ENVIRONMENT BAY OF PLENTY

ESTIMATE OF THE GEOTHERMAL NUTRIENT INPUTS TO TWELVE ROTORUA LAKES

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Environment Bay of Plenty

Estimate of the Geothermal Nutrient Inputs to Twelve Rotorua Lakes

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1. INTRODUCTION

Among recent concerns that have been expressed to Environment Bay of Plenty (EBOP) is that of the potential effects geothermal inflows may be having on the water quality of the Rotorua lakes. In response to this concern EBOP commissioned Bioresearches to collate and review existing information on geothermal inflows to twelve of the Rotorua lakes. These lakes, the location of which is shown in Figure 1, include Rotorua, Tarawera, Rotoiti, Okataina, Rotomahana, Rotoma, Rotoehu, Rerewhakaaitu, Rotokakahi, Okareka, Tikitapu and Okaro.

Examination of existing information indicates that in general there is a paucity of detailed information, such as flow, quality and origin, of potential geothermal inflows to a number of the Rotorua lakes.

To ensure that only geothermal inflows or surface water inflows containing geothermally derived constituents to the Rotorua lakes were addressed, the characteristics of geothermal inflows likely to be present in the Rotorua area are described. These characteristics were then applied to information available on inflows to these twelve lakes and the geothermal inflows identified. The information available on each of these inflows was then examined to determine whether any particular inflow had the potential to affect the water quality of the lake into which it discharged. As geothermal waters generally contain high concentrations of phosphorus and nitrogen, and such nutrients have the potential to adversely affect the quality of water in lakes, in this assessment emphasis was placed on determining the relative contribution geothermal waters make to the overall nutrient input budgets of the Rotorua lakes.

In this report the basic characteristics of each of the lakes are presented along with information on catchment land cover and nutrient input budgets. These data are based on a nutrient budget assessment of the Rotorua lakes undertaken by Bioresearches in 1991 (Reference 1 -6).

Where the lake has been identified as being influenced by geothermal inflows and these have been identified, then these inflows have been located and characterised, and their relative contribution in terms of nutrient inputs have been estimated.

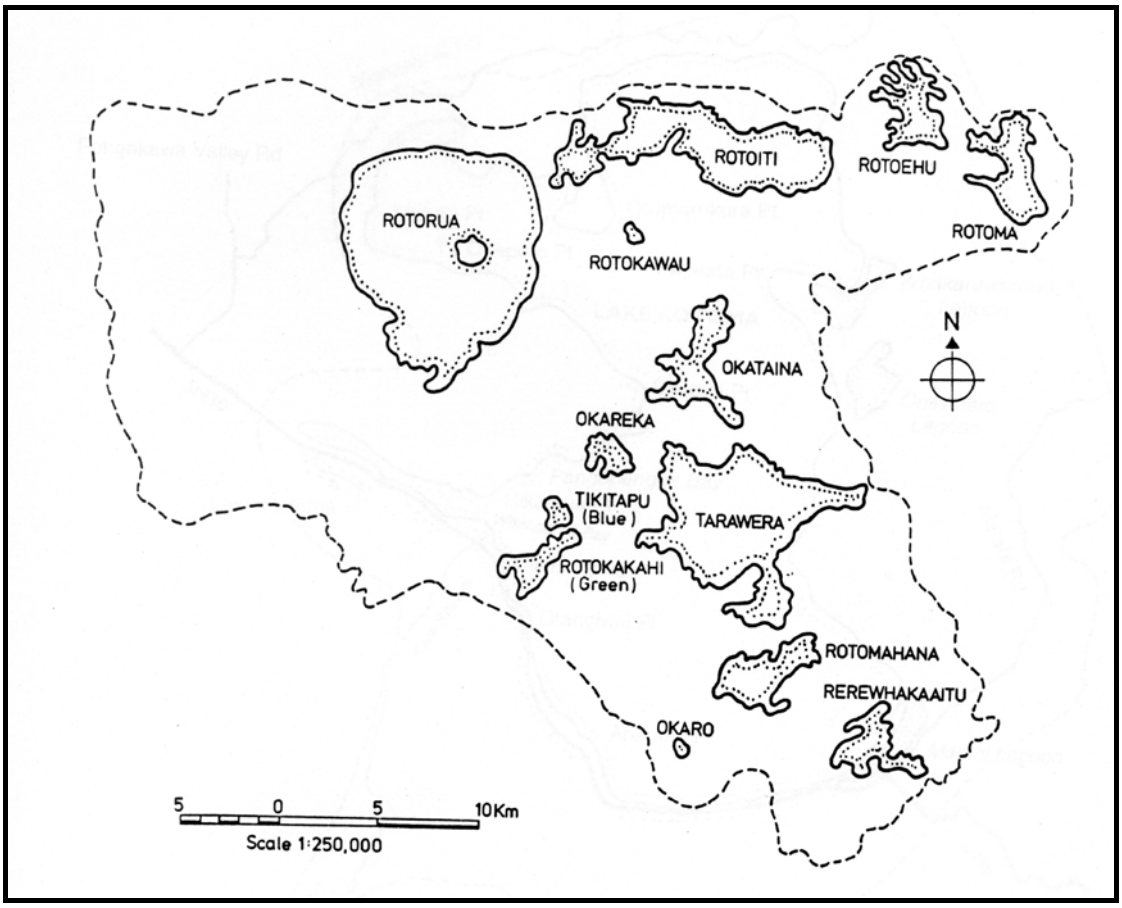

FIGURE 1 Rotorua Lakes

In a number of situations geothermal spring inflows to the lakes have been identified, however no flow data are available. To enable a nutrient budget to be derived, the flow of these springs has been estimated to be in the mid-range of flows of springs within the Rotorua lakes area. Also in the absence of data on the total nitrogen (TN) concentration of a number of inflows, the TN concentration for an inflow was calculated using the sum of total nitrogen oxides (TOXN) and total kjeldahl nitrogen (TKN) data. These data were obtained by Environment BOP over the period 1992 - 1995 (Appendix 6.2).

2. PRINCIPAL CHARACTERISTICS OF GEOTHERMAL WATERS

2.1 Introduction

Geothermal waters may be defined as waters that have been heated within the Earth. These waters differ chemically and physically from groundwater, have a wide temperature range and may occur as steam. Because geothermal waters are hot they are less dense and less viscous than cold water, are more buoyant and flow easily. They also interact rapidly with minerals in surrounding rocks and can dissolve some of their chemicals.

The main factors controlling the composition of geothermal waters are rock type, oxidation state and temperature. Some major constituents of thermal waters such as chloride, boron, ammonia and fluoride, which are minor rock constituents, dissolve very easily from fresh volcanic rocks during rock alteration. Oxidation state is important when sulphur is present. Sulphides are readily leached from rocks by hot waters and hydrolyse to hydrogen sulphide, which is released from many thermal springs. Where oxidation of the sulphide occurs, sulphate is formed and the waters may become extremely acidic. The presence or absence of sulphur either as sulphide minerals or as gaseous hydrogen sulphide is critical in the classification of thermal waters into three main groups, neutral chloride waters, acid-sulphate-chloride waters and acid sulphate waters.

With respect to this assessment, this strict definition of geothermal waters has been expanded to those inflows to the lakes that have been identified to include surface waters that are substantially influenced by geothermally derived constituents.

2.2 Classification of Geothermal Waters

2.2.1 Neutral-Chloride Waters

Neutral chloride waters are probably the most common type of geothermal waters on the North Island Volcanic Plateau, on which the Rotorua lakes are located**.** These waters contain mainly sodium and potassium chlorides with lesser amounts of calcium, magnesium, silica, boron, sulphate and bicarbonate at a pH between 6 and 8.5. Elements present in minor quantities are lithium, rubidium, caesium, arsenic, antimony, fluorine, bromine, phosphorus

and nitrogen as ammonia. Chloride waters commonly release carbon dioxide on reaching the surface. Neutral chloride waters originate at depth and at high temperatures and may surface unmodified, or under the influence of hydrogen sulphide, surface as acid-sulphate-chloride waters. Within the Rotorua region neutral chloride waters and acid-sulphate waters occur together.

2.2.2 Acid-Sulphate-Chloride Waters

Acid-sulphate-chloride waters are common within the Tikitere thermal area of Rotorua. These waters are formed either when hot neutral chloride waters dissolve sulphide minerals at depth or when neutral chloride waters mix with condensed steam containing hydrogen sulphide.

2.2.3 Acid-Sulphate Waters

Acid-sulphate waters also are common at Tikitere but are found throughout the Volcanic Plateau, wherever steam containing hydrogen sulphide condenses at the surface. Oxidation results in sulphuric acid formation and constituents dissolved from the surrounding rocks modify the water. These waters are typified by a very low chloride:sulphate ratio.

Lakes influenced by thermal springs have enhanced sodium and chloride concentrations, characteristically their bicarbonate:chloride ratio is less than unity. If the chloride:sulphate ratio is high it can be assumed that the influxes of thermal waters are of the neutral chloride type. Where chloride and sulphate are about equal in concentrations influxes of the acid-sulphate-chloride type seem likely. Lakes Rotoma, Rotoehu, Tarawera and Rotomahana have chloride waters, Lakes Rotorua and Rotoiti have chloride-sulphate waters, whereas the cold water lakes, such as Okareka, Okaro, Okataina, Rerewhakaaitu and Tikitapu which have previously been defined as not having thermal inflow, have bicarbonate waters (Reference 8).

In general phosphorus and nitrogen are abundant in thermal waters. High ammonium concentrations have been recorded in the Devils Bath hot spring at Tikitere, with 43gN/m^3 recorded. High phosphorus concentrations have also been recorded in Lake Rotowhero hot spring (0.28 gP/$m^{3)}$ (Reference 8).

3. GEOTHERMAL INFLOWS TO ROTORUA LAKES

3.1 Introduction

The following are the geothermal inflows to the twelve Rotorua lakes that have been identified to date. The principal source of information on these inflows was the database that has been assembled by EBOP from 1992 – 1995 (Reference 7).

In this section general data on each of the individual twelve lakes is presented, with a map identifying the location of each of the geothermal inflows identified to date. Because of the potential for such inflows to affect the nutrient status of some of these lakes, emphasis has been placed on identifying the potential nutrient inputs from geothermal inflows. The detailed nutrient contributions from each of the inflows, which are presented in Appendix 6.2, are summarised in the accompanying nutrient input budget component of the data presented for each lake. Such nutrient inputs are then placed into perspective in terms of other sources of nutrient inputs that have been identified previously (Reference 1-6).

3.2 Lake Rotorua

TABLE 1: LAKE ROTORUA - DATA SUMMARY

LAKE CHARACTERISTICS (Reference 12)				
Type	Volcanic			
Trophic Status	Eutrophic			
Inflow	Many surface streams			
Outflow	Ohau Channel to Lake Rotoiti and Kaituna River			
Lake Area (km^2)	79.8			
Catchment Area (km^2)	482			
Maximum Depth (m)	45			
CATCHMENT LAND COVER (%)				
Pasture	44			
Native Forest	21			
Lakes	17			
Exotic Forest	6			
Urban	7			
Lowland Scrub	4			
Swamp	1			
NUTRIENT INPUT BUDGET				
	NITROGEN		**PHOSPHORUS**	
	Tonnes per year	**%**	**Tonnes per year**	**%**
Pasture	253.00	46.7	35.40	48.7
Native forest	45.00	8.3	1.46	2.0
Exotic forest	4.40	0.8	0.32	0.4
Urban	64.76	11.9	14.83	20.4
Septic tanks	12.01	2.2	0.53	0.7
Ground water	-	-	-	-
Precipitation	18.9	3.5	1.90	2.6
Springs	45.0	8.3	8.2	11.3
Wastewater	30.0	5.5	3.0	4.1
Lake sediment	-	-	-	-
Wildfowl	1.43	0.3	1.37	1.9
Geothermal	67.34	12.4	5.60	7.7
TOTAL	**541.84**		**72.61**	

Sediment data obtained by EBOP (Reference 10) indicates that Lake Rotorua is influenced by geothermal inflows.

In a listing compiled of thermal areas and thermal springs throughout New Zealand (Reference 9) the Rotorua Geothermal Field (area approximately 10 km²) was listed as being located in and underlying much of Rotorua City, with the majority of the activity concentrated in the Whakarewarewa area (Figure 2). Geothermal features of this field include hot and boiling springs, geysers, bubbling mud pools, fumeroles, steaming ground and sinter deposits. The named features associated with this field are Whakarewarewa,

FIGURE 2 Lake Rotorua

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Puarenga Stream, Kuirau Park, Ohinemutu, Arikikapakapa, Pohutu Geyser, Mokoia ? Island, Waipa, Ngapuna and Government Gardens. According to EBOP data (Reference 7) nine geothermally influenced waters flow into Lake Rotorua. These inflows, which are shown in Figure 2, include: Waiohewa Stream – receives discharges from Tikitere geothermal area of acid-sulphate-chloride water type. Puarenga Stream – receives discharges from the Whakarewarewa geothermal area, Ohinemutu Springs, Tunuhopu Springs, Black Stream, Sewer Stream, Pipe Stream, Polynesisn Springs North & South and Springs Outlet are all located within the Ohinemutu/Whakarewarewa thermal area on the southern shores of Lake Rotorua. The waters of the Whakarewarewa thermal area have been previously defined as acid-sulphate with some neutral chloride waters also present (Reference 9).

These geothermal inflows are estimated to contribute a total of 5.6 tonnes per year of total phosphorus (TP) and 67.3 tonnes per year of total nitrogen (TN) (Table 1). The principal input of both geothermally derived phosphorus and nitrogen was the Waiohewa Stream, which contributed an estimated 60.91 tonnes of TN and 5.06 tonnes of TP (Appendix 6.1), which constituted 90% of both geothermally derived TN and TP.

TABLE 1A: LAKE ROTORUA - GEOTHERMAL INFLOWS

GEOTHERMAL INFLOWS	TYPE	MEAN FLOW (m^3/s)	MEAN DISCHARGE TOTAL PHOSPHORUS (TONNES/YEAR)	MEAN DISCHARGE TOTAL KJELDAHL NITROGEN + TOTAL NITROGEN OXIDES (TONNES/YEAR)
Waiohewa Stream (7/7/92 – 22/6/95)	Acid-sulphate-chloride	0.44	5.0	60.91
Ohinemutu Springs (22/7/92 – 23/3/94)	Acid-sulphate or neutral chloride	0.01	0.03	0.15
Tunuhopu Springs (22/7/92 – 23/3/94)	Acid-sulphate or neutral chloride	0.01	0.04	0.15
Black Stream (22/7/92 – 23/3/94)	Acid-sulphate or neutral chloride	0.01	0.06	0.35
Sewer Stream (22/7/92 – 23/3/94)	Acid-sulphate or neutral chloride	0.014	0.14	0.11
Pipe Stream (22/7/92 – 23/3/94)	Acid-sulphate or neutral chloride	0.003	0.02	0.06
Polynesian Springs Sth (22/7/92 – 23/3/94)	Acid-sulphate or neutral chloride	0.0012)	0.01	0.02
Polynesian Springs Nth (22/7/92 – 23/3/94)	Acid-sulphate or neutral chloride	0.011	0.10	0.48
Springs Outlet (22/7/92 – 23/3/94)	Acid-sulphate or neutral chloride	0.0015	0.02	0.07

Source: Environment Bay of Plenty database

Examination of the estimated nutrient input from these geothermal inflows indicates that these geothermal inflows comprise some 7.7 % of TP and 12.4 % TN that is estimated to enter Lake Rotorua (Table 1). Based on this estimate the geothermal inflows constitute the second highest input of nitrogen and the fourth highest input of phosphorus to Lake Rotorua.

3.3 Lake Tarawera

TABLE 2: LAKE TARAWERA - DATA SUMMARY

LAKE CHARACTERISTICS (Reference 13)				
Type	Volcanic			
Trophic Status	Oligotrophic			
Inflow	Wairoa Stream, a number of springs, and possible subterranean flow from Lake Rotomahana			
Outflow	Tarawera River			
Lake Area (km^2)	41			
Catchment Area (km^2)	150			
Maximum Depth (m)	87.5			
CATCHMENT LAND COVER (%)				
Lowland Scrub	31			
Lakes	27			
Native Pasture	18			
Pasture	12			
Exotic Forest	9			
Subalpine Scrub	3			
NUTRIENT INPUT BUDGET				
	NITROGEN		**PHOSPHORUS**	
	Tonnes per year	**%**	**Tonnes per year**	**%**
Pasture	21.62	23.6	3.02	17.2
Native forest	28.15	30.8	0.92	5.2
Exotic forest	1.73	1.9	0.12	0.7
Urban	1.11	1.2	0.23	1.3
Septic tanks	1.80	2.0	0.08	0.5
Ground water	-	-	-	-
Precipitation	9.73	10.6	0.97	5.5
Lake sediment	-	-	-	-
Wildfowl	0.29	0.3	0.19	1.1
Geothermal	27.0	29.5	12.0	68.5
TOTAL	**91.43**		**17.53**	

TABLE 2A: LAKE TARAWERA GEOTHERMAL INFLOWS

GEOTHERMAL INFLOWS	TYPE	MEAN FLOW (m^3/s)	MEAN DISCHARGE TOTAL PHOSPHORUS (TONNES/YEAR)	MEAN DISCHARGE TOTAL KJELDAHL NITROGEN+ TOTAL NITROGEN OXIDES (TONNES/YEAR)
Tarawera Peak and Camp Stream	Near neutral with moderate chloride	0.1	0.45	0.59
Spring 100m Nth of waterfall	Near neutral with moderate chloride	0.1	0.47	0.24

Source: Environment Bay of Plenty database

Sediment data obtained by EBOP (Reference 10) indicates that Lake Tarawera is influenced by geothermal inflows.

In a desktop study of nutrient input to Lake Tarawera (Reference 11) the nutrient content of geothermal inflows to this lake were estimated to be 4 – 20 tonnes per year of TP and 27.3 tonnes per year of TN. For the purposes of this assessment, the mean input of TP was assumed to be 12 tonnes per year, while that of TN was 27 tonnes per year.

A survey of the thermal areas and thermal springs throughout New Zealand (Reference 9) indicated that the Tarawera Geothermal Area was located on the southern shores of Lake Tarawera from the Wairua Stream to Rapatu Bay (Figure 3). Named features associated with this area include Rapatu Bay (Hot Water Beach) Hot Springs, Te Puha and Tarawera Fumeroles. Data obtained from these springs indicates that they were hot (37 -90 ºC), near neutral with moderate chloride and a flow estimated to be 100 l/s (0.1 m^3/s). Assuming that the nutrient concentrations of these springs were similar to those of the other geothermal inflows into Lake Tarawera (e.g. Tarawera Stream), then these inflows would contribute in the order of 0.46 tonnes per year of TP and 0.41 tonnes per year of TN to the lake.

Environment BOP (Reference 7) has data on two other geothermal inflows to Lake Tarawera. These inflows shown in Figure 3 are:
Tarawera Peak and Camp Stream and Spring 100 m north of waterfall.

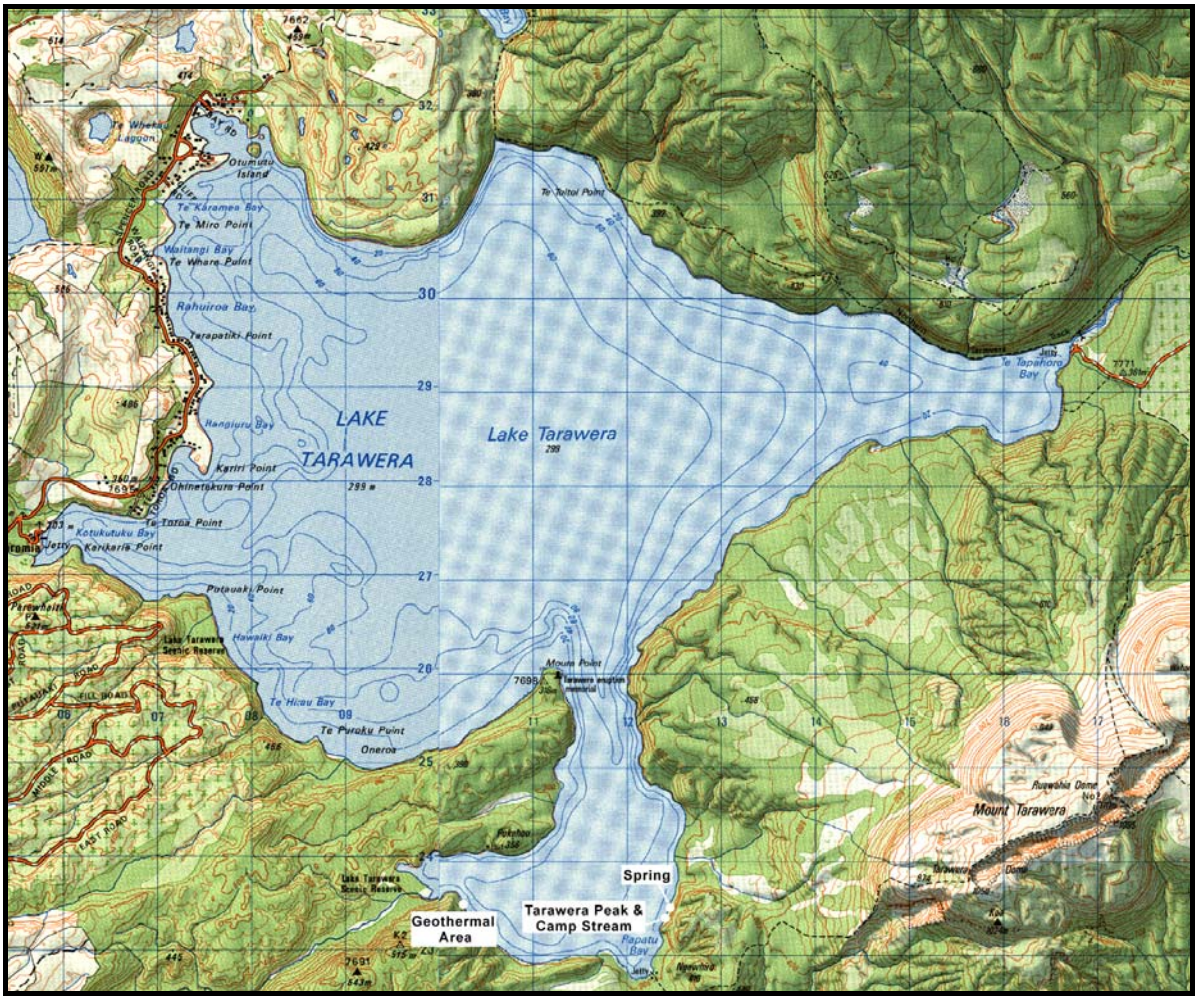

FIGURE 3 Lake Tarawera

These geothermal inflows from Te Rata Bay have previously been described as near neutral with moderate chloride (Reference 9) and are typical of discharges from the Tarawera Geothermal Area. While nutrient data are available from these inflows (Appendix 6.2), no flow data are available. For the purposes of this assessment the flows of these two geothermal inflows have been estimated to be 0.1 m^3/s.

Of this input the Tarawera Stream and the Spring are estimated to contribute around 0.92 tonne per year TP and 0.83 tonne per year TN of the total annual input from geothermal sources.

In this assessment inflows from both the Tarawera Geothermal Area and the Tarawera Stream and the Spring have been assumed to be part of the initial geothermal input figures of 12 tonnes per year of TP and 27 tonnes per year of TN.

On the basis of this assessment geothermal inflows to Lake Tarawera are the major contributor of TP (68.5 %) and the second major contributor of TN (29.5 %) and to the lake (Table 2).

3.4 Lake Rotoiti

TABLE 3: LAKE ROTOITI - DATA SUMMARY

LAKE CHARACTERISTICS (Reference 14)				
Type	Volcanic			
Trophic Status	Mesotrophic			
Inflow	From Lake Rotorua			
Outflow	Kaituna River			
Lake Area (km^2)	33.5			
Catchment Area (km^2)	120.6			
Maximum Depth (m)	120			
CATCHMENT LAND COVER (%)				
Pasture	32			
Lakes	28			
Native Forest	23			
Lowland Scrub	10			
Exotic Forest	5			
Sand Dune	1			
Tussock	1			
NUTRIENT INPUT BUDGET				
	NITROGEN		**PHOSPHORUS**	
	Tonnes per year	**%**	**Tonnes per year**	**%**
Pasture	47.1	11.3	6.5	21.0
Native forest	9.4	2.3	0.06	0.2
Exotic forest	2.5	0.6	0.23	0.7
Urban	4.4	1.1	0.9	2.9
Septic tanks	8.4	2.0	0.3	1.0
Ground water	0.01	-	-	-
Precipitation	10.0	2.4	1.34	4.3
Springs	0	0	0	0
Ohau Channel	291.0	70.1	21.0	67.8
Sediment	-	-	-	-
Wildfowl	0.9	0.2	0.5	1.6
Geothermal	41.6	10.0	0.13	0.4
TOTAL	**415.31**		**30.96**	

As with the previous lakes, sediment data obtained by EBOP (Reference 10) indicates that Lake Rotoiti is influenced by geothermal inflows.

Both the centre basin of Lake Rotoiti, estimated area of 2 km², and the Tikitere Thermal Area, located to the south of the lake, have been identified as geothermal areas associated with Lake Rotoiti (Reference 9).

A number of surveys, including bathymetry, heat flow and resistivity, of the centre basin of Lake Rotoiti, have indicated that there is a high heat flow area and hot sediments in the centre basin.

Investigations of the Tikitere Geothermal Area have indicated that natural features of this area include hot and boiling springs and pools, seepages, steaming and highly altered ground, sulphur deposits and gas discharges. Features identified in this area, shown in Figure 4, include

Wharetata Bay, Parengarenga Springs, Manupirua Springs, Papakiore Bath, Hell's Gate Thermal Area, Maraeroa Springs, Otutarara Springs and Ruahine Springs.

The waters of the Tikitere thermal area have previously been described as acid-sulphate-chloride waters (Reference 8).

Flow data obtained from these springs (Reference 7) indicates that the flow is less that 1 l/s.

An estimate of the likely input of these springs to the nutrient load of Lake Rotoiti (Reference 15) indicated that these springs might contribute almost a quarter of the lake's nitrogen input. Another estimate (Reference 2), based on the measured concentration of TP and TN in the geothermal springs of the western basin of Lake Rotoiti, put the TP input at 0.13 tonnes per year and TN input at 41.6 tonnes per year. It should be noted that no data were available to enable the contributions made by Manupirua and Wharetata Bay Springs inflows to the estimated nutrient inputs derived from geothermal sources.

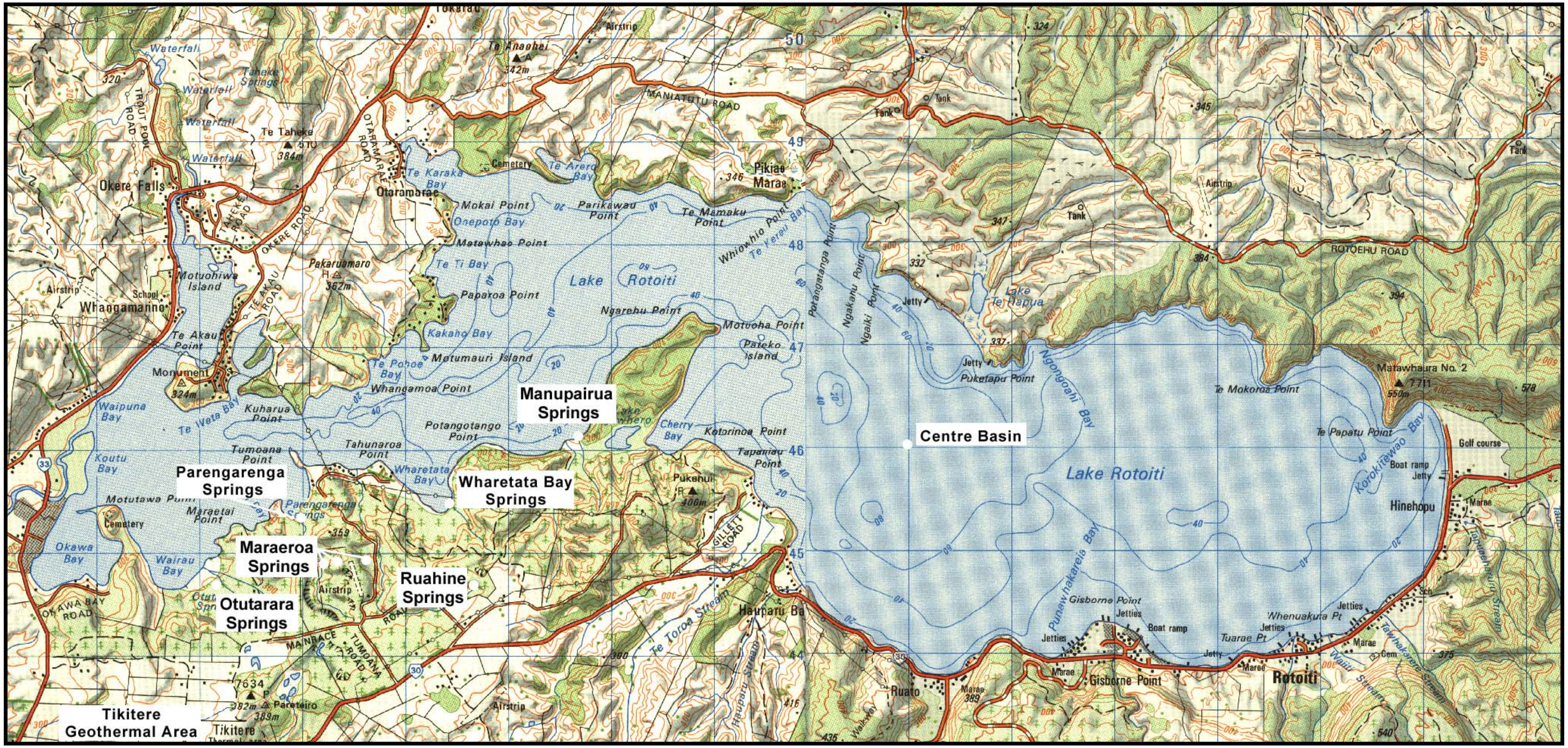

FIGURE 4 Lake Rotoiti

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TABLE 3A: LAKE ROTOITI - GEOTHERMAL INFLOWS

GEOTHERMAL INFLOWS	TYPE	MEAN FLOW (m^3/s)	MEAN DISCHARGE TOTAL PHOSPHORUS (TONNES/YEAR)	MEAN DISCHARGE TOTAL KJELDAHL NITROGEN + TOTAL NITROGEN OXIDES (TONNES/YEAR)
Wharetata Bay (22/7/92)	Acid-sulphate-chloride	0.1	0.331	-
Parengarenga Springs (5/8/92 – 15/6/94)	Acid-sulphate-chloride	0.1	0.92	66.82

Source: Environment Bay of Plenty database

For the purposes of this assessment then geothermal inflows to Lake Rotoiti, including the springs identified in the Tikitere and Wairau Bay areas, mentioned previously, have been estimated to be 0.13 tonnes per year of TP and 41.6 tonnes per year of TN. In the earlier assessment of nutrient inputs to Lake Rotoiti (Reference 2) these geothermal inflows were included in the "Springs" component of the assessment. In this assessment this input has now been identified as the "Geothermal" component, and the "Springs" component has been assumed to be zero (Table 3).

Based on these data then the geothermal inflows to Lake Rotoiti comprise 0.4 % of the total estimated TP input and 10 % of the total estimated TN input.

3.5 Lake Okataina

TABLE 4: LAKE OKATAINA - DATA SUMMARY

LAKE CHARACTERISTICS (Reference 16)				
Type	Volcanic			
Trophic Status	Oligotrophic			
Inflow	A number of small streams			
Outflow	No known surface flow but may have an underwater flow			
Lake Area (km^2)	10.8			
Catchment Area (km^2)	63.6			
Maximum Depth (m)	78.5			
CATCHMENT LAND COVER (%)				
Native Forest	66			
Lakes	17			
Pasture	9			
Lowland Scrub	5			
Exotic Forest	3			
NUTRIENT INPUT BUDGET				
	NITROGEN		**PHOSPHORUS**	
	Tonnes per year	**%**	**Tonnes per year**	**%**
Pasture	2.69	11.9	0.38	29.0
Native forest	16.60	73.1	0.54	41.2
Exotic forest	0.70	3.1	0.05	3.8
Urban	0	0	0	0
Septic tanks	0.03	0.1	-	-
Ground water	-	-	-	-
Precipitation	2.56	11.3	0.26	19.8
Sediment	-	-	-	-
Wildfowl	0.12	0.5	0.08	6.1
Geothermal	Unknown	-	Unknown	-
TOTAL	**22.7**		**1.31**	

Sediment data obtained by EBOP (Reference 10) indicates that Lake Okataina is influenced by geothermal inflows.

Information on the geothermal inflows that are influencing the quality of this lake (Reference 9) indicates that the source of such influence is the Okataina Springs, which are located on the eastern shore of Lake Okataina, just south of Oruaroa (Figure 5). Natural features of these springs include gas discharges and warm water seepages.

No specific information is available on the quality or quantity of geothermal water entering the lake from this source. As a result no estimate can be made of the geothermal influence this spring inflow has on the quality of Lake Okataina.

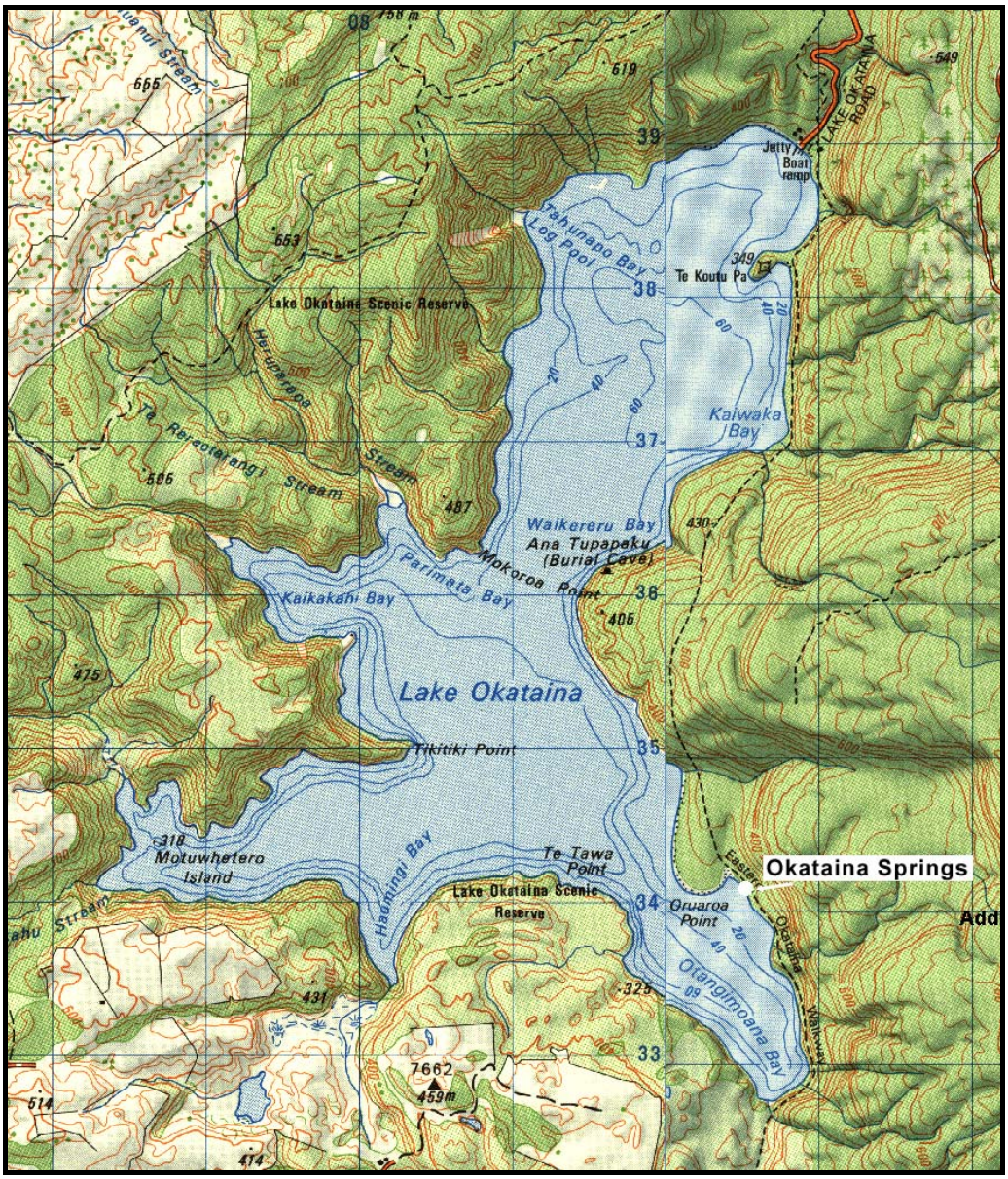

FIGURE 5 Lake Okataina

3.6 Lake Rotomahana

TABLE 5: LAKE ROTOMAHANA - DATA SUMMARY

LAKE CHARACTERISTICS (References 10, 18)				
Type	Volcanic			
Trophic Status	Mesotrophic			
Inflow	Surface stream			
Outflow	Surface outflow man-made			
Lake Area (km^2)	8.0			
Catchment Area (km^2)	88.6			
Maximum Depth (m)	125			
CATCHMENT LAND COVER (%)				
Pasture	41.6			
Lowland Scrub	28.7			
Lakes	9.9			
Native Forest	9.7			
Exotic Forest	3.7			
Subalpine Scrub	3.1			
Swamp Associated	1.9			
Other	1.3			
NUTRIENT INPUT BUDGET				
	NITROGEN		**PHOSPHORUS**	
	Tonnes per year	**%**	**Tonnes per year**	**%**
Pasture	44.04	74.6	6.15	87.3
Native forest	10.92	18.5	0.36	5.1
Exotic forest	1.20	2.0	0.09	1.3
Urban	0	0	0	0
Septic tanks	0.52	0.9	0.02	0.3
Ground water	-	-	-	-
Precipitation	1.89	3.2	0.19	2.7
Sediment	-	-	-	-
Wildfowl	0.45	0.8	0.23	3.3
Geothermal	Unknown	-	Unknown	-
TOTAL	**59.02**		**7.04**	

Information available on the sediment quality of Lake Rotomahana (Reference 10) indicates that this lake is influenced by geothermal inflows. Previous studies have estimated that 53% of the source of dissolved salts within Lake Rotomahana are derived from geothermal waters (Reference 17).

As this lake occupies the site of two former lakes, one of which was an active geothermal centre, submerged springs are considered to contribute significant inputs of nutrients to this lake. No assessment has been made of the inputs from this source and previous assessments

of nutrient inputs have been based primarily on land use within the catchment of the lake (Reference 6).

The Waimangu-Rotomahana Geothermal Area is located to the south-west of Lake Rotomahana (Figure 6). This area contains hydrothermal explosion craters, hot and boiling springs, geysers, crater lakes, steaming cliffs and fumaroles. Features located within this area (Figure 6) include:

Frying Pan Lake, Inferno Crater, Echo Crater, Southern Crater Lake, Black Crater, Taha Roto, Nga Pui O Te Papa, N Spring, Birdsnest Terrace, Clamshell, Puara, Cave Spring, Iodine Spring and Warbrick Terrace.

Limited information on Frying Pan and Inferno Crater Lakes (Reference 9) indicates that the flows from these lakes are in the order of 120 l/s (0.12 m^3/s). Cave spring has a recorded flow of about 1 l/s while both Puara and Warbrick Terrace discharge at less than 0.1 l/s (Reference 19). Such flows are unlikely to be a significant component of the overall nutrient input to this lake, given that an active sub-surface geothermal centre is present within the body of the lake.

As no data are available on what is generally considered to be the main geothermal inflow to Lake Rotomahana then the affect of geothermal inflows on the quality of this lake, in terms of the nutrient input from the geothermal sources, cannot be assessed. However it should be acknowledged that chloride analysis by Timperley and Vigor-Brown (Reference 17), tentatively suggests that this lake has the largest geothermal inputs of any of the Rotorua Lakes.

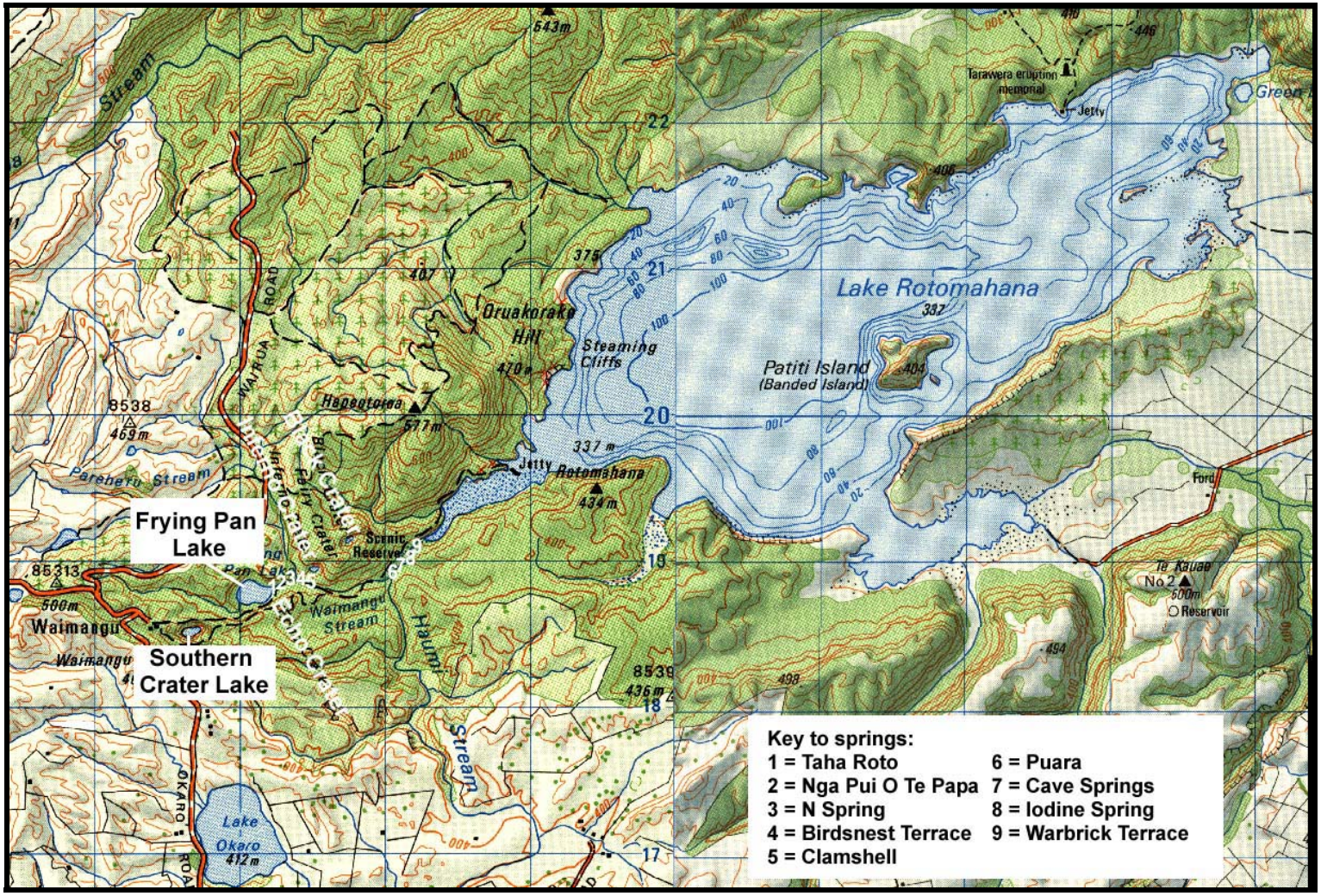

FIGURE 6 Lake Rotomahana

3.7 Lake Rotoma

TABLE 6: LAKE ROTOMA - DATA SUMMARY

LAKE CHARACTERISTICS (References 10, 18)				
Type	Volcanic			
Trophic Status	Oligotrophic			
Inflow	Rere Stream and small stream			
Outflow	Surface outflow not apparent			
Lake Area (km^2)	11.2			
Catchment Area (km^2)	33.9			
Maximum Depth (m)	36.9			
CATCHMENT LAND COVER (%)				
Pasture	37.8			
Lakes	32.8			
Native Forest	26.7			
Exotic Forest	1.5			
Urban	1.1			
Lowland Scrub	0.1			
NUTRIENT INPUT BUDGET				
	NITROGEN		**PHOSPHORUS**	
	Tonnes per year	**%**	**Tonnes per year**	**%**
Pasture	10.4	53.6	1.4	68.6
Native forest	3.3	17.0	0.1	4.9
Exotic forest	0.6	3.1	0.04	2.0
Urban	0.6	3.1	0.1	4.9
Septic tanks	1.8	9.3	0.08	3.9
Ground water	-	-	-	-
Precipitation	2.6	13.4	0.26	12.7
Sediment	0	0	0	0
Wildfowl	0.1	0.5	0.06	2.9
Geothermal	0	0	0	0
TOTAL	**19.4**		**2.04**	

As with a number of the other Rotorua lakes sediment data (Reference 10) indicates that Lake Rotoma is influenced by geothermal inflows.

According to an earlier assessment of nutrient inputs to Lake Rotoma (Reference 3) one of the hot springs located in the southwestern Rotoma Geothermal Area, namely the Otei Hot Spring, discharges into the lake. While the nutrient input remains unknown, given the low flow from all springs (11.3 - 53.1 l/s), (Reference 9) as with the earlier assessment the input of nutrients from this source was considered negligible.

In terms of the overall nutrient input budget then the contribution of geothermal inflows to Lake Rotoma is considered to be zero.

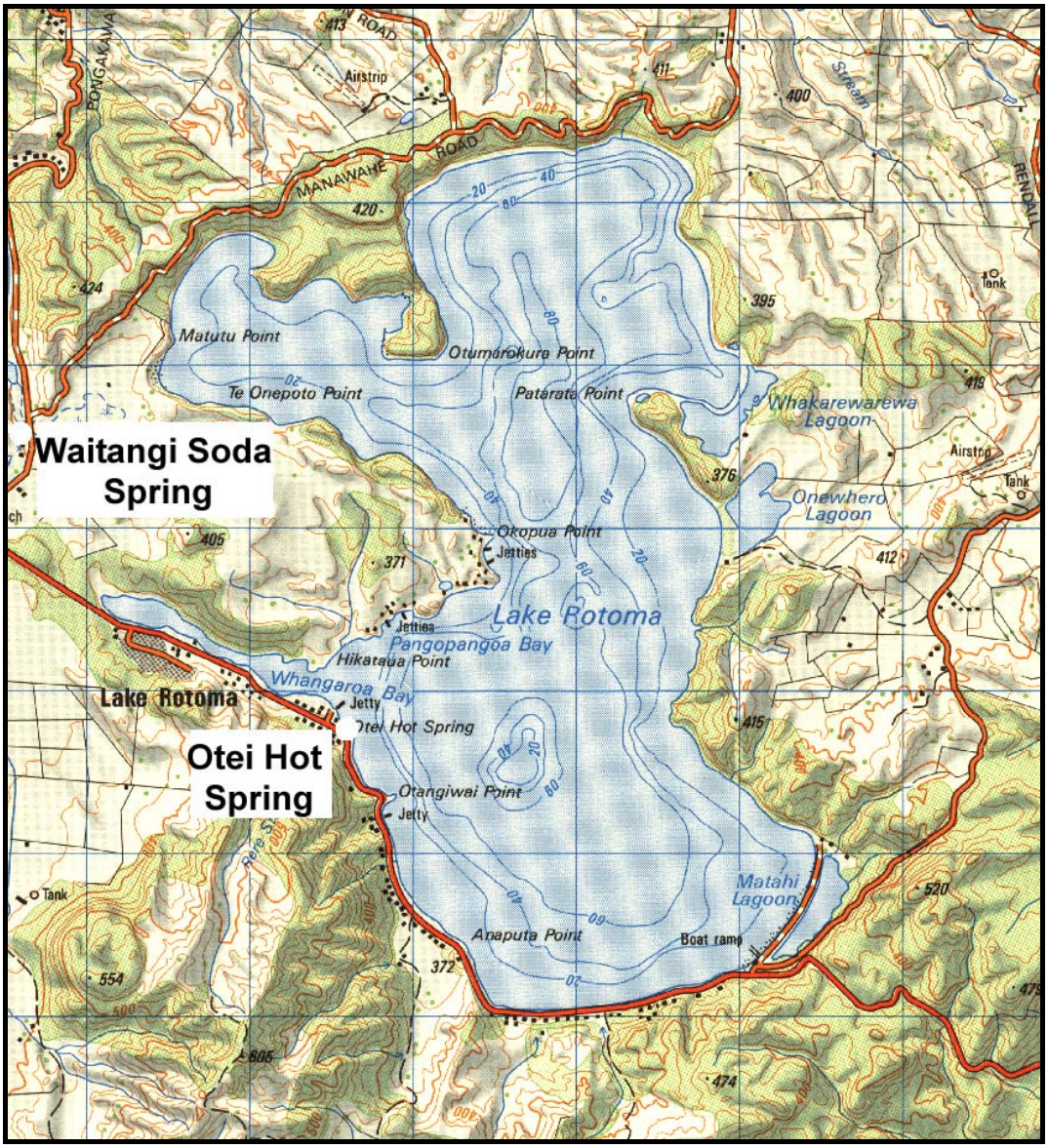

FIGURE 7 Lake Rotoma

3.8 Lake Rotoehu

TABLE 7: LAKE ROTOEHU - DATA SUMMARY

LAKE CHARACTERISTICS (References 10, 18)				
Type	Volcanic			
Trophic Status	Eutrophic			
Inflow	Surface Stream			
Outflow	Subsurface drainage			
Lake Area (km^2)	8.1			
Catchment Area (km^2)	42.3			
Maximum Depth (m)	13.5			
CATCHMENT LAND COVER (%)				
Pasture	42.9			
Native Forest	18.7			
Lakes	16.1			
Lowland Scrub	14.3			
Exotic Forest	8.0			
NUTRIENT INPUT BUDGET				
	NITROGEN		**PHOSPHORUS**	
	Tonnes per year	**%**	**Tonnes per year**	**%**
Pasture	22.0	61.1	3.0	59.5
Native forest	5.1	14.2	0.2	4.0
Exotic forest	0.4	1.1	0.03	0.6
Urban	0	0	0	0
Septic tanks	0.3	0.8	0.01	0.2
Ground water	-	-	-	-
Precipitation	1.9	5.3	0.2	4.0
Springs	0	0	0	0
Sediment	-	-	-	-
Wildfowl	1.6	4.4	0.8	15.9
Geothermal	4.7	13.0	0.8	15.9
TOTAL	**36.0**		**5.04**	

Based on sediment data obtained by Environment BOP (Reference 10) Lake Rotoehu is influenced by geothermal inflows.

In an earlier assessment of geothermal inflows to Lake Rotoehu (Reference 4) the principal geothermal surface inflow was identified as the Waitangi Soda Spring (Figure 8). This spring flows into the lake from the Rotoma Geothermal Area and has been estimated to contribute 0.8 tonnes per year of TP and 4.7 tonnes per year of TN to Lake Rotoehu (Table 7).

In the earlier assessment of nutrient inputs to Lake Rotoehu (Reference 4) the nutrient inputs from the Waitangi Soda Spring was included in the "Springs" component of the assessment. In this assessment this input has now been identified as the "Geothermal" component, and the

"Springs" component has been assumed to be zero (Table 7). These geothermally derived inputs then comprise 15.9 % TP and 13.0 % TN of the total input of nutrients to Lake Rotoehu (Table 7).

FIGURE 8 Lake Rotoehu

3.9 Lake Rerewhakaaitu

TABLE 8: LAKE REREWHAKAAITU - DATA SUMMARY

LAKE CHARACTERISTICS (Reference 20)				
Type				
Trophic Status	Mesotrophic			
Inflow	Awaroa Stream, and Mangakino Stream			
Outflow	Only occurs when lake level is high, outflow to Upper Mangaharakeke Stream			
Lake Area (km^2)	6.3			
Catchment Area (km^2)	38.2			
Maximum Depth (m)	15.0			
CATCHMENT LAND COVER (%)				
Pasture	77			
Exotic Forest	15			
Native Forest/Scrub	6			
Wetlands	2			
NUTRIENT INPUT BUDGET				
	NITROGEN		**PHOSPHORUS**	
	Tonnes per year	**%**	**Tonnes per year**	**%**
Pasture	26.68	80.6	3.73	86.9
Native forest	1.15	3.5	0.04	0.9
Exotic forest	1.00	3.0	0.07	1.6
Urban	0	0	0	0
Septic tanks	2.25	6.8	0.1	2.3
Ground water	-	-	-	-
Precipitation	1.77	5.3	0.18	4.2
Sediment	-	-	-	-
Wildfowl	0.25	0.7	0.17	4.0
Geothermal	0	0	0	0
TOTAL	**33.1**		**4.29**	

Information available on the sediment quality of Lake Rerewhakaaitu (Reference 10) indicates that this lake is not influenced by geothermal inflows.

No geothermal inflows have been identified with Lake Rerewhakaaitu therefore the nutrient input to the lake from this source is considered to be zero and the lake is not influenced by geothermal inflows.

FIGURE 9 Lake Rerewhakaaitu

3.10 Lake Rotokakahi

TABLE 9: LAKE ROTOKAKAHI - DATA SUMMARY

LAKE CHARACTERISTICS (Reference 21)				
Type	Volcanic			
Trophic Status	Mesotrophic			
Inflow	Surface stream			
Outflow	Wairoa Stream to Lake Tarawera			
Lake Area (km^2)	4.5			
Catchment Area (km^2)	17.5			
Maximum Depth (m)	30.5			
CATCHMENT LAND COVER (%)				
Exotic Forest	42			
Lakes	25			
Lowland Lakes	18			
Pasture	12			
Native Forest	3			
NUTRIENT INPUT BUDGET				
	NITROGEN		**PHOSPHORUS**	
	Tonnes per year	**%**	**Tonnes per year**	**%**
Pasture	2.34	40.3	0.33	55.0
Native forest	1.36	23.4	0.04	6.7
Exotic forest	0.96	16.5	0.07	11.7
Urban	0	0	0	0
Septic tanks	0	0	0	0
Ground water	-	-	-	-
Precipitation	1.06	18.3	0.11	18.3
Sediment	-	-	-	-
Wildfowl	0.08	1.4	0.05	8.3
Geothermal	0	0	0	0
TOTAL	**5.80**		**0.60**	

Sediment data obtained by Environment BOP (Reference 10) suggests that Lake Rotokakahi may be influenced by geothermal inflows.

As no sources of geothermal inflows have been identified in this assessment no allowance has been made in the nutrient input budget for nutrients from geothermal inflows

Although the sediment data suggests some possible influence on the lake from geothermal inflows, in the absence of data on any identifiable geothermal inflows Lake Rotokakahi is considered not to be influenced by geothermal inflows. For the purposes of this assessment the nutrient input from this source was considered to be zero.

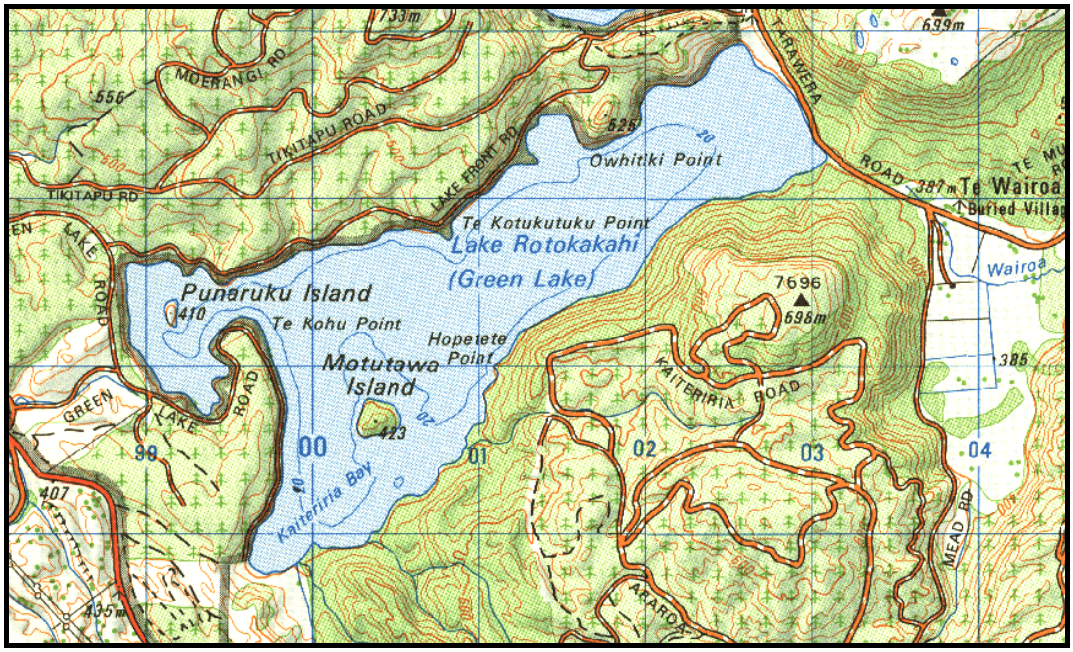

FIGURE 10 Lake Rotokakahi

3.11 Lake Okareka

TABLE 10: LAKE OKAREKA - DATA SUMMARY

LAKE CHARACTERISTICS (Reference 22)				
Type	Volcanic			
Trophic Status	Mesotrophic			
Inflow	Surface stream			
Outflow	Drainage via Waitangi Stream			
Lake Area (km^2)	3.5			
Catchment Area (km^2)	17.5			
Maximum Depth (m)	33.5			
CATCHMENT LAND COVER (%)				
Pasture	44			
Native Forest	29			
Lakes	20			
Lowland Scrub	7			
NUTRIENT INPUT BUDGET				
	NITROGEN		**PHOSPHORUS**	
	Tonnes per year	**%**	**Tonnes per year**	**%**
Pasture	9.3	60.4	1.3	74.3
Native forest	2.1	13.6	0.07	4
Exotic forest	0	0	0	0
Urban	0.5	3.2	0.1	5.7
Septic tanks	2.5	16.2	0.11	6.3
Ground water	-	-	-	-
Precipitation	0.82	5.3	0.08	4.6
Sediment	-	-	-	-
Wildfowl	0.18	1.2	0.09	5.1
Geothermal	0	0	0	0
TOTAL	**15.4**		**1.75**	

Environment BOP data (Reference 10) on the sediment quality of Lake Okareka indicates that this lake is potentially affected by geothermal activity.

As no sources of geothermal inflows have been identified in this assessment no allowance has been made in the nutrient input budget for nutrients from geothermal inflows

Although the sediment data suggests some possible influence on the lake from geothermal inflows, in the absence of data on any identifiable geothermal inflows Lake Okareka is considered not to be influenced by geothermal inflows. For the purposes of this assessment the nutrient input from this source was considered to be zero.

FIGURE 11 Lake Okareka

3.12 Lake Tikitapu

TABLE 11: LAKE TIKITAPU - DATA SUMMARY

LAKE CHARACTERISTICS (References 10,18)				
Type	Volcanic			
Trophic Status	Oligotrophic			
Inflow	Few small streams			
Outflow	Surface outflow not apparent			
Lake Area (km^2)	1.4			
Catchment Area (km^2)	6.0			
Maximum Depth (m)	27.5			
CATCHMENT LAND COVER (%)				
Native Forest	44.9			
Lakes	23.6			
Lowland Scrub	16.9			
Exotic Forest	8.7			
Pasture	5.9			
NUTRIENT INPUT BUDGET				
	NITROGEN		**PHOSPHORUS**	
	Tonnes per year	**%**	**Tonnes per year**	**%**
Pasture	0.42	15.8	0.06	38.7
Native forest	1.77	66.5	0.06	38.7
Exotic forest	0.10	3.7	-	-
Urban	0	0	0	0
Septic tanks	0.03	1.1	-	-
Ground water	-	-	-	-
Precipitation	0.33	12.4	0.03	19.3
Sediment	-	-	-	-
Wildfowl	0.01	0.4	0.005	3.2
Geothermal	0	0	0	0
TOTAL	**2.66**		**0.155**	

As with Lake Rotokakahi sediment data obtained by Environment BOP (Reference 10) suggests that Lake Tikitapu may be influenced by geothermal inflows. However no geothermal inflows to this lake have been identified.

In the absence of any identifiable geothermal inflows then the nutrient input from this source has been assumed to be zero. On this basis then Lake Tikitapu is not influenced by geothermal inflows.

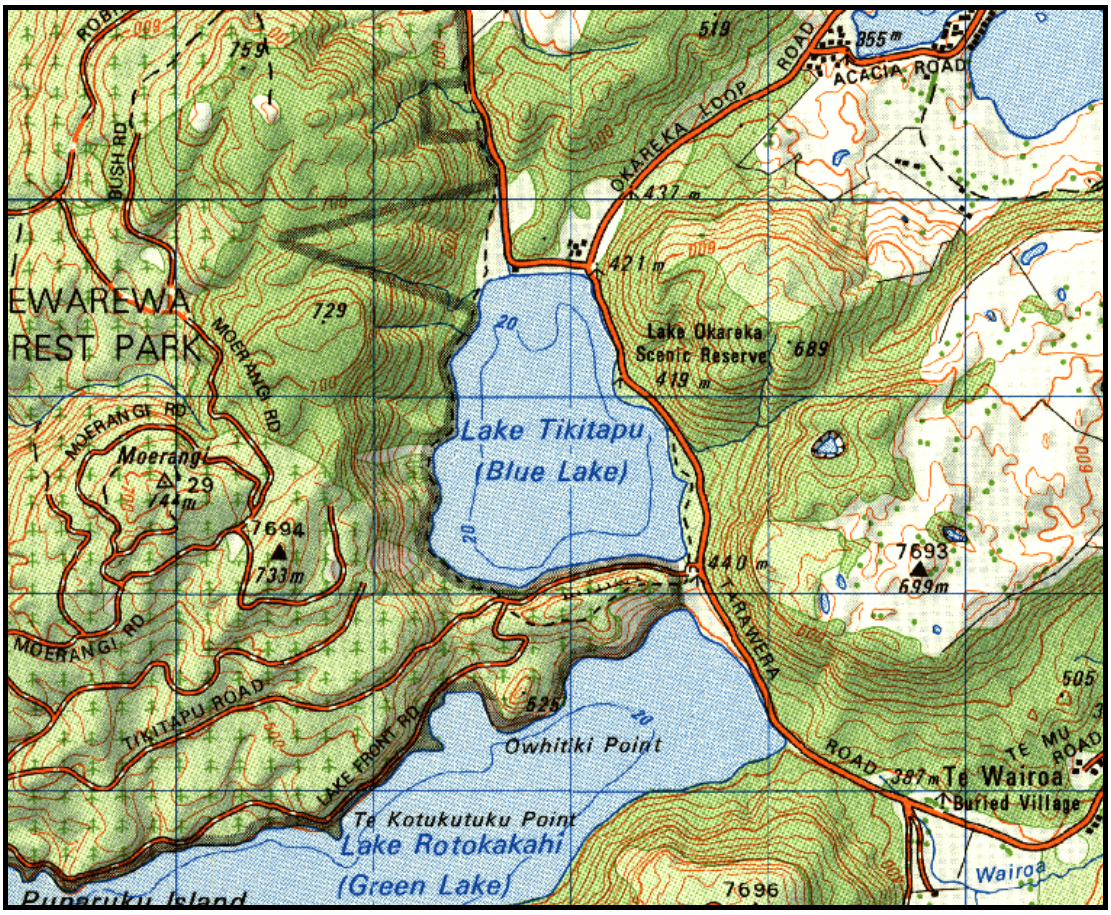

FIGURE 12 Lake Tikitapu

3.13 Lake Okaro

TABLE 12: LAKE OKARO - DATA SUMMARY

LAKE CHARACTERISTICS (References 10,18)				
Type	Volcanic			
Trophic Status	Eutrophic			
Inflow	Surface stream			
Outflow	Haumi Stream to Lake Rotomahana			
Lake Area (km^2)	0.3			
Catchment Area (km^2)	3.6			
Maximum Depth (m)	18.0			
CATCHMENT LAND COVER (%)				
Pasture	83.1			
Lakes	16.9			
NUTRIENT INPUT BUDGET				
	NITROGEN		**PHOSPHORUS**	
	Tonnes per year	**%**	**Tonnes per year**	**%**
Pasture	3.59	93.5	0.50	96.1
Native forest	0.09	2.3	-	-
Exotic forest	0	0	0	0
Urban	0	0	0	0
Septic tanks	0.05	1.3	-	-
Ground water	-	-	-	-
Precipitation	0.08	2.1	0.01	1.9
Sediment	-		-	-
Wildfowl	0.03	0.8	0.01	1.9
Geothermal	0	0	0	0
TOTAL	**3.84**		**0.52**	

Information available on the sediment quality of Lake Okaro (Reference 10) indicates that this lake is not influenced by geothermal inflows.

No geothermal inflows have been identified with Lake Okaro therefore the nutrient input to the lake from this source is considered to be zero. On this basis then Lake Okaro is not influenced by geothermal inflows.

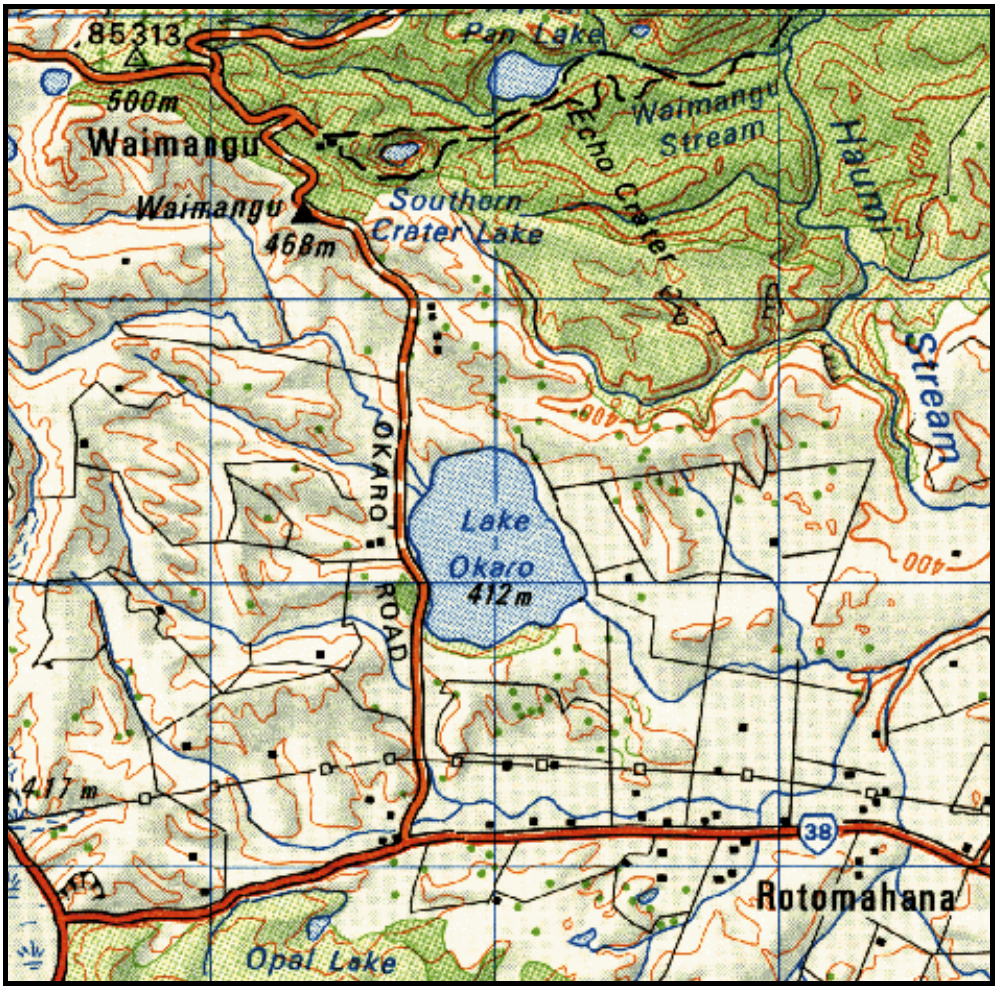

FIGURE 13 Lake Okaro

4. DISCUSSION

Of the twelve Rotorua lakes assessed the nutrient inputs to four of these lakes were able to be quantified (Table 13).

TABLE 13: SUMMARY OF GEOTHEMAL AFFECTS IN THE ROTORUA LAKES

LAKE	GEOTHERMAL INFLOWS	NUTRIENT INPUTS				GEOTHERMALLY INFLUENCED
		TN		TP		
		tonnes/year	%	tonnes/year	%	
ROTORUA	Yes	67.3	12.4	5.6	7.7	Yes
TARAWERA	Yes	27.0	29.5	12.0	68.5	Yes
ROTOITI	Yes	41.6	10.0	0.13	0.4	Yes
OKATAINA	Yes	NA	-	NA	-	Yes?
ROTOMAHANA	Yes	NA	-	NA	-	Yes
ROTOMA	Yes	0	-	0	-	No
ROTOEHU	Yes	4.7	13.0	0.8	15.9	Yes
REREWHAKAAITU	No	0	-	0	-	No
ROTOKAKAHI	Yes?	0	-	0	-	Yes ?
OKAREKA	No	0	-	0	-	No
TIKITAPU	No	0	-	0	-	Yes?
OKARO	No	0	-	0	-	No

NA : Not Available

In case of Lake Rotorua the dominant influence is the Waiohewa Stream, which is estimated to contribute 90 % of the nutrients attributed to geothermal inflows to this lake.

While recent EBOP monitoring data (Reference 7) have enabled the contribution of two small geothermal inflows to Lake Tarawera to be characterised, the desk-top study (Reference 11) utilised ammonia concentrations from five geothermal springs located in the Wairua Arm of Lake Tarawera, phosphorus data from a number of geothermal waters in the lake's catchment and flow from all waters of geothermal origin flowing into Lake Tarawera.

Geothermal inflows to this lake comprise approximately 70 % and 30 % of the total TP and TN input to the lake.

The dominant geothermal influence on Lake Rotoiti is the centre basin of the lake (inflow unquantified) and the springs associated with the Tikitere Geothermal Area.

In the case of Lake Rotoehu, the Waitangi Soda Spring was identified as the dominant geothermal input to this lake. While this source contributed less than 20% of the total nutrient input to the lake (15.9 % TP; 13.0 % TN) it is a point source of these nutrients and therefore this input may be able to be reduced.

Of the remaining eight lakes two, Okataina and Rotomahana, were found to have geothermal inflows for which there was little or no information. With respect to another three of these lakes, namely Lakes Rotoma, Rotokakahi and Okareka while sediment data indicated that these lakes were influenced by geothermal inflows, the contribution of geothermally derived nutrients to these lakes was considered to be negligible or no such inflows were identified. The remaining three, Lakes Rerewhakaaitu, Tikitapu and Okaro either had no geothermal inflows or were not influenced by inflows of this type. In the case of Lake Tikitapu however sediment data indicated that this lake may be influenced by geothermal inflows.

While geothermal inflows could be clearly identified and their influence on the relative nutrient inputs to some of the lakes assessed, in a number of the cases more information, in particular flow data, is required to enable geothermal stream and spring inflows to be correctly characterised.

In summary, five of the twelve Rotorua lakes are influenced by geothermal inflows, while three are not subject to any geothermal influences. Additional information is required to characterise geothermal inflows to the remaining four lakes and to determine whether these lakes are influenced by geothermal inflows.

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6. APPENDICES

APPENDIX 6.1

EBOP Geothermal Data Summary Table - Mean Values

EBOP Geotherm Data Summary Table – Mean Values Shown

Description	Source	Flow m3/s	Total Nitrogen g/m3-N	Total Nitrogen tonnes/year	Total Kjeldahl Nitrogen + Total Nitrogen Oxides g/m3	Total Kjeldahl Nitrogen + Total Nitrogen Oxides tonnes/year	Total Phosphorus g/m3-P	Total Phosphorus tonnes/year	Ammonium (NH4) g/m3-N	Ammonium (NH4) tonnes/year
	Waiohewa Stream	0.44	3.76	52.76	4.35	60.91	0.36	5.06	2.50	35.04
	Wharetata Bay Springs	0.1	-	-	-	-	0.10	0.33	4.00	12.61
	Parengarenga Springs	0.1	15.98	50.39		66.82	0.29	0.92	19.53	61.61
	Ohinemutu Springs	0.01	-	-	0.47	0.15	0.10	0.03	0.22	0.07
	Tunuhopu Springs	0.01	-	-	0.71	0.15	0.21	0.04	0.09	0.02
	Black Stream	0.01	-	-	1.82	0.35	0.33	0.06	0.97	0.19
	Sewer Stream	0.01	-	-	0.26	0.11	0.33	0.14	0.09	0.04
	Pipe Stream	0.00	-	-	0.58	0.06	0.21	0.02	0.26	0.03
	Polynesian Springs - South	0.00	-	-	0.52	0.02	0.40	0.01	0.35	0.01
	Polynesian Springs - North	0.01	-	-	1.33	0.48	0.27	0.10	1.04	0.38
	Springs Outlet	0.00	-	-	1.51	0.07	0.36	0.02	0.76	0.04
	Tarawera Peak & Camp Stream	0.1	-	-	0.19	0.59	0.14	0.45	0.00	0.00
	Spring 100m North of Waterfall	0.1	-	-	0.08	0.24	0.15	0.47	0.00	0.00

APPENDIX 6.2

EBOP Geothermal Raw Data

Site	Sample	Date	Time	Flow	Temp	Conductivity	Suspended solids	pH	Chloride	Sulphate	Dissolved reactive phosphorus	Total phosphorus	Ammonium nitrogen	Nitrate nitrogen	Total kjeldahl nitrogen	Total nitrogen
				m3/s	deg C	mS/m @25C	g/m3		g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3
	BOP120006		Rangiteaorere Road Bridge			Waiohewa Stream		U15:0180-4160								
BOP120006	921602	07/07/92	10:38	0.421	11.8			6.9			0.038	0.099	1.268		1.424	
BOP120006	921779	22/07/92	13:22	0.621	14.1		53.3	4.8			0.007	0.101			7.843	
BOP120006	921862	05/08/92	12:14	0.300	10.9			6.8			0.034	0.080	1.930		1.943	
BOP120006	921919	19/08/92	12:37	0.336	11.4		10.1	6.8			0.015	0.070	2.540		2.438	
BOP120006	922032	27/08/92	14:15	0.425	12.6		11.9				0.012	0.066	3.580		3.140	
BOP120006	922078	02/09/92	11:58		13.2			6.5			0.015	0.065	1.940		1.980	
BOP120006	922232	15/09/92	12:14	0.357	13.8		14.8	7.0			0.022	0.101			2.920	
BOP120006	922431	06/10/92	11:12	0.355	14.1		12.4	7.0			0.019	0.066			1.767	
BOP120006	922596	20/10/92	11:35	0.842	15.0			7.0			0.041	0.063	0.846		1.070	
BOP120006	922719	03/11/92	11:19	0.321	15.5		9.3	7.0			0.017	0.069	1.007		0.522	
BOP120006	922816	17/11/92	11:08	0.354	16.0			6.6			0.011	0.114	1.880	1.349		4.068
BOP120006	922901	27/11/92	7:35	0.275					8.5	40.0			1.351			
BOP120006	922902	27/11/92	7:38	0.275					8.5	40.7			1.187			
BOP120006	922903	27/11/92	7:41	0.275					9.0	42.2			1.471			
BOP120006	922947	01/12/92	12:28	0.368	16.7		22.2	6.4			0.011	0.129	1.610	1.274		3.144
BOP120006	923084	16/12/92	11:53	0.356	18.1			6.6			0.004	0.113	0.599	0.672		2.699
BOP120006	930033	07/01/93	11:27	0.275	17.5	16.6		5.9			0.030	0.064	0.985		1.054	
BOP120006	930179	19/01/93	11:14	0.267	17.3		4.6	6.7			0.041	0.058	0.687		0.924	
BOP120006	930522	03/02/93	11:01	0.258	14.8			7.0			0.067	0.048	0.784		0.877	
BOP120006	930784	17/02/93	10:36	0.210	14.5		3.7	7.1			0.059	0.046	0.765		0.874	
BOP120006	931071	03/03/93	10:50	0.254	16.5			7.0			0.049	0.069	1.320		1.912	
BOP120006	931323	17/03/93	11:59	0.222	15.8		6.7	7.0			0.058	0.091	0.896			2.600
BOP120006	931539	31/03/93	12:03	0.266	15.6			6.9			0.048	0.073	1.430		1.770	
BOP120006	931627	13/04/93	11:59	0.248	13.6		5.0	6.9			0.054	0.066	0.983		1.371	
BOP120006	931773	27/04/93	11:53	0.238	13.1			6.9			0.037	0.054	1.050		1.050	
BOP120006	931870	12/05/93	12:43	0.223	14.0		6.1	6.9			0.022	0.058	1.126	2.090	1.400	
BOP120006	931909	17/05/93	9:45	1.037			167.0				0.570	0.583	4.675	0.887		4.511
BOP120006	931910	17/05/93	9:45	0.880	14.0		31.4	4.8			0.023	0.095	4.675	1.163		5.881
BOP120006	931973	26/05/93	12:07	0.258	12.3			6.9			0.019	0.082	1.662	1.025		2.456
BOP120006	932012	06/06/93	12:15	1.753			125.0									

Site	Sample	Date	Time	Flow	Temp	Conductivity	Suspended solids	pH	Chloride	Sulphate	Dissolved reactive phosphorus	Total phosphorus	Ammonium nitrogen	Nitrate nitrogen	Total kjeldahl nitrogen	Total nitrogen
				m3/s	deg C	mS/m @25C	g/m3		g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3
BOP120006	932020	06/06/93	15:25	1.135			63.4									
BOP120006	932028	07/06/93	10:35	0.455			25.3									
BOP120006	932029	07/06/93	10:35	0.455			155.0									
BOP120006	932053	08/06/93	12:20	0.932	13.6		12.8	6.4			0.005	0.068	3.363	0.861		5.016
BOP120006	932113	13/06/93	9:19	1.564			112.0									
BOP120006	932121	13/06/93	10:40	1.760			90.3									
BOP120006	932129	14/06/93	9:20	0.626			30.8	5.7								
BOP120006	932130	14/06/93	9:20	0.626			184.0									
BOP120006	932150	15/06/93	9:15	0.513			24.0				0.007	0.100	3.227	0.922	3.820	
BOP120006	932151	15/06/93	9:15	0.513							0.123	1.820	3.128	0.663	3.190	
BOP120006	932165	17/06/93	11:50	0.373			14.6				0.033	0.073			2.150	
BOP120006	932186	21/06/93	10:20	0.388			16.5									
BOP120006	932202	22/06/93	11:34	0.344	12.9			6.9								
BOP120006	932209	28/06/93	9:20	0.318							0.134	0.286	0.556		3.090	
BOP120006	932227	06/07/93	10:10	0.457			63.7				0.005	0.308	3.340	0.606	5.130	
BOP120006	932231	06/07/93	11:52	0.445			56.1				0.009	0.194	3.924	0.610	4.930	
BOP120006	932233	07/07/93	9:50	0.439			21.5				0.005	0.102	2.967	1.012	3.170	
BOP120006	932234	07/07/93	9:50	0.439			110.0				0.259	0.528	2.675	0.533	3.710	
BOP120006	932248	13/07/93	12:10	0.286	11.7			7.0			0.009	0.079	2.065	1.147		3.506
BOP120006	932295	27/07/93	13:04	0.280	12.9		12.2	7.2			0.032	0.060	1.550		1.890	
BOP120006	932372	10/08/93	11:59	0.177	12.8			7.0			0.023	0.081	1.360		1.780	
BOP120006	932464	24/08/93	12:27	0.266	12.3		8.8	6.9			0.015	0.077		1.440	1.560	
BOP120006	932568	07/09/93	12:47	0.201	11.0			7.0			0.044	0.046	1.520		1.920	
BOP120006	932645	21/09/93	12:21	0.240	14.9		7.7	7.0			0.036	0.065	1.570		2.000	
BOP120006	932754	05/10/93	11:09	0.184	13.1			6.9			0.031	0.087	1.160		1.430	
BOP120006	932881	19/10/93	11:17	0.238	14.1		7.0	7.0			0.021	0.067		1.720	1.180	
BOP120006	932988	02/11/93	10:47	0.177	13.3			7.0			0.036	0.073	1.780		1.700	
BOP120006	933063	08/11/93	9:35	0.177			389.3				0.222	0.590	0.491		4.570	
BOP120006	933137	16/11/93	11:50	0.217	16.9		10.2	7.0			0.033	0.075	2.020		2.850	
BOP120006	933217	22/11/93	10:32	0.191			297.0				1.290	0.040	0.448	0.339	3.850	
BOP120006	933287	30/11/93	11:27	0.184	15.1			7.1			0.044	0.069	1.170		1.140	
BOP120006	933422	14/12/93	11:50	0.241	17.8		8.4	6.9			0.053	0.073	1.750		2.160	
BOP120006	940060	11/01/94	11:37		16.7			6.9			0.053	0.067	0.780		1.060	

Site	Sample	Date	Time	Flow	Temp	Conductivity	Suspended solids	pH	Chloride	Sulphate	Dissolved reactive phosphorus	Total phosphorus	Ammonium nitrogen	Nitrate nitrogen	Total kjeldahl nitrogen	Total nitrogen
				m3/s	deg C	mS/m @25C	g/m3		g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3
BOP120006	940167	25/01/94	8:37				8.6				0.121	0.145	1.960	1.190	2.430	
BOP120006	940183	25/01/94	11:32		18.2		7.3	6.6			0.051	0.074	2.130		2.600	
BOP120006	940363	10/02/94	11:02		15.5			7.0			0.052	0.064	0.552	2.070	0.724	
BOP120006	940424	17/02/94	13:00				30.0				0.152	0.216	1.920	1.900	2.840	
BOP120006	940464	22/02/94	9:12				69.8				0.197	0.274	4.590	0.922	6.800	
BOP120006	940490	23/02/94	11:38		16.5		8.0	6.8			0.051	0.077	2.360		2.520	
BOP120006	940616	08/03/94	11:03		13.8			6.9			0.038	0.065	0.952		1.570	
BOP120006	940728	23/03/94	11:34		12.8		6.2	7.1			0.045	0.070	1.900		2.060	
BOP120006	940846	05/04/94	9:48				33.6				0.178	0.229	3.180	1.010	3.860	
BOP120006	940882	06/04/94	11:46		13.5			6.8			0.026	0.077	1.870		1.960	
BOP120006	940973	20/04/94	9:37				76.0				0.361	10.600	4.470	1.190	5.230	
BOP120006	940990	20/04/94	12:45		15.8		12.4	6.8			0.026	0.080	2.320		2.310	
BOP120006	941095	04/05/94	11:53		14.0			6.8			0.032	0.080	2.020		2.450	
BOP120006	941175	18/05/94	11:53		13.1		7.2	6.6			0.034	0.079	1.330	1.790	1.400	
BOP120006	941263	27/05/94	9:40				42.1	4.8			0.042	0.185	7.990	0.965	9.990	
BOP120006	941264	27/05/94	9:40				56.8				0.270	0.346	1.700	1.400	2.440	
BOP120006	941271	30/05/94	9:13				27.5				0.147	0.119	7.850	0.929	2.730	
BOP120006	941297	01/06/94	12:00		10.9			6.9			0.049	0.111	1.660	1.470	1.880	
BOP120006	941352	15/06/94	11:58		11.7		16.0	6.8			0.034	0.090	2.370	1.110	3.160	
BOP120006	941379	15/06/94	11:58				483.0				0.650	1.450	1.870	1.260	9.910	
BOP120006	941412	21/06/94	9:46				126.0	6.3			0.027	0.418	2.040	0.868	4.070	
BOP120006	941419	21/06/94	11:30				150.0	4.5			0.027	0.457	4.370	0.652	5.880	
BOP120006	941457	24/06/94	9:37				86.5				0.279	0.296	2.300	0.832	4.980	
BOP120006	941464	27/06/94	9:38				82.2				0.262	0.389	3.150	0.809	0.274	
BOP120006	941471	28/06/94	9:26				17.3				0.110	0.081	4.100	0.857	0.543	
BOP120006	941558	13/07/94	13:41		10.3		12.8	7.0			0.026	0.097	1.830		1.000	
BOP120006	941588	17/07/94	9:37				57.9	4.2			0.026	0.191	9.180	1.110	10.100	
BOP120006	941601	19/07/94	9:36				30.2	6.0			0.029	0.121	5.290	1.000	6.100	
BOP120006	941622	22/07/94	9:30				860.0				0.846	3.360	4.500	0.787	10.200	
BOP120006	941630	25/07/94	9:31				230.0	4.0			0.023	0.654	3.610	0.511	7.300	
BOP120006	941637	26/07/94	9:15				235.0				0.409	0.630	4.930	0.597	6.500	
BOP120006	941657	29/07/94	9:39				95.9	4.5			0.022	0.274	3.440	0.742	5.520	
BOP120006	941665	01/08/94	9:42				160.0				0.439	0.568	4.350	0.787	1.000	

Site	Sample	Date	Time	Flow	Temp	Conductivity	Suspended solids	pH	Chloride	Sulphate	Dissolved reactive phosphorus	Total phosphorus	Ammonium nitrogen	Nitrate nitrogen	Total kjeldahl nitrogen	Total nitrogen
				m3/s	deg C	mS/m @25C	g/m3		g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3
BOP120006	941684	03/08/94	9:30				108.0	4.3			0.023	0.273	3.920	0.571	5.360	
BOP120006	941693	04/08/94	10:36				220.0				0.395	0.457	4.850		4.770	
BOP120006	941731	09/08/94	9:45				17.2				0.068	0.071	3.200	0.906	2.620	
BOP120006	941759	10/08/94	11:55		11.4		16.7				0.042	0.081	2.340		2.970	
BOP120006	941913	13/09/94	13:35		12.7	18.0	9.2	7.0			0.033	0.073	1.460		2.000	
BOP120006	941990	22/09/94	10:00				270.0				0.408	1.360	2.950	1.700	3.540	
BOP120006	942057	04/10/94	8:42				37.8				0.147	0.174	3.320	1.860	3.370	
BOP120006	942088	10/10/94	8:40				93.9				0.223	0.332	3.050	0.695	3.680	
BOP120006	942112	12/10/94	11:46		13.2		13.5				0.033	0.068	2.470		2.640	
BOP120006	942168	21/10/94	11:40			17.6		6.9								
BOP120006	942195	31/10/94	8:50				73.4				0.191	0.244	3.300		4.180	
BOP120006	942236	09/11/94	8:25				240.0				0.442	0.924	2.760	0.918	4.480	
BOP120006	942351	23/11/94	13:30		17.2		7.8				0.038	0.078	1.710		2.030	
BOP120006	942652	14/12/94	12:50		17.7		6.9				0.054	0.081	1.300	1.730	1.280	
BOP120006	950102	18/01/95	13:45		17.8		8.0				0.069	0.097	1.720	1.690	1.880	
BOP120006	950810	13/03/95	8:59				142.0	4.1			0.035	0.672	3.950	0.700	6.160	
BOP120006	950850	15/03/95	13:20		16.3		13.4				0.038	0.102	2.660	0.972	3.210	
BOP120006	951107	29/03/95	9:50				105.0				0.260	0.355	4.060	0.673	5.430	
BOP120006	951133	30/03/95	12:40		18.0		37.7				0.044	0.208	5.910	0.943	6.580	
BOP120006	951225	12/04/95	12:40		17.2		35.3				0.020	0.109	4.130	0.866	4.500	
BOP120006	951368	17/05/95	13:43		13.9		8.4				0.040	0.076	2.300	1.200	2.560	
BOP120006	951443	23/05/95	9:20				1070.0				0.025	2.470	1.970	1.720	11.900	
BOP120006	951607	22/06/95	12:15		12.8		11.2				0.031	0.064	1.970	1.090	2.170	
BOP120006	021952	17/04/02	13:43					7.1			0.033	0.025	1.000			
BOP120006	022355	15/05/02	13:49					7.0			0.035	0.021	1.600		1.130	
BOP120006	022723	12/06/02	14:11					7.0			0.054		1.590	1.370		
BOP120006	023032	09/07/02	14:00		13.2	16.7	15.0	7.0			0.014		1.660			
BOP120006	023454	13/08/02	14:30		15.0	17.0	10.0	6.9			0.028		1.570			
BOP120006	023850	17/09/02	14:15		15.9	15.6	10.0	7.0			0.034		0.894			
BOP120006	024196	15/10/02	12:05		13.8	16.4	8.8	7.2						1.630		
BOP120006	024525	12/11/02	12:20		12.9	15.3	6.0	7.1			0.036		0.872			
BOP120006	030580	28/01/03	13:25		16.5		8.0				0.043		1.020			
BOP120006	030874	11/02/03	12:38		15.0											

Site	Sample	Date	Time	Flow	Temp	Conductivity	Suspended solids	pH	Chloride	Sulphate	Dissolved reactive phosphorus	Total phosphorus	Ammonium nitrogen	Nitrate nitrogen	Total kjeldahl nitrogen	Total nitrogen
				m3/s	deg C	mS/m @25C	g/m3		g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3
	BOP120010		**Hot Pools at Lake Rotoiti**			**Manupirua Springs**		**U15:0760-4610**								
BOP120010	921759	22/07/92	10:15				0.9	5.0							4.088	
BOP120010	922476	06/10/92							112.6	143.6						
	BOP120011		**Stream at Lake Rotoiti front**			**Wharetata Bay Springs**		**U15:0650-4550**								
BOP120011	921760	22/07/92	10:35				0.4	2.4			0.099	0.105	4.000		34.840	
BOP120011	922477	06/10/92							6.8	1.4						
	BOP120012		**Stream entering Lake Rotoiti**			**Parengarenga Springs**		**U15:0490-4540**								
BOP120012	921853	05/08/92	12:10					2.3			0.134	0.139			20.120	
BOP120012	921978	25/08/92	11:10				1.6	2.3	12.4	364.0	0.092	0.125	19.420	0.003	20.060	
BOP120012	922083	02/09/92	11:50					2.3			0.106	0.089			2.000	
BOP120012	922482	06/10/92					2.3	2.4	17.3	1.0	0.085	0.099	19.700	0.004	21.910	
BOP120012	922723	03/11/92	12:13		32.9		2.8	2.3			0.075	0.080	1.500		18.560	
BOP120012	922951	01/12/92	13:11		25.2		22.6	2.4			0.103	0.140	16.080	0.015		16.430
BOP120012	923088	16/12/92	12:36		35.8			2.4			0.081	0.138	17.950	0.004		19.020
BOP120012	930037	07/01/93	11:45		33.2	261.0		2.6			0.092	0.074	20.150		20.810	
BOP120012	930183	19/01/93	11:30		35.2		1.4	2.5				0.080	21.600		21.000	
BOP120012	930526	03/02/93	11:15		28.9			2.4			0.132	0.090	23.540		20.110	
BOP120012	930788	17/02/93	10:57		28.3		0.8	2.6			0.126	0.097	21.740		23.520	
BOP120012	931075	03/03/93	11:20		28.8			2.3			0.146	0.104	21.890		23.200	
BOP120012	931327	17/03/93	12:20		29.1		9.3	2.4			0.141	0.131	21.400			18.040
BOP120012	931543	31/03/93	12:38		28.5			2.4			0.189	0.115	20.700		22.120	
BOP120012	931631	13/04/93	12:30		28.1		0.3	2.5			0.252	0.099	2.113		21.750	
BOP120012	931777	27/04/93	12:20		26.1			2.4			0.194	2.140	23.900		21.180	
BOP120012	931874	12/05/93	13:10		27.3		4.4	2.4			0.145	0.144	22.350	0.007		
BOP120012	931977	26/05/93	12:30		26.3			2.3			0.107	0.114	19.840	0.006		20.350

Site	Sample	Date	Time	Flow	Temp	Conductivity	Suspended solids	pH	Chloride	Sulphate	Dissolved reactive phosphorus	Total phosphorus	Ammonium nitrogen	Nitrate nitrogen	Total kjeldahl nitrogen	Total nitrogen
				m3/s	deg C	mS/m @25C	g/m3		g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3
BOP120012	932057	08/06/93	12:50		32.0		5.9	6.4			0.012	0.093	1.687	0.013		2.188
BOP120012	932206	22/06/93	12:08		26.7			2.4								
BOP120012	932252	13/07/93	12:28		26.3			2.3			0.081	0.125	20.121	0.048		19.839
BOP120012	932299	27/07/93	13:40		27.5		5.1	2.4			0.204	0.089	19.800		22.870	
BOP120012	932376	10/08/93	12:23		28.0			2.4			0.165	0.098	20.200		23.350	
BOP120012	932468	24/08/93	13:00		27.2		2.9	2.4			0.180	0.103	20.200		22.520	
BOP120012	932572	07/09/93	13:13		28.0			2.4			0.150	0.076	21.900		20.710	
BOP120012	932649	21/09/93	12:45		27.0		5.1	2.4			0.188	0.096	19.500		21.940	
BOP120012	932758	05/10/93	11:33		25.6			2.4			0.145	0.104	22.800		23.700	
BOP120012	932885	19/10/93	11:42		26.2		5.2	2.4			0.194	0.156	25.400	0.039	25.400	
BOP120012	932992	02/11/93	11:20		26.3			2.4			0.140	0.109	22.000		23.100	
BOP120012	933141	16/11/93	12:09		28.9		2.0	2.4			0.137	0.109	22.900		23.900	
BOP120012	933291	30/11/93	11:48		27.5			2.4			0.010	0.086	21.800		18.900	
BOP120012	933426	14/12/93	12:15		31.0		3.3	2.4			0.126	0.095	22.100		21.050	
BOP120012	940064	11/01/94	11:55		29.5			2.4			0.150	0.091	22.600		23.200	
BOP120012	940187	25/01/94	11:53		28.2		2.6	2.3			0.148	0.108	14.000		14.020	
BOP120012	940367	10/02/94	12:00		29.8			2.4			0.147	2.280	23.200	0.038	23.800	
BOP120012	940493	23/02/94	12:15		45.0		3.3	2.4			0.175	1.720	13.700		18.100	
BOP120012	940620	08/03/94	11:30		28.5			2.5			0.180	0.078	22.600		20.200	
BOP120012	940732	23/03/94	11:52		27.4		2.2	2.4			0.171	2.300	23.800		21.600	
BOP120012	940886	06/04/94	12:20		27.2			2.5			0.113	0.103	23.900		13.800	
BOP120012	940994	20/04/94	13:20		28.6		2.4	2.4			0.134	0.104	22.600		23.630	
BOP120012	941099	04/05/94	12:15		27.2			2.4			0.170	0.106	23.800		22.700	
BOP120012	941179	18/05/94	12:28		25.6		1.8	2.4			0.143	0.103	22.650		25.600	
BOP120012	941301	01/06/94	12:20		25.6			2.4			0.145	0.100	23.200	0.043	23.600	
BOP120012	941356	15/06/94	12:28		25.9		1.4	2.4			0.148	0.107	10.600	0.045	28.000	
	Thermal Springs at Lake edge				**Ohinemutu Springs**		**U16:9477-3653**									
BOP120029	921792	22/07/92	9:53	0.013		126.3		7.7	226.0		0.140	0.180	0.480	0.045	0.830	
BOP120029	921932	19/08/92	9:50	0.012		147.1			269.0		0.093	0.138	0.282	0.026	0.540	
BOP120029	922245	15/09/92	10:07	0.012		138.4			267.0		0.083	0.103	0.287	0.008	0.500	
BOP120029	922442	06/10/92	9:00	0.009		139.6			266.0		0.089	0.111	0.217	0.013	0.460	

Site	Sample	Date	Time	Flow	Temp	Conductivity	Suspended solids	pH	Chloride	Sulphate	Dissolved reactive phosphorus	Total phosphorus	Ammonium nitrogen	Nitrate nitrogen	Total kjeldahl nitrogen	Total nitrogen
				m3/s	deg C	mS/m @25C	g/m3		g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3
BOP120029	922733	03/11/92	10:05	0.010		149.8			274.0		0.093	0.110	0.316	0.015	0.400	
BOP120029	922930	27/11/92	9:10						312.2	50.2			0.005			
BOP120029	922931	27/11/92	9:11						315.6	51.0			0.005			
BOP120029	922932	27/11/92	9:12						303.9	48.4			0.005			
BOP120029	922961	01/12/92	9:55	0.013		136.1			232.0		0.089	0.115	0.308	0.046	0.500	
BOP120029	930193	19/01/93	9:55	0.011		150.8			271.0		0.078	0.101	0.233	0.011	0.290	
BOP120029	930798	17/02/93	9:55	0.010		145.5			276.0		0.093	0.105	0.224	0.002	0.380	
BOP120029	931335	17/03/93	8:39	0.012		145.5			239.0		0.060	0.087	0.233	0.012	0.480	
BOP120029	931641	13/04/93	9:56	0.011		142.9			279.0		0.083	0.189	0.238	0.013	0.480	
BOP120029	931884	12/05/93	10:21	0.011		147.5			252.0		0.063	0.077	0.298	0.007	0.430	
BOP120029	932067	08/06/93	14:15	0.009		148.0			279.0		0.091	0.106	0.261	0.012	0.520	
BOP120029	932315	27/07/93	9:51	0.010		155.0			266.0		0.059	0.085	0.229	0.002	0.480	
BOP120029	932483	24/08/93	9:34	0.006		156.7			278.0		0.053	0.070	0.247	0.002	0.430	
BOP120029	932664	21/09/93	9:35	0.009		153.0			216.0		0.074	0.080	0.292	0.009	0.470	
BOP120029	932900	19/10/93	8:36	0.010												
BOP120029	933156	16/11/93	8:45	0.007		152.8			253.0		0.056	0.073	0.177	0.002	0.460	
BOP120029	933441	14/12/93	8:55	0.008		167.7			278.0		0.059	0.074	0.233	0.002	0.390	
BOP120029	940201	25/01/94	8:55			146.0			242.0		0.049	0.061	0.184	0.012	0.370	
BOP120029	940508	23/02/94	8:50			164.0			265.0		0.056	0.075	0.236	0.002	0.440	
BOP120029	940747	23/03/94	10:00			152.0			245.0		0.047	0.068	0.180	0.014	0.390	
BOP120029	941009	20/04/94	10:08													
BOP120029	941194	18/05/94	9:30									0.018				
BOP120029	941371	15/06/94	9:40													
BOP120029	942129	18/10/94	12:40		45.0	154.8		7.9								
	BOP120030		**Thermal Springs at Lake edge**			**Tunuhopu Springs**			**U16:9474-3662**							
BOP120030	921793	22/07/92	9:45	0.012		68.0		6.8	109.0		0.110	0.200	0.340	0.670	1.180	
BOP120030	921933	19/08/92	9:45	0.008		115.6			218.0		0.053	0.120	0.055	0.163	0.620	
BOP120030	922246	15/09/92	10:03	0.008		82.8			152.0		0.040	0.115	0.230	0.100	0.790	
BOP120030	922443	06/10/92	8:55	0.004		129.1			243.0		0.038	0.078	0.032	0.130	0.360	
BOP120030	922734	03/11/92	10:00	0.006		135.5			249.0		0.075	0.134	0.091	0.110	0.510	

Site	Sample	Date	Time	Flow	Temp	Conductivity	Suspended solids	pH	Chloride	Sulphate	Dissolved reactive phosphorus	Total phosphorus	Ammonium nitrogen	Nitrate nitrogen	Total kjeldahl nitrogen	Total nitrogen
				m3/s	deg C	mS/m @25C	g/m3		g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3
BOP120030	922962	01/12/92	9:50	0.014		81.0			132.0		0.085	0.160	0.162	0.258	0.800	
BOP120030	930194	19/01/93	9:50	0.006		125.0			223.0		0.030	0.063	0.053	0.117	0.210	
BOP120030	930799	17/02/93	9:50	0.005		126.0			239.0		0.041	0.061	0.002	0.117	0.300	
BOP120030	931334	17/03/93	8:35	0.005		102.0			158.0		0.002	0.087	0.005	0.098	0.800	
BOP120030	931642	13/04/93	9:53	0.004		130.3			254.0		0.045	0.080	0.022	0.085	0.370	
BOP120030	931885	12/05/93	10:16	0.005		89.1			151.0		0.055	0.095	0.098	0.190	0.450	
BOP120030	932068	08/06/93	14:10	0.005		132.0			245.0		0.150	0.248	0.167	0.142	0.540	
BOP120030	932316	27/07/93	9:50	0.005		149.0			261.0		0.047	0.086	0.177	0.163	0.930	
BOP120030	932484	24/08/93	9:31	0.004		146.6			306.0		0.035	0.075	0.038	0.126	0.210	
BOP120030	932665	21/09/93	9:30	0.005		145.8			241.0		0.192	1.850	0.090	0.103	0.530	
BOP120030	932901	19/10/93	8:32	0.013												
BOP120030	933157	16/11/93	8:40	0.005		153.8			255.0		0.092	0.120	0.027	0.124	0.990	
BOP120030	933442	14/12/93	8:50	0.004		146.3			242.0		0.035	0.058	0.007	0.097	0.278	
BOP120030	940202	25/01/94	8:52			148.5			249.0		0.134	0.460	0.111	0.092	0.600	
BOP120030	940509	23/02/94	8:45			150.5			241.0		0.068	0.098	0.088	0.098	0.350	
BOP120030	940748	23/03/94	9:55			150.5			242.0		0.034	0.061	0.023	0.132	0.240	
BOP120030	941010	20/04/94	10:04													
BOP120030	941195	18/05/94	9:35													
BOP120030	941372	15/06/94	9:45													
BOP120030	942130	18/10/94	12:55		39.7	139.4		8.1								
	BOP120031		**Thermal Springs at Lake edge**			**Black Stream**		**U16:9583-3515**								
BOP120031	921794	22/07/92	10:10	0.000		15.0		4.6	18.0		0.030	0.100	0.090	0.077	0.330	
BOP120031	921934	19/08/92	10:00	0.000		10.7			9.0		0.046	0.273	0.184	0.171	1.170	
BOP120031	922247	15/09/92	10:56	0.001		19.5			31.0		0.072	0.172	0.147	0.002	0.660	
BOP120031	922444	06/10/92	9:35	0.002		77.7			178.0		0.114	0.165	0.303	0.002	0.550	
BOP120031	922735	03/11/92	10:15	0.000		95.5			170.0		0.056	0.176	0.531	0.002	0.670	
BOP120031	922963	01/12/92	10:57	0.041		14.3			12.0		0.046	0.098	0.187	0.093	0.520	
BOP120031	930195	19/01/93	10:10	0.003		106.0			194.0		0.176	0.184	0.363	0.002	0.580	
BOP120031	930800	17/02/93	10:40	0.004		103.3			184.0		0.479	0.497	2.150	0.002	4.030	
BOP120031	931342	17/03/93	9:25	0.003		119.8			204.0		0.470	0.559	2.980	0.002	4.320	

Site	Sample	Date	Time	Flow	Temp	Conductivity	Suspended solids	pH	Chloride	Sulphate	Dissolved reactive phosphorus	Total phosphorus	Ammonium nitrogen	Nitrate nitrogen	Total kjeldahl nitrogen	Total nitrogen
				m3/s	deg C	mS/m @25C	g/m3		g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3
BOP120031	931643	13/04/93	10:45	0.005		85.0			144.0		0.611	0.663	3.910	0.002	4.980	
BOP120031	931886	12/05/93	11:05	0.004		20.3			28.0		0.158	0.227	0.437	0.092	1.130	
BOP120031	932069	08/06/93	14:35	0.006		92.0			148.0		0.063	0.389	0.462	0.034	0.820	
BOP120031	932317	27/07/93	9:31	0.004		112.4			179.0		0.265	0.308	0.830	0.002	1.300	
BOP120031	932485	24/08/93	10:16	0.003		108.1			191.0		0.223	0.256	0.687	0.002	1.050	
BOP120031	932666	21/09/93	10:12	0.003		107.9			172.0		0.400	0.500	0.940	0.002	2.900	
BOP120031	932902	19/10/93	9:16	0.020												
BOP120031	933158	16/11/93	9:30	0.006		102.2			157.0		0.300	0.410	0.920	0.027	1.740	
BOP120031	933443	14/12/93	9:15	0.005		139.0			221.0		0.330	0.470	1.010	0.002	1.810	
BOP120031	940203	25/01/94	9:41			110.6			179.0		0.730	0.790	2.260	0.002	6.200	
BOP120031	940510	23/02/94	9:30			142.3			239.0		0.203	0.220	0.500	0.002	0.600	
BOP120031	940749	23/03/94	10:15			145.6			235.0		0.197	0.212	0.470	0.002	0.600	
BOP120031	941011	20/04/94	10:49													
BOP120031	941373	15/06/94	10:05													
BOP120031	942127	18/10/94	11:35		25.9	142.4		6.0								
	BOP120032		**Thermal Springs at Lake edge**			**Sewer Stream**			**U16:9575-3528**							
BOP120032	921795	22/07/92	10:15	0.001		107.2		6.2	222.0		0.230	0.280	0.070	0.003	0.270	
BOP120032	921935	19/08/92	10:10	0.007		120.0			224.0		0.249	0.278	0.099	0.002	0.320	
BOP120032	922248	15/09/92	10:28	0.027		154.8			311.0		0.239	0.272	0.108	0.002	0.270	
BOP120032	922445	06/10/92	9:10	0.012		130.5			256.0		0.332	0.336	0.118	0.002	0.230	
BOP120032	922736	03/11/92	10:25	0.006		145.1			265.0		0.359	0.378	0.183	0.002	0.260	
BOP120032	922964	01/12/92	11:10	0.031		131.8			228.0		0.298	0.340	0.081	0.018	0.290	
BOP120032	930196	19/01/93	10:20	0.006		164.1			295.0		0.295	0.307	0.098	0.002	0.190	
BOP120032	930801	17/02/93	10:35	0.009		112.2			193.0		0.424	0.448	0.136	0.002	0.220	
BOP120032	931340	17/03/93	9:14	0.007		149.3			238.0		0.297	0.335	0.063	0.002	0.170	
BOP120032	931644	13/04/93	10:40	0.006		112.8			184.0		0.412	0.439	0.130	0.002	0.230	
BOP120032	931887	12/05/93	10:59	0.008		119.0			191.0		0.277	0.300	0.098	0.002	0.230	
BOP120032	932070	08/06/93	14:50	0.040		104.0			177.0		0.404	0.439	0.125	0.002	0.280	
BOP120032	932318	27/07/93	10:27	0.014		169.9			294.0		0.259	0.287	0.038	0.002	0.190	
BOP120032	932486	24/08/93	10:09	0.008		158.5			288.0		0.228	0.258	0.086	0.002	0.250	

Site	Sample	Date	Time	Flow	Temp	Conductivity	Suspended solids	pH	Chloride	Sulphate	Dissolved reactive phosphorus	Total phosphorus	Ammonium nitrogen	Nitrate nitrogen	Total kjeldahl nitrogen	Total nitrogen
				m3/s	deg C	mS/m @25C	g/m3		g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3
BOP120032	932667	21/09/93	9:50	0.009		134.2			217.0		0.360	0.380	0.111	0.002	0.220	
BOP120032	932903	19/10/93	9:10	0.017												
BOP120032	933159	16/11/93	9:20	0.033		186.0			311.0		0.195	0.225	0.002	0.002	0.269	
BOP120032	933444	14/12/93	9:25	0.007		110.4			164.0		0.400	0.390	0.095	0.002	0.215	
BOP120032	940204	25/01/94	9:35			198.8			347.0		0.157	0.213	0.030	0.002	0.400	
BOP120032	940511	23/02/94	9:20			184.4			337.0		0.195	0.248	0.027	0.002	0.440	
BOP120032	940750	23/03/94	10:25			90.0			132.0		0.430	0.460	0.135	0.002	0.260	
BOP120032	941012	20/04/94	10:44													
BOP120032	941197	18/05/94	9:55													
BOP120032	941374	15/06/94	10:20													
BOP120032	942125	18/10/94	11:07		31.2	213.0		6.8								
	BOP120033		**Thermal Springs at Lake edge**			**Pipe Stream**			**U16:9575-3530**							
BOP120033	921796	22/07/92	10:30	0.002		93.7		6.0	155.0		0.016	0.220	0.090	0.002	0.380	
BOP120033	921936	19/08/92	10:25	0.005		150.0			273.0		0.015	0.180	0.230	0.002	0.710	
BOP120033	922249	15/09/92	10:43	0.002		134.5			215.0		0.011	0.257	0.490	0.002	0.750	
BOP120033	922446	06/10/92	9:25	0.004		147.3			278.0		0.182	0.233	0.093	0.002	0.430	
BOP120033	922737	03/11/92	10:35	0.007		153.2			263.0		0.015	0.237	0.341	0.002	0.540	
BOP120033	922965	01/12/92	10:42	0.007		117.3			175.0		0.009	0.404	0.224	0.018	0.710	
BOP120033	930197	19/01/93	10:40	0.002		161.8			280.0		0.006	0.157	0.151	0.002	0.510	
BOP120033	930802	17/02/93	10:25	0.004		135.1			234.0		0.151	0.161	0.083	0.013	0.220	
BOP120033	931339	17/03/93	9:07	0.001		175.6			300.0		0.134	0.167	0.063	0.002	0.300	
BOP120033	931645	13/04/93	10:35	0.000		111.4			167.0		0.306	0.316	0.115	0.002	0.230	
BOP120033	931888	12/05/93	10:56	0.004		176.1			300.0		0.092	0.144	0.101	0.002	0.580	
BOP120033	932071	08/06/93	14:54	0.005		173.0			286.0		0.013	0.166	0.277	0.002	0.740	
BOP120033	932319	27/07/93	10:16	0.002		175.3			266.0		0.030	0.201	0.532	0.002	0.830	
BOP120033	932487	24/08/93	10:06	0.003		147.3			241.0		0.027	0.256	0.505	0.002	0.750	
BOP120033	932668	21/09/93	10:00	0.003		173.0			242.0		0.040	0.145	0.266	0.002	0.600	
BOP120033	932904	19/10/93	9:07	0.002												
BOP120033	933160	16/11/93	9:08	0.002		170.7			266.0		0.026	0.158	0.248	0.002	0.480	
BOP120033	933445	14/12/93	9:35	0.000		130.0			160.0		0.014	0.248	0.560	0.005	0.720	

Site	Sample	Date	Time	Flow	Temp	Conductivity	Suspended solids	pH	Chloride	Sulphate	Dissolved reactive phosphorus	Total phosphorus	Ammonium nitrogen	Nitrate nitrogen	Total kjeldahl nitrogen	Total nitrogen
				m3/s	deg C	mS/m @25C	g/m3		g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3
BOP120033	940205	25/01/94	9:32			127.5			181.0		0.014	0.069	0.310	0.002	0.540	
BOP120033	940512	23/02/94	9:10			151.3			239.0		0.045	0.137	0.128	0.002	0.660	
BOP120033	940751	23/03/94	10:37			113.7			121.0		0.058	0.360	0.430	0.002	0.760	
BOP120033	941013	20/04/94	10:39													
BOP120033	941198	18/05/94	9:55													
BOP120033	941375	15/06/94	10:30													
BOP120033	942124	18/10/94	10:50		24.5	201.0		5.9								
	BOP120034		**Thermal Springs at Lake edge**			**Polynesian Springs - South**			**U16:9575-3534**							
BOP120034	921797	22/07/92	10:35	0.001		100.5		4.6	162.0		0.020	0.380	0.340	0.007	0.310	
BOP120034	921937	19/08/92	10:30	0.003		100.0			166.0		0.100	0.410	0.051	0.002	0.630	
BOP120034	922250	15/09/92	10:45	0.001		109.8			158.0		0.090	0.375	0.640	0.002	0.810	
BOP120034	922447	06/10/92	9:27	0.005		168.8			178.0		0.374	0.389	1.190	0.002	1.490	
BOP120034	922738	03/11/92	10:39	0.002		151.1			158.0		0.368	0.380	1.090	0.002	1.220	
BOP120034	922966	01/12/92	10:45	0.002		112.4			169.0		0.024	0.380	0.541	0.002	0.620	
BOP120034	930198	19/01/93	10:45	0.001		110.4			171.0		0.427	0.434	0.147	0.002	0.230	
BOP120034	930803	17/02/93	10:27	0.000		108.3			169.0		0.415	0.422	0.232	0.002	0.230	
BOP120034	931338	17/03/93	9:06	0.001		97.7			127.0		0.417	0.458	0.204	0.002	0.340	
BOP120034	931646	13/04/93	10:33	0.001		102.9			155.0		0.348	0.393	0.171	0.002	0.200	
BOP120034	931889	12/05/93	10:54	0.000		100.7			142.0		0.405	0.431	0.216	0.002	0.330	
BOP120034	932072	08/06/93	14:57	0.001		95.0			126.0		0.030	0.380	0.261	0.002	0.470	
BOP120034	932320	27/07/93	10:17	0.001		102.9			125.0		0.022	0.487	0.330	0.002	0.390	
BOP120034	932488	24/08/93	10:04	0.001		96.2			154.0		0.373	0.394	0.215	0.002	0.400	
BOP120034	932669	21/09/93	10:02	0.000		94.1			106.0		0.340	0.450	0.185	0.002	0.500	
BOP120034	932905	19/10/93	9:05	0.000												
BOP120034	933161	16/11/93	9:10	0.000		128.8			129.0		0.320	0.380	0.129	0.002	0.500	
BOP120034	933446	14/12/93	9:40	0.000		93.8			120.0		0.033	0.370	0.176	0.002	0.400	
BOP120034	940206	25/01/94	9:31			93.0			119.0		0.330	0.360	0.288	0.002	0.430	
BOP120034	940513	23/02/94	9:12			96.9			137.0		0.294	0.360	0.320	0.002	0.440	
BOP120034	940752	23/03/94	10:40			104.7			128.0		0.148	0.320	0.370	0.002	0.500	
BOP120034	941014	20/04/94	10:37													

Site	Sample	Date	Time	Flow	Temp	Conductivity	Suspended solids	pH	Chloride	Sulphate	Dissolved reactive phosphorus	Total phosphorus	Ammonium nitrogen	Nitrate nitrogen	Total kjeldahl nitrogen	Total nitrogen
				m3/s	deg C	mS/m @25C	g/m3		g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3
BOP120034	941199	18/05/94	9:57													
BOP120034	941376	15/06/94	10:35													
BOP120034	942123	18/10/94	10:45		36.1	89.9		5.1								
	BOP120035		**Thermal Springs at Lake edge**			**Polynesian Springs - North**			**U16:9575-3538**							
BOP120035	921798	22/07/92	10:40	0.010		133.3		3.3	148.0		0.280	0.310	0.830	0.008	0.320	
BOP120035	921938	19/08/92	10:32	0.010		140.0			200.0		0.270	0.293	1.000	0.002	1.320	
BOP120035	922251	15/09/92	10:46	0.018		141.9			183.0		0.154	0.249	1.020	0.002	1.280	
BOP120035	922448	06/10/92	9:30	0.011		140.3			202.0		0.183	0.271	0.986	0.002	1.220	
BOP120035	922739	03/11/92	10:45	0.008		163.6			163.0		0.294	0.319	1.210	0.002	1.420	
BOP120035	922967	01/12/92	10:47	0.011		154.0			197.0		0.229	0.263	1.140	0.002	1.070	
BOP120035	930199	19/01/93	10:48	0.010		175.4			125.0		0.333	0.362	1.170	0.002	1.530	
BOP120035	930804	17/02/93	10:30	0.009		158.4			194.0		0.063	0.265	1.030	0.002	1.400	
BOP120035	931337	17/03/93	9:03	0.008		163.2			190.0		0.216	0.287	0.920	0.002	1.550	
BOP120035	931647	13/04/93	10:30	0.009		1574.4			182.0		0.129	0.248	1.040	0.002	1.420	
BOP120035	931890	12/05/93	10:52	0.007		155.6			178.0		0.064	0.239	0.930	0.002	1.170	
BOP120035	932073	08/06/93	14:59	0.049		160.0			180.0		0.127	0.235	0.910	0.002	1.300	
BOP120035	932321	27/07/93	10:20	0.009		178.2			138.0		0.266	0.282	1.140	0.005	1.500	
BOP120035	932489	24/08/93	10:02	0.007		155.6			176.0		0.214	0.252	1.000	0.002	1.500	
BOP120035	932670	21/09/93	10:03	0.011		160.1			166.0		0.048	0.237	1.020	0.002	1.300	
BOP120035	932906	19/10/93	9:02	0.008												
BOP120035	933162	16/11/93	9:15	0.005		318.0			183.0		0.155	0.231	1.150	0.002	1.450	
BOP120035	933447	14/12/93	9:42	0.005		156.8			173.0		0.116	0.227	1.060	0.002	1.260	
BOP120035	940207	25/01/94	9:28			167.0			137.0		0.229	0.330	1.100	0.002	1.800	
BOP120035	940514	23/02/94	9:15			164.4			190.0		0.253	0.270	1.150	0.002	1.400	
BOP120035	940753	23/03/94	10:43			155.1			165.0		0.223	0.248	1.090	0.002	1.400	
BOP120035	941015	20/04/94	10:34													
BOP120035	941200	18/05/94	10:00													
BOP120035	941377	15/06/94	10:37													
BOP120035	942122	18/10/94	10:40		42.0	180.7		3.2								

Site	Sample	Date	Time	Flow	Temp	Conductivity	Suspended solids	pH	Chloride	Sulphate	Dissolved reactive phosphorus	Total phosphorus	Ammonium nitrogen	Nitrate nitrogen	Total kjeldahl nitrogen	Total nitrogen
				m3/s	deg C	mS/m @25C	g/m3		g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3
	BOP120036		**Thermal Springs at Lake edge**			**Springs Outlet**			**U16:9576-3540**							
BOP120036	921799	22/07/92	10:25	0.002		244.0		2.6	192.0		0.260	0.300	1.180	0.001	1.700	
BOP120036	921939	19/08/92	10:20	0.001		280.0			85.0		0.580	0.600	1.720	0.056	2.190	
BOP120036	922252	15/09/92	10:37	0.006		168.0			31.0		0.330	0.362	1.060	0.002	1.690	
BOP120036	922449	06/10/92	9:20	0.001		607.0			126.0		1.880	1.970	0.519	0.049	5.940	
BOP120036	922740	03/11/92	10:30	0.001		321.0			63.0		0.800	0.820	2.100	0.048	2.670	
BOP120036	922968	01/12/92	10:24	0.004		135.7			24.0		0.161	0.200	0.662	0.165	1.030	
BOP120036	930200	19/01/93	10:30	0.000		81.9			18.0		0.227	0.267	0.522	0.002	0.860	
BOP120036	930805	17/02/93	10:18	0.000		39.8			64.0		0.029	0.135	0.066	0.002	0.460	
BOP120036	931336	17/03/93	9:00	0.000		35.4			17.0		0.120	0.173	0.287	0.013	0.700	
BOP120036	931648	13/04/93	10:23	0.000		101.2			34.0		0.235	0.165	0.730	0.002	1.200	
BOP120036	931891	12/05/93	10:48	0.001		24.0			8.0		0.059	0.090	0.192	0.022	0.350	
BOP120036	932074	08/06/93	14:50	0.001		331.0			33.0		0.517	0.557	1.690	0.071	2.330	
BOP120036	932322	27/07/93	10:10	0.002		85.1			95.0		0.034	0.163	0.423	0.024	0.720	
BOP120036	932490	24/08/93	9:58	0.002		75.7			27.0		0.183	0.227	0.562	0.002	0.910	
BOP120036	932671	21/09/93	9:55	0.002		61.5			94.0		0.009	0.186	0.252	0.165	2.100	
BOP120036	932907	19/10/93	8:58	0.001												
BOP120036	933163	16/11/93	9:05	0.001		174.0			37.0		0.310	0.340	1.080	0.002	1.420	
BOP120036	933448	14/12/93	9:32	0.001		123.6			35.0		0.233	0.256	0.840	0.002	1.130	
BOP120036	940208	25/01/94	9:22			86.7			123.0		0.011	0.171	0.330	0.002	0.640	
BOP120036	940515	23/02/94	9:05			64.8			26.0		0.107	0.137	0.410	0.002	0.660	
BOP120036	940754	23/03/94	10:35			92.3			99.0		0.100	0.120	0.560	0.002	0.860	
BOP120036	941016	20/04/94	10:29													
BOP120036	941201	18/05/94	9:50													
BOP120036	941378	15/06/94	10:45													
	BOP120037		**Parengarenga Bay**			**Lake Rotoiti**		**U15:0490-4560**								
BOP120037	921963	25/08/92	11:15		10.2				25.9	29.6						
BOP120037	921964	25/08/92	11:17		10.2				22.7	25.4						
BOP120037	921965	25/08/92	11:19		10.2				24.8	28.1						

Site	Sample	Date	Time	Flow	Temp	Conductivity	Suspended solids	pH	Chloride	Sulphate	Dissolved reactive phosphorus	Total phosphorus	Ammonium nitrogen	Nitrate nitrogen	Total kjeldahl nitrogen	Total nitrogen
				m3/s	deg C	mS/m @25C	g/m3		g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3
BOP120037	922483	06/10/92							32.1	35.7						
BOP120037	922484	06/10/92							31.3	35.0						
BOP120037	922485	06/10/92							31.2	35.1						
BOP120037	930833	17/02/93	11:40						34.7	38.7			0.005			
BOP120037	930834	17/02/93	11:41						34.8	38.9			0.005			
BOP120037	930835	17/02/93	11:42						35.1	39.0			0.005			
	BOP120077		**(Soda Springs) Swamp Outlet**				**Waitangi Spring Rot. ID 301**									
BOP120077	941833	30/08/94	14:35		45.0	162.6		6.0	350.0	46.0	0.268	0.273	0.439	0.003		
BOP120077	013504	16/10/01	7:55					6.2			0.111	0.161	0.237	0.260	0.232	0.492
BOP120077	014252	11/12/01	11:00					5.9			0.086	0.123	0.212	0.271	0.210	
	BOP120078		**Soda Spring 2**			**Waitangi Spring Rot. ID 302**										
	941834	30/08/94	14:23		41.0	143.2		5.9	300.0	41.0	0.273	0.268	0.301			
	BOP120091		**At Lake Edge**		**Tarawera Peak & Camp Stream**			**V16:1240-2341**								
BOP120091	941928	14/09/94	12:05		15.5	146.0		7.0			0.113	0.152	0.002		0.069	
BOP120091	942394	24/11/94	9:22		15.6						0.127	0.146	0.001		0.059	
BOP120091	950136	19/01/95	10:06		15.9		0.2				0.118	0.145	0.001	0.140	0.063	
BOP120091	950919	16/03/95	9:40		15.8		1.6	6.8			0.116	0.139	0.002	0.129	0.042	
BOP120091	951403	18/05/95	11:07		15.6						0.118	0.142	0.002	0.125	0.044	
BOP120091	951724	27/07/95	10:40		15.5						0.116	0.123	0.001	0.149	0.038	
	BOP120094		**At Lake Tarawera Edge**			**Spring 100m North of Waterfall**			**V16:1246-2352**							
BOP120094	941933	14/09/94	11:50		15.7	14.7		6.8			0.107	0.150	0.001		0.076	
	BOP120105		**SH30 Culvert, Tikitere**			**Waiohewa Stream**			**U15:0505-4313**							

Site	Sample	Date	Time	Flow	Temp	Conductivity	Suspended solids	pH	Chloride	Sulphate	Dissolved reactive phosphorus	Total phosphorus	Ammonium nitrogen	Nitrate nitrogen	Total kjeldahl nitrogen	Total nitrogen
				m3/s	deg C	mS/m @25C	g/m3		g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3
BOP120105	001924	24/05/00	11:00	17.300	16.8			7.1			0.061	0.070	0.261	0.320	0.440	
BOP120105	002019	07/06/00	11:10	18.700	16.9	20.1		7.0			0.049	0.067	0.192	1.150	0.464	
BOP120105	002182	27/06/00	10:25	14.400		25.8		7.1			0.071	0.089	0.422	1.330	0.677	
	BOP120106		**Lower Stream at Tikiteretere**			**Waiohewa Stream**			**U15:0502-4318**							
BOP120106	001925	24/05/00	11:20	2.500	34.8			2.8			0.048	0.055	55.300	0.066	56.600	
BOP120106	002020	07/05/00	11:35	5.900	33.8	222.0		2.6			0.043	0.067	57.400	0.003	64.500	
BOP120106	002183	27/06/00	10:28	2.900		121.8		2.9			0.018	0.043	41.800	0.055	45.000	
	BOP120107		**Tikitere at SH30 Culvert**			**Waiohewa Stream**			**U15:0476-4309**							
BOP120107	001926	24/05/00	12:55	14.900	28.3			2.9				0.048	33.900	0.054	31.300	
BOP120107	002021	07/05/00	12:12	31.000	28.5	112.5		2.8			0.018	0.053	32.400	0.078	36.600	
BOP120107	002184	27/06/00		20.600		87.8		3.1			0.029	0.055	32.500	0.053	41.700	
	BOP160120		**Soda Springs**			**Rotoehu Soda Springs**		**V15:2160-4550**								
BOP160120	013045	30/08/01	7:55			127.2		6.1			0.110	0.151	0.249	0.290	0.251	
BOP160120	020603	01/02/31	8:15					6.0			0.091	0.139	0.239	0.210	0.272	
BOP160120	021644	26/03/02	9:52			131.1		6.1			0.085		0.236	0.183		
BOP160120	022072	24/04/02	11:00			132.7		6.0			0.124	0.086	0.254		0.233	
BOP160120	022792	18/06/02	9:50			130.2		6.1			0.110		0.241			
BOP160120	023475	14/08/02	10:05			12.5		6.1			0.117		0.234			
BOP160120	024127	09/10/02	10:10			13.0		6.1			0.109	0.191	0.019	0.218	0.240	

Site	Sample	Date	Time	Flow	Temp	Conductivity	Suspended solids	pH	Chloride	Sulphate	Dissolved reactive phosphorus	Total phosphorus	Ammonium nitrogen	Nitrate nitrogen	Total kjeldahl nitrogen	Total nitrogen
				m3/s	deg C	mS/m @25C	g/m3		g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3	g/m3
BOP160120	025250	20/12/02	7:45			132.1		6.0			0.107		0.237	0.189		