Waikato Regional Council Technical Report 2012/11

Geothermal features annual monitoring report, July 2011

www.waikatoregion.govt.nz
ISSN 2230-4355 (Print)
ISSN 2230-4363 (Online)

Waikato
REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

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October 2011

Document #: 2142584

Approved for release by:
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Waikato Regional Council

Oct 2011

Acknowledgement

I would like to acknowledge the co-operation and assistance of the Tourism concessionaires and business owners, farmers, and Department of Conservation, in allowing access, and sharing their time and knowledge of the geothermal features.

Thank you.

Contents

1. Outline

Project

Monitoring reported here is undertaken for the Waikato Regional Council for the purpose of monitoring the natural geothermal features of the Waikato Region that are associated with high temperature geothermal systems. The brief is to report on the geothermal surface manifestations in the geothermal areas listed below, and specifically to be alert to any changes, whether human-induced or natural, and to advise of any potential threat to these features.

Method

This report covers three of the quarterly sampling rounds for the July 2010 to June 2011 period. The work was carried out in October and December 2010, April-May 2011, and July 2011.

Most of the map locations were already given from previous work; where necessary for this report a Garmin GPSmap 60Cx was used to record or check locations. The accuracy of the GPS is +/-5m. Sketch maps of some features are included in order to assist future monitoring.

Direct temperature measurements were made with a thermocouple on a 5 m long wire, or a 100 mm long rigid probe, connected to a Fluke multimeter. If the surface to be measured was not accessible, a Fluke IR thermometer was used (and noted), however this is subject to limitations, particularly if there is steam present.

pH is measured with a Hanna Instruments pH meter with a maximum operating temperature of 50°C; if the spring temperature is > 50°C the water is cooled to less than 50°C before the pH measurement was taken. Unfortunately the instrument was not robust enough to survive continued field work, and there are no pH measurements for December 2010 or for 2011.

The liquid flow rate or discharge is estimated if we believe the estimate is realistic, i.e. that the entire flow can be seen and seepage or flow diversion is not occurring on a large scale. The water level was recorded for some features; subject to choosing an easily identified and physically long-lived benchmark in the vicinity, or relative to the overflow level. 'Ebullience' and gas discharge are recorded, also water clarity and colour, and the general condition of the sinter is noted.

Temperature dataloggers were placed in features at Orakeikorako (Soda Fountain and Diamond Geyser), Waiotapu (Waiotapu Geyser), and Ngatamariki (Hydrothermal Eruption Crater Pool), and have provided a temperature record every 2 minutes for 45 day periods. Graphs of these times series data are shown in this report, along with climate and seismic data which may be relevant to an analysis. Some initial analysis of the data is also reported here. The data itself has been given to the Waikato Regional Council.

Discussion

It is noted that a requirement of this contract is to advise on the relevance of features to the monitoring programme. Specific comments are given below:

1. For this reason, some features have been eliminated from the monitoring program, such as the Waikite Hot Pools sites that were intermediate between the supply springs and the baths, and more effort has been put into monitoring the supply springs area. In April I realised the Department of Conservation may require a permit to visit some Te Kopia sites, and unfortunately the permit could not be obtained in time for the April monitoring round.

2. The current monitoring of Tokaanu involves many of the pools on the Tourist walk behind the baths. This should be reduced to four pools (Hoanis and Matewai, Paurini, Taumatapuhipuhi) and photographs of the cooking area. Many of the other features are flooded and have very minor visible discharge.
3. I believe that there should be a concerted effort to relate historical and current names of the features, which have 'evolved' over the years. I suspect that finding and combing all the old records, and relating to current work is quite a large job, and maybe should also be part of a separate contract. There is probably some urgency here as many older researchers who know so much about New Zealand geothermal features are retired or on the verge of retiring, and from conversations I have had, there is still much unrecorded knowledge.
4. The natural variability of the TVZ geothermal systems is not well understood. I recommend that at least one feature from each geothermal system be selected, and continuously monitored with dataloggers recording temperature and conductivity (and water level if possible).

The Appendix to this report is the full Excel spreadsheet of data and is compiled in a separate, accompanying document (Waikato Regional Council Doc 2142693), which may be obtained on request from the Council.

2. Atiamuri

Matapan Rd

E2779201 N6302030

There are two springs here; one discharging around ~6 m above the pool, and a cooler spring with a lower flow rate discharging from the right-hand side of the rock face (looking upstream) around >3 m above the pool (there was less vegetation covering the springs in 2011 than in 2010, allowing a better estimate of discharge location). There was no smell of H_2S, the rocks below the springs and in the pool below are covered with black algae. There is cold groundwater seeps in the lower grassy slopes surrounding the head of the stream. In July 2011 the temperature of the stream ~10 m downstream of the spring was 31°C.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
12 April 2010	64	7.8	~5	-	-	Clear
23 Jul 2011	70	nd	2-3	-	-	Clear
12 April 2010	22		~0.5	-	-	Clear
23 Jul 2011	12		~0.5	-	-	Clear

a)

2-1. Matapan Rd Springs, July 2011.

Whangapoa Pools

Northwest Pool

E2776598 N6311134

It is difficult to approach the pool due to the fence and blackberry. The fence is in a state of disrepair but is still difficult to cross, and the sides of the pool may be unstable. In July moderate gas discharge could be seen in the pool. The temperature was measured in the pool, near the outlet.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
12 April 2010	58	-	~2	-	Upwelling.	Blue-green, slightly cloudy.
23 Jul 2011	60	-	1-2	-	Upwelling and gas discharge.	Green, clear.

a)

b)

2-2. Outlet of Northwest Whangpoa Pool. Arrow indicates measurement point. a) April 2010; b) July 2011

Southeast Pool

E2776615 N6311082

The pool is fenced. A channel has been cut in the sinter (where it crosses the fence-line) to direct the discharge.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
12 April 2010	61	8.1	~1	-	Upwelling in centre of pool.	Blue-green, clear.
23 Jul 2011	62	nd	~0.5	-	Minor gas discharge in centre of pool.	Blue-green, clear.

2-3 Southeast Whangpoa Pool, April 2010.

2-4 Southeast Whangpoa Pool, July 2011.

Two small springs off Ohakuri Rd

E2776420 N6311366

These springs are small, deep holes in the ground surrounded by blackberry and weed. They are enclosed by a fence. In July 2011 these features were flooded.

West

This feature appears to be the slightly more active of the two.

Date	T(°C)	pH	Flow (l/s)	Water level	Depth (m)	Diameter (m)	Ebullition	Colour
12 April 2010	97	nd	steam	nd	~1	~0.3	Audible continual bubbling.	Probe came up clean. Could smell H_2S.

East

Date	T(°C)	pH	Flow (l/s)	Water level	Depth (m)	Diameter (m)	Ebullition	Colour
12 April 2010	98	nd	steam	nd	~0.5	~0.3	Audible intermittent bubbling.	Probe came up clean. Could smell H_2S.

East & West (pools were flooded)

23 Jul 2011	22	nd	0	nd	nd		Occasional gas discharge.	Brown. Scum on surface.

a) b)

2-5. Two mud pools, Ohakuri Rd; a) April 2010; b) July 2011.

3. Golden Springs

Pools in the stream through the Golden Springs Motel

Downstream Pool

E2798840 N6298535

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
10 April 2010	36	6.9	~30	nd	-	Beige, cloudy.
2 Aug 2011	29	nd	~35	nd	-	Green-yellow, cloudy.

3-1. Golden Springs Downstream Pool in the motel grounds, July 2011

Upstream Pool

E2798774 N6298395

One swimmer.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
10 April 2010	33	7.4	~40	nd	-	Beige, cloudy.
2 Aug 2011	33	nd	~35	nd	-	Green-yellow, cloudy.

a)

b)

3-2. Golden Springs Upstream Pool in the motel grounds; a) April 2010; b) July 2011.

Pools across the road from the motel

In July 2011 Pool 4 was difficult to approach due to blackberry. The 2011 temperature was measured near the outflow, and may be significantly lower than the upflow temperature (based on the steam around the upflow).

Pool 3

E2798940 N6298927

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
13 April 2010	43	6.3	nd	nd	calm	Milky yellow-brown.
25 Jul 2011	40	nd	nd	nd	Moderate gas discharge	Milky yellow-brown.

Pool 4

E2798921 N6299017

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
13 April 2010	46	6.2	~30	nd	Calm, minor gas discharge.	Milky pale green.
25 Jul 2011	40	nd	nd	nd	Strong gas discharge	Milky yellow-brown.

a)

b)

3-3. Golden Springs, April 2010; a) Pool 3 and b) Pool 4.

a)

b)

3-4. Golden Springs, July 2011; a) Pool 3 and b) Pool 4.

4. Horohoro

2788384E 6323144N

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
14 April 2010	49	8.2	5 to10	nd	Calm, gentle effervescence.	Dark green, slightly cloudy.
25 Jul 2011	45	nd	5 to10	nd	Calm, moderate bubble streams.	Dark green.

a) b)

4-1. The pool at Horohoro;a) April 2010; b) July 2011.

5. Mokai

Tirohanga Rd

I have put a 'T' prefix on these feature numbers to distinguish them from Paerata Rd features.

This group of features are surrounded by an electric fence. There is an area of mudpools immediately by the cowshed (Features T1, T2, and T3), and another group of features (T4 and T5) over a slight rise from these.

Feature T1 & T2

E2763460 N6295714

This site has two merged pools.

Date	Feature	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
14 June 2010	T1	57	7.0	0 visible	~0.3 below rim	Calm.	Milky khaki.
24 July 2011	T1	58	nd	0 visible	~0.3 below rim	Calm.	Milky khaki.
14 June 2010	T2	19	7.1	0 visible	~0.3 below rim	Calm.	Milky pale brown.
24 July 2011	T2	15	nd	0 visible	~0.3 below rim	Calm.	Milky pale brown.

a)

b)

5-1. Features 1&2, June 2010. a) Feature 2; b) Feature 1.

5-2. Features 1&2, July 2011..

Feature T3

E2763455 N6295751

This pool is ~5 m from T1 and T2, but the water level is ~1.5 above T1 and T2.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
14 June 2010	36	7.1	No visible	-0.3 rel to stump.	Calm.	Murky pale brown.
24 July 2011	33	nd	No visible	~-0.2 rel to stump.	Calm.	Murky green.

a) b)

5-3. Feature T3; a) June 2010; b) July 2011.

Feature T4a and T4b

E2763460 N6295777

Site T4a has three features, T4a_i, T4a_ii, and T4a_iii. These have cooled considerably since February 2009.

Date	Feature	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
14 June 2010	T4a_i	29	nd	0 visible	-1.5 below rim	Calm.	Clear, slightly milky.
24 July 2011	T4a_i	28	nd	0 visible	-1.3 below rim	Calm.	Green, milky.
14 June 2010	T4a_ii	19	nd	0 visible	-1.5 below rim	Calm.	Milky pale brown.
24 July 2011	T4a_ii	22	nd	0 visible	-1.3 below rim	Calm.	Milky pale brown.
14 June 2010	T4a_iii	16	nd	0 visible	-1.5 below rim	Calm.	Milky pale brown.
24 July 2011	T4a_iii	21	nd	0 visible	-1.3 below rim	Calm.	Milky pale brown.

a) b)

5-4. Features T4a_i, T4a_ii, and T4a_iii, June 2010. a) all of feature 4a; b) Feature 4a_i.

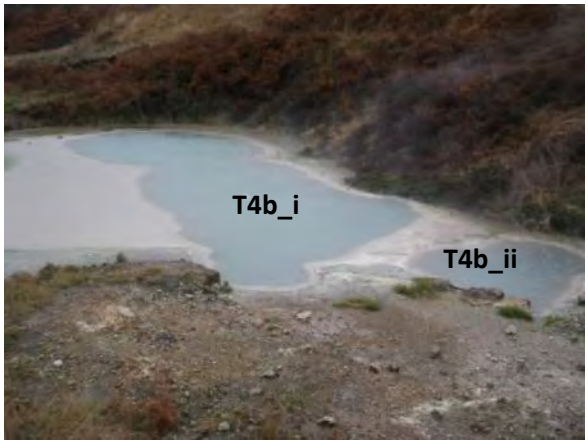
a)

b)

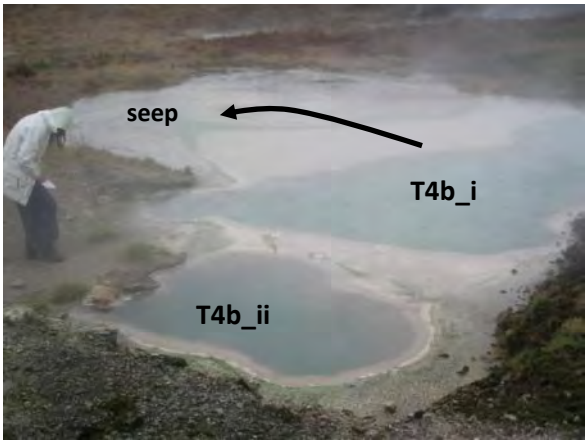
5-5. Features T4a_i, T4a_ii, and T4a_iii, July 2011. a) all of feature 4a; b) Feature 4a_i.

Site T4b has two pools, the smaller (T4b_ii) of which was draining into the larger (T4b_i). There is white sinter surrounding both the pools, and covering the outflow from the larger pool.

Date	Feature	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
14 June 2010	T4b_i	71	7.5	0 visible	g.l.	Calm.	Slightly milky blue green.
24 July 2011	T4b_i	71	7.5	0 visible	g.l.	Calm.	Slightly milky blue green.
14 June 2010	T4b_ii	70	7.2	0 visible	g.l.	Calm.	Slightly milky brownish-blue.
24 July 2011	T4b_ii	71	7.2	Seep over sinter/white mud apron	g.l.	Calm.	Slightly milky blue-green.

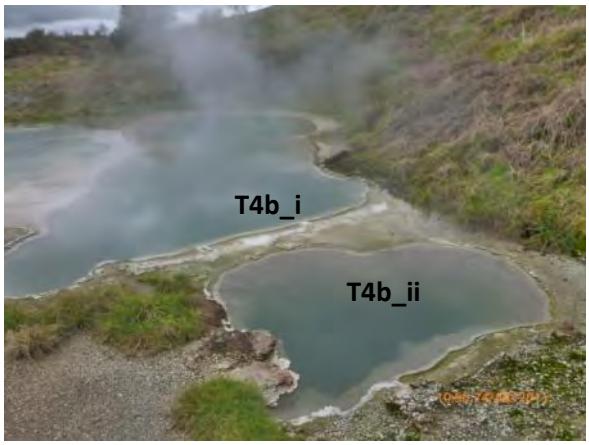


a)



b)

5-6. Features T4b_i, and T4b_ii, June 2010; a) Feature T4b pools; b) T4b_i outflow,



a)

5-7. a) Features T4b_i, and T4b_ii, July 2011.

Feature T5

E2763448 N6295832

Site T5 has two pools, with the larger (T5_i) draining into the smaller (T5_ii).

Date	Feature	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
14 June 2010	T5_i	41	6.1	~2	-1.5 below rim	Calm.	Murky brown.
14 June 2010	T5_ii	66	7.0	~2	-1.5 below rim	Calm.	Murky brown.
24 July 2011	T5_ii	63	nd	~0.5	-1.5 below rim	Calm.	Murky brown.

a) b)

5-8. Features T5_i, T5_ii; a) June 2010; b) July 2011.

Paerata Rd

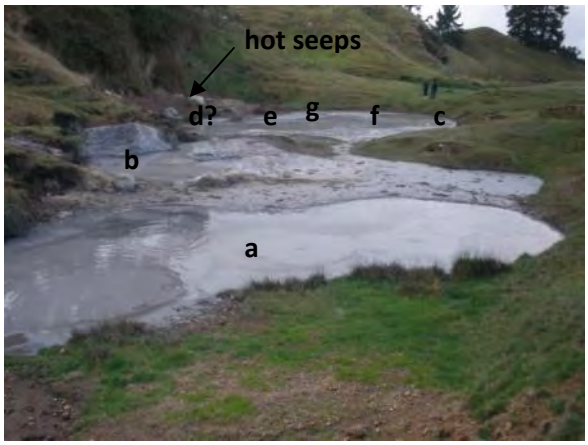
The Paerata Rd features are prefixed with a 'P' here to distinguish them from the Tirohanga Rd sites.

Feature P1a, b, c, d, e, f, g

E2765402 N6294657

This is referred to as Feature 1 in the 2009 Annual Report. Site P1 is a muddy area with seven pools, and small hot seeps on the margins near the cliff. In 2010 the maximum temperature recorded from the hot seeps was 77°C, with a pH of 3.4. A small gas discharge with no visible liquid had a temperature of 93°C.

Date	Feature	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
14 June 2010	P1aN	38	3.8	0		Gas discharge.	Light grey- brown.
14 June 2010	P1aS	41	3.5	0		Gas discharge.	Light grey- brown.
24 July 2011	P1a S	53	nd	0		Gas discharge.	Light grey- brown.
14 June 2010	P1b	39	2.7	0		Calm.	Light grey- brown.
24 July 2011	P1b	76	nd	0		Calm.	Light grey- brown.
14 June 2010	P1c_i	21		0		Calm.	Light grey- brown.
14 June 2010	P1c_ii	17		0		Calm.	Light grey- brown.
14 June 2010	P1c (flooded)	18	nd	0		Gas discharge.	Light grey- brown.
14 June 2010	P1d		Uncertain of the location of P1d				
14 June 2010	P1e	20	2.7	0		Gas discharge.	Light grey- brown.
14 June 2010	P1f	17	2.5	0		Gas discharge.	Light grey- brown.
14 June 2010	P1g	16	2.5	0		Gas discharge.	Light grey- brown.
14 June 2010	P1e-g	34	nd	0		Gas discharge.	Light grey- brown.



a)

b)

5-9. Features P1; a) June 2010 b) July 2011.

a)

b)

5-10. June 2010; a) Feature P1a, and b) Feature P1b.

a)

b)

5-11. June 2010; a) Feature P1c, and b) Feature P1e, f and g.

b)

5-12. June 2010; b) Feature P1b.

a)

b)

5-13. July 2011; a) Feature P1c are flooded; b) The area with Features P1e, f and g is flooded.

a)

5-14. Sketch map of area P1.

Mud Geyser (Feature P3)

E2765575 N6295092

The Mud Geyser vent is rectangular with the long axis east-west. The highest rim is the east rim, and the depth to the pool at the bottom of the vent is approximately 15 m. There is light grey muddy water in the eastern end, with a boulder 'beach' at the western end. The top of the vent is approximately 10 m wide in a north-south direction, which narrows to approximately 5 m at the pool. In June there was violent activity in the eastern end of the pool with upwelling to a height of around 1.5 m. The maximum temperature of the upwelling water was measured at 88°C (IR). In July 2011 the maximum IR temperature was 82°C, but there was still violent activity, and a strong H_2S smell.

a)

5-15. Mud Geyser, June 2010.

a)

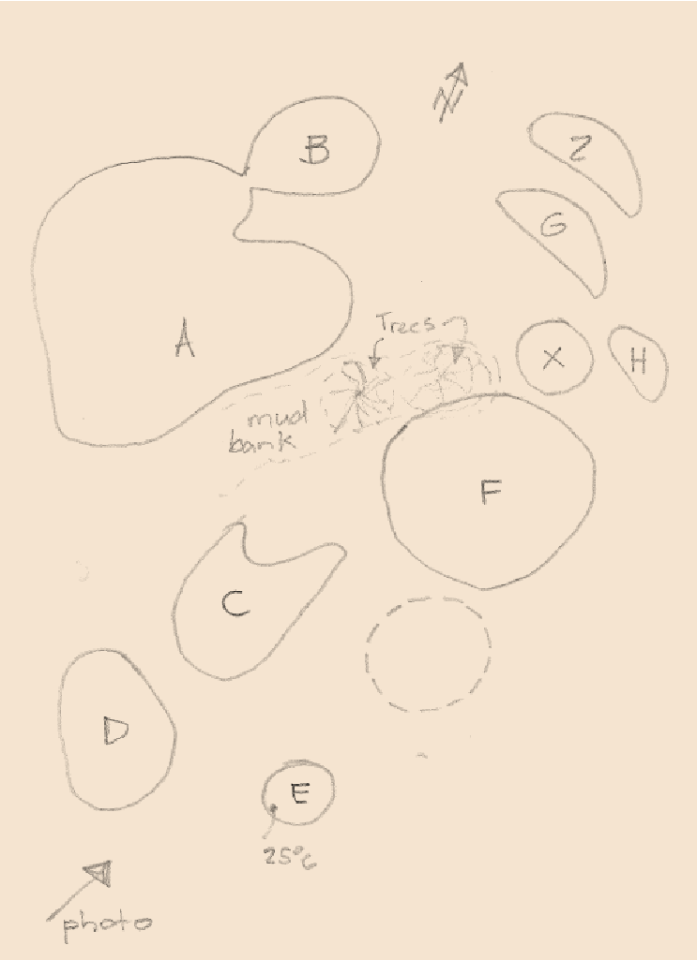
5-16. Mud Geyser, July 2011.

Feature P4a, b, c, d, e, f, g, and x

This is referred to as Feature 4 in the 2009 Annual Report. P4 is a muddy depression approximately 30 m diameter. In July 2011 the entire feature was flooded.

Date	Feature	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
14 June 2010	P4a	18	2.3	0		Calm.	Murky grey- brown.
14 June 2010	P4b	18	2.4	0		Calm.	Murky grey- brown.
14 June 2010	P4c	18	2.3	0		Calm.	Murky grey- brown.
14 June 2010	P4d	17	2.5	0		Calm.	Murky grey- brown.
14 June 2010	P4e	24		0			
14 June 2010	P4f	10	2.4	0		Calm.	Murky grey- brown.
14 June 2010	P4g	12	4.6	0		Calm.	Green-brown.
14 June 2010	P4x	14	2.3	0		Calm.	Murky grey- brown.
24 July 2011	all	16	nd	0		Calm.	Murky grey- brown.

5-17. Features P4 June 2010.



5-18. Sketch map of Feature P4 June 2010. Note that D and C are joined in June 2010. The dotted outline is a small mud volcano which did not appear to be currently active.

6. Ngatamariki

Hydrothermal Eruption Crater

Large Pool occupying the crater

E2786600 N6291801

The main pool appears to be unchanged over this period. There are many small (~0.01 m dia) vents on the eastern and northern margins of the pool (shown in Fig 2-1 to 2-4). These discharge gas and liquid. The temperature in these small vents is between 52 °C and 89 °C, the surrounding ground is soft, unconsolidated, saturated, hot, dark grey mud. It does not support the weight of a person.

In October 2010 the total mass flow rate in the pool discharge channel was estimated by measuring the cross sectional area of the channel, and recording the time taken for a small twig to float 1.6 m. The travel time was measured 3 times.

It appears as though the maximum activity occurs on the cliff edge of the pool, where there is significant steam near the pool surface. There is minor gas discharge all over the large pool.

A temperature datalogger was installed at the pool from the period of 14th October to 28th November 2010. The probe was located at ~ 1.5 m depth on the northern margin of the pool. The depth is uncertain as it was not possible to ascertain the angle of the sides of the pool, or if the probe had settled into the sediment. The datalogger was placed in the pool again on the 4th May 2011, with the probe as close as possible to the previous location.

The temperature record For the October-November period is shown in Figure 6-9. Figure 6-10 a) shows the temperature record superimposed with recorded air temperature at Taupo Airport for the same period (downloaded from NIWA website). The correspondence with both diurnal and non-cyclic temperature variation is very clear. The results of a Fourier analysis of the Ngatamariki data are shown in Figure 6-10 b). The dominant cycle is 24.082 hours, with an amplitude of 0.5°C.

The temperature time series for the May to June period is shown in Figure 6-11. There appears to be a cyclic (diurnal) component to the temperature record, however there are strong non-cyclic variations which may be related to weather. The maximum temperature in the diurnal component of the series occurs in the evening (the exact time is not always clear as the top of the curve is often flat) which is 3 to 6 hours out of phase with diurnal air temperature. No further analysis has been done.

Table 6-1. Ngatamariki Hydrothermal Eruption Pool data

Date	T(°C)	Flow (l/s)	Water level	Ebullition	Colour
14 Oct 2010	49	10-15		Calm, moderate gas discharge.	Dark green.
29 Dec 2010	48	5-10		Calm, moderate gas discharge.	Dark green.
04 May 2011	49	10-15		Calm, moderate gas discharge.	Dark green.
25 Jul 2011	47	5-10		Calm, moderate gas discharge.	Dark green.

a)

b)

c)

d)

6-1. The large pool occupying the hydrothermal eruption crater, October 2010. a) Overview of the pool; b) Area of gas discharge at the pool margin. c) Overview showing the shallow clay feature, which is less distinct than in June 2010. d) Detail of the small gas vents on the eastern margin (near the mud pool).

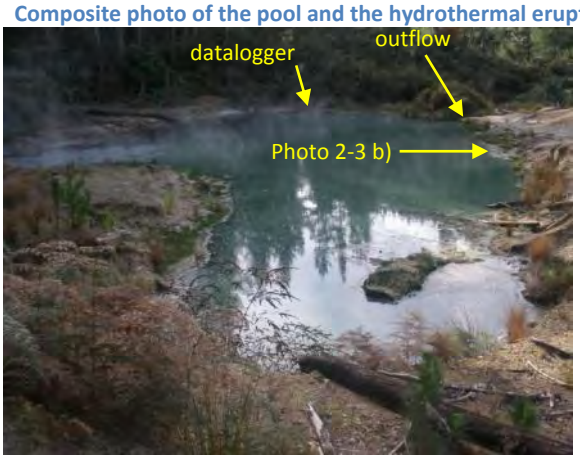
a)

b)

c)

d)

6-2. The large pool occupying the hydrothermal eruption crater, December 2010. a) Overview of the pool; b) Area of gas discharge at the pool margin. c) Overview showing the shallow clay feature, which is less distinct than in June 2010. d) Composite photo of the pool and the hydrothermal eruption deposits.



a)

b)

c)

d)

6-3. The large pool occupying the hydrothermal eruption crater, May 2011. a) Overview of the pool; b) Area of gas discharge at the pool margin. c) Overview showing the shallow clay feature. d) North-western end of the pool.

a)

b)

c)

d)

6-4. The large pool occupying the hydrothermal eruption crater, May 2011. a) Overview of the pool; b) Area of gas discharge at the pool margin. c) Overview showing the shallow clay feature. d) approach to the pool, with the remains of trees destroyed by the 2005 eruption.

Mud pool beside large pool

The small pool is a murky battleship grey, and there was moderate gas discharge. In October and December the water level appears to be approximately the same as the main pool. The water levels are difficult to estimate due to lack of a datum, and have appeared approximately the same, however, the photographic record (Fig 6-7 and Fig 6-8) shows the water level was slightly higher in May, and higher again in July.

The grey colour is due to relatively large particles which rapidly settled out of the water that was collected in a cup.

Table 6-2. Ngatamariki mud pool beside large pool data.

Date	T(°C)	Flow (l/s)	Water level	Ebullition	Colour
14 Oct 2010		0 visible	~0.5 m below outlet.	Gas discharge.	Murky battleship grey.
29 Dec	52	0 visible	~0.5 m below outlet.	Minor gas discharge.	Dark Grey.
04 May 2011	40	0 visible	~0.5 m below outlet.	Minor gas discharge.	Dark Grey.
27 Jul 2011	39	0 visible	~0.5 m below outlet.	Minor gas discharge.	Dark Grey.

a) b)

6-5. October 2010; Small mud pool, Ngatamariki. a) Mud Pool (toe of boot for scale); b) pool water in a cup with settled grey particles.

a)

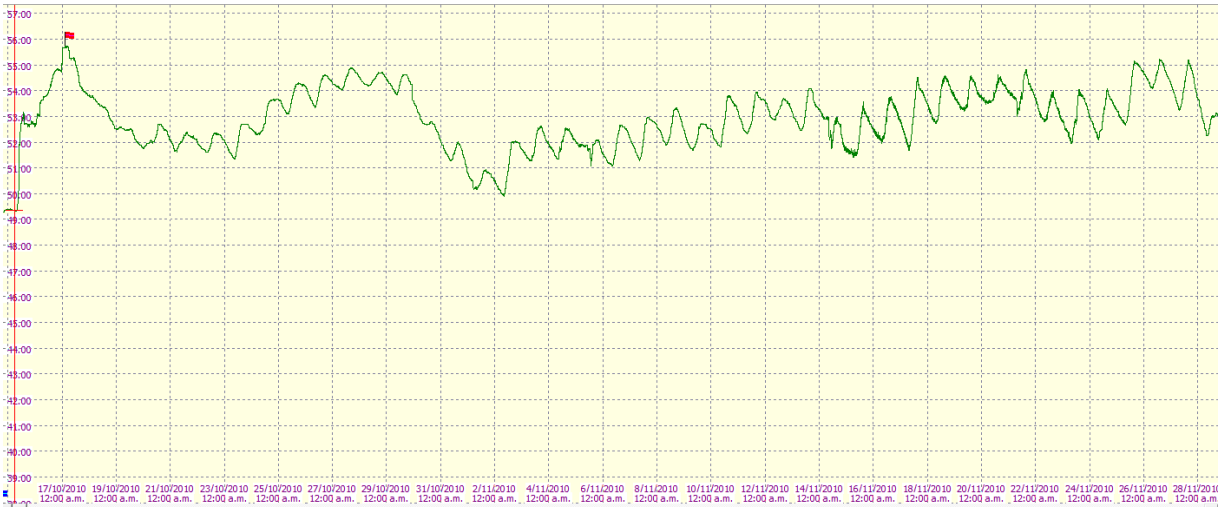
6-6. December 2010; a) Small mud pool, Ngatamariki.

a) b)

6-7. May 2011; a)Small mud pool, Ngatamariki; b) Small pool in relation to the large hydrothermal eruption carter pool.

a)

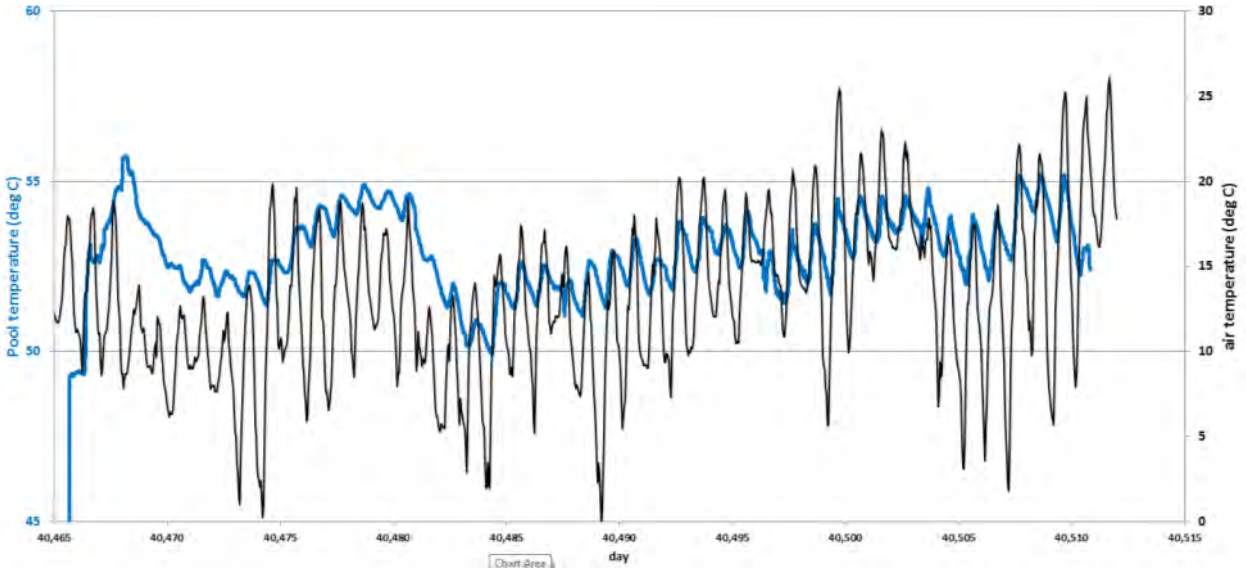
6-8. July 2011; a) Small mud pool, Ngatamariki.



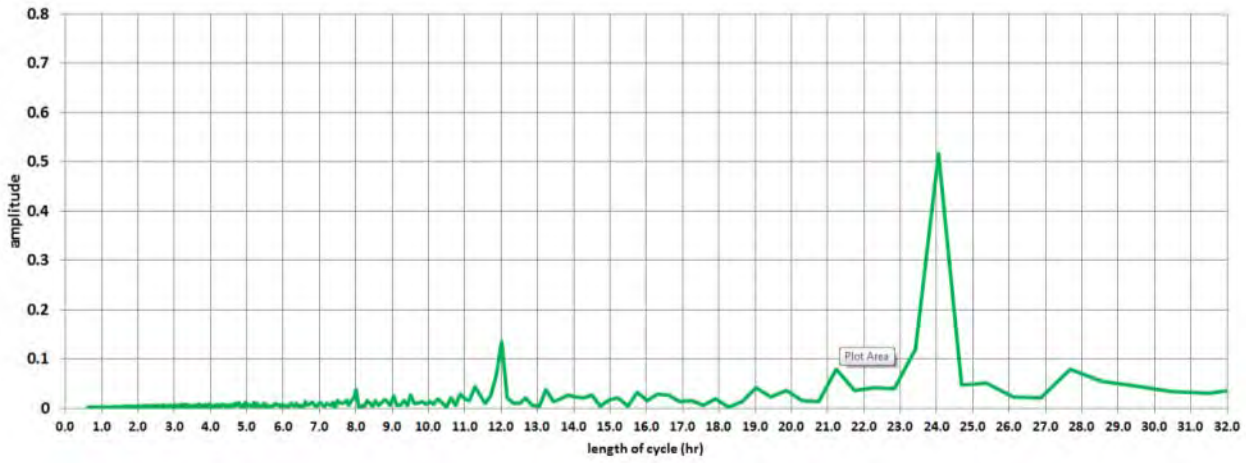
a)

b)

6-9. Ngatamariki Hydrothermal eruption pool time-temperature series; a) the entire record from 16th October 2010 to 28th December 2010; b) a detail of the temperature record for 8th to 13th December 2010.

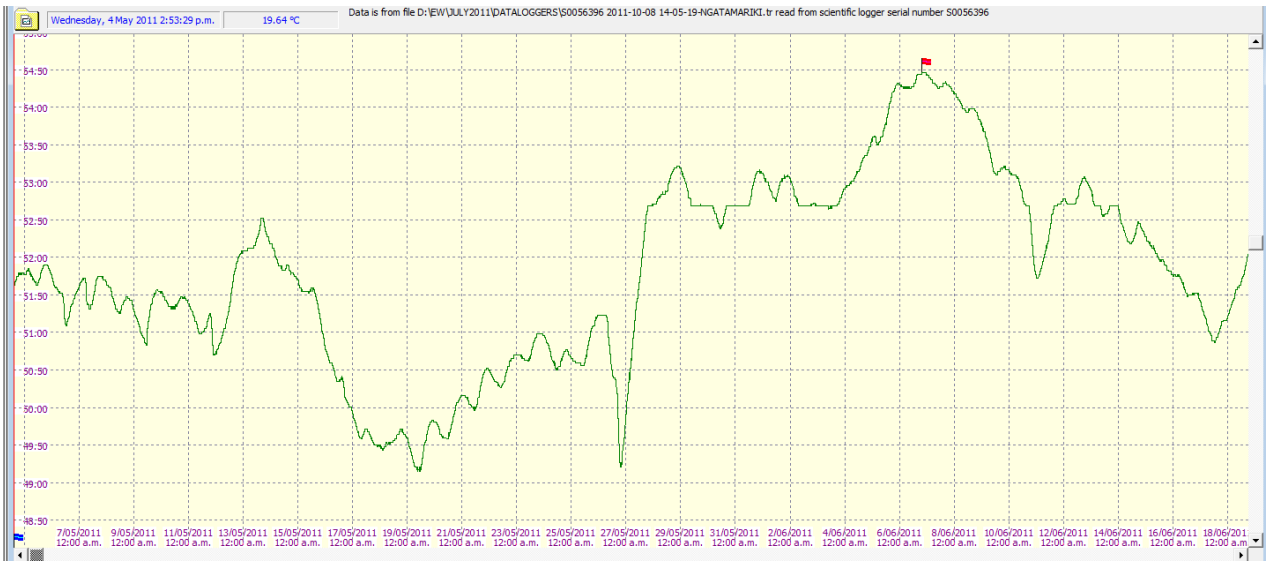


a)

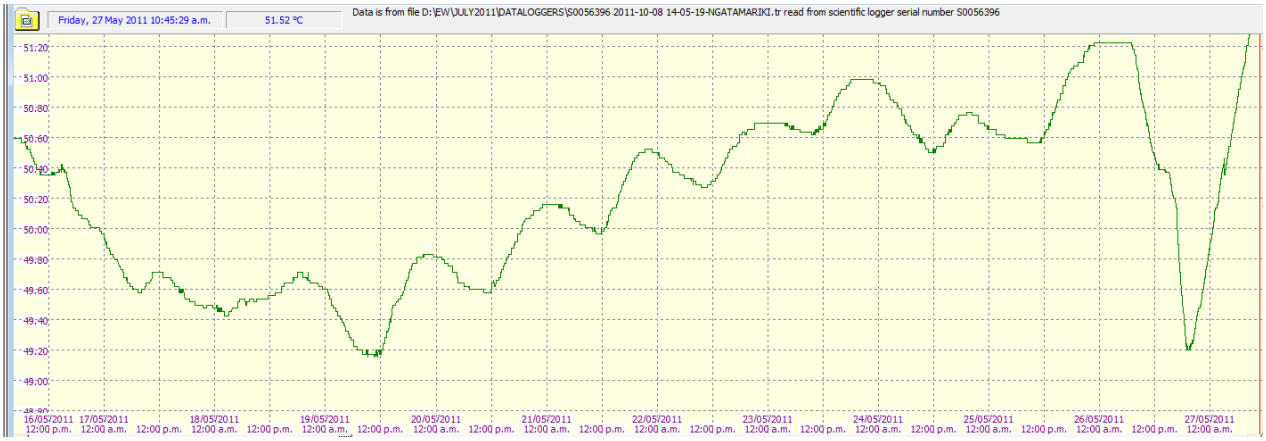


b)

6-10. Ngatamariki Hydrothermal eruption pool time-temperature series; a) superimposed on the corresponding air temperature time series from Taupo Airport; b) the periodogram of the temperature time series, showing the dominant period to be 24.082 hours with an amplitude of approximately 0.5°C.



a)



b)

6-11. Ngatamariki Hydrothermal eruption pool time-temperature series; a) the entire record from 4th May 2011 to 18th June 2011;,b) a detail of the temperature record for 16th to 27th May 2011.

7. Orakeikorako

Waihunuhunu Inlet

In October and December the lake level was extremely low, and the mud was exposed around both the spring discharges. There was hot seeps and hot mud (48 - 50°C at 0.1 m depth) up to 10 m away from the Inlet 1 discharge; the hot mud may have extended all the way to the spring but it got a little uncomfortable to walk through. In October there was a power boat with a family of five at the inlet. They had launched elsewhere.

In May the lake level was higher, within 0.1 m of the top of the pipe at Inlet 2.

The flow from the pipes does not appear to be under any direct threat but the area is littered.

In July the lake level was also high. The flow did not appear to have changed. Inlet 2 was completely submerged.

Inlet 1

E2785533 N6300770

Table 7-1. Inlet 1 data.

Date	T(°C)	pH	Flow (l/s)	Water level (from base of pipe)	Ebullition	Colour
4 Oct 2010	54	nd	~10	nd	-	Clear.
29 Dec 2010	52	nd	~10	0.5	-	Clear.
05 May 2011	52	nd	~10	nd	-	Clear.
25 July 2011	51	nd	~10	0.3	-	Clear.

Inlet 2

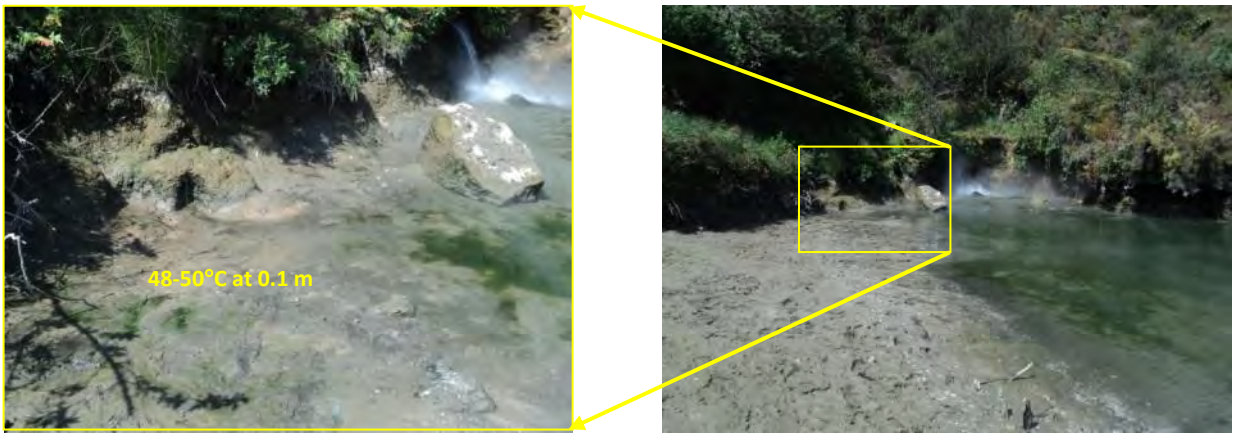
E2785509 N6307774

Table 7-2. Inlet 2 data.

Date	T(°C)	pH	Flow (l/s)	Water level (from base of pipe)	Ebullition	Colour
4 Oct 2010	46	7.6	~7	-	-	Clear.
29 Dec 2010	45	-	5-10	~0.3	-	Clear.
05 May 2011	47	nd	nd	~-0.3 (covering most of pipe)	-	Clear
25 July 2011	nd	nd	~10	~-0.1	-	Clear.

a) b)

7-1. a) Waihunuhunu Inlet 1; and b) Waihunuhunu Inlet 2, October 2010



a) b)

7-2. a)The exposed hot mud and seeps between Waihunuhunu Inlet 1 and the parking area b) Waihunuhunu Inlet 1 and surrounds. October 2010.

a) b)

7-3. a) Waihunuhunu Inlet 1; and b) Waihunuhunu Inlet 2, December 2010

a) b)

7-4. a) Waihunuhunu Inlet 1; and b) Waihunuhunu Inlet 2, May 2011

a) b)

7-5. a) Waihunuhunu Inlet 1; and b) Waihunuhunu Inlet 2, July 2011

Sinter Terraces

7-6. Lower Terrace in October 2010.

7-7. Lower Terrace in March 2011.

7-8. Lower Terrace in May 2011.

7-9. Lower Terrace in July 2011.

Diamond Geyser

E2784619 N6298509

The geyser has not erupted any time we have observed it.

There are three pools on the top of the geyser mound shown in Figure 7-13. The Main Pool is overflowing down the sinter face of the mound. The Top pool has a small seep to the east, into a small lower pool (Side Pool) which also seeps to the east. There is fresh white sinter on the margins of the main and top pools.

A Temprecord datalogger recorded water temperature of the Main Pool of this feature in the period from 16th August to 30th September 2010, and 3rd March to 17th April 2011. Graphs of the temperature time series are shown in Figure 7-15. There is possibly a very low amplitude periodicity during the March-April 2011 recording time, but the resolution of the dataset is not adequate to characterise this.

Table 7-3. Diamond Geyser data.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
Main Pool, 4 Oct 2010	89	8.1	<0.5	Overflowing.	Upwelling by outlet.	Clear.
Main Pool, 30 Dec 2010	88	nd	<0.5	Overflowing.	Upwelling by outlet.	Clear green.

Main Pool, 03 Mar 2011	nd	nd	seep	Overflowing.	Gentle upwelling, minor gas bubbles.	nd
Main Pool, 27 Apr 2011	nd		<0.5	Overflowing	Constant upwelling, gas discharge.	Clear green.
Main Pool, 26 July 2011	87	nd	seep	Overflowing.	Minor gas bubbles.	Slightly murky green.
Top Pool, 4 Oct 2010	86	nd	seep	Overflowing.	Calm, minor gas discharge.	Slightly murky green.
Top Pool, 30 Dec 2010	79	nd	seep	Overflowing.	Minor upwelling.	Slightly murky.
Top Pool, 27 Apr 2011	nd	nd	0 visible	Not overflowing (-0.01 m from rim)	none	Cloudy green.
Top Pool, 26 July 2011	85	nd	seep	Overflowing to small side pool below.	Minor upwelling.	nd

a) b)

7-10. Diamond Geyser; a) October 2010; and b) December 2010.

a)

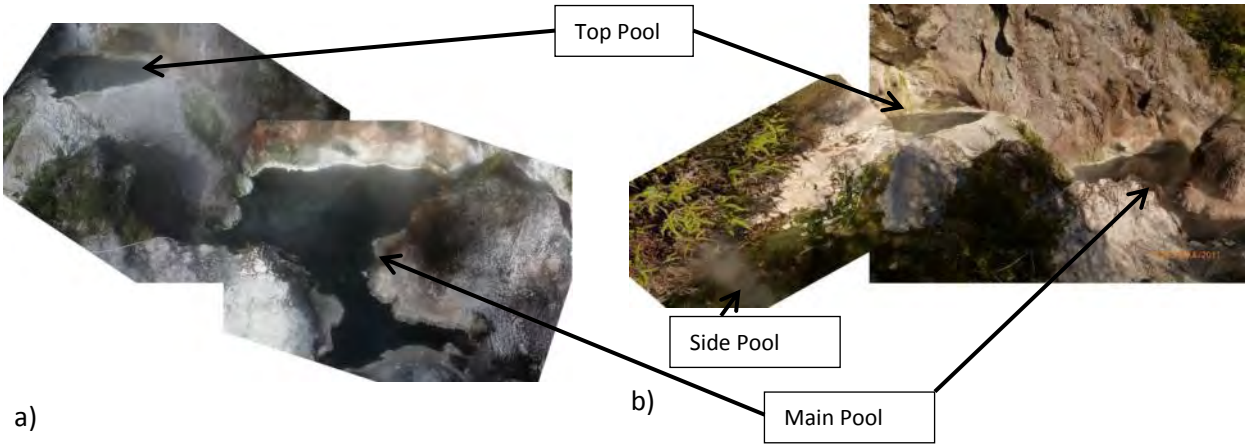
7-11. Diamond Geyser; a) April 2011.

a)

7-12. Diamond Geyser; a) July 2011.

Main pool Top pool Small Side pool

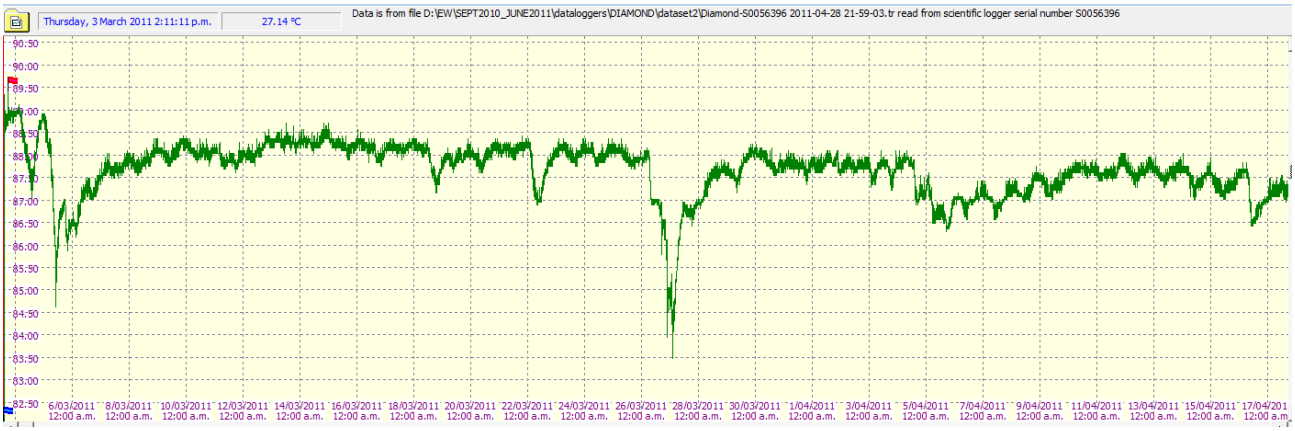
7-13. Pools at the top of the Diamond Geyser, December 2010.



a) b)

7-14. a) Top Pool and Main Pool of the Diamond Geyser; March 2011. The datalogger cable can be seen on the left-hand side of the photo. b) Side Pool, Top Pool and Main Pool of the Diamond Geyser; July 2011.

a)



b)

7-15. Temperature time series for the main pool of the Diamond Geyser; a) for the time period 16th August to 30th September 2010; b) for 3rd March to 17th April 2011.

Bush Geyser and Sapphire Geyser

Did not approach the geyser. The geyser did not erupt while we observed it.

Cascade Geyser

In October, December, and July we did not see the geyser erupt.

Table 7-4. Cascade Geyser data.

Date	T(°C)	Flow (l/s)	Eruption duration (s)	Eruption height (m)	Number of eruptions
4 Oct 2010	nd	nd	No eruption	-	0
30 Oct 2010	nd	nd	No eruption	-	0
27 April 2011	nd	nd	3 min 20 s	~1 m horiz	1

a)

b)

7-16. Cascade Geyser; a) October 2010; b) December 2010.

a)

b)

7-17. Cascade Geyser; a) April 2011; b) July 2011.

Map of Africa

E2784682 N6298522

Orange, green, and black algal mats surround the pool. The water appears dark, due to the rocks being covered with algae. In April there appeared to be more green algal growth surrounding the pool, replacing the orange algae seen in December.

Table 7-5. Map of Africa data.

Date	T(°C)	Flow (l/s)	Water level	Ebullition	Colour
4 Oct 2010	53	nd	Diffuse discharge over sinter.	Calm.	Clear.
30 Oct 2010	50	nd	Diffuse discharge over sinter.	Calm, minor upwelling at western margin.	Clear.
27 April 2011	49	nd	Diffuse discharge over sinter.	Calm.	Clear.
26 Jul 2011	42	nd	Diffuse discharge over sinter.	Calm.	Clear.

a)

b)

7-18. Map of Africa; a) October 2010; b) December 2010.

a)

b)

7-19. Map of Africa; a) April 2011; b) July 2011.

Devil's Throat

E2784703 N6298564.

Table 7-6. Devil's Throat data.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
4 Oct 2010	99	8.3	1	Overflowing.	Ebullient.	Clear.
30 Dec 2010	99	nd	<0.5	Overflowing.	Ebullient.	Clear.
27 Apr 2011	99	nd	2	Overflowing.	Ebullient.	Clear.
26 Jul 2011	99	nd	2	Overflowing.	Ebullient.	Clear.

a)

b)

7-20. The Devil's Throat; a) October 2010; b) December 2010.

a)

b)

7-21. The Devil's Throat; a) April 2011; b) July 2011.

Fred and Maggies Pool

E2784752 N6298549

Table 7-7. Fred & Maggies Pool data.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
4 October 2010	99	8.5	~0.5	Overflowing.	Ebullient, vigorous boiling.	Clear blue-green.
30 Dec 2010	99	nd	~0.5	Overflowing.	Ebullient, vigorous boiling.	Clear blue-green.
27 Apr 2011	99	nd	~0.5	Overflowing.	Ebullient, vigorous boiling.	Clear blue-green.
26 Jul 2011	98	nd	~0.5	Overflowing.	Ebullient, vigorous boiling.	Clear blue-green.

a)

b)

7-22. Fred and Maggie's Pool; a) October 2010; b) December 2010.

a)

b)

7-23. Fred and Maggie's Pool; a) April 2011; b) July 2011.

Wairiri Geyser

E2784747 N6298519

Table 7-8. Wairiri Geyser data.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
4 October 2010	78	7.3	0	0.14 m below rim.	Calm.	Clear blue-green.
30 Dec 2010	82	nd	0 visible	0.3 below rim	Calm, minor disturbance.	
27 Apr 2011	53	nd	Seeping inflow.	0.5 below rim	Calm.	Clear.
27 Apr 2011	74	nd	0 visible	0.6 below rim	Calm.	Clear.

a)

b)

7-24. Wairiri; a) October 2010; b) December 2010.

No photo is available for July 2011

a)

7-25. Wairiri; a) April 2011.

Steaming Ground on western edge of Artists Palette.

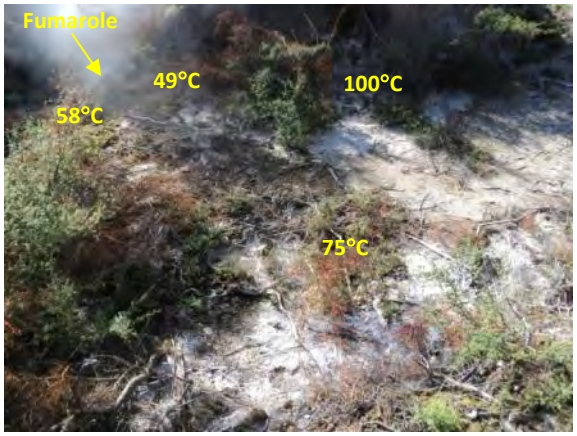
E2784765 N6298478.

Measured the ground temperature in several places, shown on the photo in Figure 7-26. Depth of probe 0.01 m. There is a small fumarole which appears to be in an older crater.

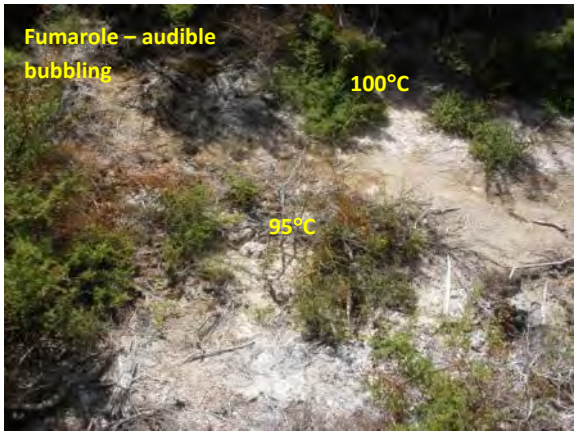
In April the ground was relatively cool and the crater with the fumarole was filled with slightly murky 30°C water.

Table 7-9. Steaming ground temperature data.

Date	T(°C)
4 Oct 2010	49-100
30 Dec 2010	95-100
27 Apr 2011	17-19
26 Jul 2011	16 (water temperature) 22 (ground at 0.1 m)

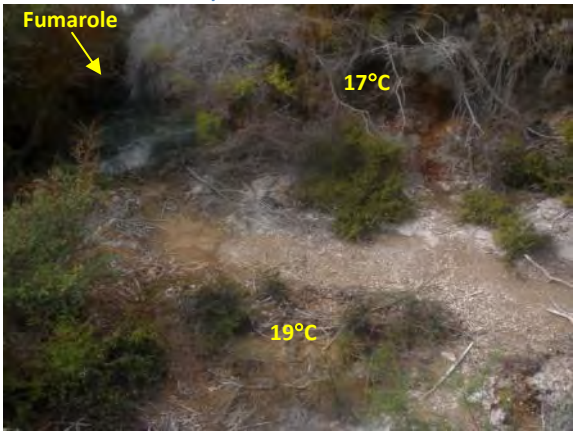


a)



b)

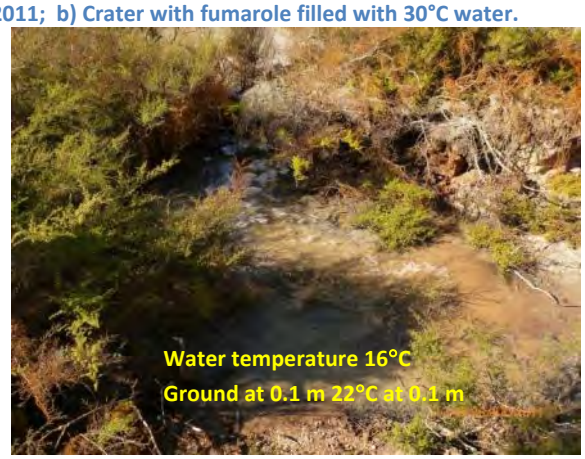
7-26. Steaming ground on western edge of Artists Palette. Temperatures were measured at 0.1 m depth; a)10:30 am 4th October 2010 and b) 10:40 am 30th December 2010.



a)

b)

7-27. Steaming ground on western edge of Artists Palette. Temperatures were measured at 0.1 m depth; a)12:20 am 27th April 2011; b) Crater with fumarole filled with 30°C water.



7-28. Steaming ground on western edge of Artists Palette was flooded; July 2011.

Artists Palette and Pyramid of Geysers.

7-29. Composite photo of Artists Palette and Pyramid of Geysers, looking north, October 2010.

7-30. Composite photo of Artists Palette and Pyramid of Geysers, looking north, December 2010.

7-31. Composite photo of Artists Palette and Pyramid of Geysers, looking north, April 2011.

7-32. Composite photo of Artists Palette and Pyramid of Geysers, looking north, July 2011.

a)

b)

7-33. a) Scarp, with water flowing over the darker grey section; b) the top of the scarp, with water flowing over the sinter, April 2011.

a)

b)

7-34. a) Scarp, with water flowing over the darker grey section; b) the top of the scarp, with water flowing over the sinter, July 2011.

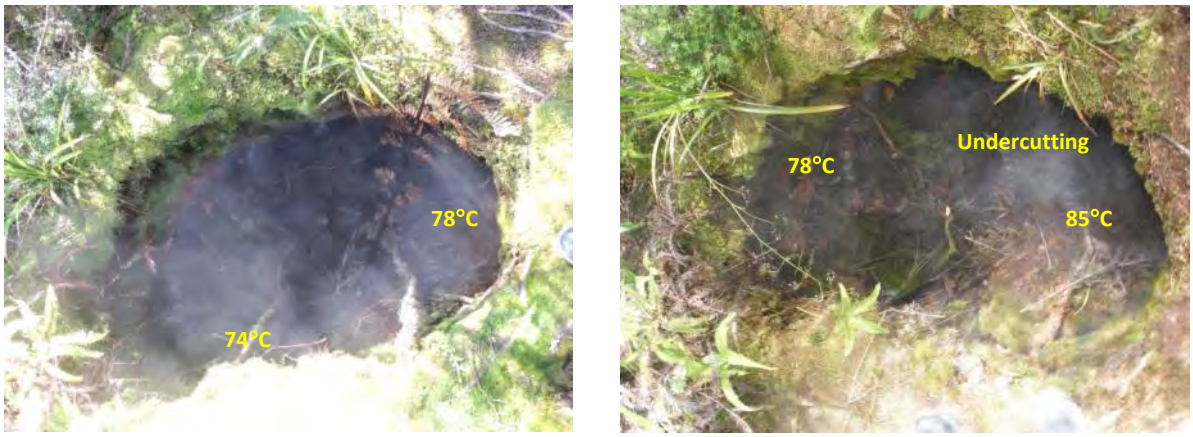
Fumarole to left of the boardwalk

E2784766 N6298446.

Ground temperature in the fumarole was between 74°C and 78°C at 0.1 m depth, as shown in Figure 7-35.

Table 7-10. Fumarole data.

Date	T(°C)	pH	Flow (l/s)	Water level	Depth (m)	Diameter (m)
4 October 2010	74-78	nd	Steam	dry	~0.7	~1.0
30 Dec 2010	78-85		Weak steam.	dry	~0.7	1.0
27 Apr 2011	34-44		0	dry	~0.7	1.0
26 Jul 2011	36		0	dry	~0.7	1.0



a) b)

7-35. Fumarole beside boardwalk; a) October 2010; b) December 2010.

a) b)

7-36. Fumarole beside boardwalk; a) April 2011.

Two pools by boardwalk

E2784774 N6298443.

South Pool

Table 7-11. South Pool data.

Date	T(°C)	Flow (l/s)	Water level	Ebullition	Colour
4 Oct 2010	74	0 observed.	1.4 m below mossy rim.	Moderate gas discharge.	Slightly cloudy.
30 Dec 2010	79	0 observed.	1.8 m below mossy rim.	Moderate gas discharge.	Slightly cloudy.
27 April 2011	60	0 observed.	0.3 m below mossy rim.	Moderate gas bubble streams.	Slightly cloudy brown.
26 Jul 2011	54	0 observed.	0.5 m below mossy rim.	Moderate gas bubble streams.	Slightly cloudy brown.

a) b)

7-37. South Pool by boardwalk; a) October 2010 b) December 2010.

a) b)

7-38. South Pool by boardwalk; a) April 2011; b) July 2011.

North Pool

The water level on this pool is difficult to record due to lack of an easily identifiable marker. The pool is lined with brown-green algae. In April the water level in the pool was much higher than previously observed, and the surface area of pool larger than previously seen. Water was covering a lower terrace that is around 0.5 to 1 m below the ground surface. There was a surface inflow of water from the Artists

palette sinter terraces which was forming a grey deposit. The volume of the flow varied depending on discharge from an adjacent pool on the terrace.

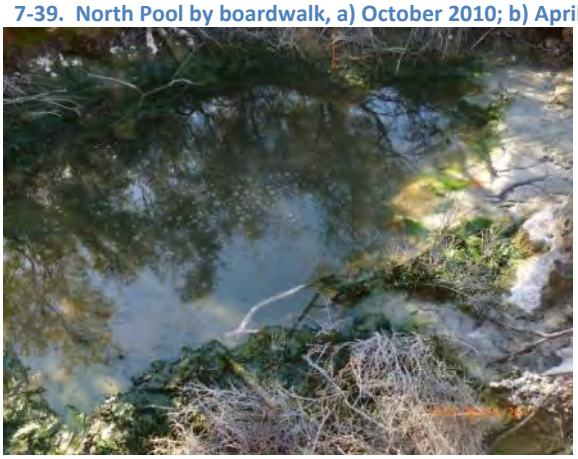
In July a lower terrace around the edge of the pool was exposed.

Table 7-12. North Pool data.

Date	T(°C)	Flow (l/s)	Water level	Ebullition	Colour
4 Oct 2010	66	0 observed.	nd	Calm but water convecting.	Slightly milky.
30 Dec 2010	75	0 observed.	nd	Calm.	Slightly milky.
27 Apr 2011	41	Inflow of surface water from Artists Palette	High.	Streams of bubbles upwelling in centre of pool.	Slightly milky.
26 Jul 2011	48	0 observed.	Med.	Streams of bubbles upwelling in centre of pool.	Slightly milky.

a) b)

7-39. North Pool by boardwalk, a) October 2010; b) April 2011.



a)

7-40. North Pool by boardwalk, a) July 2011.

Ruatapu Cave

E2784856 N6298338

The Ruatapu cave has previously (early 2010) had two pools, a large pool on the left looking into the cave, and a small pool to the right. There is also a side cave (Rahurahu) which has been explored in the past (Browne and Rodgers (2006) Geothermics, vol 35, p211) and which has an ephemeral pool . The current contract does not include monitoring Rahurahu although we do measure the pool temperature if it is possible to do so without entering the cave.

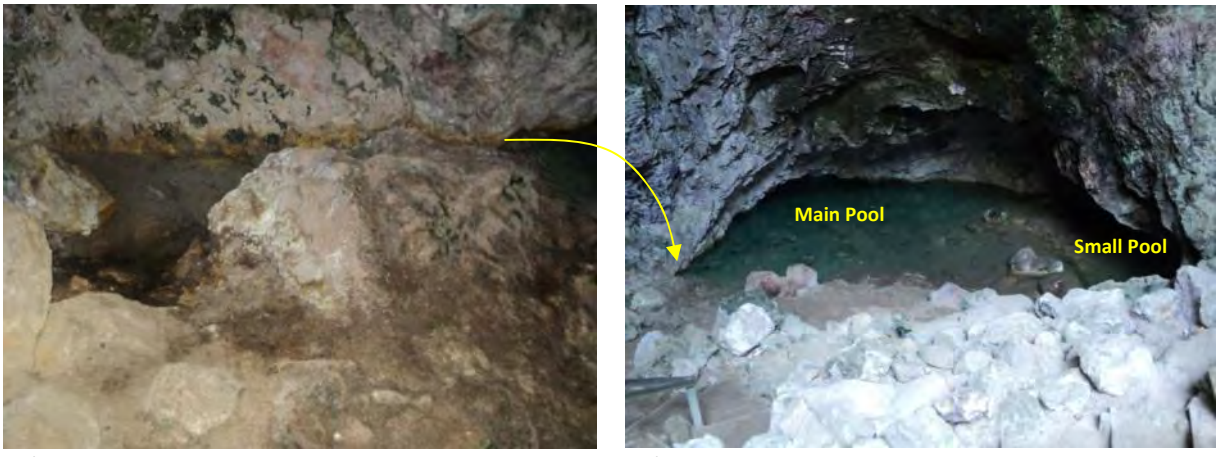
Main Pool and small pool at the base of the cave

The cave wall on the far side of the pool (from the cave mouth) is stained brown, and in June ~ 0.5 m of brown stain was showing. In October the water level in the pools was much higher, (estimated 0.4 m higher), ~0.1 m brown stain could be seen, and the pools had merged.

By December the water level had receded to the June level, and the Main and Small Pools were separate. The roof of the cave has had some rock-falls and the cave is no longer accessible to the public. There is a viewing platform at the mouth of the cave.

Table 7-13. Ruatapu Pool cave.

Date	T(°C)	pH	Flow (l/s)	Water level (rel to top of Fe staining) (m)	Ebullition	Colour
4 Oct 2010	37	2.5	0 observed.	-0.1	Calm.	Clear blue-green.
30 Dec 2010	38	nd	0 observed.	-0.5	Calm	Clear blue-green.



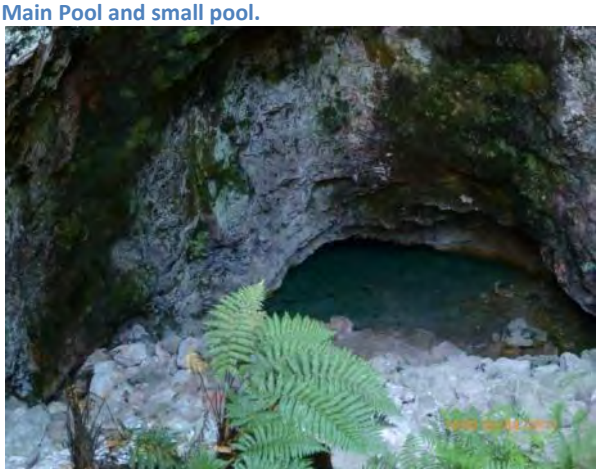
a) b)

7-41. a) flooded area at far left of cave, October 2010; b) Main Pool in the Ruatapu Cave.

a)

b)

7-42. December 2010; a) Main Pool in the Ruatapu Cave; b) Main Pool and small pool.



a)

7-43. The Ruatapu Cave, which is no longer accessible; a) April 2011; b) July 2011.

Rahurahu

This cave has a pool in it which was previously < 4 m from the entrance and approximately 2 m vertically below the cave mouth. In October 2010 the water was almost to the cave mouth and the water temperature was 55°C. The photograph shows only steam. In December the water level was also quite close to the cave mouth as can be seen from the photograph in Figure 7-45.

It is n o longer possible to approach Rahurahu.

Table 7-14. Rahurahu Cave data.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
4 Oct 2010	55	3.0	0 observed.	Almost to the cave mouth.	nd	nd
30 Dec 2010	31	nd	0 observed.	Within distance of thermocouple (<4m).	nd, but no sound from the cave.	From photo evidence, moderately clear.

7-44. Rahurahu Cave, October 2010; a) steam can be seen drifting from the cave mouth; b) Mouth of Rahurahu.

7-45. Rahurahu Cave. Note the water surface defined by ripples. The glasses were dropped by the author, who could not retrieve them.

Soda Fountain

E2784659 N6298492

In October there was a small amount of water in the base of the pool. This pool has had a temperature datalogger in it since June. The data is recorded every 2 minutes for 45 days.

The periods with data are

15th June to 30th July 2010 (Figure 7-48 and 7-49);

16th August to 30th Sept 2010 (Figure 7-50 and 7-51);

4th October to 18th November 2010 (Figure 7-52 and 7-53);

30th December 2010 to 13th February 2011 (Figure 7-54 and 7-55);

3rd March to 17th April 2011 (Figure 7-56 and 7-57).

The datalogger was returned to the pool after April 17th, but malfunctioned and the data cannot be downloaded.

There are periods in the data which have a large temperature variation, for instance for the period 7th to 30th July (Figure 7-48). My interpretation is that the logger sensor was above the lowest water level over

these periods, and immersed for part of the cycle. If this is correct, then this is a record of the water level cycle over this period, but unfortunately is not a good record of water temperature.

In March & April the pool was filling with water, which continued until for 15 minutes while we watched.

Some initial analysis has been done for both cyclic and non-periodic signals.

Climate data has been downloaded from the National Institute for Water and Atmospheric Research (NIWA)

To date the data has been sorted into subsets which show a regular cycle and where the amplitude indicates that the probe was immersed for the entire cycle (i.e. with an amplitude of <10°C). A Fourier analysis of these datasets gives a dominant period of 1.15 to 1.3 hrs, with some of the datasets also showing a period of 2.4 to 2.9 hrs (Figure 7-59).

Table 7-15. Soda Fountain data.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
4 Oct 2010	91	nd	0 observed.	~1.4 m below rim.	Calm.	Clear blue-green.
30 Dec 2010	98	nd	0 observed.	~0.9 m below rim.	Bubbling, upwelling, and boiling	Clear blue-green.
03 Mar 2011	nd	nd	0 observed	Pool filling.	Bubbling, upwelling, and boiling	Clear blue-green.
27 Apr 2011	nd	nd	0 observed	Pool filling.	Upwelling.	Clear blue-green.
26 Jul 2011	98	nd	~0.5	Pool overflowing.	Vigorous upwelling.	Clear blue-green.

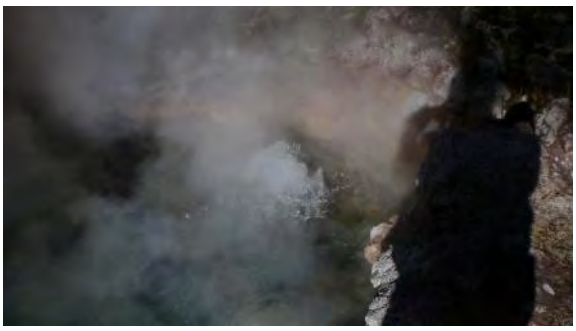
a)

b)

7-46. The Soda Fountain; a) October 2010; b) December 2010.

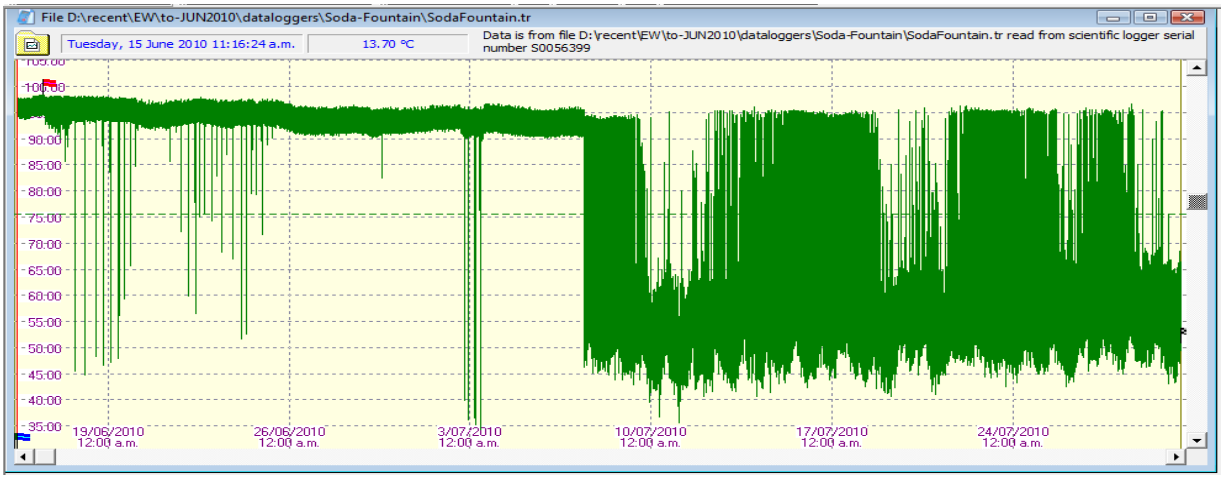
a)

b)

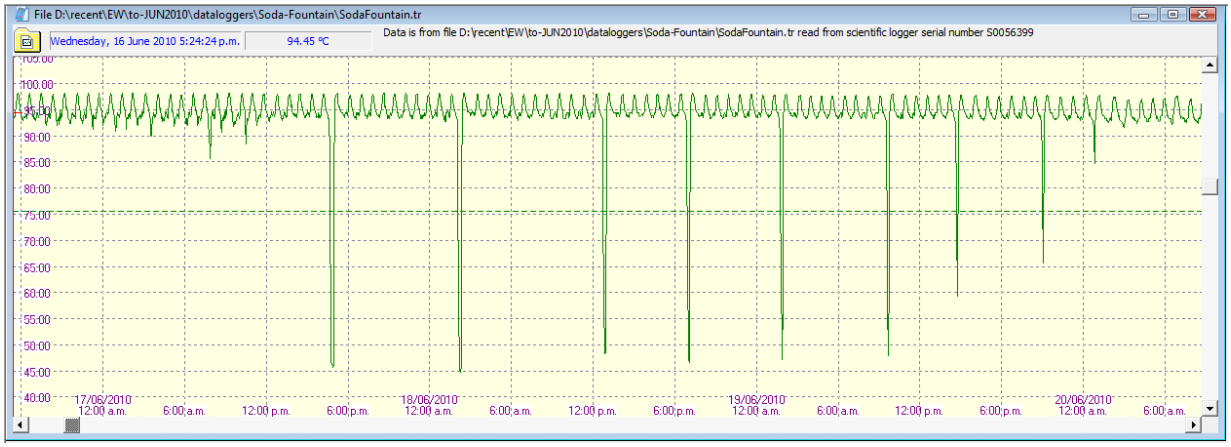


c)

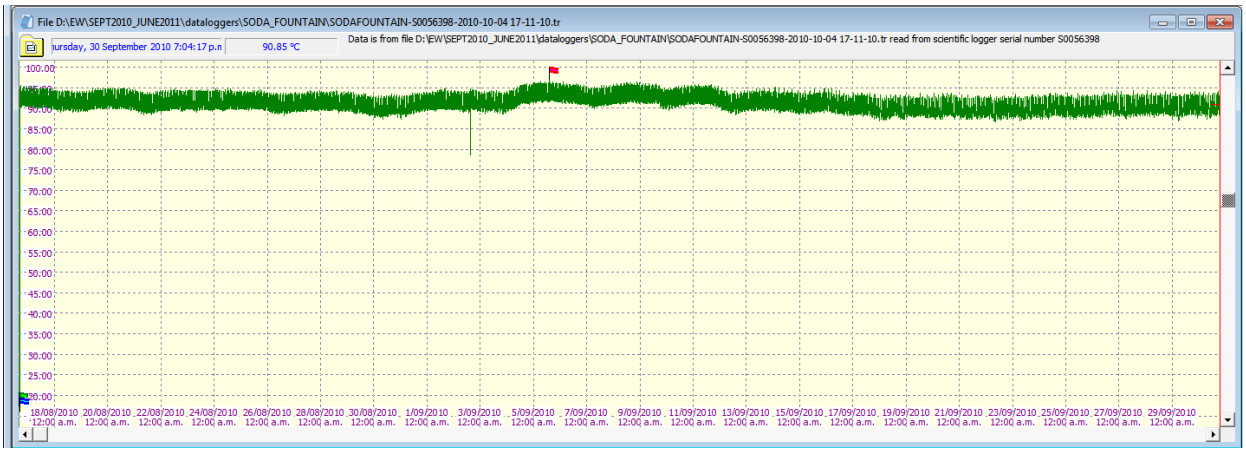
7-47. The Soda Fountain, July 2011; a) overview of the pool. The water was overflowing at the time of the photograph; b) Overflow channel; c) Ebullience above inflow.



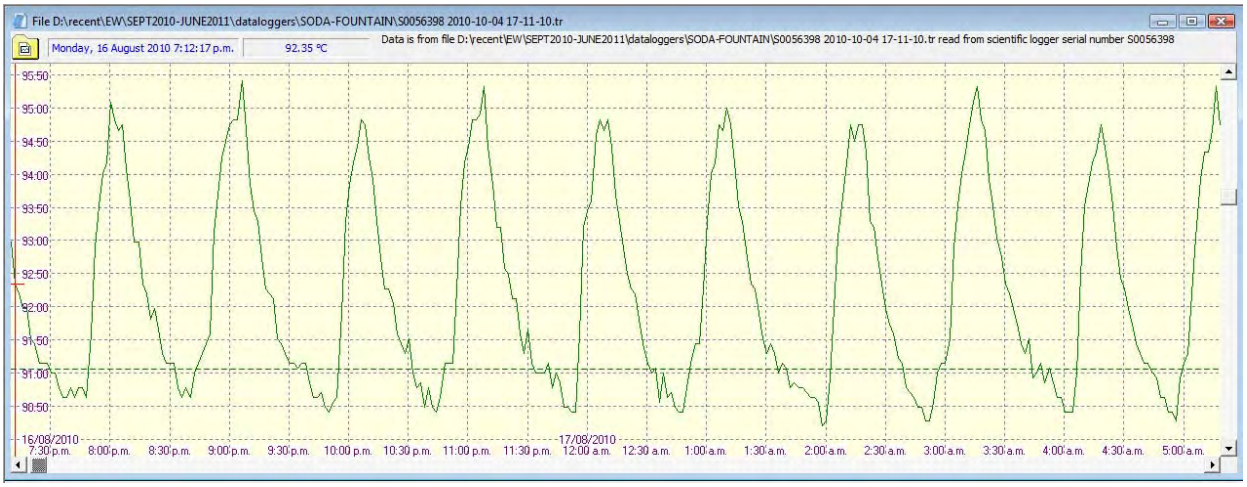
7-48. The Soda Fountain, temperature record, 15th June to 30th July 2010.



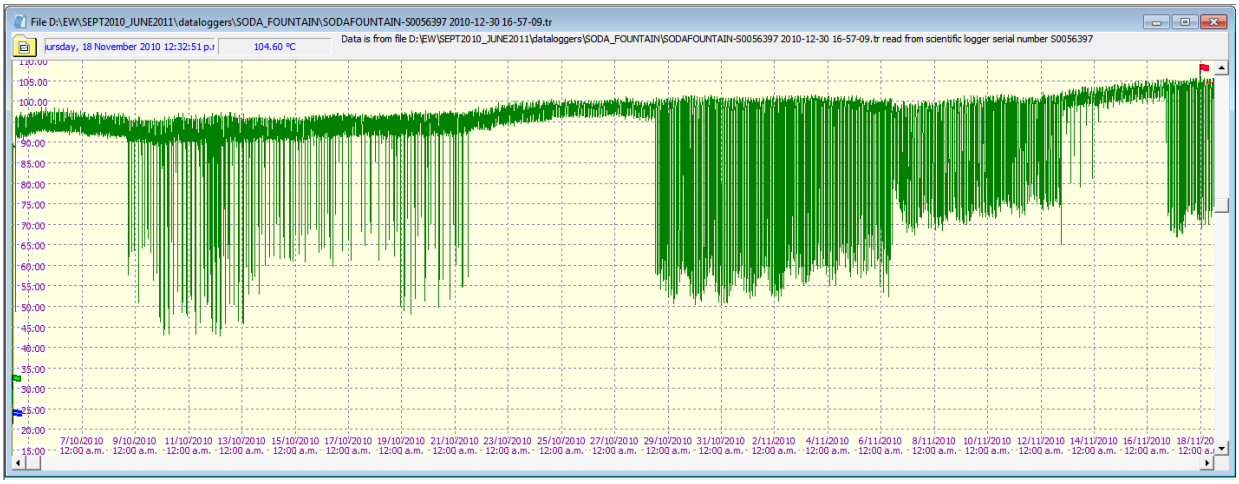
7-49. The Soda Fountain, detail of measured temperature from 17th to 20th June 2010.



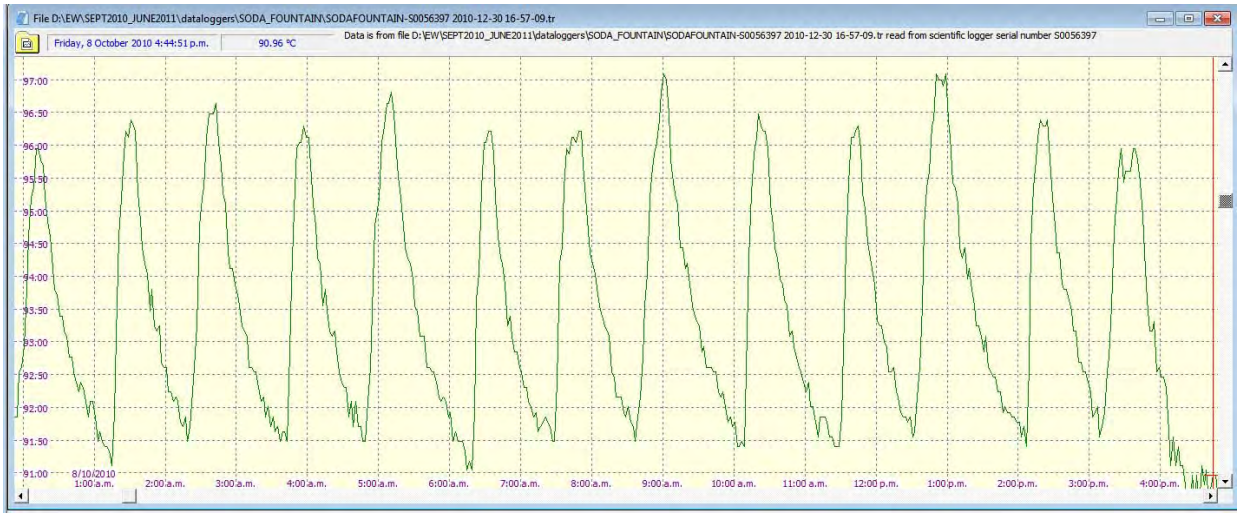
7-50. The Soda Fountain, temperature record, 16th August to 30th September 2010.



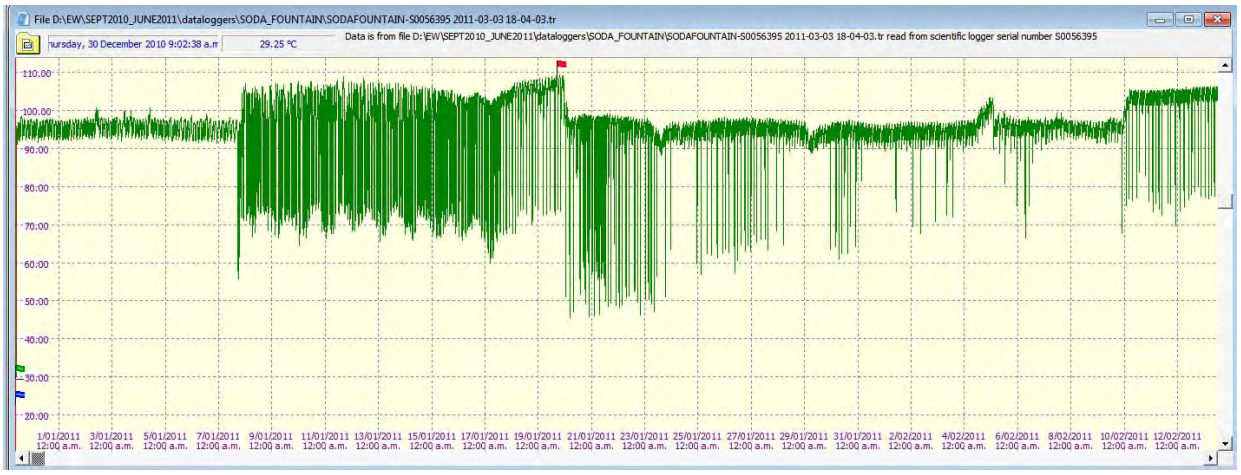
7-51. The Soda Fountain, detail of measured temperature from 16th and 17th August 2010 This is typical of the entire six week record for 16th August to 30th September 2010.



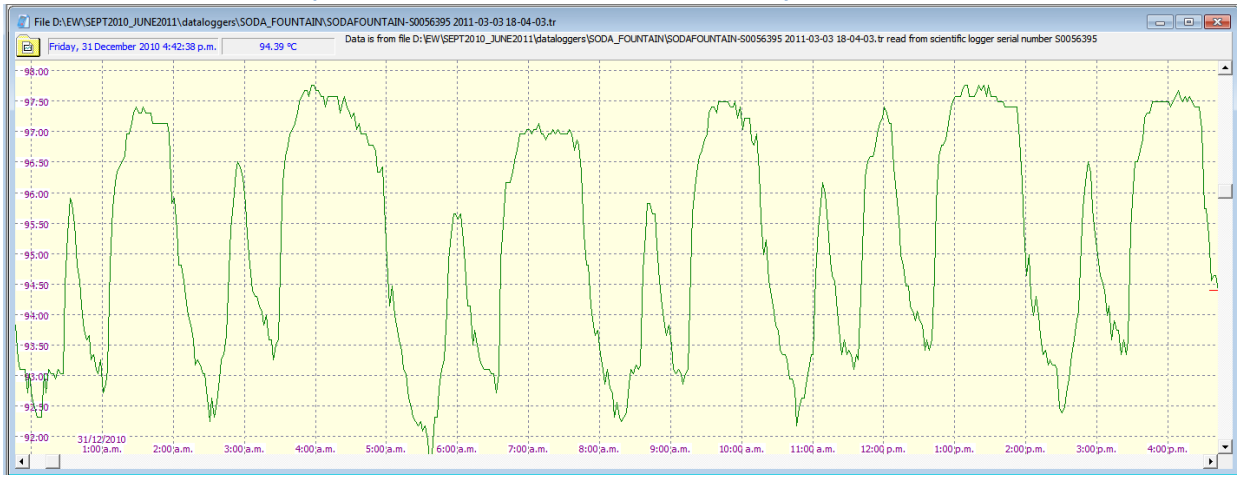
7-52. The Soda Fountain, temperature record, 4th Oct to 18th November 2010.



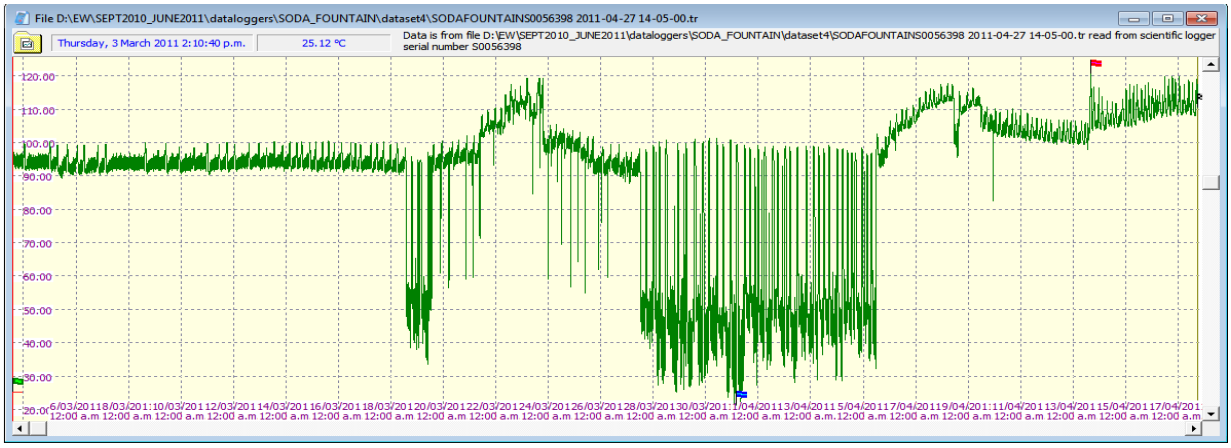
7-53. The Soda Fountain, detail of measured temperature from 8th October 2010.



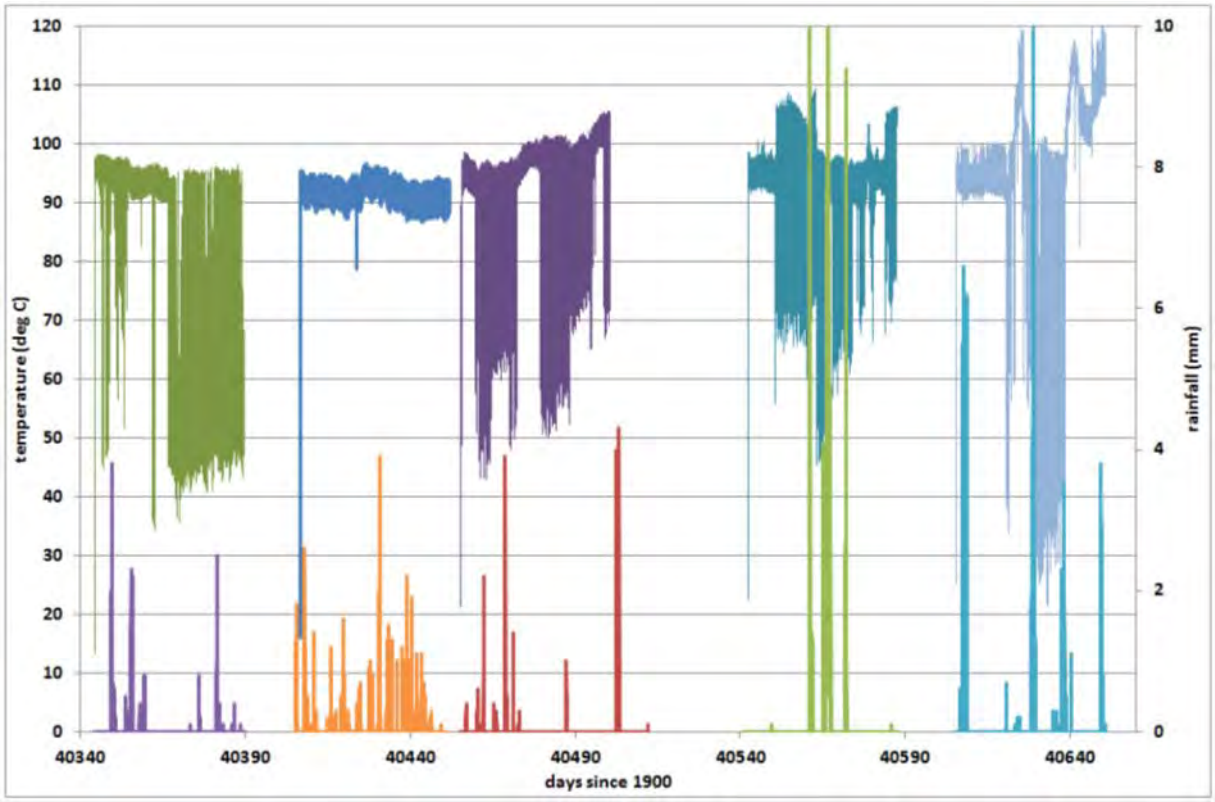
7-54. The Soda Fountain, temperature record, 30th December to 13th February 2011.



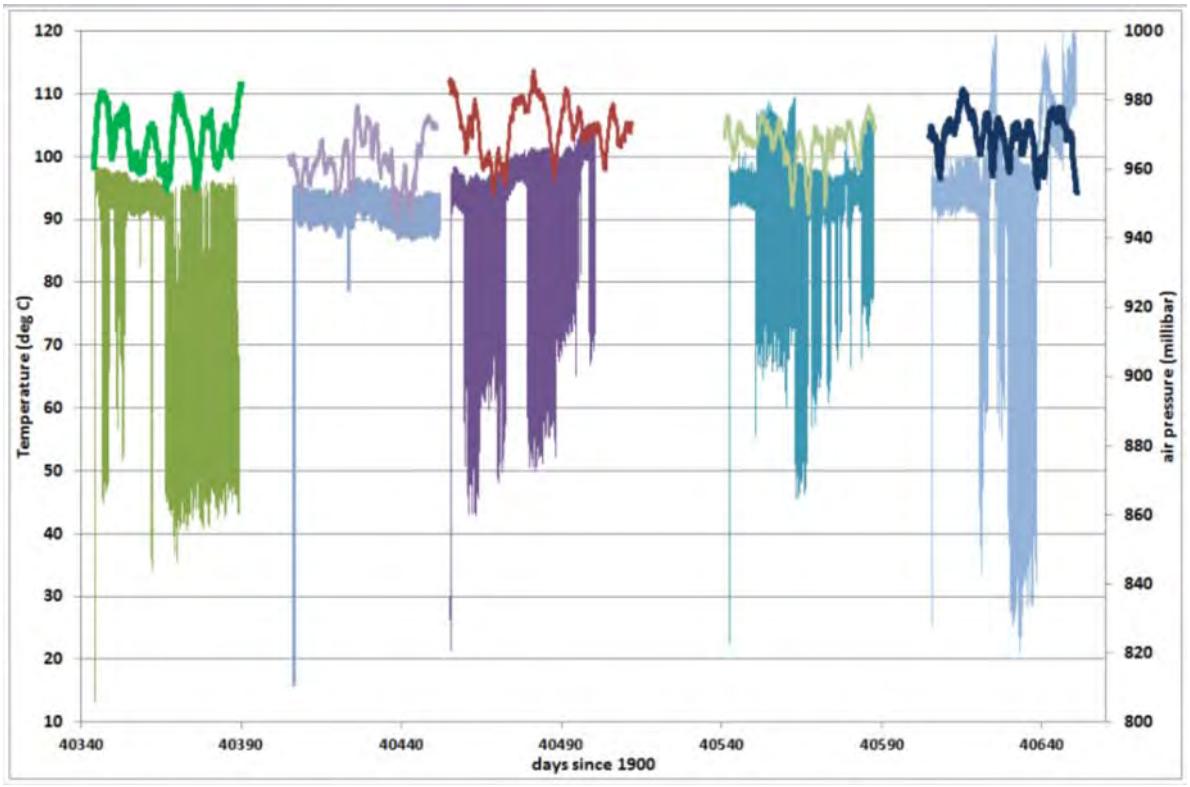
7-55. The Soda Fountain, detail of measured temperature from 31st December 2010.



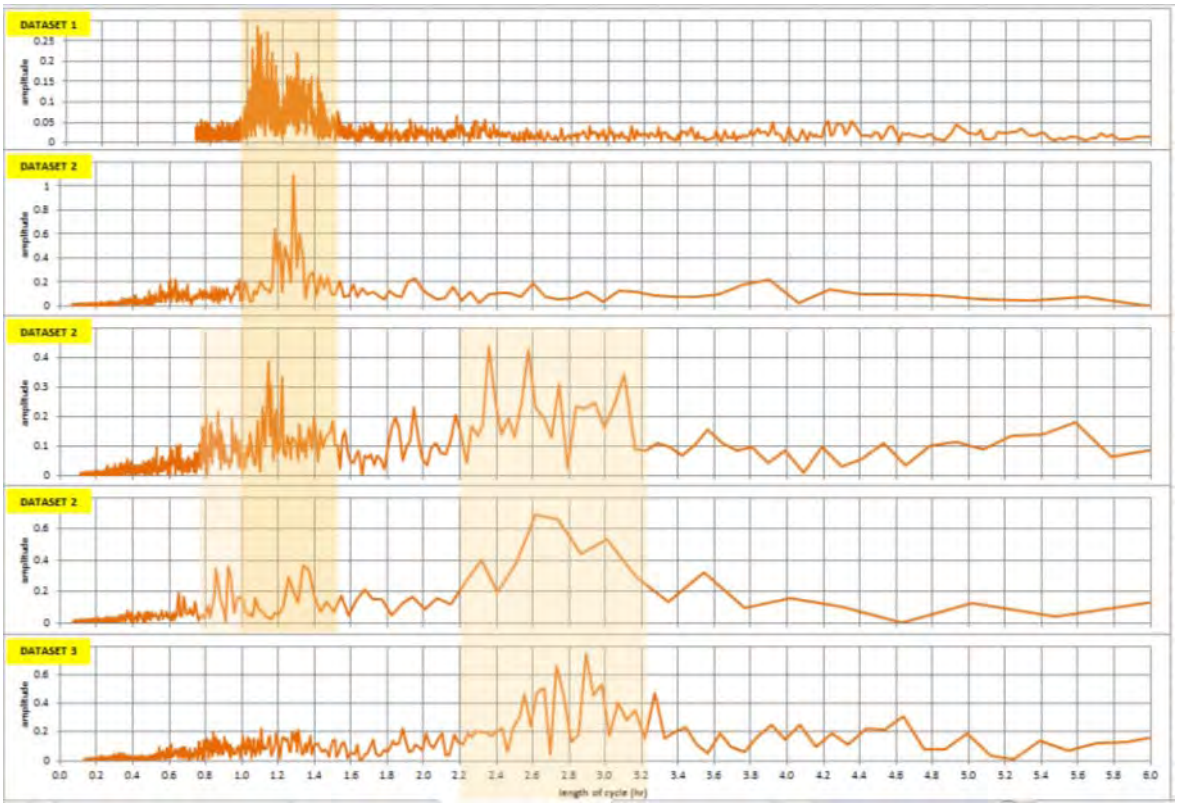
7-56. The Soda Fountain, temperature record, 3rd March to 17th April 2011.



7-57. Soda Fountain temperature record for all datasets, plotted with rainfall over the corresponding periods. The data is provided in an accompanying excel file.



7-58. Soda Fountain temperature record for all datasets, plotted with air pressure over the corresponding periods. This data is also provided in the accompanying excel file.



7-59. Results of Fourier analysis of the Soda Fountain temperature record. Periodograms for datasets 1, 2, and 3; all subsets of the data that are considered suitable for Fourier analysis.

Map of Australia

E2784264 N6298545

This pool is on carpark side of lake, through a large gate on the far side of the carpark from the tourist shop. The grass in front of the pool was flooded in October 2010.

In December there was extensive warm water over the grass in front of the pool. In April this had dried, leaving moist wrinkled pinkish-grey dehydrated algae which bore a resemblance to discarded offal.

Table 7-16. Map of Australia data.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
4 Oct 2010	81	8.5	~5	80 cm on ruler.	Minor gas discharge. Upwelling from deepest point.	Clear blue-green.
30 Dec 2010	82	nd	nd	90 cm on ruler	Calm, upwelling and gas discharge.	Clear blue-green.
27 April 2011	80	nd	nd	100 cm mark on ruler	Calm, upwelling, and streams of large (~50mm dia) gas bubbles.	Clear blue-green.
26 Jul 2011	80	nd	nd	110 cm mark on ruler	Calm, upwelling, and streams of gas bubbles.	Clear blue-green.

a) b)

7-60. The Map of Australia; a) October 2010; b) December 2010.

a)

b)

c)

d)

7-61. Grassed area in front of the Map of Australia, December 2010; a) looking SW; b) looking W; c) looking NW; d) looking N.

a)

b)

7-62. The Map of Australia April 2011; a) Main Pool; b) dried algae on grass in front of pool.

a)

b)

c)

d)

7-63. Grassed area in front of the Map of Australia, April 2011; a) looking SW; b) looking W; c) looking NW; d) looking N.

a)

7-64. The Map of Australia July 2011; a) Main Pool.

a)

b)

c)

d)

7-65. Grassed area in front of the Map of Australia, July 2011; a) looking SW; b) looking W; c) looking NW; d) looking N.

8. Reporoa

Fumaroles

E2800900 N6304314

2010: audible gurgling from all vents. Features 1-4 were apparently much hotter in 2011, although it may be that the scientists were better at choosing where to measure maximum temperature.

Date	Pool	T(°C)	Flow (l/s)	Depth (m)	Diameter (m)	Ebullition	Colour
11 April 2010	1	45	steam	~1	~0.5	Audible gas discharge.	Black mud.
26 Jul 2011	1	72	steam	~1	~0.5	Audible gas discharge.	Black mud.
11 April 2010	2	45	steam	~1	~0.5	Audible gas discharge.	Black mud.
26 Jul 2011	2	87	steam	~1	~0.5	Audible gas discharge.	Black mud.
11 April 2010	3	60	steam	~1	~0.4	Audible gas discharge.	Black mud.
26 Jul 2011	3	99	steam	~1	~0.4	Audible gas discharge.	Black mud.
11 April 2010	4	41	steam	>1	~0.8	Audible gas discharge.	Black mud.
26 Jul 2011	4	98	steam	>1	~0.8	Audible gas discharge.	Black mud.
11 April 2010	5	39	steam	nd	nd	Audible gas discharge.	Black mud.
26 Jul 2011	5	98	steam	0.15	~1.2	Audible gas discharge.	Black mud.
11 April 2010	6	92	steam	>0.2	~0.1	Audible gas discharge.	nd
26 Jul 2011	6	87	steam	0.05	~0.1	Quiet.	nd

a) b)

8-1. Fumaroles at Reporoa; a) April 2010; b) July 2011.

Figure 8 shaped hot pools

E2800884 N6304388

The pools have merged, however the larger pool seems to be more active.

Date	Pool	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
11 April 2010	Large	94	nd	0 visible	-20 cm below ground level.	Upwelling, gas discharge.	Clear, dark brown mud base.
26 Jul 2011		89	nd	0 visible	-50 cm below ground level.	Calm, minor gas discharge.	Clear, dark brown mud base.

8-2. The Figure 8 Pool, April 2010.

Hot Pool 3

E2800959 N6304325

This is difficult to photograph due to steam. By 2011 the pool had been properly fenced.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
11 April 2010	95	nd	~5		Upwelling.	Clear blue-green.
26 Jul 2011	97	nd	~5		Upwelling, moderate gas discharge. .	Clear blue-green.

a)

b)

8-3. Hot Pool 3; a) April 2010; b) July 2011.

Hot Pool 4

E2801252 N6304570

Unable to get close. The water level is an estimate from beyond fence.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
11 April 2010	nd	nd	None visible	~-0.8	nd	
26 Jul 2011	nd	nd	None visible	~-0.3	nd	

a)

b)

8-4. Hot Pool 4; a) April 2010; b) July 2011.

Bathing area

In July 2011 the formed hot pools (accessed from State Highway 5), and the adjacent (~ 100 m to the north) hot ground and boiling pool were visited. The GPS battery was flat so there is no co-ordinates given for the site. The pool supplying the baths was 91°C.

a)

b)

8-5. July 2011; a) Hot Pool supplying the baths (91°C); b) the bathing pools.

a)

b)

8-6. July 2011; a) Hot ground approximately 100 m north of bathing pools; b) sinter-precipitating hot pool.

9. Tauhara

Lake Taupo Shore

Taharepa Spring

E2793082 N6294721

The lake level was high, almost to the spring, and the sand had banked up into the spring. There was a hot seep through the sand.

In December the sand had been eroded slightly and there was ~0.1 m depth of water in the spring. The flow rate was low, although there is hot water seeping through the rocks on the shore platform lakeward of the spring.

In May 2011 a small channel had been excavated from the spring to the adjacent pool. The pool temperature was a pleasant 38°C. The channel was iron-stained. By July there was still a small flow from the spring.

Table 9-1. Taharepa Spring data.

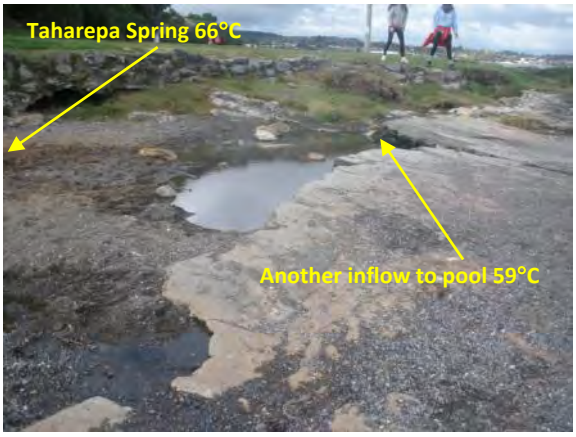
Date	T(°C)	Flow (l/s)	Water level	Ebullition	Colour
4 Oct 2010	66	(seep)	nd	No gas.	Clear
30 Dec 2010	65	0.5-1	nd	No gas.	Clear
4 May 2011	66	0.5-1	nd, lake level low.	No gas.	Clear
25 Jul 2011	66	0.5-1	nd, lake level low.	No gas.	Clear

a)

b)

9-1. Taharepa Spring; a) October 2010; b) December 2010.

a)



b)

9-2. Taharepa Spring, May 2011; a) The spring; b) The adjacent pool.

9-3. Taharepa Spring, July 2011.

Rocky Point Spring

E2778368 N6273387

This spring was completely submerged in October and December 2010. In December a hole had been dug in the sand adjacent to the rocks, about 2 m from the lake shore. The water in the hole was at lake level, and was 48°C.

In May the lake level was lower and the spring exposed. The hole in the sand mentioned above was dry. In July the spring appeared to be at lake level (it is difficult to see the source of the spring).

Table 9-2. Rocky Point Spring data

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
4th Oct 2010	nd	nd	nd	nd	nd	nd
30 Dec 2010	nd	nd	nd	nd	nd	nd
4 May 2011	63	nd	nd	nd	No gas.	Clear, strong Fe staining on rocks.
25 Jul 2011	nd	nd	nd	nd	No gas.	Clear, strong Fe staining on rocks.

a)

b)

9-4. Rocky Point Spring; a) October 2010; b) December 2010.

a)

b)

9-5. Rocky Point Spring; a) May 2011; b) July 2011. Note the snow on the hills across the lake.

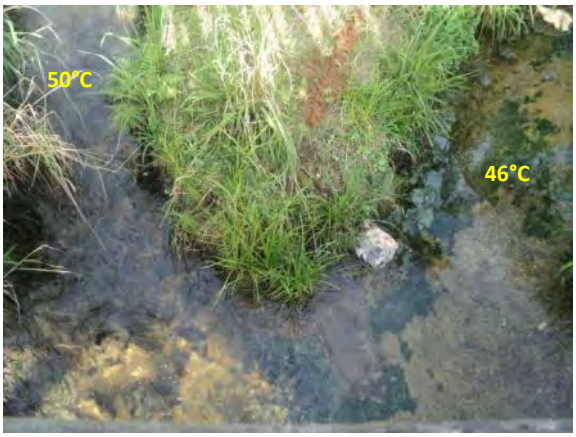
Otumuheke

E2779160 N6276670

The correct location in the Otumuheke Stream was found (around 50 m downstream from the location described in the April and June reports).

Table 9-3. Otumuheke data.

Date		T(°C)	pH	Flow (l/s)	Ebullition	Colour
4th Oct 2010	Right fork	50	nd		No gas.	Clear.
4th Oct 2010	Left fork	46	nd		No gas.	Clear.
30 Dec 2010	Right fork	53	nd		No gas.	Clear.
30 Dec 2010	Left fork	54	nd		No gas.	Clear.
4 May 2011	Right fork	51	nd		No gas.	Clear.
4 May 2011	Left fork	53	nd		No gas.	Clear, orange ppt on bed.
25 Jul 2011	Right fork	47	nd		No gas.	Clear.
25 Jul 2011	Left fork	41	nd		No gas.	Clear, orange ppt on bed.

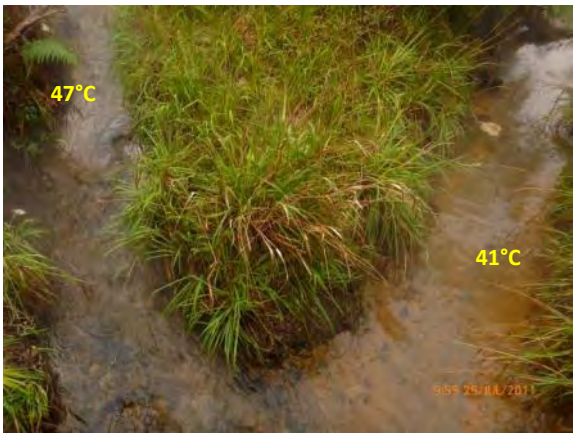


a)

b)

9-6. Otumuheke Stream at bridge, Spa Rd, looking upstream; a) October 2010; b) December 2010.

a)



b)

9-7. Otumuheke Stream at bridge, Spa Rd, looking upstream; a) May 2011; b) July 2011.

Wapahihi Source

E2779885 N6273260

In April the blackberry in the area had been sprayed, and a track bulldozed across the stream and past the spring. Trees had been planted near the spring.

Table 9-4. Waipahihi Source Spring data.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
4 Oct 2010	72	7.4	seep	White deposits on margin above water level.	No gas, Calm.	Clear, surrounded by brackish water.
30 Dec 2010	67	nd	0.35	flowing	Calm.	Clear.
4 May 2011	70	nd	~1	flowing	Calm.	Clear.
25 Jul 2011	66	nd	~1	flowing	Calm.	Clear.

a)

b)

9-8. V mber 2010.

a)

b)

c)

d)

9-9. Waipahihi Source; a) May 2011; b) The surrounding vegetation has been sprayed, and new trees planted in the vicinity of the spring; c) Bulldozed track past the spring; d) The stream downstream of the spring has been bulldozed, and blackberry sprayed.

b)

9-10. Waipahihi Source, July 2011.

10. Te Kopia

Mud Geyser and associated pools

Large Pool and Mud Geyser

E2790866 N6306251

This feature is a large (50 m diameter collapse pool), with a mud geyser in the western wall of the pool. In June the sides of the pool were cracked and slumped and the water level is ~5 m below the surrounding ground level. The ground in the entire area is light grey hydrothermally altered clay.

In October the entire feature was filled with pale milky blue water to within 0.3 m of the rim on the southern side of the bare ground. The implication is that the water was 4 to 5 m deep. The mud geyser was flooded. In December the water level was around 0.5 to 0.75 m lower than in October. The surface of the water shows many upwelling areas which are identifiable by the white suspended clay, and gas discharge.

This area was not visited in April. In July the water level had returned to the October (relatively high) level.

Table 10-1. Te Kopia Mud Geyser data.

Date	Pool	T(°C)	pH	Flow (l/s)	Water level (m) rel to S margin	Diam (m)	Ebullition	Colour
4 Oct 2010	Large pool	36	3.2	0	~-0.3	~50	Gas discharge.	Pale milky blue water with suspended light grey mud.
4 Oct 2010	Mud geyser	nd		nd	nd		Moderate gas discharge.	Flooded by larger pool.
4 Jan 2011	Large pool	47	nd	0	~-0.8	~50	Moderate gas discharge	Pale grey milky green.
4 Jan 2011	Mud geyser	nd		nd				Flooded by larger pool.
25 Jul 2011	Large pool	34		nd	Almost at the south rim of the pool.	~50	Moderate gas discharge	Pale grey milky green.
25 Jul 2011	Mud geyser	nd		nd				Flooded by larger pool.

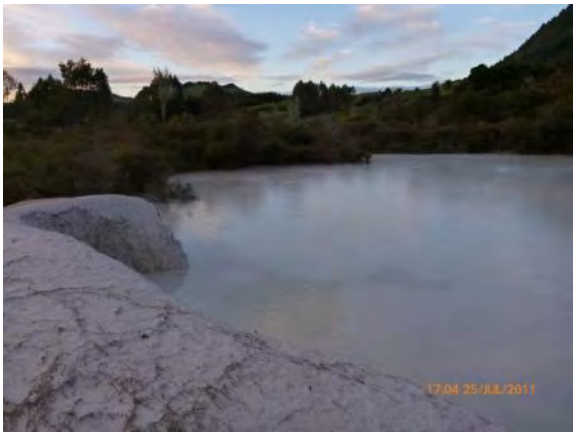
a) b)

10-1. Large mud pool; a) looking north, b) looking east, October 2010.

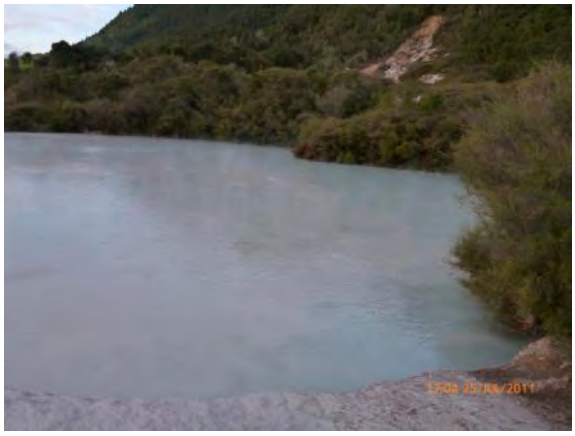
a)

b)

10-2. Large mud pool; a) looking north, b) looking east, December 2010.



a)



b)

10-3. Large mud pool; a) looking north, b) looking east, July 2011.

a)

b)

10-4. Mud Geyser; a) October 2010; b) December 2010.

a)

10-5. Mud Geyser; a) July 2011.

Small Mud Pool on the Geyser Ridge

E2790858 N6306249

Table 10-2. Small mud pool on geyser ridge data.

Date	T(°C)	Flow (l/s)	Depth (m)	Diameter (m)	Ebullition	Colour
4 Oct 2010	84 0.05 m in vent	Weak steam	0.5	~1.5 x 2 (unchanged)	-	Light grey dry cracked mud. No water visible.
4 Jan 2011	99 in vent	Weak steam	0.5	unchanged	-	Light grey dry cracked mud. No water visible.
25 Jul 2011	97	Weak steam	0.5	unchanged	No water visible, audible bubbling sound	Light grey damp mud. .

a)

b)

10-6. Small Mud Pool on Geyser ridge; a) October 2010 ; b) January 2011.

a)

10-7. Small Mud Pool on Geyser ridge; a) July 2011.

New Pool 1

E2790869 N6306212

This is a group of features uphill of the mud geyser. This group of features may already have a name. It consists of one large pool ~5 m diameter, which has an adjacent mud volcano structure, and another crater 3 m to the SW which does not appear to be hot, although there is a small mud mound (~0.5 m high) in the middle which shows evidence of activity. The temperature in the clay at the top of this mound was 83°C. In July we approached these pools from a different path, and could not reach the small mud mound. However there was boiling mud in the centre of the mud volcano and the large pool was vigorously boiling.

a)

b)

10-8. New mud pool; a) October 2010; b) January 2011.

a)

b)

10-9. Adjacent mud Volcano; a) October 2010; b) January 2011.

10-10. Small mound in adjacent crater; January 2011.

a)

10-11. Large pool (background) and adjacent mud Volcano (foreground); a) July 2011.

Mud Pools (Tomos) on west of Te Kopia Rd

The area is accessed from the road at a gate with GPS co-ordinates E2791149 N6306610. Walk straight across a paddock towards a Eucalypt forest, cross the fence into the forest and continue to the top of the hill then turn north-west down hill.

The three vents are on the north-west and south facing slope in the Eucalypt forest. Walk around the top of the middle vent and approach from the downhill side. The GPS co-ordinates of the middle vent are E2791030 N6306688. The Southern vent is accessed by walking around the forest to the western margin. In January 2011 this area was completely inaccessible due to blackberry growth.

In May we also visited a small new mud pool which is on the margin of the swamp ~ 20 m north of the tomos.

Eastern Vent (Doom), central vent (TK8), and Southern vent.

E2791030 N6306688

Doom

In October it was still possible to see into the vent, which extends > 7 m into the hill from the downhill lip. The base of the vent has grey muddy liquid which is bubbling furiously at the back of the vent, with lesser activity closer to the downhill lip. The temperature is measured close to the lip, which is unlikely to be the hottest part of the pool. Depth to liquid from the downhill lip is ~ 2 m. There is still a weathering mud apron around this lip.

In May and July the ground downhill of the pool, and the walls of the cave, had no fresh mud, indicating less activity than before the previous visits. The vents were still active, although in May there appeared to be less liquid and more viscous mud in the pool, and in July the base of the pool was mostly dry and cracked mud.

TK8

~ 5 m west of Doom, and has boiling mud and also effervescing gas, but no apron of mud. In October 2010 it was possible to get the thermocouple into TK8, which indicates it was 4 m deep. By January 2011 the level of boiling mud had declined past the reach of a 5 m long thermocouple lead. In January there was a strong smell of H_2S.

In May it was not possible to reach the mud in the base of the pool. There was vigorous activity in the pool, and mud covering the vegetation surrounding the pool, suggesting some violent discharge of mud (from a depth of ~ 5 m). By July the mud surrounding the pool had been weathered away. There was still vigorous activity in the base of the pool.

Southern Vent

The Southern Vent was visited in July as part of a Wildlands geothermal investigation. At that time sketch maps and cross-sections of the feature drawn and passed to Wildlands to be included in their report. This feature has several interesting characteristics. The first is that the boiling mud appears to be confined by a mud dam. In front of this dam is an area of damp geothermal mud which also appears to have an older dam in front of it, although now there is no liquid in this area. In front of the second, older, dam the soil is anomalously hot, and there is a large area of dead grass of at least 5 m diameter. The soil on the western margin of this area is steaming, with measured temperatures of 99°C at 0.1 m depth (measured at 4:00 pm).

In October the mud pool was vigorously boiling/discharging gas. The blackberry did not permit access in January, however the land-owner had cleared a path in May. The pool was still bubbling vigorously, however the water level was relatively low. In July the water level was ~ 0.5 m higher than in May, and was bubbling vigorously.

Table 10-3. Te Kopia Tomo data.

Date	Feature	T(° C)	Flow (l/s)	Depth to water (m)	Width (m)	Ebullition	Colour
4 Oct 2010	Doom	60	steam	~2 (very rough est)	~3	Violent gas discharge at back of feature.	Brown-grey mud.
4 Oct 2010	TK8	100	steam	~4	~4	Violent boiling and strong H_2S smell.	Brown-grey mud.
4 Oct 2010	Southern Vent	97	steam	0.2 m below lip.	~3	Vigorous boiling.	Brown-grey mud.
4 Jan 2011	Doom		Steam	~2	~3	Violent gas discharge at back of feature.	Brown-grey mud.
4 Jan 2011	TK8		Steam.	>5	~4	Violent boiling and strong H_2S smell.	Brown-grey mud.
5 May 2011	Doom	64 (IR)	Steam.	~ 2	~3	Vigorous gas discharge at back of feature, minor discharge near lip on west side.	Brown-grey mud.
5 May 2011	TK8	85 (IR)	Steam.	>5	~5	Violent boiling and strong H_2S smell.	Brown-grey mud.
5 May 2011	Southern Vent		Steam.	1 below lip.	~3	Vigorous boiling.	Brown-grey mud.

26 Jul 2011	Doom	71 (IR)	Steam.	~ 2	~3	Vigorous gas discharge at back of feature, minor discharge near lip on west side.	Brown-grey mud.
26 Jul 2011	TK8	73 (IR)	Steam.	>5	~5	Violent boiling and strong H_2S smell.	Brown-grey mud.
26 Jul 2011	Southern Vent	94	Steam.	0.5 m below lip.	~3	Vigorous boiling.	Brown-grey mud.

a)

b)

10-12. Doom; a) October 2010; b) January 2011.

a)

b)

10-13. Doom, May 2011; a) The mouth of the feature; b) the recovering vegetation in front of the feature.

a)

10-14. Doom; a) July 2011

10-15. TK8; a) October 2010; b) January 2011.

a)

b)

10-16. TK8; a) May 2011; b) July 2011.

a)

b)

c)

10-17. South Tomo, October 2010; a) the pool; b) mud in front of the pool; c) the dead vegetation downhill from the pool is caused by warm ground (up to 50°C at 0.1 m depth).

a)

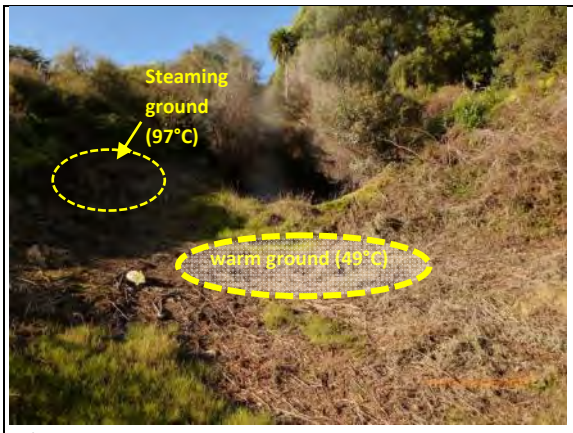
b)

c)

10-18. South Tomo, May 2011; a) the pool; b) mud in front of the pool; c) the dead vegetation downhill from the pool is caused by warm ground (up to 50°C at 0.1 m depth), there is also an area of steaming ground as shown in the photo.

a)

b)



c)

10-19. South Tomo, July 2011; a) the pool; b) mud in front of the pool; c) the dead vegetation downhill from the pool is caused by warm ground (max measured 49°C at 0.1 m depth), and the area of steaming ground is shown in the photo.

11. Tokaanu

Tourist Walk

Hydrothermal Eruption Pool beside Te Waihoto Pool

E2749577 N6244826

Table 11-1. Hydrothermal Eruption Pool beside Te Waihoto Pool data.

Date	T(°C)	Flow (l/s)	Depth to water (m)	Diameter (m)	Ebullition	Colour
1 Oct 2010	46	0	0.6	~1.5	Calm, no gas.	Clear.
31 Dec 2011	57	0	0.5	~1.5	Calm.	Clear.
26 Apr 2011	55	0	0.5	~1.5	Calm.	Clear, algae on surface.
24 Jul 2011	54	0	0.5	~1.5	Calm.	Green-brown, clear.

a)

b)

11-1. Hydrothermal Eruption crater beside Te Waihoto; a) October 2010; b) December 2010.

a)

No photo is available for April

b)

11-2. Hydrothermal Eruption crater beside Te Waihoto; a) April 2011; b) July 2011..

Matewai Pool

E2749593 N6244781

There is an inflow from Hoani A Pool.

Table 11-2. Matewai Pool data.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
1 Oct 2010	68	nd	~1 (inflow)	-0.6 m below ground level.	Calm.	V. slightly

				(covering central ridge)		cloudy blue-green.
31 Dec 2010	75	nd	~1 (inflow)	+0.43 m deep over ridge between pools.	Calm.	Clear green.
26 Apr 2011	72		~1 (inflow)	0.35 m deep over ridge between pools.	Calm	Clear green.
24 Jul 2011	67		~1 (inflow)	~0.55 m deep over ridge between pools.	Calm	Clear green.

a)

b)

11-3. The Matewai Pool; a) October 2010; b) December 2010.

a)

b)

11-4. The Matewai Pool; a) April 2011; b) July 2011.

Hoani A Pool

E2749583 N6244773

There is an outflow to Matewai Pool. There is bright white sinter on the margins of the pool.

Table 11-3. Hoani A Pool data.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
1 Oct 2010	82	7.4	~1 (outflow)	Close (within 0.02 m) to ground level.	Gentle upwelling, minor gas bubbles.	Clear blue-green.
31 Dec 2010	92	nd	~1 (outflow)	~ ground level.	Calm	Clear blue-green.
26 Apr 2011	86	nd	~1	~ ground level.	Calm.	Clear blue-green.
24 Jul 2011	86	nd	~1	~ ground level.	Calm.	Clear blue-green.

a)

b)

11-5. The Hoani A Pool, October 2010. a) View from the boardwalk b) Detail of the sinter on the pool margins.

a)

11-6. The Hoani A Pool, December 2010. a) View from the boardwalk.

a)

b)

11-7. The Hoani A Pool, April 2011. a) View from the boardwalk b) Detail of the sinter on the pool margins.

a)

b)

11-8. The Hoani A Pool, July 2011. a) View from the boardwalk b) Detail of the sinter on the pool margins.

Hoani B and C Pools

E2749572 N6244769

Behind the Hoani A Pool there is the Hoani B Pool, and another cooler pool (Hoani C).

The water from Hoani B is flooding the surrounding ground for ~ 1.5 m radius, hence it is difficult to estimate the outflow rate. Next to Hoani B an area of sinter has cracked and collapsed.

There is no change to Hoani C. Water level is difficult to record due to lack of a suitable datum. The south-west edge of the pool has been used as datum here.

Table 11-4. Hoani B & C Pool data.

	Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
Hoani B	1 Oct 2010	70	8.1	nd	g.l.	One zone of gas discharge. Visible upwelling.	Clear blue-green.
Hoani C	1 Oct 2010	32	7.4	No visible	g.l.	Calm.	Murky brown.
Hoani B	31 Dec 2010	82	nd	0 visible	g.l.	Calm.	Clear blue-green.
Hoani C	31 Dec 2010	49	nd	0 visible	~-0.3 m from g.l.	Calm.	Murky brown.
Hoani B	26 Apr 2011	77	nd	0 visible	g.l.	Calm.	Clear blue-green.
Hoani C	26 Apr 2011	40	nd	0 visible	~-0.3 from g.l.	Calm.	Murky brown.
Hoani B	24 Jul 2011	73	nd	0 visible	g.l.	Calm.	Clear blue-green.
Hoani C	24 Jul 2011	35	nd	0 visible	~+0.3 from g.l.	Occasional gas bubble.	Murky brown.

a)

b)

11-9. The Hoani B Pool Oct 2010; a) the Hoani B Pool, and b) cracked sinter.

a)

b)

11-10. The Hoani B Pool December 2010; a) the Hoani B Pool, and b) cracked sinter.

a)

b)

11-11. The Hoani B Pool April 2011; a) the Hoani B Pool, and b) cracked sinter.

a)

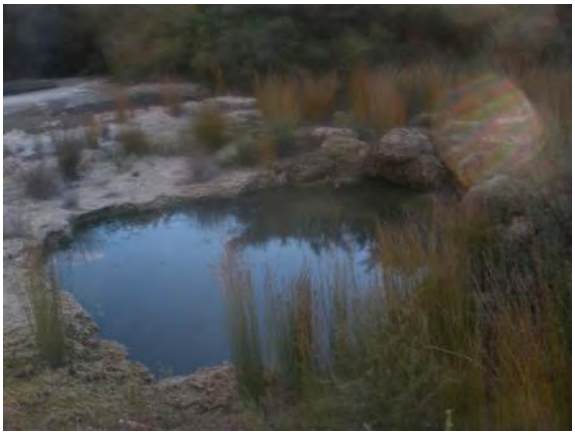
b)

11-12. The Hoani B Pool July 2011; a) the Hoani B Pool, and b) cracked sinter.

a)

b)

11-13. The Hoani C Pool; a) October 2010; b) December 2010.



a)

b)

11-14. The Hoani C Pool; a) April 2011; b) July 2011.

Takarea 6 Pool

E2749449 N6244723

Table 11-5. Takarea 6 Pool data.

Date	T(°C)	pH	Flow (l/s)	Water level	Ebullition	Colour
1 Oct 2010	62	7.4	0 visible	-0.15 m (measured from boardwalk surface)	Occasional slight gas discharge.	Clear blue-green. Orange microbial mats.
31 Dec 2010	65	nd	0 visible	nd-appears unchanged in photo	Calm.	Clear blue-green.
26 Apr 2011	65	nd	0 visible	nd-appears unchanged in photo	Calm.	Clear blue-green.

24 Jul 2010	62	nd	0 visible	nd-appears unchanged in photo	Calm.	Clear blue-green.

a)

b)

11-15. The Takarea 6 Pool; a) October 2010; b) December 2010.

a)

b)

11-16. The Takarea 6 Pool; a) April 2011; b) July 2011.

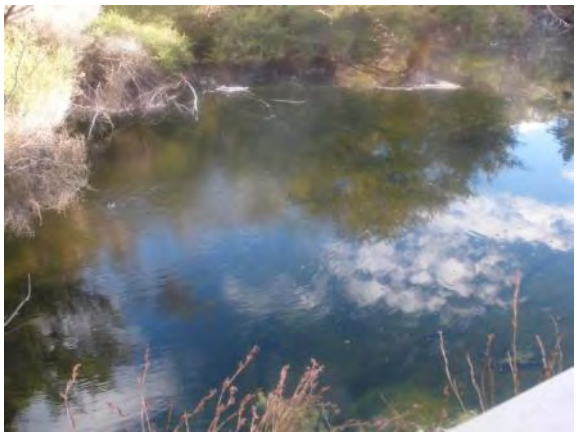
Takarea 5 Pools

Table 11-6. Takarea 5 Pool data.

Date	Pool	T(°C)	pH	Liq disch (l/s)	Water level	Ebullition	Colour
1 Oct 2010	East	59	7.2	0 visible	The water was over the lip between pools.	Moderate gas discharge.	Clear blue-green.
	West	nd	nd	0 visible		Very minor gas discharge.	Clear blue-green.
31 Dec 2010	East	61	nd	0 visible	The water was over the lip between pools.	Moderate gas discharge.	Clear blue-green.
	West	nd	nd	0 visible		Very minor gas discharge.	Clear blue-green.
26 April 2011	East	54	nd	0 visible	The water was over the lip between pools.	Moderate gas discharge.	Clear blue-green.
	West	49	nd	0 visible		Moderate gas discharge.	Clear blue-green.
24 Jul 2011	East	59	nd	0 visible	The water was over the lip between pools.	Moderate gas discharge.	Clear blue-green.
	West (or south)	44	nd	0 visible		Moderate gas discharge.	Clear blue-green.

a) b)

11-17. The Takarea 5 Pool; a) October 2010; b) December 2010.



a)

11-18. The Takarea 5 Pool East; a) April 2011; b) July 2011.

Mud Pools close to Paurini

E2749405 N6244701

Mud Pool 1

The dimensions of the pool have not changed. There is more activity on right-hand side (as viewed in photo).

Table 11-7. Mudpool 1 data.

Date	T(°C)	flow (l/s)	Depth (m)	Diameter (m)	Ebullition	Colour
1 Oct 2010	99	0	0.3	0.8 x 1.2	Two areas of bubbling mud at base. Moderate steam.	Black-brown mud.
31 Dec 2010	99	0	~0.4	0.8 x 1.2	Two areas of bubbling mud at base. Right-hand side more active, and deeper.	Black-brown mud.
26 Apr 2011	95	0	0.4	0.8 x 1.2	Two areas of bubbling mud at base.	Black-brown mud.
24 Jul 2011	97	0	0.4	0.8 x 1.2	Two areas of bubbling mud at base.	Black-brown mud.

a)

b)

11-19. Mud Pool 1; a) October 2010; b) December 2010.

No photo available for July 2011

a)

11-20. Mud Pool 1; a) April 2011.

Mud Pool 2

Table 11-8. Mudpool 2 data.

Date	T(° C)	Flow (l/s)	Depth (m)	Diameter (m)	Ebullition	Colour
1 Oct 2010	72	0	0.4	0.2 w x 0.4	Weak steam.	Black-brown mud.
31 Dec 2010.	93	0	0.4	0.2 x 0.4	Weak steam.	Black-brown mud.
26 Apr 2011	74	0	0.3 to water	0.2 x 0.4	Weak gas discharge.	Black-brown water.
24 Jul 2011	97	0	0.3 to water	0.2 x 0.4	Moderate steam discharge (boiling).	Black-brown water.

a)

b)

11-21. Mud Pool 2; a) Oct 2010; b) April 2011.

a)

11-22. Mud Pool 2; a) July 2011.

Mud Pool 3

Table 11-9. Mudpool 3 data.

Date	T(°C)	Liq discharge (l/s)	Depth (m)	Diameter (m)	Ebullition	Colour
1 Oct 2010	93	0	0.25	0.3	Bubbling muddy water at base.	Black-brown.
31 Dec 2010	72	0	0.4	0.3	Bubbling mud at base.	Black-brown.
26 Apr 2011	95	0	0.25	0.3	Bubbling muddy water at base. Partially slumped.	Black-brown.
24 Jul 2011	97	0	0.1 to muddy water.	0.3	Bubbling muddy water.	Black-brown.

a)

b)

11-23. Mud Pool 3; a) October 2010; b) April 2010.

a)

11-24. Mud Pool 3; a) July 2011.

Mud Pool 4

Table 11-10. Mudpool 4 data.

Date	Pool	T(°C)	Liq disch (l/s)	Dia (m)	Water level difference (m)	Ebullition	Colour
1 Oct 2010	4N	79			~0.4		Brown muddy water.
1 Oct 2010	4S	99 at 1 m depth				Gas discharge through mud.	Brown mud.
31 Dec 2010	4N	79		1.2	0	Mud has been erupting over the sides (both pools). Gas discharge through mud.	Brown muddy water.
31 Dec 2010	4S	99		0.8			Brown muddy water.
26 Apr 2011	4N	74		1.2	~0.3	Mud has been erupting over the sides (both pools). Gas discharge through mud.	Brown muddy water.
26 Apr 2011	4S	99		0.8			Brown mud.
24 Jul 2011	4N	99		1.2	~0.3	Mud has been erupting over the sides (both pools). Gas discharge through mud.	Brown muddy water.
24 Jul 2011	4S	98		0.8			Brown muddy water.

11-25. Mud Pools 4S and 4N; a) October 2010; b) December 2010.

a) b)

11-26. Mud Pools 4S and 4N; a) April 2011; b) July 2011.

Paurini Pool

E2749403 N6244684

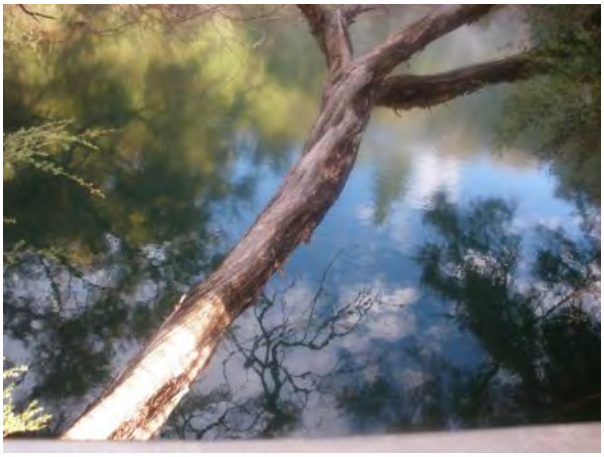
Table 11-11. Paurini Pool data.

Date	T(°C)	pH	Liq discharge (l/s)	Water level	Ebullition	Colour
1 Oct 2010	65	nd	0 visible, possibly an outflow opposite lookout.	-1.4 m rel to lookout floor.	Upwelling and vigorous gas discharge in centre.	Slightly murky green.
31 Dec 2010	61	nd		-1.4 m rel to lookout floor.	Upwelling and vigorous gas discharge in centre.	Slightly murky green.
26 Apr 2011	59	nd		-1.3 m rel to lookout floor.	Upwelling and vigorous gas discharge in centre.	Slightly murky green.
26 Apr 2011	63	nd		nd	Moderate upwelling & gas discharge in centre.	Slightly murky green.

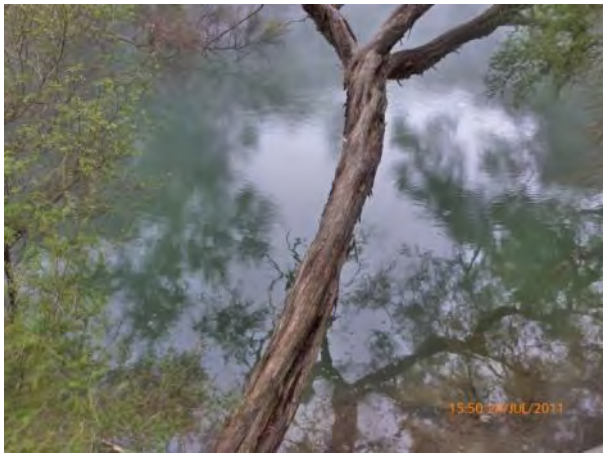
a)

b)

11-27. Paurini Pool; a) October 2010; b) December 2010.



a)



b)

11-28. Paurini Pool; a) April 2011; b) July 2011.

Toretiti Pool

E2749426 N6244714

The Toretiti Pool is linked to Te Ngutu. This was visited in April.

11-29. The Toretiti Pool.

Te Ngutu Pool

E2749426 N6244714

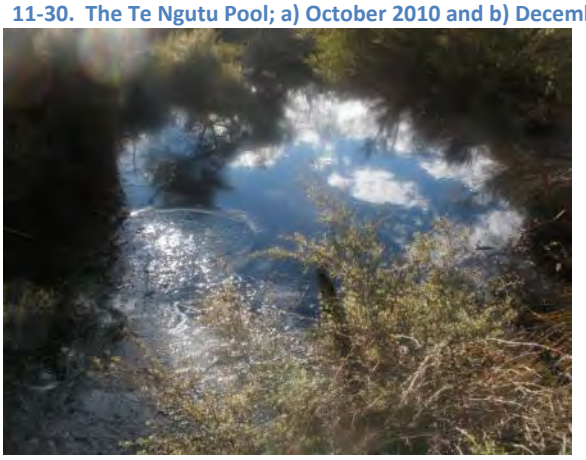
Table 11-12. Te Ngutu Pool data.

Date	T(°C)	pH	Liq discharge (l/s)	Water level (m)	Ebullition	Colour
1 Oct 2010	50	nd	0 visible	-0.35 (rel to top of boardwalk).	Calm.	Clear with green algae.
31 Dec 2010	52	nd	0 visible	-0.3 (rel to top of boardwalk).	Calm	Clear, microbial mats on margins.
26 Apr 2011	44	nd	0 visible	-0.2 (rel to top of boardwalk).	Some gas.	Clear, microbial mats on margins.
24 Jul 2011	nd	nd	0 visible	nd	Some gas.	Clear, microbial mats on margins.

a)

b)

11-30. The Te Ngutu Pool; a) October 2010 and b) December 2010.



a)

b)

11-31. The Te Ngutu Pool; a) April 2011 (the setting sun made photography difficult); b) July 2011.

Teretere Pool

E2749431 N6244757

Table 11-13. Teretere Pool data.

Date	T(°C)	pH	Liq discharge (l/s)	Water level (m rel to boardwalk)	Ebullition	Colour
1 Oct 2010	15	8.3	0 visible.	0 .0 (Level with boardwalk)	Calm.	Murky brown.

31 Dec 2010	31	nd	0 visible	-0.18 (rel to top of boardwalk).	Calm.	Murky brown, scum on surface.
26 Apr 2011	21	nd	0 visible	-0.1 (rel to top of boardwalk).	Calm.	Murky brown.
24 Jul 2011	19	nd	0 visible	-0.1 (rel to top of boardwalk).	Calm.	Murky green-brown.

a)

11-32. The Teretere Pool; a) October 2010 and b) December 2010.

a) b)

11-33. The Teretere Pool; a) April 2011; b) July 2011.

Hydrothermal Eruption crater Pool

E2749431 N6244757

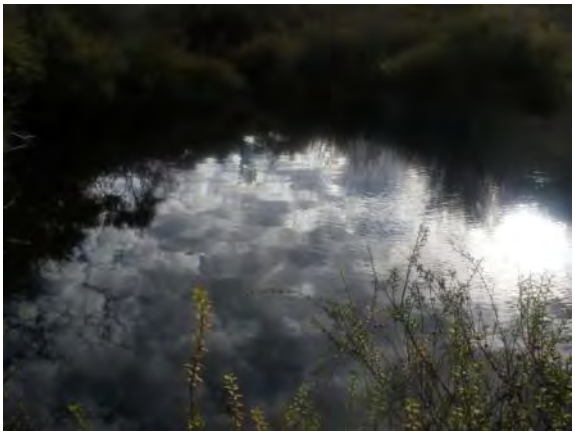
Table 11-14. Hyrothermal Eruption Crater Pool data.

Date	T(° C)	pH	Liq discharge (l/s)	Water level	Ebullition	Colour
1 Oct 2010	28	6.9	0 visible	Surrounding swamp flooded.	Calm.	Black.
31 Dec 2010	30	nd	0 visible	nd	Calm.	Brown.
26 Apr 2011	25	nd	0 visible		Calm.	Brown.
24 Jul 2011	23	nd	0 visible		Calm.	Brown.

a)

b)

11-34. The Hydrothermal Eruption Crater Pool; a) October 2010 and b) December 2010.



a)

b)

11-35. The Hydrothermal Eruption Crater Pool; a) April 2011 and b) July 2011.

Vent by gravel walkway

E2749529 N6244815

Surrounding vegetation is dead.

Table 11-15. Vent by walkway data.

Date	T(°C)	pH	Liq discharge (l/s)	W.L	Diameter (m)	Ebullition	Colour
1 Oct 2010	17	6.0	0	Ground level	0.6	Still.	Bottom of pool is orange-brown (Fe) coloured.
31 Dec 2010	36 at 0.1 m	-	0	Moist.	0.6	-	-
26 Apr 2011	19	nd	0 visible	Surrounding swamp flooded.	-	Calm, occasional gas bubbles.	
24 Jul 2011	17	nd	0 visible	Surrounding swamp flooded.	-	Calm, occasional gas bubbles.	Brown.

a)

b)

11-36. Hot vent near gravel walkway; a) October 2010; b) December 2010. The photo from April 2011 was completely out of focus.

a)

11-37. Hot vent near gravel walkway; a) July 2011.

Cooking area

Taumatapuhipuhi

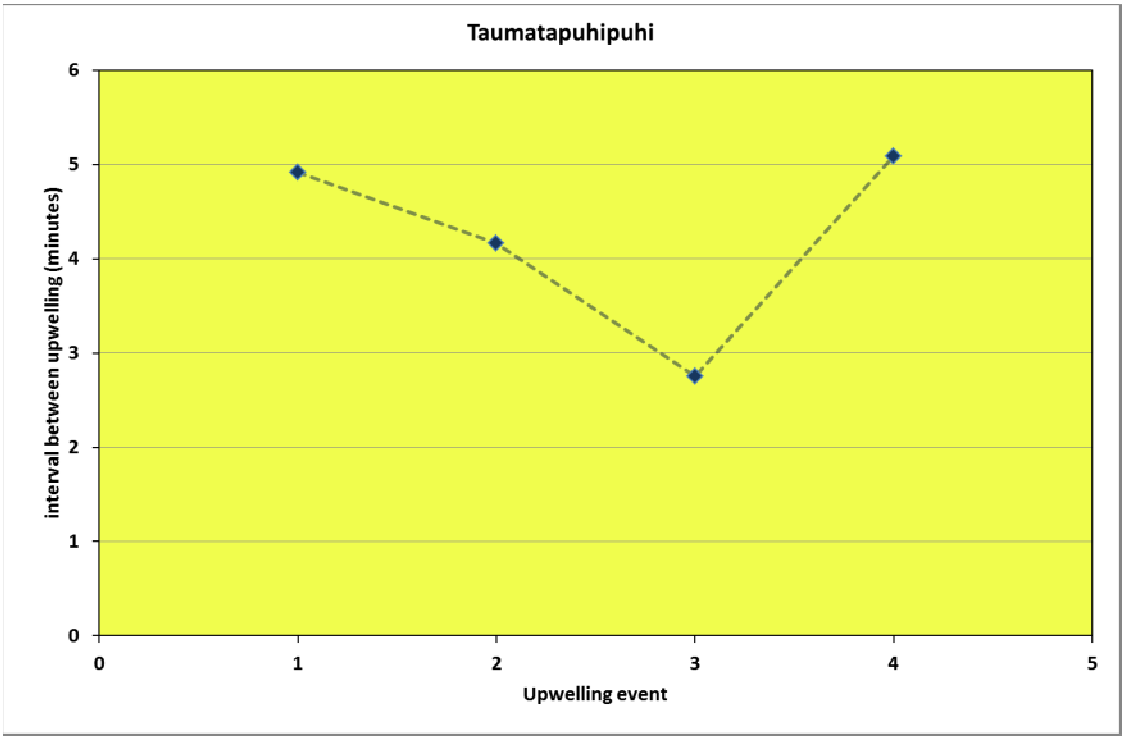
E2749633 N6244801

In October Taumatapuhipuhi was discharging to ~1.2 m height when we arrived. We observed four cycles as recorded below in Table 7-1.

In April we observed one 'eruption', with a duration of 20 s. The period between the start of this 'eruption' and the next 'eruption' was 5 min 30 s. The change in water level over one cycle was 100 mm. After discharge some of the water flows back into the pool from the channel.

Table 11-16. Upwelling times for Taumatapuhipuhi Pool, Oct 2010.

Time (24hr:ss)	1310:00	1314:55	1319:05	1321:50	1326:55
Interval (mm:ss)	4:55	4:10	2:45	5:05	



11-38. Taumatapuhipuhi upwelling cycles October 2010.

Table 11-17. Taumatapuhipuhi data.

Date	T(°C)	pH	Height (m)	Eruption interval	Eruption duration	Colour
1 Oct 2010	102-99	7.9	~1.2	See chart	nd	Clear
31 Dec 2010	100	nd	nd	Only 1 upwelling obs	25	Clear.
26 Apr 2011	99-110	nd	~1	5:30	20 s	Clear.
24 Jul 2011	99-100	nd	~0.5	Only one upwelling obs	nd	Clear.

a) b)

11-39. Taumatapuhipuhi; a) October 2010; b) December 2010.

a)

b)

11-40. Taumatapuhipuhi; a) April 2011 and b) July 2011.

Hot vents at entry to cooking area

E2749630 N6244775

In October these Vent 1 was overgrown with grass, Vent 2 was active, and Vent 3 had a post in it.

In December there was an area of hot mud where Vent 1 had previously existed, and everywhere else was dry. Vent 4 is on the left side of the opening, and remains active, although it is difficult to see into this inclined vent.

In April 2011 Vent 1 had a 0.4m diameter hot pool in it, with surrounding warm ground, Vents 2 and 3 were still inactive, and Vent 4 was active.

Table 11-18. Vents at entry to cooking area data.

Date	Vent	T(°C)	Liq. discharge (l/s)	Depth (m)	Diameter (m)	Ebullition	Colour
1 Oct 2010	1	nd	0	nd	nd	No activity, grass has grown over vent.	-
1Oct 2010	2	77	0 visible.	nd	nd	Vigorous gas discharge from several small vents.	Cloudy grey. water.
1 Oct 2010	3	nd	0			Has a post in it.	nd
1 Oct 2010	4	64 at 0.2 m into vent.	0 visible.	>1m	~0.2 m high.	Audible vigorous bubbling. Visible water.	Difficult to see.
31 Dec 2010	1	99	0	nd, probably <0.1 m	~1	Bubbling mud.	Brown.
31 Dec 2010	4	Unable to reach into vent.	0 visible.	nd	~1 x 0.25	Audible bubbling.	nd
26 Apr 2011	1	94	0 visible.	nd	0.4	Moderately vigorous gas bubbles.	Brown.
26 Apr 2011	4	63	0 visible.	nd		quiet	nd

a)

b)

11-41. a) Vents 1, 2, 3 at entry to cooking area, October 2010; b) December 2010.

11-42. Vent 4 at entry to cooking area, December 2010.

11-43. a) Vents 1 at entry to cooking area, April 2011. Vent 2 is a cold rainwater puddle, and Vent 3 does not exist

a)

b)

11-44. a) Vent 4 at entry to cooking area, April 2011; b) Entry to cooking area, showing location of Vents 1 and 4, April 2011.

a)

b)

11-45. a) Vent 1 at entry to cooking area, July 2011; b) Vent 1 detail.

a)

11-46. a) Vent 4 at entry to cooking area, July 2011.

Main cooking area

E2749660 N6244788

Feature 5 is a cooking hole, Feature 6 was a mud pool in October, Feature 7 has wooden edges, and was covered in December, and Feature 8 is a small hot pool approximately 5 m from Features 5,6, and 8. In December Feature 8 was filled with a half-round of concrete.

Table 11-19. Main cooking area data.

Date		T(°C)	pH	Liq discharge (l/s)	Depth (m)	Diameter (m)	Ebullition	Colour
1 Oct 2010	5 (cooking hole)	100		0	nd	1.2 x 1	Audible bubbling.	Black.
1 Oct 2010	6 (muddy pool)	87	6.6	0	nd	1	Steam discharge.	Black-brown mud.
1 Oct 2010	7 mudpot (wooden edges)	99		0	nd	0.5	Vigorous steam discharge.	Black-brown mud.
1 Oct 2010	8 mudpool	67	6.7	0	0.1 m below lowest ground.	0.3 x 0.4	Weak steam discharge.	Murky brown.
31 Dec 2010	5	nd	nd	0	nd	1.2 x 1	Audible bubbling.	Black.
31 Dec 2010	6	95	nd	0		1	Moist soil.	Brown-grey.

31 Dec 2010	7	nd	nd	0	nd	0.5	Audible bubbling.	nd
31 Dec 2010	8	nd	nd	0	nd	0.3 x 0.4	Hissing steam.	Grey-brown soil.
26 Apr 2011	5	nd	nd	0	nd	1.2 x 1	nd	nd
26 Apr 2011	6	88	nd	0	nd	1	Vigorous gas discharge.	Brown & muddy.
26 Apr 2011	7	99	nd	0	nd	0.5	Vigorous boiling.	Clear.
26 Apr 2011	8	92	nd	0	nd	0.3 x 0.4	Vigorous gas discharge.	Brown, muddy.
24 Jul 2011	6	97	nd	0	nd	1	Bubbling muddy water. Evidence of splashing mud.	Brown & muddy.
24 Jul 2011	8	90	nd	0	nd	0.3 x 0.4	Vigorous gas discharge.	Brown, muddy.

a) b) c) d)

11-47. October 2010; a) Feature 6; b) Feature 8; c) the main cooking area; d) Feature 7.

a)

b)

c)

8

11-48. 11-49. December 2010; a) Feature 6; b) Feature 8; c) the main cooking area.

a)

b)

c)

11-50. April 2011; a) Feature 6; b) Feature 8; c) Feature 7.

a)

b)

Feature 7 had people in the vicinity, so we did not photograph it.

11-51. July 2011; a) Feature 6, and b) Feature 8.

12. Waikite

Waikite Swimming Pool area

Manaroa

E2799016 N6314261

The major upwelling appears to always be toward the far side of the pool from the platform, and minor zones in the centre and centre left. In October another weak upwelling could be seen on the right-hand side of the pool (near the outflow). The activity was extremely vigorous and the upwelling water reached heights of ~1.0 m. The upwelling of the water is accompanied by a roaring sound, hence the commencement of an upwelling event can be recognised even if the pool is obscured by steam. On the last three visits the time between upwelling has been recorded for six minutes each time. The data are given in Table 11-16 below, and plotted in 12-3.

Table 12-1. Manaroa data.

Date	T(°C)	pH	Liq discharge (l/s)	Water level	Ebullition	Colour
1 Oct 2010	99	nd	~40	overflowing	0.5 to 1.0 m. Also effervescing.	Clear blue-green.
29 Dec 2010	boiling	nd	40-50	overflowing	0.5-1.0 up-doming. Also effervescing.	Clear blue-green.
04 May 2011	boiling	nd	40-50	overflowing	Up-doming to 1.2 m Also effervescing.	Clear blue-green.
23 Jul 2011	boiling	nd	40-50	overflowing	Up-doming to 1.2 m Also effervescing.	Clear blue-green.

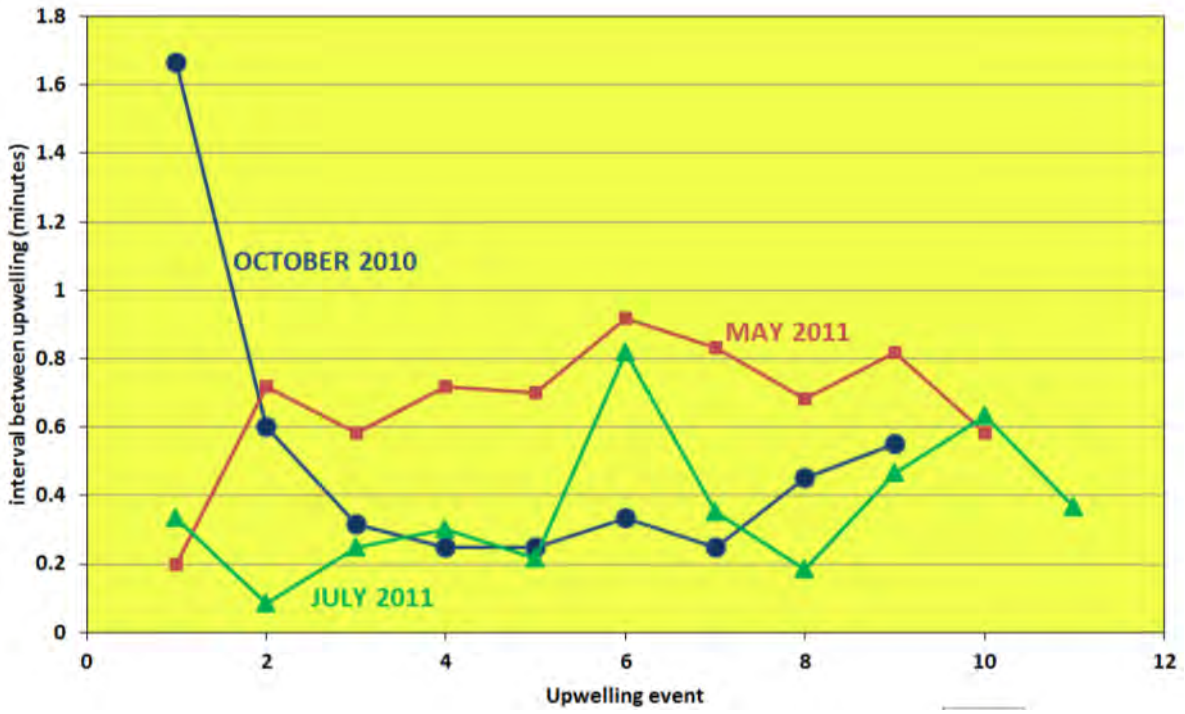
a) b)

12-1. The Manaroa Pool; a) October 2010; b) December 2010.

a)

b)

12-2. The Manaroa Pool; a) May 2011.



12-3. Interval between upwelling events for Manaroa Pool. The data is given below.

Table 12-2. Upwelling times for Manaroa Pool, October 2010.

Time (24hr:ss)	1544:20	1546:00	1546:36	1546:55	1547:10	1547:25	1547:45	1548:00	1549:27	1550:00
Interval (mm:ss)	1:40	0:36	0:19	0:15	0:15	0:20	0:15	0:27	0:33	

Table 12-3. Upwelling times for Manaroa Pool, April 2011.

Time (24hr:ss)	1649:05	1649:17	1650:00	1650:35	1651:18	1652:00	1652:55	1653:45	1654:26	1655:15	1655:50
Interval (mm:ss)	0:12	0:43	0:35	0:43	0:42	0:55	0:50	0:41	0:49	0:35	

Table 12-4. Upwelling times for Manaroa Pool, July 2011. In this case only cumulative time was recorded, however the time of the visit it was close to midday.

Time (mm:ss from 0)	00:00	00:20	00:25	00:40	00:58	01:11	02:00	02:21	02:32	03:00	03:38	04:00
Interval (mm:ss)	0:20	0:05	0:15	0:18	0:13	0:49	0:21	0:11	0:28	0:38	0:22	

Stream from Manaroa

Sampling site is by sign about scale in stream.

Table 12-5. Stream from Manaroa data.

Date	T(°C)	pH	Liq flow (l/s)	Water level	Ebullition	Colour
1 Oct 2010	87	nd	~50	-	-	Clear.
04 May 2011	87	nd	~50	-	-	Clear.
24 Jul 2011	85	nd	~50	-	-	Clear.

a)

b)

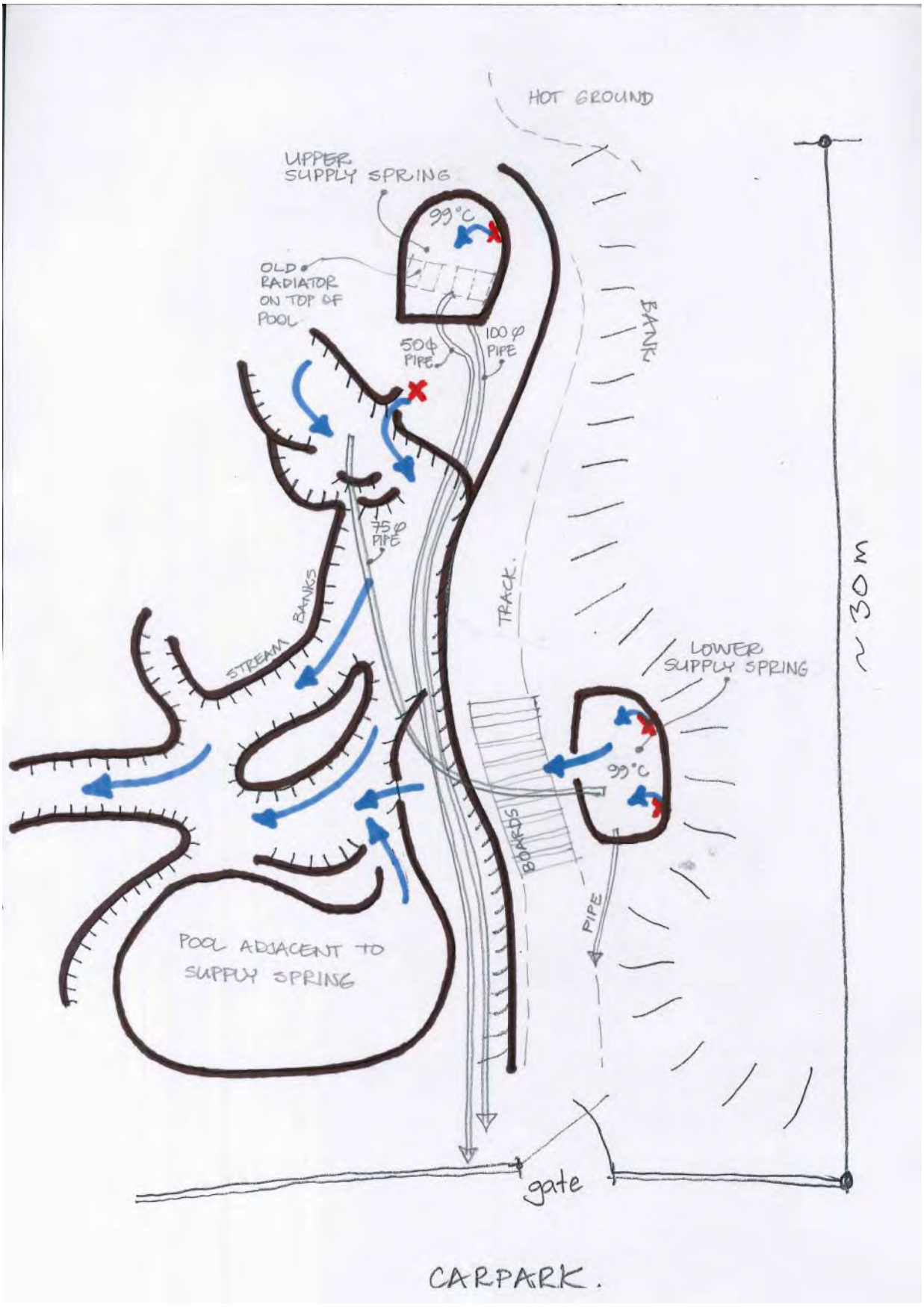
12-4. Stream from Manaroa a) October 2010; b) May 2011.

a)

12-5. Stream from Manaroa a) July 2011. The edges of the sinter appeared greyish.

Hot Pool Supply Gully

In the past there were several monitoring points as the water cascaded from the supply spring to the swimming pools. The only information from these monitoring points is the temperature change as the water approached the pool inlet. It was decided instead to visit the small gully at the north end of the carpark which hosts the natural springs which actually supply the swimming pool. Several of these springs appear to supply the pool via a complicated system of operational pipes, interwoven with some apparently redundant pipes. This area is moderately dangerous, with boiling water discharging in the springs to a small stream which runs down the gully. We did not attempt to map the area with a tape and compass or GPS, but a sketch map is given below to show the main features of this area.



12-6. Sketch map of hot pool supply springs gully May 2011. The red crosses represent observed hot inflows; it is likely there are others which are difficult to see.

Upper supply spring

E2798978 N6314244

Table 12-6. Upper Supply Spring data.

Date	T(°C)	pH	Liq flow (l/s)	Water level	Ebullition	Colour
1 Oct 2010	97	8.1	piped	No overflow.	Vigorous discharge.	Clear.
29 Dec 2010	97	nd	piped	No overflow.	Vigorous discharge.	Clear.
04 May 2011	97	nd	piped	No overflow.	Vigorous discharge.	Clear.
23 Jul 2011	95	nd	piped	No overflow.	Vigorous discharge.	Clear.

a)

b)

12-7 a) Upper Supply Spring, October 2010. Arrows show the spring inflow location; b) December 2010.

a)

b)

12-8 a) & b) Upper Supply Spring; a) May 2011 and b) July 2011.

Lower Supply Spring

Table 12-7. Lower Supply Spring data.

Date	T(°C)	pH	Liq flow (l/s)	Water level	Ebullition	Colour
1 Oct 2010	99	8.1	piped	Overflowing.	Vigorous discharge.	Clear.
29 Dec 2010	99	nd	piped	Overflowing.	Vigorous discharge.	Clear.
04 May 2011	99	nd	piped	Overflowing.	Vigorous discharge.	Clear.
23 Jul 2011	97	nd	piped	Overflowing.	Vigorous discharge.	Clear.

a)

b)

c)

d)

12-9. Lower Supply Spring; a) October 2010; b) December 2010; c) May 2011; d) July 2011. Arrows show spring inflows.

Pool adjacent to Supply Spring

In May there was green algae around the edges of the pool.

Table 12-8. Pool adjacent to Supply Spring data.

Date	T(°C)	pH	Liq flow (l/s)	Water level	Ebullition	Colour
01 Oct 2010	83	nd	nd	overflowing	Calm.	Clear.
29 Dec 2010	nd	nd	nd	overflowing	Calm	Clear
04 May 2011	82	nd	nd	overflowing	Calm	Clear
23 Jul 2011	83	nd	nd	overflowing	Calm	Clear

a)

b)

c)

d)

12-10. d) Pool adjacent to Supply Spring; a) October 2010; b) December 2010; c) May 2011; d) July 2011.

Bridge at Corbett Rd

E2798396 N6314187

Table 12-9. Bridge at Corbett Rd stream data.

Date	T(°C)	pH	Liq flow (l/s)	Water level	Ebullition	Colour
1 Oct 2010	47	8.7	~150	-	-	Clear.
29 Dec 2010	52	nd	~150	-	-	Clear.
04 May 2011	48	nd	~150	-	-	Clear.
23 Jul 2011	45	nd	~150	-	-	Clear.

a)

b)

c)

12-11. Sampling point under the bridge at Corbett Rd; a) October 2010; b) December 2010; c) May 2011.

Spring on Landcorp Farm (Scalding Spring?)

HT Geyser outflow (Waikite Scarp Swamp?)

These features were not visited.

13. Waiotapu

Tourist Walk

Weather Pool

E2804421 N6310781

Table 13-1. Weather Pool data.

Date	T(°C) (IR)	Water level	Ebullition	Colour
02 Oct 2010	59	nd	Calm.	Murky turquiose.
28 Dec 2010	45	Not overflowing.	Calm.	Murky turquiose.
27 April 2011	55	Overflowing (seep)	Calm.	Murky turquiose.

13-1. Weather Pool; a) Oct 2010; b) May2011.

Pool north of Jean Batten Geyser

There was very heavy rain in the central North Island on the 27th Dec 2010. On the 29th Dec the water level this pool was ~0.45 m below the rim as shown in Figure 8-2 b)). The next day on Dec 30th the pool was overflowing (Figure 8-3 a)).

Table 13-2. Pool north of Jean Batten Geyser data.

Date	T(°C)	pH	Liq flow (l/s)	Water level	Ebullition	Colour
02 Oct 2010	20	nd	0 visible.	~-0.45 m	calm	nd
29 Dec 2010			0 visible.			
30 Dec 2010				overflowing	calm	Clear, slightly brown
23 Jul 2011	17			~-0.45 m	calm	Slightly milky.

a) b)

13-2. Pool north of Jean Batten Geyser; a) 29th Dec 2010; b) Close-up of sides of pool; this mineral precipitate was originally bright yellow (orpiment?) but fades to this pinkish grey over time.

a)

b)

30 Dec 2010: a) The Pool North of Jean Batten Geyser, b) Jean Batten Geyser. Both the features are overflowing after heavy rain 3 three days previously.

a)

b)

13-3. Pool north of Jean Batten Geyser; a) April 2011; b) Looking into the pool.

a)

The Pool North of Jean Batten Geyser; a) July 2011.

Jean Batten Geyser

E2804548 N6310482

Table 13-3. Jean Batten Geyser data.

Date	T(°C)	pH	Liq flow (l/s)	Water level	Ebullition	Colour
02 Oct 2010	nd	nd	0 visible.	nd	Mod steam.	-
29 Dec 2010	nd	nd	0 visible.	nd	Weak steam.	-
27 Apr 2011	nd	nd	0 visible.	nd	Weak steam.	-
23 Jul 2011	nd	nd	0 visible.	nd	Weak steam.	-

a)

b)

c)

d)

13-4. Jean Batten Geyser; a) Oct 2010; b) Dec 2010; c) April 2011; d) July 2011.

Sinter Terraces

a)

b)

c)

13-5. Overview of the Sinter Terraces and Champagne Pool; a) October 2010, b) December 2010; c) April 2011.

13-6. Overview of the Sinter Terraces and Champagne Pool, July 2011. Unfortunately the steam was too dense to allow a reasonable photo.

Sinter Terraces-Yellow coloured vent

The Sinter Terraces were submerged north of the boardwalk on all visits. There are yellow-green pools near the track as shown Figure 13-7. Figure 13-7 d) shows a vent that has recently become intense yellow, which is possibly orpiment precipitating.

a)

b)

c)

d)

13-7. Yellow Pool, Sinter Terraces; a) October 2010; b) December 2010; c) April 2011; d) the vent in the centre of the photo has become an intense yellow (orpiment?).

a)

b)

13-8. Sinter Terraces July 2011; a) Overview; b) Yellow Pool.

Sinter Terraces-Foreground Pool

Table 13-4. Foreground Pool data.

Date	T(°C)	pH	Liq flow (l/s)	Water level	Ebullition	Colour
02 Oct 2010	66	nd	0 visible.	Submerged.	Upwelling close to south edge.	Murky brown.
29 Dec 2010		nd	0 visible.	Submerged.	Upwelling and gas discharge close to south edge.	Murky brown.
27 Apr 2011	67	nd	0 visible.	Submerged.	Upwelling close to south edge.	Murky brown.
23 Jul 2011	Too much steam present for IR thermometer or visual check.					

a)

b)

c)

d)

13-9. Foreground Pool, Sinter Terraces; a) October 2010; b) December 2010; c) April 2011; d) July 2011.

Waiotapu geyser

E2804491 N6310256

A temperature datalogger was recording temperature at two minute intervals over the period 2nd Oct to 16th November 2010, and from 31st December 2010 to 13th February 2011, and 3rd March to 17th April 2011. There is also a dataset from the previous year's monitoring. This is also shown in this report for completeness.

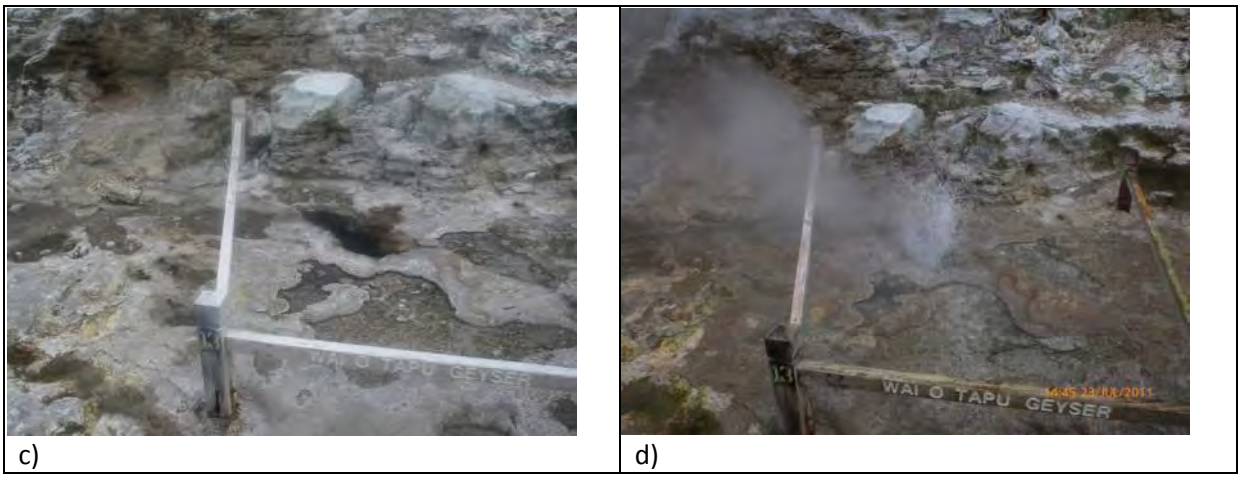
The original data, plotted directly from the datalogger software, is shown in Figures 13-12 to 13-15. Following these are lots showing the spring temperature data with the air pressure, air temperature, rainfall, and earthquakes over the same period (Figures 13-16 to 13-19). These Figures are given to show the data that is available and has already been extracted from the NIWA and GNS databases, and which may be useful in understanding the behaviour of the Waiotapu Geyser.

Table 13-5. Waiotapu Geyser data.

Date	T(°C)	pH	Liq flow (l/s)	Water level	Ebullition	Colour
02 Oct 2010	87	nd	0 visible.	0.075 m below rim	Calm.	Clear blue.
29 Dec 2010	85	nd	0 visible.	0.05 m below rim	Calm.	Clear blue.
27 Apr 2011	87	nd	seep	overflowing	Calm.	Clear blue.
23 Jul 2011	(boiling)	nd	Splashing discharge	overflowing	Boiling	Clear blue.

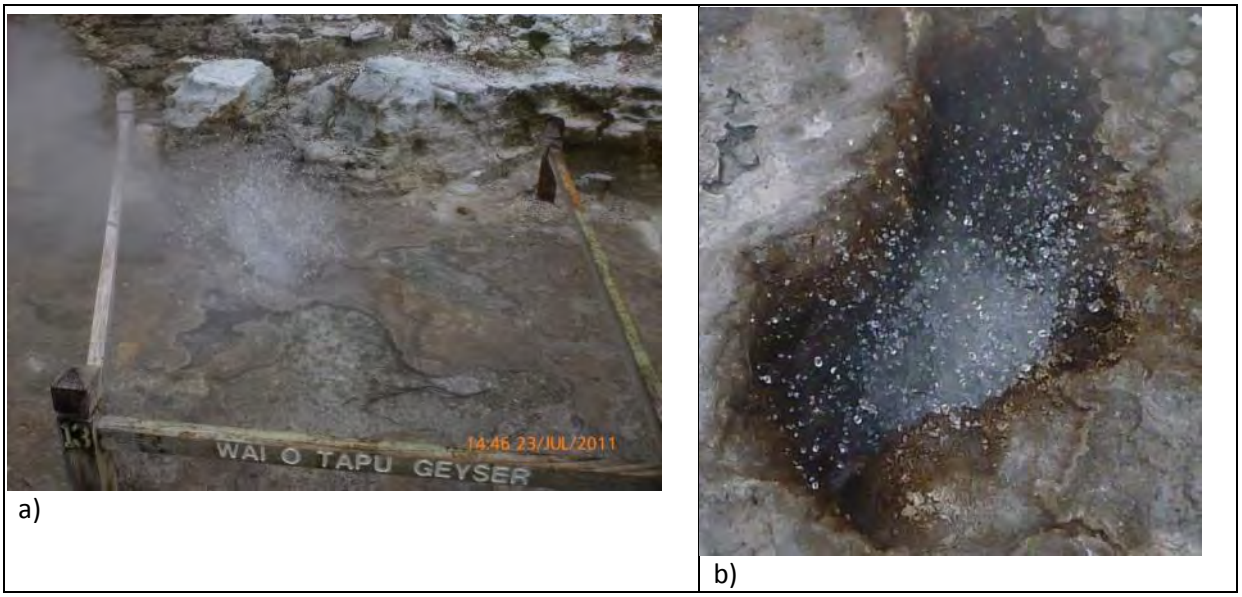
a)

b)



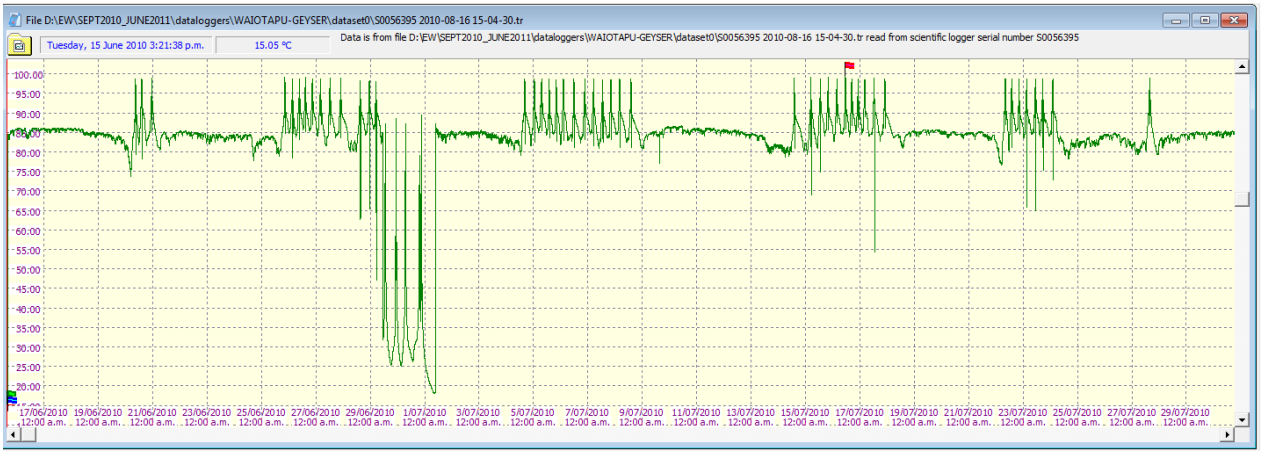
c) d)

13-10. Waiotapu Geyser; a) October 2010; b) March 2011; c) April 2011; d) July 2011.

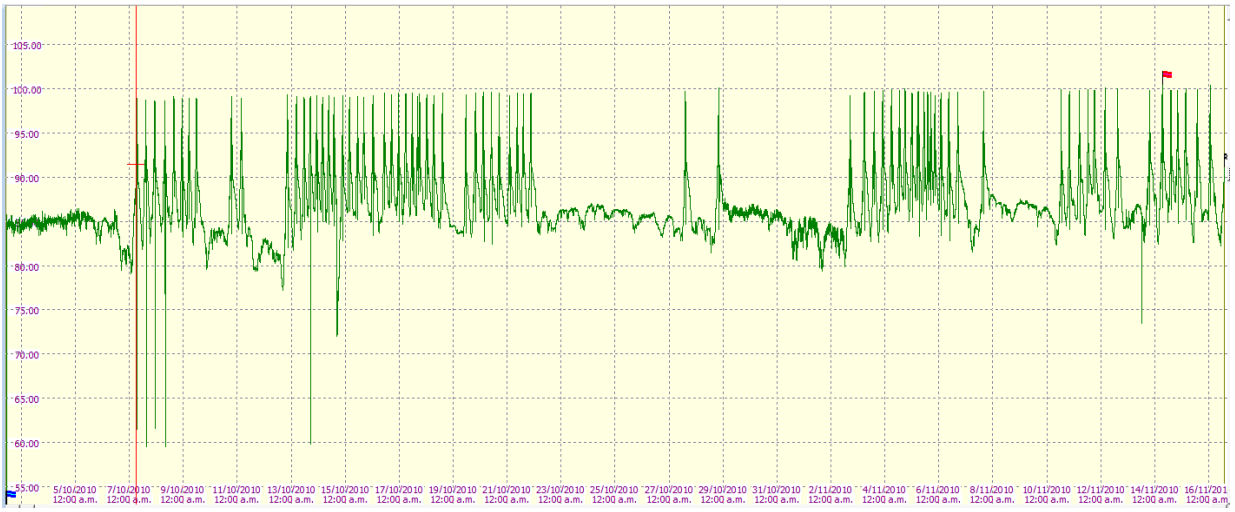


a) b)

13-11. Waiotapu Geyser, July 2011 a) geyser and surrounds; b) Splashing discharge (at the end of a more vigorous event).



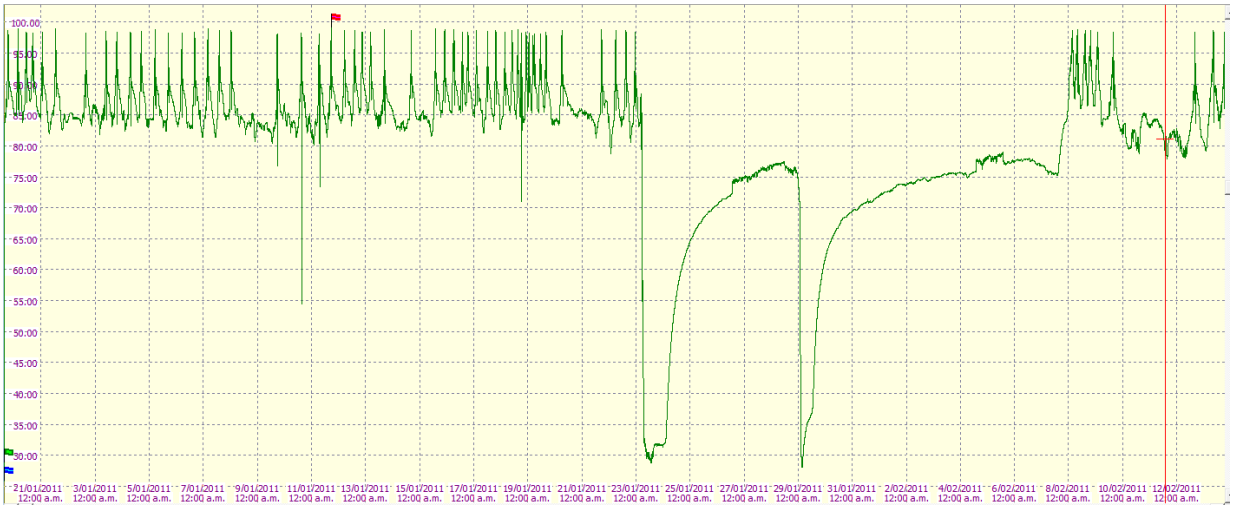
13-12. Waiotapu Geyser time-temperature series; a) the entire record from 17th June to 29th July 2010.



a)

b)

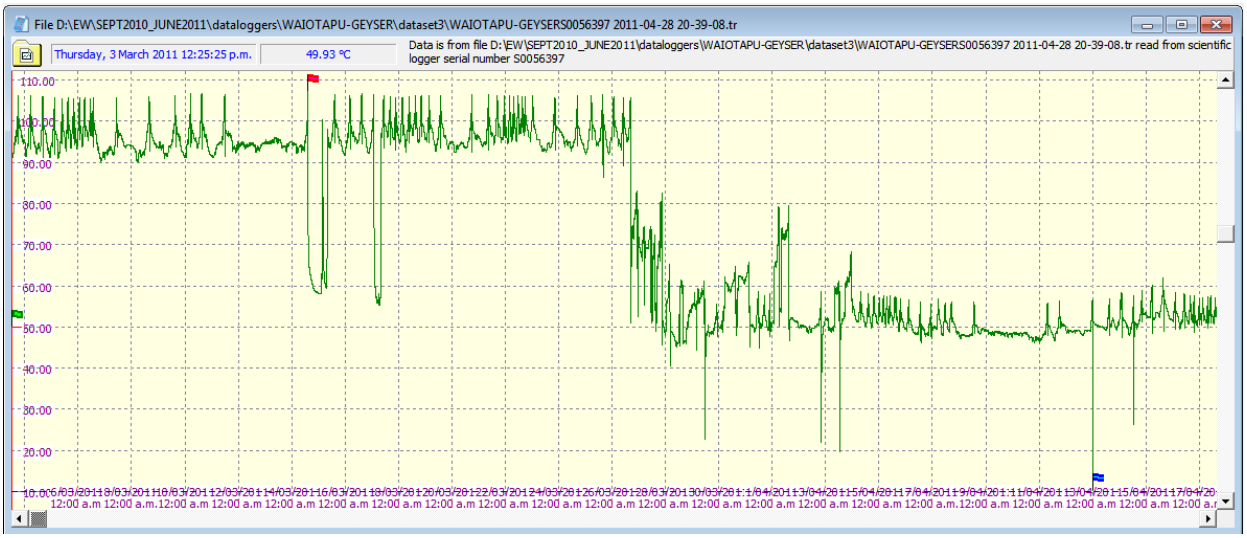
13-13. Waiotapu Geyser time-temperature series; a) the entire record from 2nd Oct to 16th November 2010; b) a detail of the temperature record for 14th and 15th November 2010.



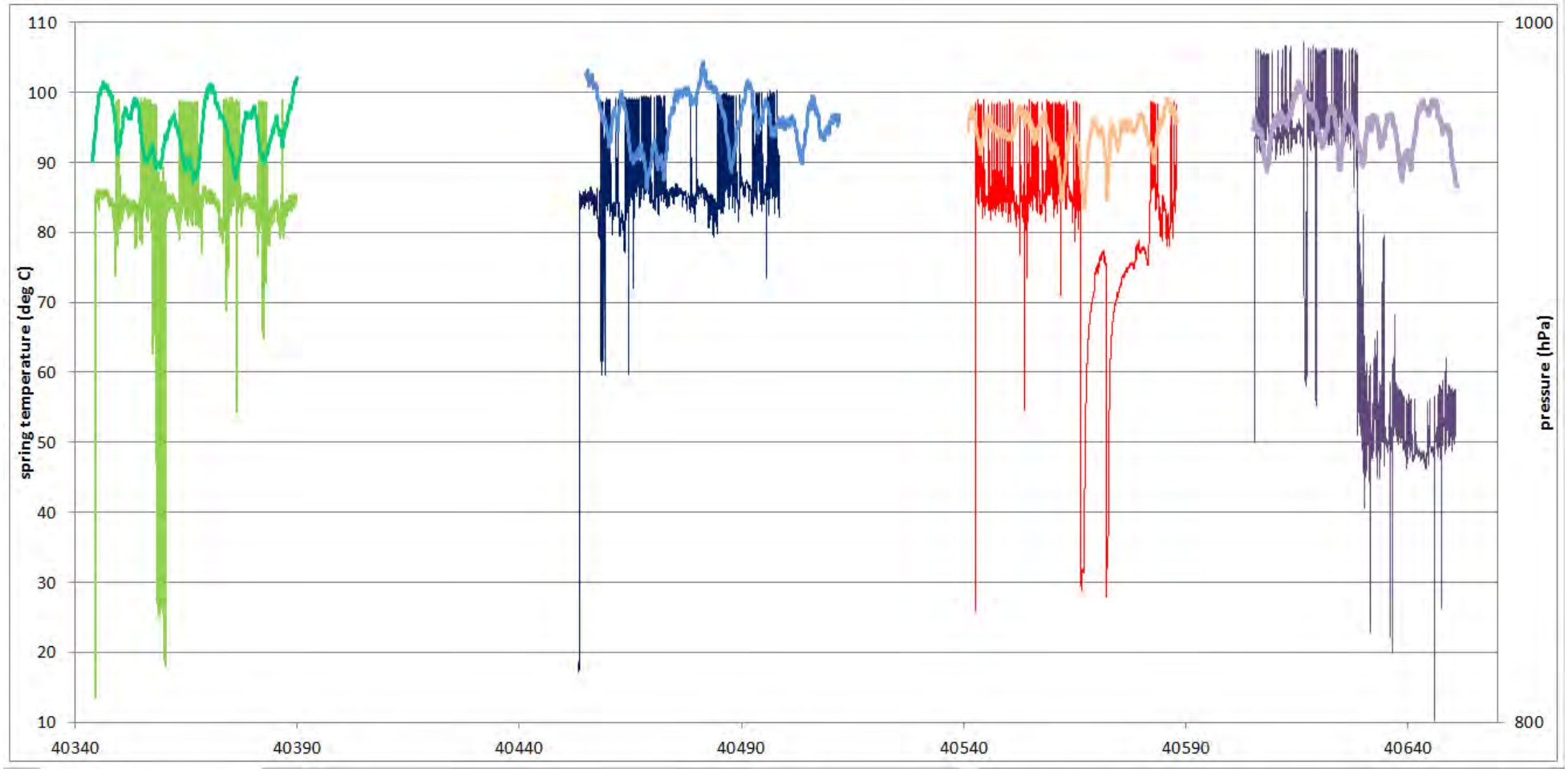
a)

b)

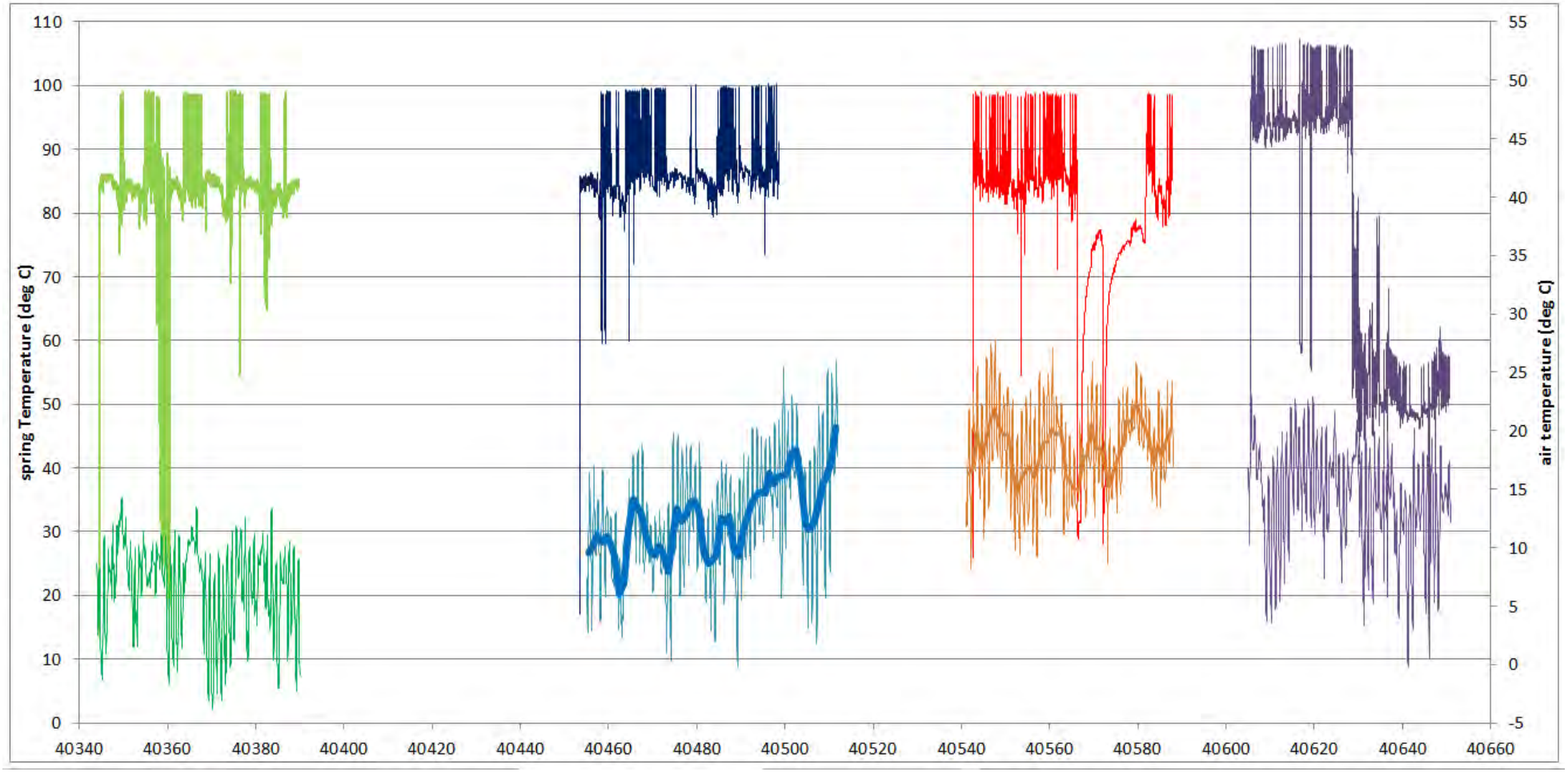
13-14. Waiotapu Geyser time-temperature series; a) the entire record from 30th Dec 2010 to 13th February 2011; b) a detail of the temperature record for 17th and 18th January 2011.



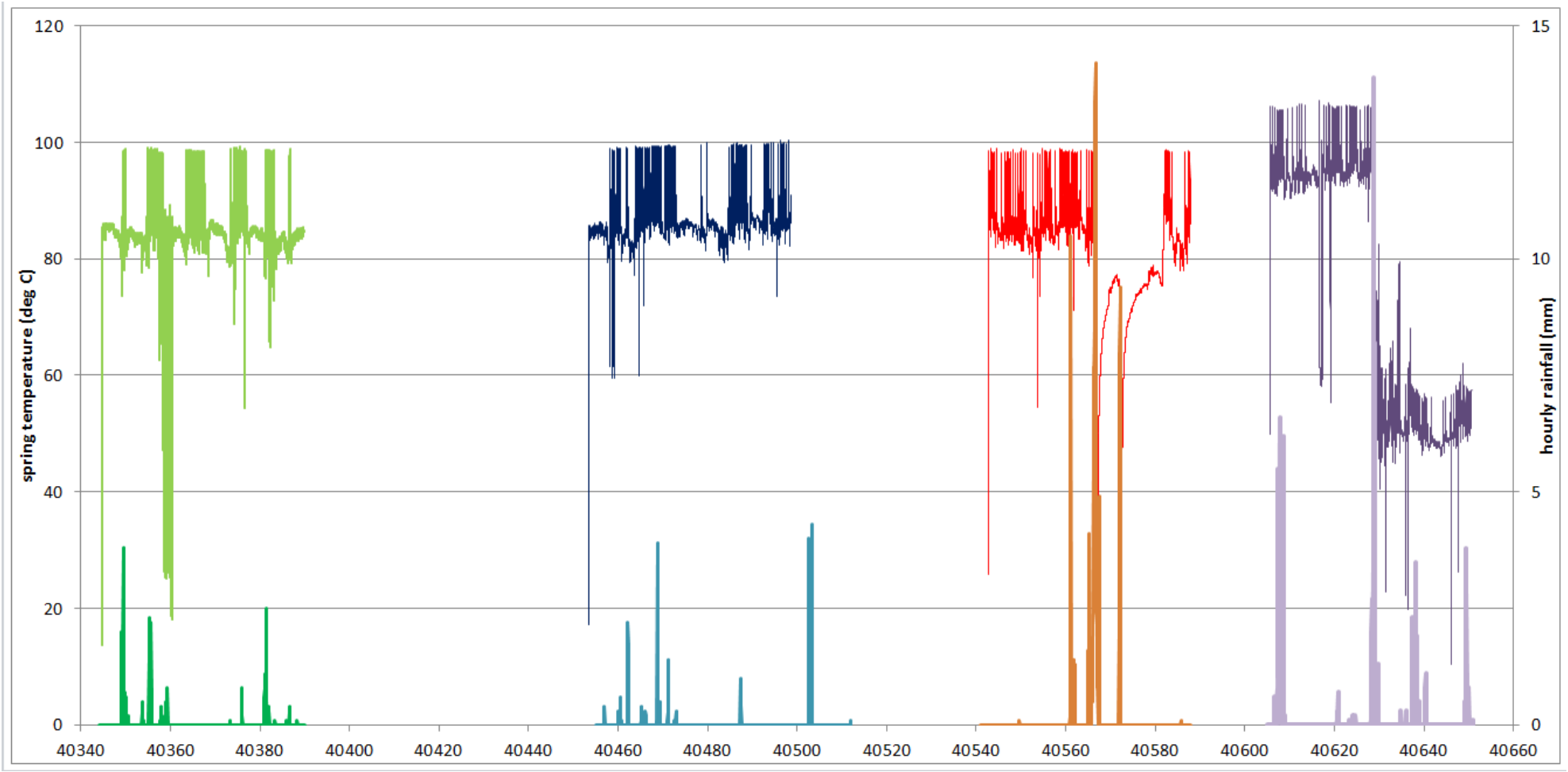
13-15. Waiotapu Geyser time-temperature series; the entire record from 3rd March 2011 to 17th April 2011.



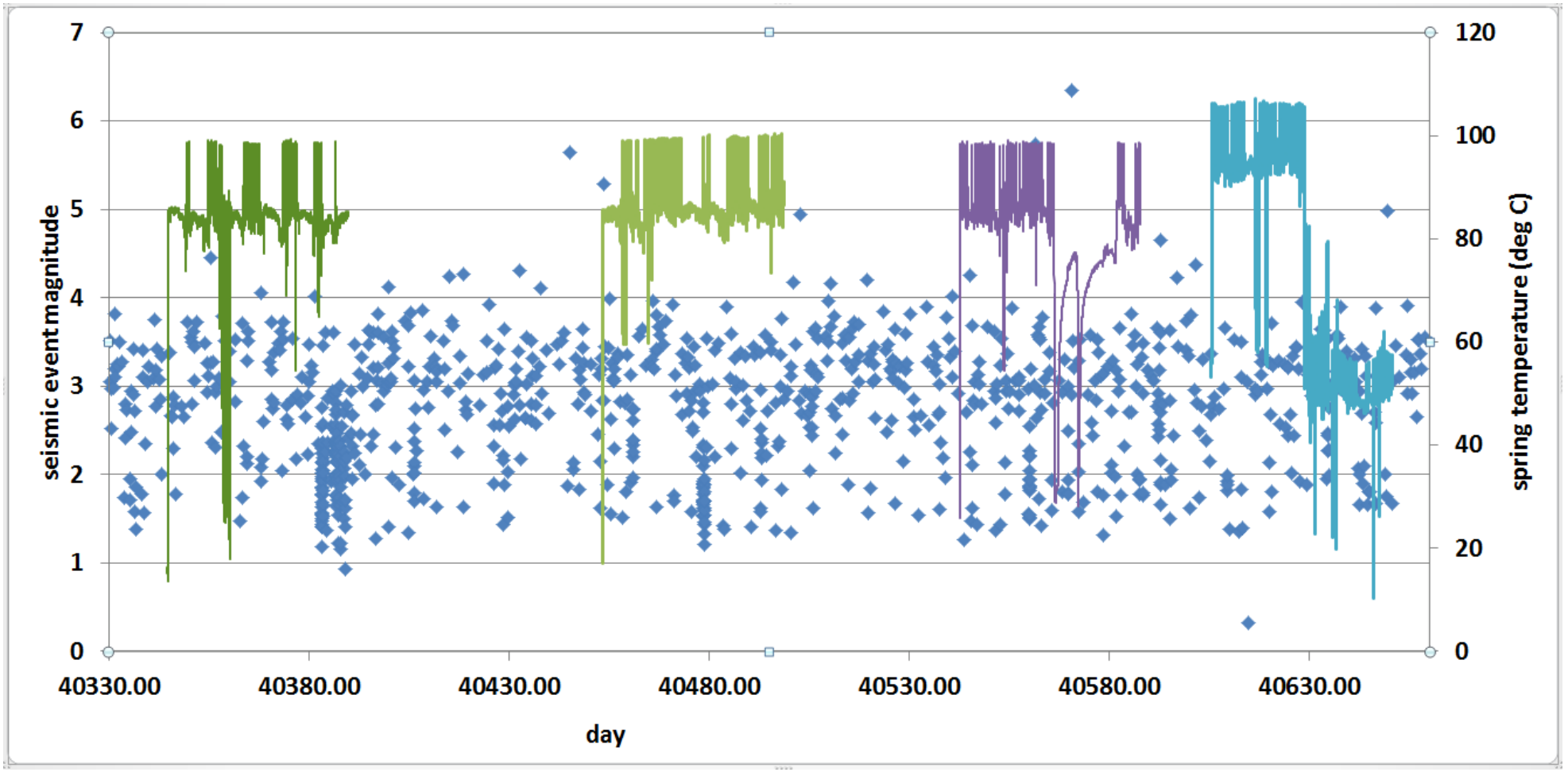
13-16. Waiotapu Geyser time-temperature series; the entire record from 3rd March 2011 to 17th April 2011, plotted with air pressure.



13-17. Waiotapu Geyser time-temperature series; the entire record from 3rd March 2011 to 17th April 2011, plotted with air temperature (hourly and daily average).



13-18. Waiotapu Geyser time-temperature series; the entire record from 3rd March 2011 to 17th April 2011, plotted with rainfall.



13-19. Waiotapu Geyser time-temperature series; the entire record from 3rd March 2011 to 17th April 2011, plotted with earthquake magnitude.

Oyster Pool

E2804516 N6310204

There are delicate silica spicules in the mud surrounding the Oyster Pool. The Oyster Pool has been a pale cloudy green every time I have seen it, until 17th July 2011. This was not a monitoring round, but a visit with some overseas guests. The Oyster Pool water level was ~ 0.3 m below the rim and the water was muddy brown. By 23rd July the water level had returned to the rim, but the water was still slightly brown.

Table 13-6. Oyster Pool data.

Date	T(°C)	pH	Liq flow (l/s)	Water level	Ebullition	Colour
02 Oct 2010	59	nd	seep	overflowing	Moderately vigorous gas discharge in centre, weaker gas discharge at eastern edge.	Cloudy pale green.
29 Dec 2010	62	nd	seep	overflowing	Minor gas discharge.	Cloudy pale green.
27 Apr 2011	69	nd	seep	overflowing	Minor gas discharge.	Cloudy pale green.
17 Jul 2011	nd	nd	0	~-0.3	Minor gas discharge.	Cloudy pale green.
23 Jul 2011	76	nd	seep	overflowing	Minor gas discharge.	Cloudy pale green.

a)

b)

c)

d)

e)

13-20. Oyster Pool; a) October 2010; b) December 2010; c) April 2011; d) 17th July 2011; e) 23rd July 2011.

Lake Ngakoro

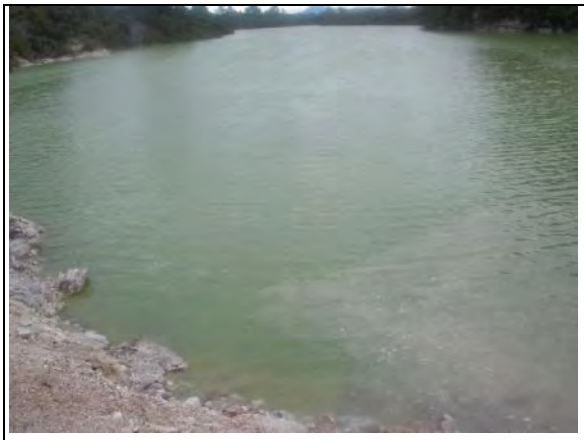
Steam on eastern and southern shores in both Oct and Dec. The temperature of the inflowing stream is also given in the table below. The plume of the stream entering the lake can usually be clearly seen as a zone of pale muddy discoloration. There is hydrothermal activity (identified by steam discharge) on the eastern shores.

Table 13-7. Lake Ngakoro data.

Date	T(°C) (IR)	pH	Inflow T(°C) (IR)	Water level	Ebullition	Colour
02 Oct 2010	20	nd	27	nd	Calm.	Mid green.
29 Dec 2010	20	nd	31	nd	Calm.	Mid green.
27 Apr 2011	22	nd	25	nd	Calm.	Mid green.
23 Jul 2011	24	nd	25	nd	Calm.	Mid green.

a)

b)



c)

d)

13-21. Lake Ngakoro; a) October 2010; b) December 2010; c) April 2011; d) July 2011.

Champagne Pool

E2804517 N6310486

Table 13-8. Champagne Pool data.

Date	T(°C)	pH	Liq flow (l/s)	Water level	Ebullition	Colour
02 Oct 2010	75	nd	nd	Overflowing	Effervescing	Clear green.
29 Dec 2010	74	5.3	nd	Overflowing	Effervescing	Clear green.
27 Apr 2011	75	nd	nd	Overflowing	Effervescing	Clear green.
23 Jul 2011	76	nd	nd	Overflowing	Effervescing	Clear green.

a)

b)

c)

d)

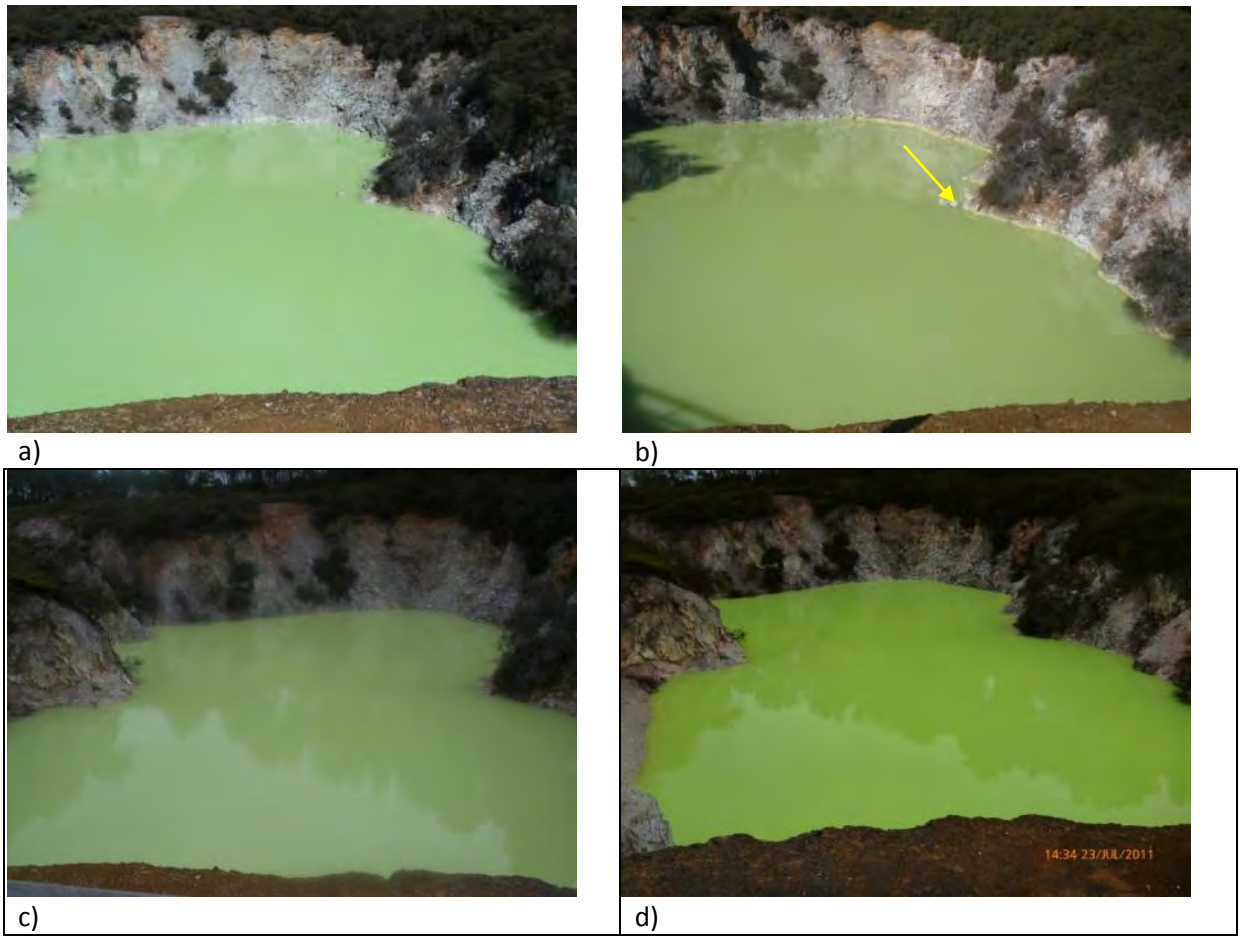
13-22. The Champagne Pool; a) October 2010; b) December 2010; c) April 2011; d) July 2011; orange precipitate and silica sinter on pool margin.

Devils Bath

In December the water level had declined relative to the October height, by ~0.1 m, leaving a rim of yellow (sulphur(?) precipitate around the edge of the pool. After several visits I have decided that the best water level indicator is the rock shown by the arrow in Figure 13-23 b). The water level has been higher on every visit since.

Table 13-9. Devil's Bath data.

Date	T(°C) (IR)	pH	Liq flow (l/s)	Water level (rel to rock at northern shore)	Ebullition	Colour
02 Oct 2010	18	nd	nd	high	Calm	Bright green.
29 Dec 2010	22	nd	nd	low	Calm	Bright green.
27 Apr 2011	20	nd	nd	high	Calm	Bright green.
23 Jul2011	17	nd	nd	high	Calm	Bright green.



13-23. Devil's Bath; a) October 2010; b) December 2010; c) April 2011; d) July 2011. The water colour is unchanged. The arrow points to the rock which is the best indicator of relative water level.

Knox Geyser area

Venus Pool in creek on lady Knox Rd. I no longer visit this site.

E2804580 N6311425

Lady Knox Geyser

The Lady Knox Geyser was not erupting during any of the visits reported here. There was a weak steam discharge from the geyser vent. In October there was logging activity in the forest, approximately 50 m from the Lady Knox area.

Table 13-10. Lady Knox Geyser data.

Date	T(°C)	pH	Height (m)	Eruption interval	Eruption duration	Colour
02 Oct 2010	nd	nd	-			nd
29 Dec 2010	nd	nd	-			nd
27 Apr 2011	nd	nd	-			nd
23 Jul 2011	nd	nd	-			nd

a)

b)

c)

d)

13-24. Lady Knox Geyser, a) October 2010; b) December 2010; c) April 2011; d) July 2011.

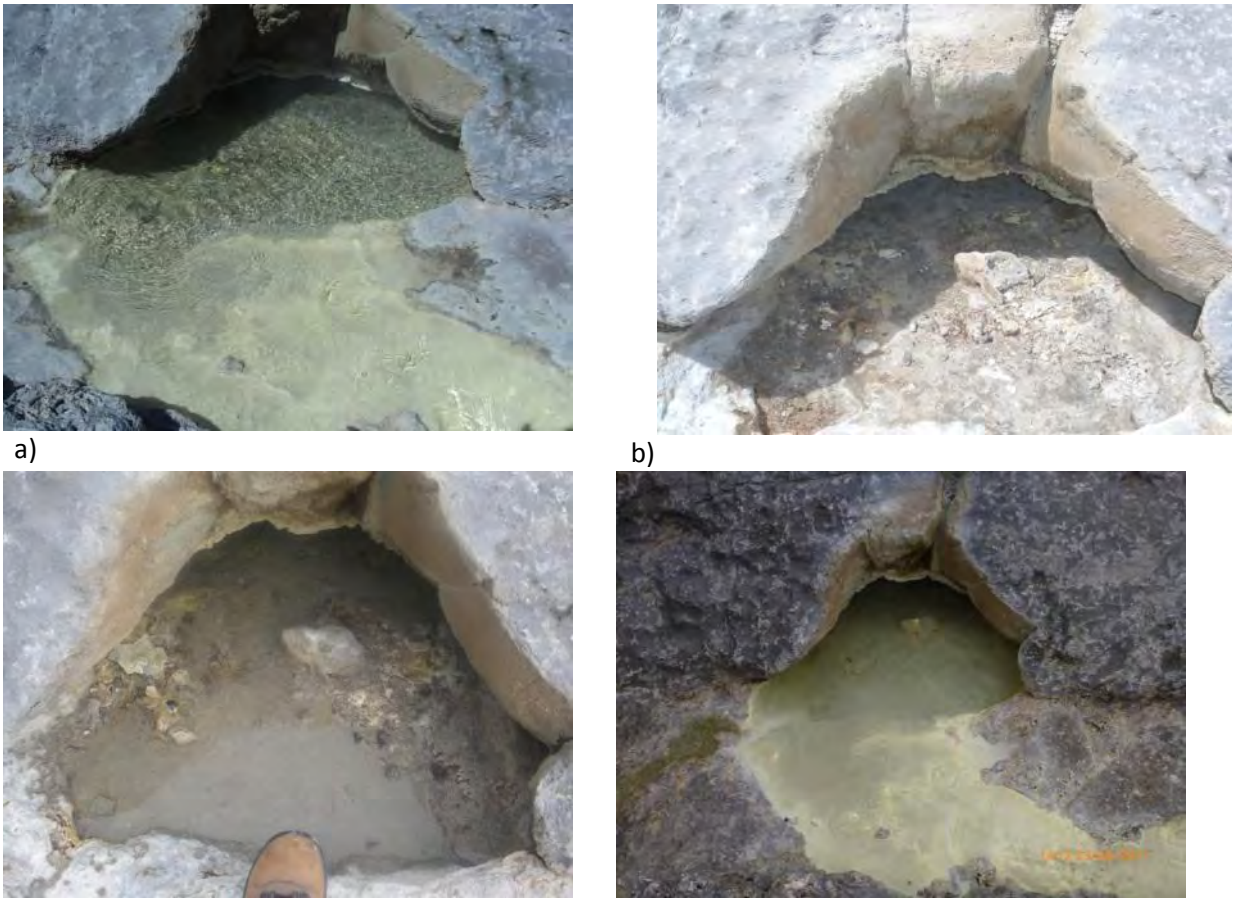
Knox Hole Spring and channel

E2805226 N6311403

The spring was discharging clear water in October, precipitating a pale yellow mineral in the channel and on the pool margins. In December the spring was dry, but there was water discharging into the channel 3.5 m from the spring. This was depositing a greyish precipitate. In April there was water in the spring but it was not overflowing. There was a grey precipitate lining the pool, with pale yellow around the vents. In July the pool and discharge channel were lined with pale yellow precipitate.

Table 13-11. Knox Spring data.

Date	T(°C)	pH	Liq flow (l/s)	Water level	Ebullition	Colour
02 Oct 2010	56	3.1	<0.5	overflowing	Vigorous gas discharge.	Clear.
29 Dec 2010	-		0	dry	Audible bubbling, steam discharge.	-
27 Apr 2011	70		0	0.05 m deep	Moderate gas discharge.	Clear.
23 Jul 2011	56		<1	0.05 m deep	Moderate gas discharge.	Clear.



a) b) c) d)

13-25. Knox Hole Spring; a) October 2010; b) December 2010; c) April 2011; d) July 2011.

Hidden Pool

E2804937 N6311515

There was one swimmer in the pool in October.

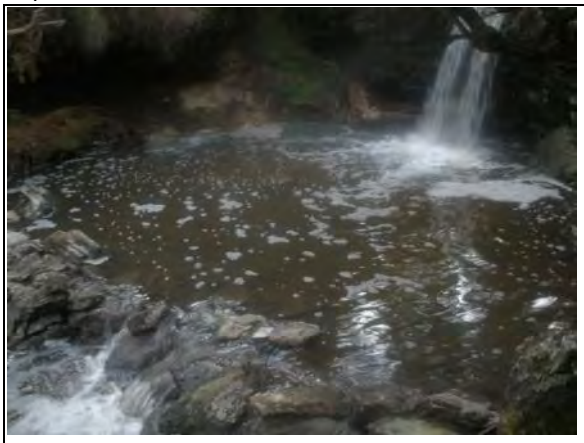
In December steaming ground on the right bank was exposed, and covered in a pale yellow precipitate.

Table 13-12. Hidden Pool data.

Date	T(°C)	pH	Liq flow (l/s)	Water level	Ebullition	Colour
02 Oct 2010	36	3.0	nd	overflowing	Gas discharge in pool.	Cloudy brown
29 Dec 2011	41	nd	nd	overflowing	Gas discharge in pool.	Cloudy brown
27 Apr 2011	37	nd	nd	overflowing	Gas discharge in pool.	Cloudy brown
23 Jul 2011	36	nd	nd	overflowing	Gas discharge in pool.	Cloudy brown

a)

b)



c)

d)

13-26. Hidden Pool; a) October 2010, the photo is rotated due to an original poor camera angle; b) December 2010; c) April 2011; d) July 2011.

Kerosene Creek area

Kerosene Creek Pool

E2806110 N6313104

In October there were two swimmers here; we explained who we were and that the photo would appear in a report, and they stayed in the pool. There were 9 cars at the park.

The visit in May 2011 was after several days of heavy rain, and the river temperature was lower than usual with a higher flow.

Table 13-13. Kerosene Creek Pool data.

Date	T(°C)	pH	stream flow (l/s)	Colour
02 Oct 2010	36	4.0	~100-150	Slightly cloudy.
29 Dec 2011	39	nd	~100-150	Slightly cloudy.
04 May 2011	35	nd	~150	Slightly cloudy.
23 Jul 2011	34	nd	>150	Slightly cloudy.

a)

b)

c)

d)

13-27. Kerosene Creek Pool; a) October 2010; b) December 2010; c) May 2011; d) July 2011.

Kerosene Creek Steaming Ground

E2806118 N6312772

This area of steaming ground has numerous small pools and seeps. Part of the area is covered by shallow water which has a pale yellow base, and the maximum temperature of this shallow pool is 63°C. The total liquid discharge to the stream from this area is < 0.5 l/s. The adjacent stream temperature was 35 °C with a pH of 3.6. Two small hot pools (0.1-0.3 m dia) are monitored. One is ringed with grey sinter (Kerosene Creek A); the other does not have a well-defined sinter rim (Kerosene Creek B), however the black deposit around the rim has been increasing between October 2010 and May 2011.

Table 13-14. Kerosene Creek steaming ground data.

Date	Pool	T(°C)	pH	Liq flow (l/s)	Water level	Ebullition	Colour
02 Oct 2010	Kerosene Creek A	95	7.3	0	0.1 m from rim	Vigorous gas discharge.	Clear.
02 Oct 2010	Kerosene Creek B	91	2.5	seep		Vigorous gas discharge.	Clear.
29 Dec 2011	Kerosene Creek A	99	nd	0		Liquid around rocks in base of pool.	Clear.
29 Dec 2011	Kerosene Creek B	99	nd	0	0 (moist)	Audible hissing. Measurement in the soil.	-
04 May 2011	Kerosene Creek A	95	nd	0	nd	Vigorous boiling.	Clear.
04 May 2011	Kerosene Creek B	97	nd	0	nd	Vigorous gas discharge.	Brown.

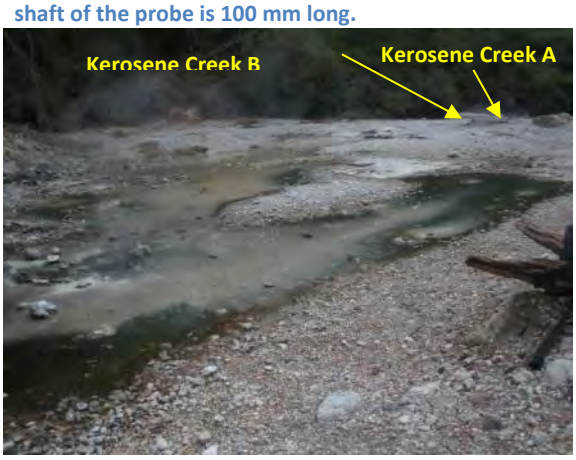
23 Jul 2011	Kerosene Creek A	94	nd	0	nd	Vigorous boiling.	Slightly cloudy.
23 Jul 2011	Kerosene Creek B	87	nd	0	nd	Vigorous gas discharge.	Slightly cloudy.

13-28. Kerosene Creek steaming ground, October 2010.

13-29. Kerosene Creek steaming ground features, December 2010; a) Kerosene Creek A Pool; b) Kerosene Creek B Pool. The steel shaft of the probe is 100 mm long.

13-30. Kerosene Creek steaming ground, December 2010.

13-31. Kerosene Creek steaming ground features, October 2010; a) Kerosene Creek A Pool; b) Kerosene Creek B Pool. The steel shaft of the probe is 100 mm long.



13-32. Kerosene Creek steaming ground, May 2011.

a)

b)

13-33. Kerosene Creek steaming ground features, May 2011; a) Kerosene Creek A Pool; b) Kerosene Creek B Pool.

13-34. Kerosene Creek steaming ground, May 2011.

a)

b)

13-35. Kerosene Creek steaming ground features, July 2011; a) Kerosene Creek A Pool; b) Kerosene Creek B Pool.

14. Appendices

The Appendix to this report is the full Excel spreadsheet of data and is compiled in a separate, accompanying document (Waikato Regional Council Doc 2142693), which may be obtained on request from the Council.