the Kinloch site (1233 mm), lowest at the Airport site (948 mm) and intermediate at the Kuratau site (1171 mm). Rainfall has been monitored since 1977 at the Airport site. The average annual rainfall during 1977–2005 was 970 mm/yr, slightly higher than the total for 2005. Similarly, rainfall has been monitored since 1967 at Kuratau @ SH41, where the total for 2005, namely 1323 mm, was also close to the long-term average (= 1345 mm/yr). Rainfall during 2005 at these sites was thus within about 2% of the long-term average values. The annual rainfall totals for 2005 at the study sites were therefore probably all close to the long-term average values.

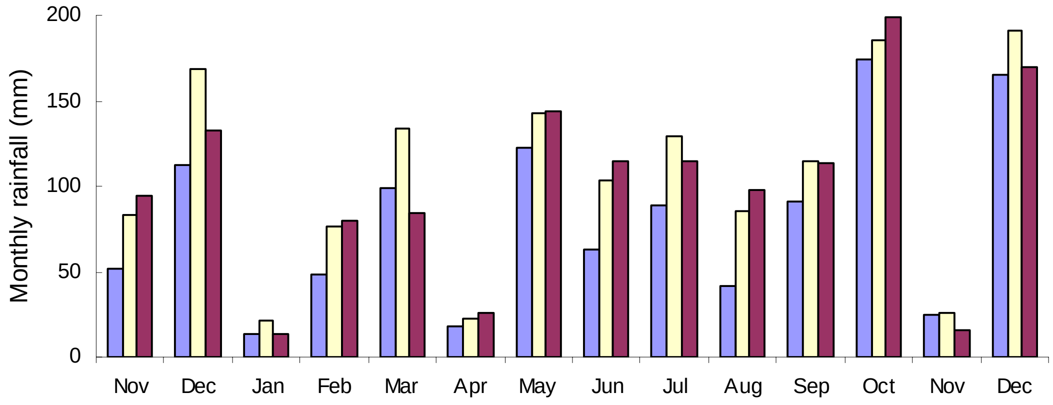

Figure 2: Monthly rainfall totals during November 2004 to December 2005 at three sites near Lake Taupo. For each month the bars are in the following order: Airport, Kinloch, Kuratau.

3.2 Nutrient Concentrations

The results of the nutrient analyses for the individual monthly composite samples from each of the sites are listed in Appendix 3. Appendix 3 also includes results for four daily samples that the site operators suspected may have been contaminated, so they were stored and analysed separately. Two of these—samples collected at Kuratau in December 2004 and February 2005—showed signs of contamination (e.g. bird faeces), and were disregarded. When compared to the results for the corresponding composite samples, the other two daily samples did not appear to have been contaminated. Their results were therefore incorporated into revised values for the relevant months. This was done by calculating weighted-average concentrations based on the volumes of the relevant composite and daily samples. The revised values are also shown in Appendix 3.

Table 1 summarises the results for the various forms of nitrogen and phosphorus found in the monthly composite rainfall samples. Concentrations varied both from month-to-month and between sites. Overall, the results for the Airport and Kuratau sites were broadly similar, but the average and maximum values for some of the forms of nitrogen and phosphorus at the Kinloch site were substantially higher. Of particular note for Kinloch were the results for NH_4-N and DON—and thus for total N, and for DRP and DOP—and thus for total P. By contrast, the minimum values at all three sites were similar. This suggests that compared to the samples from Airport and Kuratau, some of the monthly samples from Kinloch had been contaminated.[3]

During 2004–05, earthworks were undertaken at a property near the Kinloch site, as part of the development of a residential subdivision there. This may well have contributed to the elevated concentrations observed there (including the exceptionally-high values in the samples for November and December 2004). The Kinloch results will therefore not be considered further.

While in some cases the contamination of the samples was obvious (e.g. bird faeces), in other cases it may have been more subtle. This means that even some of the results for the Airport and Kuratau sites may be suspect, and may over-estimate the true values.

[3] Some of the results for the Kinloch samples for November and December 2004 were exceptionally high (Appendix 3), and were not included in the summary statistics in Table 1.

Table 1: Concentrations of dissolved and particulate forms of nitrogen and phosphorus in rainfall at sites near Lake Taupo during November 2004 to December 2005. Values are the averages of the monthly composite samples, weighted according to the quantity of rainfall falling in each month. Values in brackets are the minima and maxima. Units are mg/m^3.

	Airport		Kinloch*		Kuratau	
NNN	73	(33–209)	39	(25–127)	49	(26–162)
NH_4-N	119	(54–265)	293	(66–1460)	117	(55–330)
DON	113	(32–686)	1131	(63–5267)	171	(45–684)
PN	76	(15–189)	102	(17–3070)	110	(23–724)
Total N	380	(137–1125)	1566	(174–6037)	446	(200–1727)
DRP	14	(3–146)	139	(4–1660)	23	(3–131)
DOP	6	(2–23)	20	(1–114)	7	(<1–46)
PP	7	(2–19)	11	(1–71)	12	(2–89)
Total P	27	(7–184)	170	(7–1754)	42	(5–254)

*The values shown for DON, total N, DRP and total P at Kinloch were obtained after excluding the results for the samples collected in November and December 2004.

On average, between 37% (Kuratau) and 50% (Airport) of the nitrogen was dissolved inorganic, being either nitrate (11–19%) or ammonia (26–31%). Dissolved organic nitrogen accounted for between 30% (Airport) and 38% (Kuratau) of the nitrogen. The remaining 20–25% of the nitrogen was present as particulates.

Similarly, on average about half (52–55%) of the phosphorus was dissolved reactive P, while dissolved organic forms accounted for 17–22% of the total. The remaining 26–29% of the phosphorus was present as particulates.

Figure 3 shows the total nitrogen and total phosphorus concentrations for each of the monthly composite samples plotted against the monthly rainfall totals. At both the Airport and Kuratau sites, the highest nutrient concentrations generally occurred in months where rainfall was low. Apart from this, nutrient concentrations in the different months tended to be broadly-similar, being close to the average values shown in Table 1. That is, much of the variability in concentrations of nitrogen and phosphorus in the monthly composite samples appeared to be associated with low rainfall. In drier months there may have been more dust in the air, due to nearby soils being drier. Together with the lower rainfall, this could have caused the nutrient concentrations in the composite samples to be higher.

3.3 Nutrient Loads in Rainfall

For each site, the monthly loads of nitrogen and phosphorus in rainfall were calculated from the recorded monthly rainfall (Figure 2) and the concentrations in the corresponding composite sample (Appendix 2). Table 2 summarizes the information on the calculated loads of total nitrogen and total phosphorus.

Monthly loads of total nitrogen and total phosphorus varied during the study period by an order of magnitude or more, depending on both the amount of rainfall and the monthly average nutrient concentration. Pairwise comparison of the 14 individual monthly results for the Airport and Kuratau sites showed that the average values of the monthly loads of total nitrogen at the two sites were not statistically different (p-value = 11%); nor were the loads of total phosphorus (p-value = 18%).

Loads for calendar year 2005 were calculated by summing the relevant monthly loads. The annual load of total nitrogen at the Airport site was 3.7 kg/ha/yr, while that at the Kuratau site was about 40% higher (5.2 kg/ha/yr). And the annual load of total phosphorus at Kuratau (0.51 kg/ha/yr) was about 76% higher than that at Airport (0.29 kg/ha/yr).

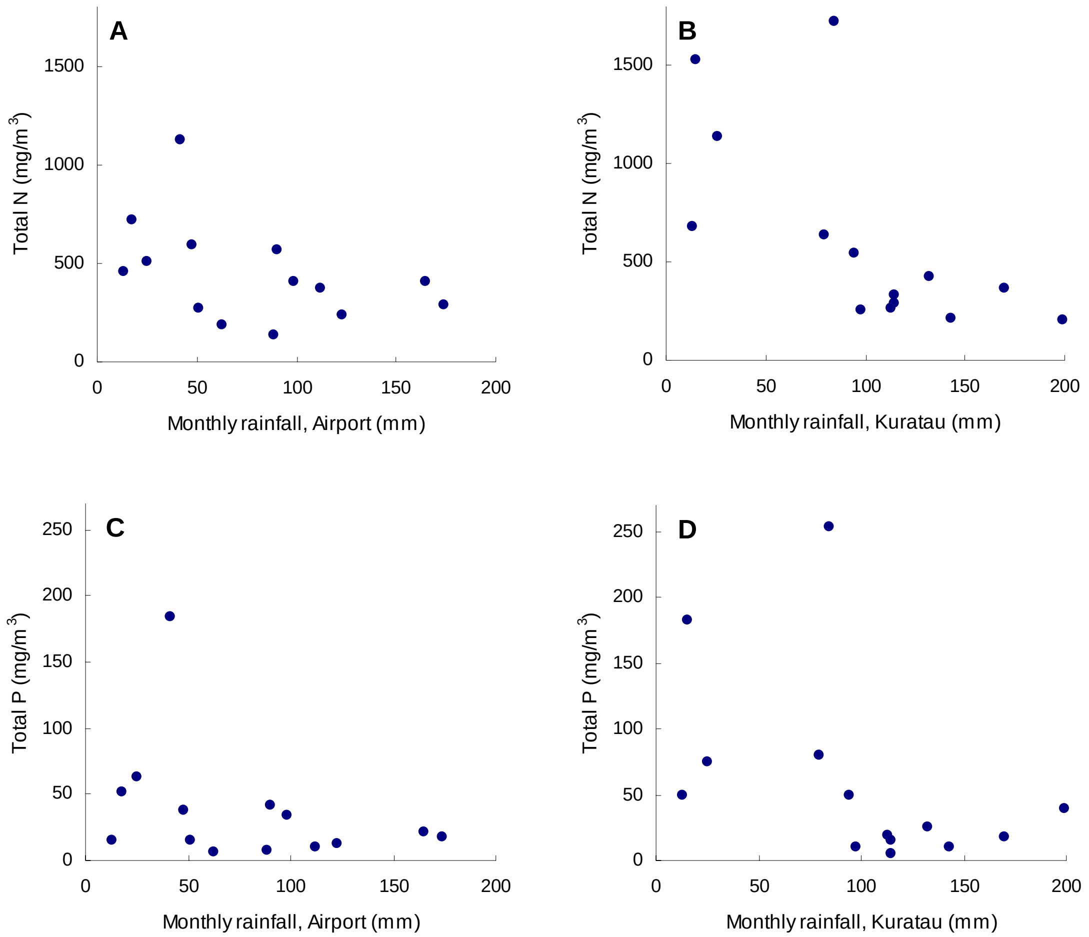

Figure 3: Total monthly rainfall and concentrations of total nitrogen in the monthly composite rainfall samples from **A**, Airport and **B**, Kuratau during November 2004 to December 2005. **C** and **D** show the corresponding results for total phosphorus.

Table 2: Minimum and maximum monthly loads of total nitrogen and total phosphorus in rainfall at two sites near Lake Taupo during 2004–05. The annual loads for 2005 are also shown.

	Airport	Kuratau
Monthly loads, Nov 04-to-Dec 05 (kg/ha)		
Total N	0.06–0.67	0.09–1.46
Total P	<0.01–0.08	0.01–0.21
Annual load, 2005 (kg/ha/yr)		
Total N	3.7	5.2
Total P	0.29	0.51

Table 3: Loads (kg/ha/yr) of dissolved and particulate forms of nitrogen and phosphorus in rainfall near Lake Taupo. Values for 1973–74 from White & Downes (1977), for 1981–83 from Timperley et al. (1985) and for 2005 from this study.

	DIN	DON	TFN	PN	DRP	DOP	PP
Taupo urban, 1973–74	3.7	–	>3.7	–	0.13	–	–
Taupo urban, 1983	2.1	1.0	3.1	–	–	–	–
Taupo airport, 1981–82	0.25	2.2	2.5	–	–	–	–
Taupo airport, 2005	1.9	1.1	3.0	0.7	0.15	0.06	0.07
Kuratau, 2005	1.9	2.0	3.9	1.4	0.28	0.09	0.14

The nitrogen and phosphorus loads for rainfall near Lake Taupo during 2005 were broadly-similar to those previously-reported for rainfall in New Zealand in general (namely 3.7 kg N/ha/yr and 0.38 kg P/ha/yr: Rutherford et al. 1987), and near Lake Taupo in particular (Table 3). The load of inorganic N at both the Airport and Kuratau sites was 1.9 kg/ha/yr, compared to an estimate of 3.7 kg/ha/yr in the Taupo urban area in 1973–74 (White & Downes 1977), and 2.1 kg/ha/yr in 1983 (Timperley et al. 1985).

The load of inorganic N determined for the Airport site for 1981–82 was just 0.25 kg/ha/yr (Timperley et al. 1985), but this was offset by a load of DON of 2.2 kg/ha/yr, compared to the load of 1.1 kg/ha/yr at this site in 2005. As a result, the load of total filterable N at the Airport site in 2005 (3.0 kg/ha/yr) was only 20% higher than that measured in 1981–82 (2.5 kg/ha/yr).

The load of reactive phosphorus at the Airport site in 2005 (0.15 kg/ha/yr) was also similar to that for the Taupo urban area in 1973–74 (0.13 kg/ha/yr). And the loads of total phosphorus at both the Airport (0.29 kg/ha/yr) and Kuratau (0.51 kg/ha/yr) sites were similar to values previously-reported for New Zealand sites, namely 0.26–0.5 kg/ha/yr (Rutherford et al. 1987).

3.4 Comparisons with Loads in Rainfall Elsewhere

Previous comparisons have shown that loads of nitrogen in rainfall in densely-populated parts of the world were typically higher—and were often much higher—than those found in New Zealand (Timperley et al. 1985, Rutherford et al. 1987, Nichol et al. 1997). This has generally been attributed to a number of factors including (1) lower use of fossil fuels in New Zealand so that emissions of nitrogen oxides are lower, (2) lower emissions of ammonia from agriculture (e.g. because of little use of feedlots), and (3) strong prevailing winds that rapidly-disperse atmospheric contaminants.

In parts of North America and Northern Europe, loads of nitrogen in rainfall are believed to currently be an order of magnitude greater than before the agricultural and industrial revolutions (Phoenix et al. 2006). In the USA, the National Atmospheric Deposition Program runs an ongoing, long-term monitoring programme for contaminants in rainfall, including nitrate and ammonia (but not organic or particulate N). Their results for 2005[4] can be compared with those from near Lake Taupo. The loads of nitrate and ammonia at the Airport and Kuratau sites were similar to those in the least-contaminated parts of the USA, namely sites in the Pacific Northwest and the Southwest. Elsewhere in the USA, loads of inorganic forms of N during 2005 were up to five times higher than those from Lake Taupo (e.g. loads of ammonia in the Midwest were four times those from Taupo, while loads of nitrate in Ohio were five times higher).

The loads of nitrogen and phosphorus in rainfall near Lake Taupo during 2005 were thus low compared to loads found in more densely-populated and industrialized parts of the world, and were similar to those first measured near the lake two-to-three decades ago.

3.5 Loads to Lake Taupo

The loads of nitrogen and phosphorus entering Lake Taupo in rainfall during 2005 can be estimated from the area of the lake (about 615 km^2) and the specific loads measured on opposite sides of the lake at the Airport and Kuratau sites. This gives loads of about 225–317 t/yr for nitrogen and 17–31 t/yr for phosphorus (or about 270 t/yr and 24 t/yr, respectively). Elliott & Stroud (2001) used somewhat lower loads of 228 t N/yr and 10.5 t P/yr. And the section 32 analysis for Environment Waikato's

[4] http://nadp.sws.uiuc.edu/isopleths/maps2005/

proposed Regional Plan variation for Lake Taupo used an average load of nitrogen in direct rainfall of 230 t/yr.[5]

To obtain more accurate estimates of the nutrient loads entering the lake in direct rainfall, a network of collectors could be moored on the lake itself. While this would reduce the risk of contamination from nearby sources, the retrieval of daily samples from the collectors would be much less straight-forward than in this study.

4 Conclusions

1. By using locally-based site operators, daily sampling of rainfall proved to be feasible throughout the 14-month study period. But to minimize analytical costs, the daily samples collected during any given month were composited.

2. A number of the samples, particularly those from the Kinloch site, appeared to be contaminated, and were disregarded. The source(s) of the contamination were often not clear, but may have included air-borne dust from nearby activities (e.g. subdivision earthworks).

3. The nutrient concentrations varied from month-to-month, with higher values often occurring in samples from drier months—possibly because conditions were dustier then. About half of the nitrogen and phosphorus was present in inorganic forms, with the remainder being organic and particulate forms.

4. The loads of nitrogen and phosphorus in rainfall at Taupo Airport during 2005 were similar to those found there in the early 1980s (and in Taupo town in the 1970s). The loads at the Kuratau site were 40–76% higher (for N and P, respectively). As previous studies have also shown, the loads measured near Lake Taupo in 2004–05 were lower than those found in more densely-populated and industrialized areas.

References

Elliott, A.H. and Stroud, M.J. 2001: *Prediction of Nutrient Loads Entering Lake Taupo Under Various Landuse Scenarios.* NIWA Client Report EVW01224. National Institute of Water and Atmospheric Research, Hamilton.

Gibbs, M.M. 2006: *Lake Taupo Long-Term Monitoring Programme 2004–2005.* Environment Waikato technical report 2006/30. Environment Waikato, Hamilton.

Nichol, S.E.; Harvey, M.J. and Boyd, I.S. 1997: Ten years of rainfall chemistry in New Zealand. *Clean Air* 3: 30–37.

Phoenix, G.K.; Hicks, W.K. ; Ineson, P.; Cinderby, S.; Kuylenstierna, J.C.I.; Stock, W.D.; Dentener, F.J.; Giller, K.E.; Austin, A.T.; Lefroy, R. and Gimen, B.S. 2006: Atmospheric nitrogen deposition in world biodiversity hotspots: the need for a greater global perspective in assessing N deposition impacts. *Global Change Biology* 12: 470–476.

Rutherford, J.C.; Williamson, R.B. and Cooper, A.B. 1987: Nitrogen, phosphorus, and oxygen dynamics in rivers. In A.B. Viner (Ed.) *Inland Waters of New Zealand.* Wellington, DSIR. DSIR Bulletin 241. pp. 139–165.

[5] See Table 1 (p. 10) of Environment Waikato 2005: Proposed Waikato Regional Plan Variation 5 – Lake Taupo catchment (proposed). Analysis of alternatives, benefits and costs under section 32 of the RMA. EW document #983579.

Timperley, M.H.; Vigor-Brown, R.J.; Kawashima, M. and Ishigami, M. 1985: Organic nitrogen compounds in atmospheric precipitation: their chemistry and availability to phytoplankton. *Canadian Journal of Fisheries and Aquatic Sciences* 42: 1171–1177.

Vant, B. and Huser, B. 2000: Effects of intensifying catchment land-use on the water quality of Lake Taupo. *Proceedings of the New Zealand Society of Animal Production* 60: 261–264.

White, E. and Downes, M.T. 1977: Preliminary assessment of nutrient loads on Lake Taupo, New Zealand. *New Zealand Journal of Marine and Freshwater Research* 11: 341–356.

Appendix 1

Procedures for site operators, November 2004

Lake Taupo Rainfall collection programme

At three sites located around Lake Taupo, samples of rainfall will be collected for a period of about 14 months, from November 2004 to the end of December 2005. Rainfall will be collected at each site at daily intervals, with the daily samples being composited to produce a single monthly sample from each site. Each sample will be analysed for dissolved and particulate forms of nitrogen and phosphorus. The results from each rainfall collection site will then be used, in conjunction with rainfall data and distribution patterns, to estimate the annual aerial contribution of nitrogen and phosphorus to Lake Taupo.

Collector design

At each rainfall collection site there is a purpose built rainfall collector with a 150 mm diameter glass funnel and a 1.25 litre collection bottle contained inside a protective stainless steel housing. This collector is mounted on a wooden post with the collector funnel at a height of 1.5 m above the ground. A 2-mm stainless steel mesh screen inside a short stainless steel collar fits over the collection funnel, to prevent large particulate matter (e.g. leaves, twigs, grit) from entering the collector.

Also attached to the wooden post are two cylindrical bottle holders. Finally, a wedge-shaped plastic rain-gauge is mounted on a second post nearby.

Sample handling

Rainfall contains very low levels of nitrogen and phosphorus, and there is a risk that samples may be contaminated during handling. Fingerprints—particularly those of smokers, along with perspiration, hair and dust could contaminate the sample. Please take care to avoid any contamination.

Procedure

1. The rainfall collector should be visited every day at about the same time. Take a new collection bottle to the collector and place it in one of the bottle holders.

2. Read the rain-gauge, and record the value to the best accuracy practical for that day on the monthly record sheet provided. Then empty the rain-gauge onto the ground.

    - IF the rainfall value is 0.5 mm or less for the previous 24 hour period, do not change the collection bottle. Just check the screen for leaves/twigs etc. and, if required, remove it and shake out the debris then replace it. Take the new collection bottle away and keep for the next visit.

    - IF the rainfall value is more than 0.5 mm for the previous 24 hour period, change the collection bottle as follows:

        (i) Remove the R-clip and the retaining bar, withdraw the used bottle, and place it in the other bottle holder.
        (ii) Take the lid from the new bottle and screw it on the used bottle.
        (iii) Take the new bottle and insert it into the rainfall collector.
        (iv) Insert the retaining bar and secure with the R-clip.

    Now check the screen for leaves/twigs etc. and, if required, shake out the debris then replace the screen. Take the used collection bottle back to base, keeping it upright.

3 The rainwater in the used collection bottle needs to be added to the large, pre-labelled composite bottle (5-litre) and frozen. This should be done as follows, taking care to avoid finger contact with the neck of either bottle:

(i) Remove the composite bottle from the freezer and dry the lid and neck area with a new paper towel before taking the lid off – place the lid up-side-down on a second new towel.
(ii) Take the used collection bottle and swirl vigorously to dissolve any salts dried on the side of the bottle and suspend any fine particulate matter.
(iii) Remove the lid and carefully pour the contents of the used collection bottle into the 5-litre composite bottle. The used collection bottle should have minimal water droplets left inside and can be inverted with its neck inside the composite bottle to drain.
(iv) Remove and discard[6] the used collection bottle.
(v) Replace the lid on the composite bottle and return it to the freezer.

The small chest freezer has been checked, and left at a setting ("6") that will provide a sufficient degree of freezing to preserve the rainfall sample. Please don't alter the setting; and don't put anything other than the collected rainfall in the freezer (because of the risk of contaminating the sample).

It is possible that in some months there will be more than 5 litres of rainwater collected. When the first 5-litre composite bottle has been filled to the shoulder[7] of the bottle, label and start one of the spare composite bottles provided ("Site, month, second bottle").

4 At the end of each month (i.e. usually on the first day of the following month), place the composite bottle(s) and the monthly record sheet in a black (= "completed") plastic bag, close the bag with a tie, and return to the freezer. During the next few weeks the frozen composite bottle(s) will be collected by EW, and taken to the analytical laboratory at NIWA, Hamilton (in a chilli-bin).

5 A new pre-labelled, 5-litre composite bottle should be started for the new month. A new monthly record sheet should also be started. Additional new, clean rainfall collection bottles will also be supplied each month.

Queries

Any queries or problems, please contact Bill Vant or Ian Buchanan, EW, Hamilton

Phone 0800 800 401 or 07 856 7184
Fax 07 856 0551
Email bill.vant@ew.govt.nz

[6] The discarded bottles should be sent to the local plastics recycler, and not reused for rainfall sample collection.

[7] Water expands as it freezes, and over filling will cause the bottle to split. As the rainwater is added incrementally and frozen an a daily basis, this should not be a problem. Do not allow the compositing bottle to thaw while adding the rainwater.

Appendix 2

Monthly rainfall totals for the three sites near Lake Taupo.

Month	Airport	Kinloch	Kuratau
Nov 04	51	83	95
Dec 04	112	168	132
Jan 05	13	21	13
Feb 05	48	76	80
Mar 05	98	134	84
Apr 05	18	23	26
May 05	123	143	143
Jne 05	63	103	115
Jly 05	89	130	115
Aug 05	42	85	98
Sep 05	91	114	113
Oct 05	174	186	199
Nov 05	25	26	15
Dec 05	165	191	170
Total 2005	948	1233	1171

Appendix 3

Concentrations of dissolved and particulate forms of nitrogen and phosphorus in monthly composite rainfall samples from three sites near Lake Taupo. Concentrations for four daily samples are also shown: underlined values were regarded as highly-contaminated and were ignored. Units are mg/m^3. The volume of each sample is shown ("vol", units mL, obtained by weighing). "rev", revised (see text).

	Vol	NNN	NH_4-N	DON	PN	TN	DRP	DOP	PP	TP
Monthly composite samples										
Airport										
Nov 04	410	73	79	87	31	270	6	4	5	15
Dec 04	1505	50	110	109	99	368	4	2	5	11
Jan 05	380	109	207	96	42	454	5	6	5	16
Feb 05	714	115	170	166	138	589	17	10	11	38
Mar 05	1350	68	81	90	166	405	8	7	19	34
Apr 05	226	209	265	201	46	721	29	15	7	51
May 05	1619	60	98	64	16	238	8	3	2	13
Jne 05	920	44	62	63	15	184	3	2	2	7
Jly 05	2046	33	54	32	18	137	3	2	2	7
Aug 05	694	70	222	686	147	1125	146	23	15	184
Sep 05	1257	107	131	192	139	569	14	11	17	42
Oct 05	2421	46	129	61	49	285	10	4	4	18
Nov 05	268	128	71	121	189	509	39	7	17	63
Dec 05	2379	104	158	77	65	404	9	6	6	21
Kinloch										
Nov 04	914	43	1460	>8600	3070	>13000	1660	60	34	1754
Dec 04	2188	43	1190	>8130	1072	>10000	1460	80	34	1574
Jan 05	209	127	519	2974	305	3925	574	32	36	642
Feb 05	694	92	915	1663	323	2993	179	31	50	260
Mar 05	1800	38	133	476	135	782	66	15	9	90
Apr 05	185	114	230	4946	273	5563	696	45	25	766
rev Apr 05	*280*	*85*	*204*	*5267*	*481*	*6037*	*560*	*114*	*71*	*745*
May 05	1891	37	162	411	17	627	13	9	2	24
Jne 05	1403	29	198	468	34	729	60	5	1	66
Jly 05	1700	34	833	3793	163	4823	526	39	9	574
Aug 05	1062	26	698	4596	250	5570	565	97	19	681
Sep 05	1386	27	68	180	45	320	17	4	4	25
Oct 05	2703	25	66	63	20	174	4	1	2	7
Nov 05	255	93	204	255	392	944	26	10	64	100
Dec 05	2391	56	189	95	49	389	12	8	6	26
Kuratau										
Nov 04	1277	69	172	235	69	545	30	10	9	49
Dec 04	1927	55	119	155	94	423	10	6	10	26
Jan 05	500	63	125	155	334	677	17	15	18	50
Feb 05	791	40	148	359	91	638	62	8	10	80
Mar 05	907*	59	405	866	619	1949	182	24	69	275
rev Mar 05	*1358*	*41*	*280*	*684*	*721*	*1727*	*131*	*34*	*89*	*254*
Apr 05	105	100	330	600	108	1138	25	37	13	75
May 05	2069	31	70	91	24	216	6	2	2	10
Jne 05	1400	26	88	153	26	293	7	6	3	16
Jly 05	1713	41	81	185	23	330	3	<1	2	5
Aug 05	1490	32	100	81	41	254	5	2	4	11
Sep 05	1425	34	55	73	102	264	4	4	11	19
Oct 05	2972	31	65	45	59	200	30	4	5	39
Nov 05	163	162	320	324	724	1530	50	46	87	183
Dec 05	1829	98	130	60	73	361	8	5	5	18
Daily samples not composited										
KL, Apr 05	94	29	153	5898	891	6971	293	249	161	704
KT, Dec 04	300	50	16000	>22600	1203	>40000	19000	400	109	19510
KT, Feb 05	348	59	194	1557	687	2497	184	68	53	305
KT, Mar 05	451	5	30	318	928	1281	27	54	131	212

* Includes a daily sample of 210 mL from April 2005 that was inadvertently added to the March composite bottle. It has not been possible to adjust the results for either March or April samples for this.