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Monday 25th August 2014

MEMO: Nutrient Budgets for Lake Tarawera

Background

Bay of Plenty Regional Council (BoPRC) requires a nutrient budget to underpin an 'Action Plan' for Lake Tarawera. This lake receives water, either directly or indirectly, from seven smaller lakes of the Rotorua region. Therefore, estimates of the total nutrient load to Tarawera using land use nutrient export rates must consider:

1) Nitrogen (N) and phosphorus (P) loads from within the immediate (surface topographical) catchment of the lake.
2) Additional load received from the connected smaller lakes, including the volume and quality of discharge.
3) The degree to which nutrient loads are attenuated prior to reaching Tarawera.

Catchment nutrient budgets have been calculated for several previous studies.

1) Hamilton et al. (2006) estimated total loads to Lake Tarawera using areal land use export rates for Tarawera and the seven smaller lakes. For the smaller lakes, an attenuation coefficient was applied to account for net retention of nutrients and the position of each lake on the landscape (i.e., whether it connected via another lake to Lake Taawera or had a direct connection via groundwater or surface water). The budget of Hamilton et al, (2006) is reproduced in Appendix 1. From that report estimated loads for the immediate Tarawera catchment were 51.2 t N $y^{-1}$and 6.0 t P y^{-1}. Estimated loads for the entire catchment, including all contributing lakes, were 84.6 t N y^{-1} and 10.4 t P y^{-1}.

2) BoPRC (2012) estimated loads to Lake Tarawera using areal export rates only for the surface topographical catchment which connected directly to the lake. The budget from BoPRC (2012) is reproduced in Appendix 2. Estimated loads for the immediate Tarawera catchment were 64.1 t N y^{-1} and 5.3 t P y^{-1}. No estimate was made for the whole catchment using the areal method.

3) Verburg et al. (2013, unpubl. draft): utilised the model CLUES (NIWA) to provide an alternative estimate of total load to Lake Tarawera. Estimated loads for the catchment were 36.9 t N y^{-1} and 7.1 t P y^{-1}. It is likely that CLUES excludes any nutrient loads from many of the smaller lakes due to lack of connectedness to Tarawera under the REC classification for streams and lakes used.

From the above studies it can be seen that there is considerable variation in estimates of loads and methodologies to estimate nutrient loads to Lake Tarawera. This is due to differences in assumed areal export rates and catchment boundaries, as well as the complex hydrology (i.e. assumed connectedness of smaller lakes) to Tarawera.

As an alternative to the areal export rate method, several nutrient budgets for lakes in the BoP region have used a Vollenweider (1975) style 'mass balance' approach to estimate total loads. This has the advantage of not requiring prior knowledge of the nutrient source(s). However, it is highly dependent on estimates of lake-water nutrient concentrations, hydrological residence time, and assumed annual retention coefficients for N and P. Estimation of N retention is uncertain relative to estimates for P, and particularly complicated where N-fixation may occur (as has been observed in Tarawera; Baldwin 2009).

This memo seeks to briefly evaluate the robustness of methods to estimate nutrient loads, the values used, and to provide a revision of those estimates where appropriate.

Methods

1) The monitoring record for N and P in Lake Tarawera were visually assessed. Rapid changes in water quality need to be considered when estimating catchment load by mass balance methods, which are highly dependent on lake water concentrations and assume steady-state conditions in the lake. Implications for TLI and target TLI were considered.
2) Assessment and revision of areal rates used for calculating catchment load. An alternative approach to estimate the load from the smaller lakes was tested, using modelled lake outflow and measured water column nutrient concentrations to estimate load (as opposed to catchment areal loads with attenuation, as in Hamilton et al 2006).
3) Assessment of the values used for the mass balance estimate given in BoPRC (2012). A revised estimate was also produced.

Results and Discussion

Monitoring data

Figure 1 presents the long term monitoring record for TN and TP for all depths in Lake Tarawera. A slight increase in TN and TP is evident between 1994 and 2008 (Scholes, 2010). Since 2009, an abrupt decrease in TN and increase in TP has been observed. Further, variability of TN measurements appears markedly reduced. These changes occur simultaneously with a change in labs and methods in late 2008/early 2009 (A. Spence, BOPRC, pers. comm.). Current analyses are performed in-house at BoPRC, in an iANZ accredited lab, and quality control/quality assurance procedures are more robust than previous years. The BoPRC lab performs well in domestic and international inter-laboratory comparison tests, and this suggests a greater level of confidence can be placed in current analytical procedures and results (A. Spence and P. Baraclough, pers. comm.). These aspects suggest that nutrient results prior to 2009 may not be properly representative of actual concentrations and that this may have resulted in target TLI and nutrient concentrations that cannot be compared with those based on nutrient methods currently used.

The TLI target for Tarawera is 2.6, and BoPRC 2012 has indicted that this is based on 1990s' water quality. According to the available data, whole water column TN and TP concentrations for 1990–1999 were approximately 8.5 mg P m^{-3} and 110 mg N m^{-3}, equivalent to a TLp of 2.96 and TLn of 2.53, respectively. Whole water column averages for 2009 – 2012 of 20 mg P/m^3 and 76 mg N m^3 are equivalent to TLp of approximately 4 and TLn of 2. This disparity suggests that productivity in Lake Tarawera may be highly N-limited. The high relative abundance of cyanobacteria observed in Tarawera and occasional blooms, is consistent with N-limitation, despite relatively high water quality.

Mean water column TN and TP concentrations are given in BoPRC (2012) as 112.3 mg N m^{-3} and 10.2 mg P m^{-3} (1999-2011 data). However, mean water column TN and TP concentrations for the period 2009 – 2014 were approximately 76 mg N m^{-3} and 20 mg P m^{-3}. Therefore, in light of questions around analytical results prior to 2009 (summarised above) we strongly suggest that the nutrient values used for setting TLI targets, and mass balance estimates be reconsidered.

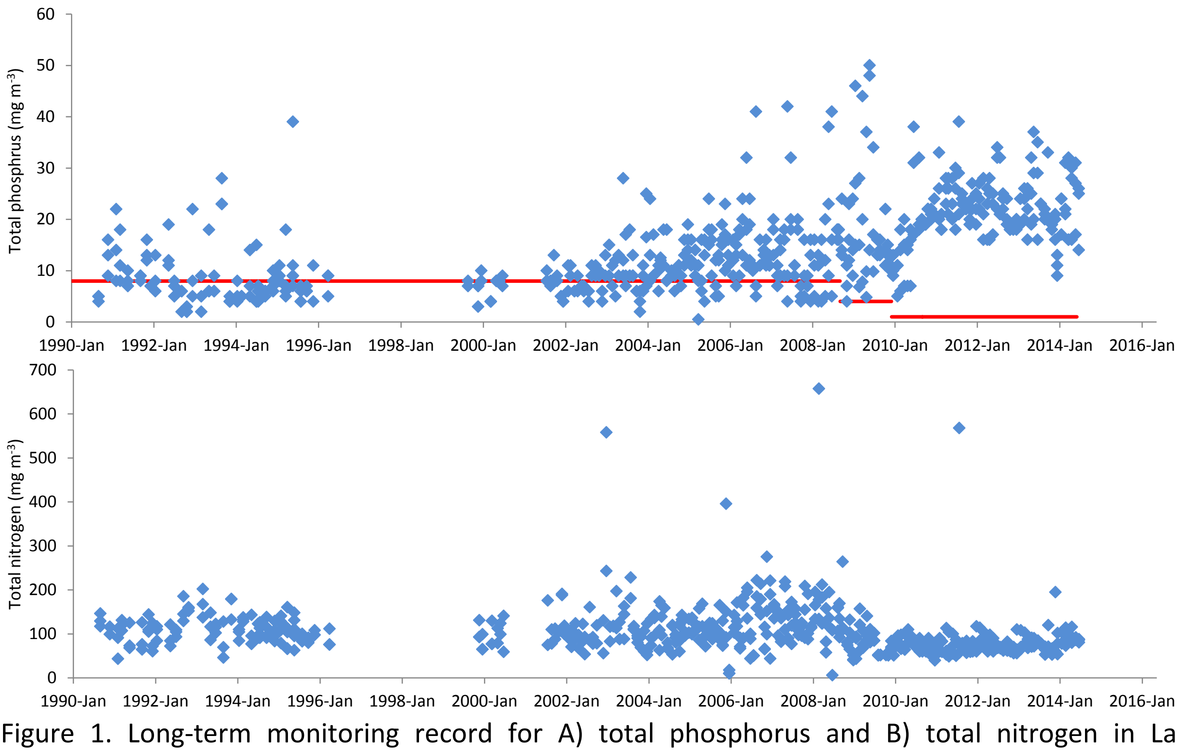

Figure 1. Long-term monitoring record for A) total phosphorus and B) total nitrogen in Lake Tarawera. Data from BOPRC, courtesy of Paul Scholes. The red line represents historical detection limits for total phosphorus. The step changes in the line represent a change of lab.

Areal catchment load estimates

Immediate surface catchment.

The areal load estimate for the immediate Tarawera catchment from BoPRC (2012) is reproduced in Appendix 2. Recent literature searches by UoW have suggested some revision of estimates of export rates are required for some land uses, particularly native and exotic forest, which are the dominant land uses in the Tarawera catchment. Table 1 gives a revised estimate of load for the surface topographical catchment. Despite differences in areal nutrient loss coefficients for different land uses, the revised catchment load differs only slightly from estimates of BoPRC (2012).

Table 1. Revised land use nutrient export rates and catchment loads for the immediate surface topographical catchment of Tarawera, adapted by UoW, from BoPRC (2012).

Land cover	Area	% area	kg P yr^{-1} ha^{-1}	kg N yr^{-1} ha^{-1}	kg P yr^{-1}	kg N yr^{-1}	%P	%N
Bare ground	279.5	1.9	1	5	279.5	1397.5	5.3	2.2
Exotic forest	1524.4	10.5	0.18	2.81	274.4	4283.6	5.2	6.7
Native forest	6421	44.4	0.12	3.67	770.5	23565.1	14.7	36.7
Mixed scrub/pasture	136.6	0.9	0.5	5	68.3	683.0	1.3	1.1
Mixed sheep/beef/deer	1725.9	11.9	1	10	1725.9	17259.0	32.9	26.9
Beef	81.1	0.6	1	15	81.1	1216.5	1.5	1.9
Horse/lifestyle/grazing	21.1	0.1	0.8	8	16.9	168.8	0.3	0.3
Recreational area	50	0.3	4	14	200.0	700.0	3.8	1.1
Wetlands	0.1	0.0	0	0	0.0	0.0	0.0	0.0
Urban built	93.5	0.6	0.7	3	65.5	280.5	1.2	0.4
Septic tanks (291pp)	n/a	n/a	n/a	n/a	1062.2	106.2	20.2	0.2
Rainfall to lake	4138.8	28.6	0.17	3.5	703.6	14485.8	13.4	22.6
Totals	**14472**	**100**			**5248**	**64146**	**100**	**100**

Additional load from small lakes.

The additional load to Tarawera from Lakes Okareka, Okataina, Rerewhakaaitu, Okaro, Rotomahana, TIkitapu, and Rotokakahi was estimated by Hamilton et al. (2006) to be 33.5 t N y^{-1} and 4.4 t P y^{-1}. These loads were calculated by areal nutrient export rates in the small lakes, with attenuation factors applied.

Verburg et al. (2013 unpubl.) estimates annual loads for outflows from all Rotorua lakes by multiplying annual average water column nutrient concentrations by modelled lake outflow volumes (Woods et al. 2006). This allows the estimation of additional load to Tarawera from all other lakes. Loads from Lakes Rerewhakaaitu and Okaro were not considered because they are assumed to flow to Tarawera via intermediary lakes and to otherwise have negligible effect. It should also be noted that the method assumes no attenuation between the 'tributary' lake output and the input to Lake Tarawera, i.e. via stream or groundwater flow (some attenuation or loss is possible, especially where the flow is via groundwater). Further, outflow loads are based on long-term averages and may be subject to analytical uncertainties summarised above.

Table 2. Total lake loads, calculated from the updated Tarawera catchment load (from Table 1) plus outgoing loads from "tributary lakes" as calculated by Verburg (2013 unpubl).

Load	t N y^{-1}	t P y^{-1}	Source	Notes
Tarawera catchment	64.146	5.248	BoP 2012	Table 1 modified by C McB
Buried village septic	0.1825	0.01825	McIntosh 2012	50pp
Okareka	3.4	0.11	Verburg (unpubl. 2013)	Mean lake conc * outflow
Rotokakahi	3.5	0.19	Verburg (unpubl. 2013)	
Tikitapu	0.5	0.01	Verburg (unpubl. 2013)	
Rotomahana	18.2	2.53	Verburg (unpubl. 2013)	Includes loads from Okaro and Rerewhakaaitu implicitly
Okataina	10.5	0.63	Verburg (unpubl. 2013)	
	100.4285	**8.73625**		

Table 2 includes an additional load from five lakes and the buried village septic tank (i.e. total load minus Tarawera catchment) of 36.3 t N y^{-1} and 3.45 t P y^{-1}. These estimates are in very good agreement with those of Hamilton et al. (2006), although slightly lower for TP.

Mass balance calculations

Table 3 (taken from BoPRC 2012) gives a mass balance nutrient budget For Lake Tarawera. For this method, total catchment load is estimated from in-lake nutrient concentrations (median annual average from 1999 to 2011; Scholes 2011), average hydraulic loading, and assumed attenuation coefficients for N and P (in this case assumed to be the same for N and P, = 0.57 retained). The estimated catchment load is highly sensitive to these values, therefore, the numbers used require careful consideration.

Table 3. Mass balance estimates of whole-catchment N and P loads. From BoPRC (2012)

lake concentration mg/m^3	10.59	112.32		C
	land	**lake**	**total**	
Lake volume (m^3)		2273700000		
Area (ha)	10833	4138.8		
flow (l/sec)	10.7			
flow/yr(m^3)			337435200	**Q**
Hydraulic loading (Q/lake area A) (m/yr)			8.2	**Q/A**
Retention R (15/(18+Q/A))			0.57	**R**
	TP	**TN**		
M=CQ/(1-R) kg/yr	8379	88875		**M**

M = Total load to lake

C = lake concentration: TN of 112.32 mg m^{-3} is considerably higher, and TP of 10.59 mg m^{-3} is considerably lower, than monitoring data post-2009 (full water column TN ≈ 75 mg m^{-3} and TP ≈ 20 mg m^{-3}). For example, all else being equal, a doubling of the value used for TP will result in a doubling of estimated TP load (see table 4).

Q = Hydraulic load:

The value used for hydraulic discharge in Table 3 is 10.7 m^3 s^{-1}. This comprises the measured outflow long-term average of 6.7 m^3 s^{-1}, with an additional 4 m^3 s^{-1} added, with the justification:

> "Recent groundwater investigations (White et al. 2010) have provided an estimate of groundwater flow from the catchment of the Tarawera group of lakes. An additional 4 $m^3 s^{-1}$ is added to the surface discharge so that the average annual discharge from the Tarawera group of lakes is 10.7 $m^3 s^{-1}$. This flow rate is used in the calculation of nutrient loads as there is a large discharge of water to Lake Tarawera from the contributing catchments of several other lakes (Okataina, Okareka, Tikitapu, Rotokakahi, Rotomahana, Okaro, part of Rerewhakaaitu), which makes the calculation of a water balance from rainfall data difficult." (BoPRC 2012; p.5)

The suggestion that the entirety of this additional groundwater loss from the Tarawera group of lakes occurs via input into Lake Tarawera itself and subsequent loss from the lake by groundwater, requires further justification. This assumption (i.e. elevated hydraulic load), strongly influences the catchment load estimation. True hydraulic load to Tarawera may be substantially lower than 10.7 $m^3 s^{-1}$ and we suggest it is closer to 6.7 $m^3 s^{-1}$.

R = Retention coefficient:
BoPRC (2012) uses the method of Nurnberg (1984) to estimate the retention coefficient (R_{pred}) for TP of 0.57, and assumes equal retention for TN. Verburg (2013, unpubl.) notes that Nurnberg's equation had not been accepted universally, and performs poorly for the Rotorua lakes, particularly for TN. Furthermore, the value of 0.57 is derived using Q = 10.7 $m^3 s^{-1}$ (see above). For comparison, using the Vollenweider (1975) method (preferred by Verburg 2013, unpubl.), a revised method for TN (author's unpubl. data), and Q = 6.7 $m^3 s^{-1}$, estimates are obtained for R_{pred} N of 0.7 and for R_{pred} P of 0.77.

Using the above numbers, one can obtain the revised catchment nutrient load estimates shown in Table 4. The large differences between the loads of Tables 3 and 4 highlight the uncertainty of these methods in the case of Lake Tarawera. Furthermore, the recently observed strong N limitation in Tarawera may mean that nutrient retention processes and rates are unusual compared with the diverse lakes and reservoirs used to derive the equations upon which the mass balance methods are based.

Table 4. Estimated catchment loads for TN and TP, based on alternative values to those used by BoPRC (2012).

	Land	**Lake**	**Total**
Lake volume (m^3)		22737000000	
Area (ha)	10833	4138.8	
Flow (m^3/s) lake outlet	6.7		
Hydraulic load (m^3/y) Q			211435920
Hydraulic load Q/A (m/y)			5.11

	TP	**TN**
Lake concentration (mg/m^3)	20	76
Retention (R_{pred})	0.77	0.7
Estimated load M (kg/y)	**18386**	**53564**

Conclusions

Lake Tarawera is hydrologically complex, and unusual in the dominance of TN:TP compared with other lakes in the Rotorua region and indeed lakes globally. Uncertainty in historical nutrient concentrations further complicates estimates of catchment load by mass balance equations. Recent monitoring data show TP levels are highly elevated relative to other variables of trophic state. This means that N-fixation or increases in external catchment N load will likely result in a deterioration of water quality as a result of stimulation of increased phytoplankton production. The sources and drivers of the observed high TP, be they from external or internal (sediment) sources, warrant further investigation. We recommend that the regular sampling programme of T. Beckett (residence and Lake Tarawera Ratepayers' Association committee member) be examined in detail to better understand relationships of land use and nutrient load.

Mass balance catchment load estimates presented in BoPRC (2012) were derived using nutrient concentrations from before the observed dramatic increase in TP and decrease in TN after 2009. They are also subject to a high degree of uncertainty in both hydraulic loading and nutrient retention. Therefore, the nutrient reduction targets calculated in BoPRC (2012) should no longer be considered to accurately represent the management needs of the total Tarawera catchment.

We recommend that the TLI target for Lake Tarawera be reconsidered in the context of recent monitoring data and uncertainty in historical measurements.

Although previous areal estimates of catchment load appear robust compared with literature values, there was poor agreement between the areal and mass balance methods. The observed TP increase to values c. 20 mg P m^{-3} suggests that TP load to Lake Tarawera may be much higher than previous estimates. Contributions from the 'tributary' lakes represent a substantial portion of the total nutrient load to the lake and need to be considered in the Tarawera nutrient budget and targets. For example, there have been recent periods of highly elevated TP concentrations in Lake Rotokakahi and these could be expected to have impacted upon nutrient loads and water quality of Lake Tarawera.

A detailed analysis of all available data (nutrients, chlorophyll, oxygen profiles, monitoring buoy), both in-lake and from stream inflows, might help elucidate the sources and drivers of lake nutrient concentrations. The extent to which climatic variability may have driven changes in TP should also be considered. Nevertheless, Lake Tarawera appears to require a substantial reduction in TP load. Management should focus on reducing sources of P to the lake, concurrently with ensuring that increases in TN, which could drive further water quality decline, do not occur.

NOTE Added Bruere after memo: Table 1 results for septic tanks are incorrect. Replace with:

Septic tank loads= 2829Kg N, 283 Kg P, 4.2% and 5.4 % N and P respectively,
283 Kg P = 24% of draft P target reduction.

References

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Appendix 1: Nutrient budget for Lake Tarawera using areal export rates for N and P. From Hamilton et al. (2006). Yields are from Maneer, et al (2005), and based on soil type, slope, grazing intensity for pastoral land use. Morphometry, sub-catchment areas and land use for Lake Tarawera were obtained from regional council records (Hamilton et al, 2006).

Lake	Land Use	Land use	Catchment area		Nutrient yields		Nutrient load		Factor	Tarawera input	
		%	ha	km^2	($tN/km^2/yr$)	($tP/km^2/yr$)	N (t/yr)	P (t/yr)		N (t/yr)	P (t/yr)
Tarawera	Native forest	62.53	6361.31	63.61	0.250	0.04	15.903	2.545	1.00	15.903	2.545
	Exotic forest	15.74	1601.26	16.01	0.250	0.04	4.003	0.641	1.00	4.003	0.641
	Pasture (mixed)	17.96	1827.11	18.27	0.700	0.100	12.790	1.827	1.00	12.790	1.827
	Urban	0.96	97.66	0.98	0.290	0.066	0.283	0.064	1.00	0.283	0.064
	Septic tanks (104 houses x 2.8 occupancy)						1.063	0.204	1.00	1.063	0.204
	Bare ground	2.81	285.87	2.86	0.25	0.05	0.715	0.143	1.00	0.715	0.143
	Lake/rainfall		4138.56	41.39	0.396	0.0148	16.389	0.613	1.00	16.389	0.613
	Total	100.00	10173.21	101.73			50.431	5.893		51.146	6.036
Okareka	Pasture/Grassland	37.96	613	6.13	0.7	0.1	4.291	0.613	0.33	1.416	0.202
	Native forest	42.91	693	6.93	0.25	0.04	1.733	0.277	0.33	0.572	0.091
	Exotic forest	7.80	126	1.26	0.25	0.04	0.315	0.050	0.33	0.104	0.017
	Scrub mixed	4.64	75	0.75	0.25	0.04	0.188	0.030	0.33	0.062	0.010
	Mixed woody vegetation	2.72	44	0.44	0.25	0.04	0.110	0.018	0.33	0.036	0.006
	Wetlands	0.31	5	0.05	0	0	0.000	0.000	0.33	0.000	0.000
	Septic tanks (288 houses, 2.3 occupancy)						2.418	0.464	0.33	0.798	0.153
	Urban	2.85	46	0.46	0.29	0.066	0.133	0.030	0.33	0.044	0.010
	Bare ground	0.80	13	0.13	0.25	0.05	0.033	0.007	0.33	0.011	0.002
	Lake/rainfall		334	3.34	0.396	0.0148	1.323	0.049	0.33	0.436	0.016
	Total	100.00	1615	16.15			10.542	1.538		3.479	0.508
Okaro	Sheep/beef	66.45	237.5	2.375	0.7	0.11	1.663	0.261	0.109	0.181	0.028
	Deer	11.9	42.8	0.428	0.6	0.15	0.257	0.064	0.109	0.028	0.007
	Dairy	10.7	38.3	0.383	1.5	0.18	0.575	0.069	0.109	0.063	0.008
	Exotic forest	5.6	19.9	0.199	0.25	0.04	0.050	0.008	0.109	0.005	0.001
	Scrub	3.7	13.2	0.132	0.25	0.04	0.033	0.005	0.109	0.004	0.001
	Wetland	0.45	1.4	0.014	0	0	0.000	0.000	0.109	0.000	0.000
	Other	1.2	4.3	0.043	0.25	0.04	0.011	0.002	0.109	0.001	0.000

	Lake/rainfall		32	0.32	0.396	0.0148	0.127	0.005	0.109	0.014	0.000
	Total	100	357.4	3.574			2.714	0.414		0.296	0.122
Rotokakahi	Pasture	27.8	547.94	5.48	0.7	0.1	3.836	0.548	0.330	1.266	0.181
	Native forest	25.7	506.55	5.07	0.25	0.04	1.266	0.203	0.330	0.418	0.067
	Exoic forest	46.5	916.52	9.17	0.25	0.04	2.291	0.367	0.330	0.756	0.121
	Septic (50 pp @ Buried Village)						0.183	0.035	1.000	0.183	0.035
	Lake/rainfall		433	4.33	0.396	0.0148	7.805	0.292	0.330	2.576	0.096
	Total	100	1971.00	19.71			15.381	1.444		5.198	0.500
Okataina	Native forest	84.7	5066.75	50.6675	0.25	0.04	12.667	2.027	0.330	4.180	0.669
	Exotic forest	5.7	340.974	3.40974	0.25	0.04	0.852	0.136	0.330	0.281	0.045
	Pasture	9.6	574.272	5.74272	0.7	0.1	4.020	0.574	0.330	1.327	0.190
	Septic (30 pp @ lodge)						0.110	0.021	0.330	0.036	0.007
	Lake/rainfall		1173	11.73	0.396	0.0148	4.645	0.174	0.330	1.533	0.057
	Total	100	5407.73	54.0773			22.294	2.932		7.357	0.968
Tikitapu	Native forest	79.2	492.62	4.926	0.25	0.04	1.232	0.197	0.330	0.406	0.065
	Exotic forest	17.3	107.61	1.076	0.25	0.04	0.269	0.043	0.330	0.089	0.014
	Pasture/ grassed recreation	3.5	21.77	0.218	0.7	0.1	0.152	0.022	0.330	0.050	0.007
	Septic (545 @ camp ground)						1.995	0.382	0.330	0.654	0.131
	Lake/rainfall		144	1.44	0.396	0.0148	0.570	0.006	0.330	0.188	0.002
	Total	100	622	6.22			2.406	0.303		0.794	0.100
Rotomahana	Pasture	41.4	3446.55	34.4655	0.7	0.1	24.126	3.447	0.330	7.962	1.137
	Native forest	42.7	3554.78	35.5478	0.25	0.04	8.887	1.422	0.330	2.933	0.469
	Exotic forest	14.1	1173.83	11.7383	0.25	0.04	2.935	0.470	0.330	0.968	0.155
	Unassigned (wetlands etc.)	1.8	149.85	1.4985	0.25	0.04	0.375	0.060	0.330	0.124	0.020
	Lake/rainfall		902	9.02	0.396	0.0148	3.572	0.133	0.330	1.179	0.044
	Total		8325	83.25			39.894	5.531		13.165	1.825
Rerewhakaaitu	Native forest	6.2	229.15	2.2915	0.25	0.04	0.573	0.092	0.054	0.031	0.005
	Exotic forest	14.7	543.31	5.433	0.25	0.04	1.358	0.217	0.054	0.074	0.012
	Pasture	76.7	2834.83	28.348	1.5	0.18	42.522	5.103	0.054	2.315	0.278
	Wetlands	1.4	51.74	0.517	0	0	0.000	0.000	0.054	0.000	0.000
	Urban	1	36.96	0.37	0.29	0.066	0.107	0.024	0.054	0.006	0.001
	Septic (estimate 250 people)						0.913	0.175	0.054	0.050	0.010
	Lake/rainfall		517	5.17	0.396	0.0148	2.047	0.077	0.054	0.111	0.004
	Total	100	3696	36.96			47.521	5.688		2.587	0.310
Grand total										**84.62**	**10.41**

Appendix 2. Nutrient budget for the immediate surface topographical catchment of Lake Tarawera, reproduced from BoPRC (2012).

	Area	Rate of P loss	Rate of N loss	P Load	N Load
	ha	kg/ha/yr	kg/ha/yr	kg/yr	kg/yr
Bare Ground	279.5	0.5	3	140	839
Exotic Forest	1524.4	0.4	4	610	6098
Indigenous Forest	6421.0	0.28	3	1798	19263
Mixed scrub/pasture	136.6	0.5	5	68	683
Mixed sheep/beef/deer	1725.9	1	10	1726	17259
Beef	81.1	1	15	81	1217
Horse/lifestyle grazing	21.1	0.8	8	17	169
Recreation/other grass	50.0	0.3	4	15	200
wetland	0.1	0	0	0	0
Urban built (stormwater)	93.5	0.8	8	75	748
septic tanks (3.65 kgN/p/yr, 0.37 kfP/p/yr)	291	people		106	1062
Rainfall on lake	4138.8	0.15	4	621	16555
Total	14763.0			**5256**	**64092**