Waikato Regional Council Technical Report 2013/29

# Geothermal features annual monitoring report - January 2013

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# Acknowledgement

We are appreciative of the owners and operators of the tourism facilities, land owners, and the Department of Conservation for allowing us access to monitor the geothermal features. I would also like to acknowledge Asaeli Tulagi, Paul Stanley and Chris McKinnon for their assistance in the field. Thank you.

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# Executive summary

The Resource Management Act 1991 (RMA) requires that regional councils sustainably manage geothermal resources. Geothermal surface features are an important part of the geothermal resource and some cases are outstanding natural features to be protected from inappropriate use and development (RMA s6(b)). Throughout the region, most geothermal features and ecosystems are adversely affected to a greater or lesser degree by geothermal resource use or uses of land and water. Section 35(1) and (2a) of the RMA require the regional council to gather information and undertake or commission research to monitor the state of the environment as necessary to carry out its functions. Waikato Regional Council monitors the natural state of the geothermal resource and assesses what changes of state have occurred or are occurring.

This report describes the results of the quarterly monitoring schedule for the 2012 to 2013 year on the state of geothermal features throughout the region.

Uses of the quarterly and annual monitoring reports include:

- Providing Waikato Regional Council and other researchers with long-term information on the natural range of heat and mass outputs of geothermal features
- Identifying significant changes in the behaviour of features that could be precursors to extreme events such as hydrothermal eruptions
- Identifying departures from the baseline trend of feature activity so that the cause can be investigated
- Identifying unintended human-induced adverse effects on springs (e.g. litter blowing into them, road runoff, pines falling in) that can then be remediated
- Similarly, identifying threats to the features that can mitigated before they happen
- Identifying activities that may require enforcement action, such as discharge of contaminants to geothermal pools
- Counting the number of visitors to springs, to aid in quantification of the economic value of the geothermal resource to the Waikato Region.

There has been a significant increase in temperature of many springs throughout the year; however historic records show that these temperatures are still within the normal range for the springs. At Orakei Korako, the Soda Fountain has resumed overflow after several months of low water level.

At Waiotapu, several springs have shown a marked drop in water level during October 2012.

No major hydrothermal eruptions or other major changes of either natural or human-induced origin was observed in the months Apr 2012 to Jan 2013.

This is the first annual report to include infrared photos of the springs, which gives an indication of the locus of subsurface heat flow in the spring.

# 1 Introduction

## 1.1 Background

Monitoring of the geothermal features in the Waikato Region was implemented in 1995. The aim of the monitoring is to observe the natural state of geothermal surface features. Assessments are made on changes that are occurring over time, as well as reporting on any threats or damage to the features. This will allow us to make more informed decisions to protect and enhance the geothermal resources and ecosystems.

## 1.2 Report Content

Geothermal monitoring is conducted quarterly, with a more extensive range of sites monitored annually. This report covers the monitoring period from Apr 2012 to Jan 2013. The specific sites monitored for this report are as follows:

- Atiamuri
- Golden Springs
- Horohoro
- Ngatamariki
- Orakei Korako
- Reporoa
- Rotokawa
- Tauhara
- Te Kopia
- Tokaanu
- Waikite
- Waiotapu
- Whangairorohea

## 1.3 Method

Water temperature was measured using a Fluke IR gun along with a 6m long thermocouple.

GPS co-ordinates gathered during previous site visits have been converted from NZMG to NZTM. Where co-ordinates have not been available, a Garmin GPSmap 60CSx has been used to record locations, with an accuracy of ± 5 m. Each GPS reading was taken in the same spot as the photograph.

pH indicator paper was used to determine pH, Samples were cooled before being tested, to comply with the paper's temperate range.

Where possible, water flow was estimated. The liquid flow or discharge was estimated when assessed to be 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.

For many features, photos in both the visible andfrared spectra are shown. Composite photos of both spectra are used to give a better indication of the location of the hot areas in a feature. The photos were taken using a Mikron Thermal Imaging Camera (Model M7816), which has a temperature range of -40ºC to 500ºC.

# 2 Monitoring Results: Atiamuri

## 2.1 Matapan Road

E1869089 N5740458; Located number 72.3005 (Geothermal Spring)

There are two springs at this location; the one on the left is geothermal, the one on the right is cool. Measurements are also taken downstream of the springs to get a combined reading.

Vegetation growth surrounding the cool stream was greater in Jan 2013 than in Jan 2012, making visibitity difficult. There were no visible changes to the geothermal stream; there is still green algal growth on the rocks. The temperature of the geothermal stream was 7.9 degrees warmer than was in the previous visit in Jan 2012.

**Table 1: Data from the Matapan Road Spring at Atiamuri**

| | Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|---|
| Geothermal Spring | 16 Jan 2012 | 61.1 | 7 | ± 5 | - | - | Clear |
| Geothermal Spring | 24 Jan 2013 | 69.0 | 7-8 | ± 5 | - | - | Clear |
| Cool Spring | 16 Jan 2012 | 15.8 | 6 | ± 0.5 | - | - | Clear, slightly yellow |
| Cool Spring | 24 Jan 2013 | 16.6 | 5 | seep | - | - | Clear |
| Combined Stream | 16 Jan 2012 | 37.2 | 7 | ± 5 | - | - | Clear |
| Combined Stream | 24 Jan 2013 | 42.7 | 7 | ± 5 | - | - | Clear |


**Figure 1: Matapan Road geothermal spring at Atiamuri taken in Jan 2013**


**Figure 2: Matapan Road geothermal spring at Atiamuri taken in Jan 2012 (A) and Jan 2013 (B)**

The infrared photos below show the geothermal spring flowing between the plants. Photo A in Figure 3, shows both the infrared and visible image. Photo B is a composite photo of both to give a better perspective of where the hot areas are. This will be the same throughout the report where infrared photos have been taken.

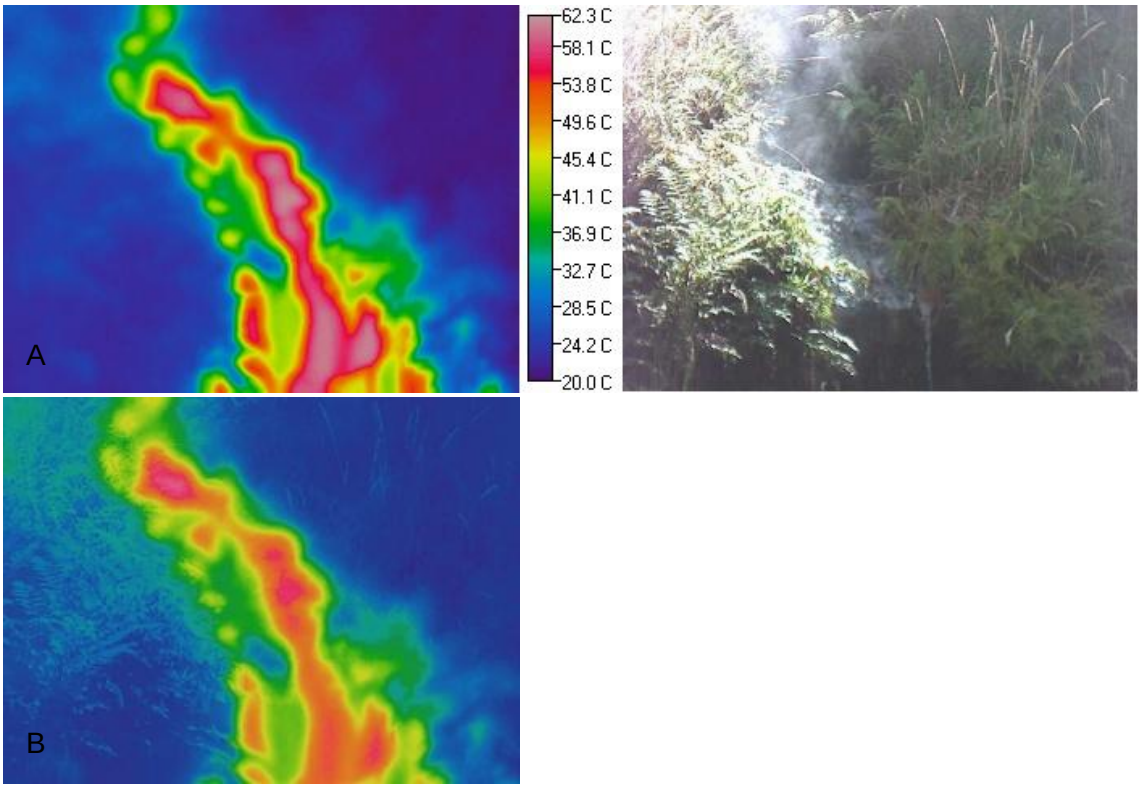


**Figure 3: Infrared photos showing the Geothermal Spring at Atiamuri in Jan 2013**

## 2.2 Whangapoa Pools

- **Northern Pool**
  E1866474 N5749565; Located number 72.3004

  The geothermal pool itself cannot be accessed easily; therefore the measurements are taken from near the outflow.

  In June 2012 the pool was surging, with the flow rate changing from 0.3l/s to 0.5l/s during surges. It did not appear to be surging in Jan 2013. The colour has changed from being a murky green-blue in June 2012 to a cloudy blue-green in Jan 2013. The temperature has also increased by 4.4°C.

**Table 2: Data from the Northern Pool at Whangapoa Pools, Atiamuri**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 25 June 2012 | 61.6 | - | 0.3-0.5 | Overflowing | Vigorous bubbling at outflow | Murky green-blue |
| 24 Jan 2013 | 66 | 7 | 0.5 | Overflowing | Upwelling near outlet | Cloudy, blue-green |


**Figure 4: Northern Whangapoa Pool in June 2012 (A), Jan 2013 (B) at Atiamuri**

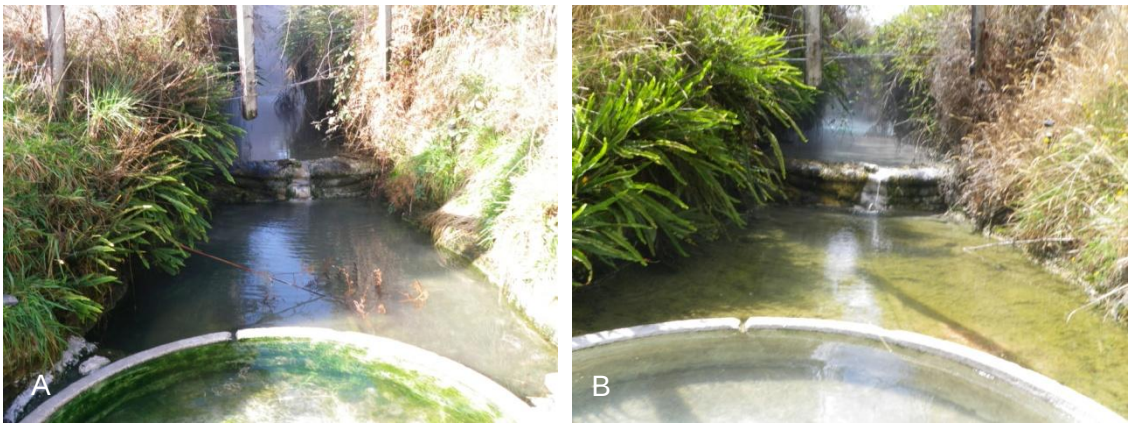


**Figure 5: Northern Whangapoa Pool outlet, June 2012 (A), Jan 2013 (B), Atiamuri**

- **Southern Pool**
  E1866491 N5749513; Located number 72.4387

  The pool is fenced. Historically, a channel has been cut from the pool as an outlet to the apron. This appears to be healing over as the sinter is growing. It has a sinter apron extending about 40m from the pool outlet.

  The flow has increased from <0.5l/s to <1l/s since the previous monitoring visit in June 2012, and the temperature has also increased by 4.8°C.

**Table 3: Data from the Southern Pool, Whangapoa Pools, Atiamuri**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 25 June 2012 | 60.9 | - | <0.5 | Overflowing | Upwelling in centre | Clear, blue-green |
| 24 Jan 2013 | 65.7 | 8 | <1 | Overflowing | Constant upwelling in centre | Clear, blue-green |

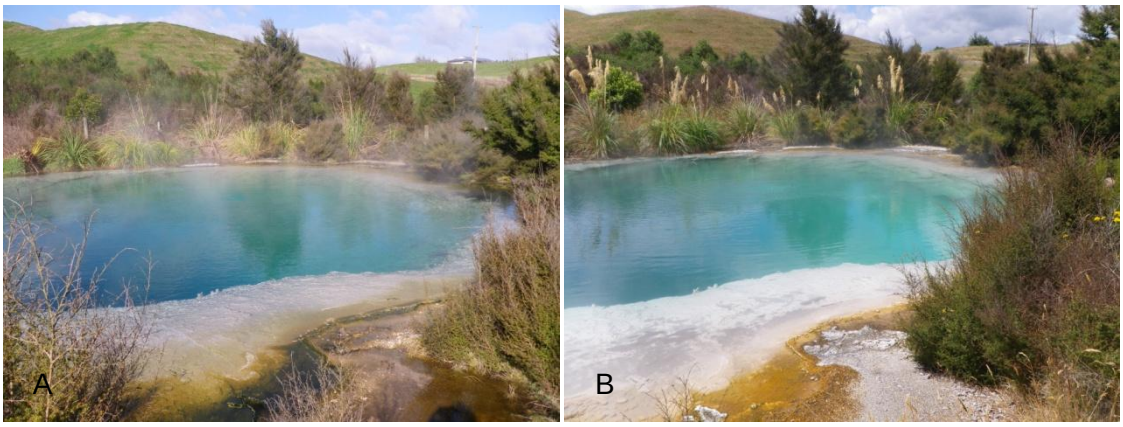


**Figure 6: Southern Pool, Whangapoa Pools in June 2012 (A), Jan 2013 (B), Atiamuri**


**Figure 7: Sinter apron, Southern Whangapoa Pool, June 2012 (A), Jan 2013 (B), Atiamuri**


**Figure 8: Outlet, Southern Whangapoa Pool, June 2012 (A), Jan 2013, Atiamuri**

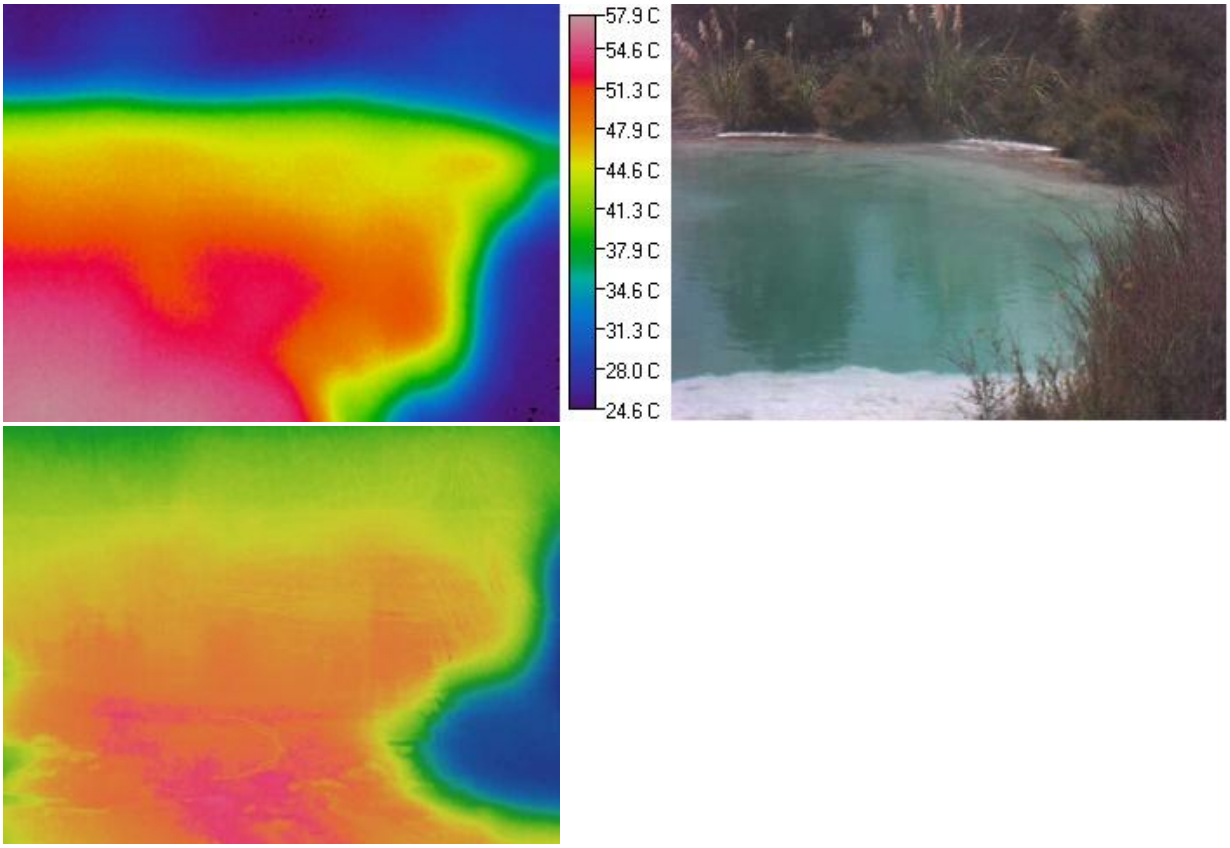


**Figure 9: Infrared photos, outlet, Southern Whangapoa Pool, Atiamuri in Jan 2013**

- **Two small mud pools off Ohakuri Road**
  E1866296 N5749797

  These are two small mud pools, which are fenced off. The Eastern pool was dry and the Western pool contained water. The pools had been drowned by rain in the previous visit in Jan 2012.

**Table 4: Data from the two small mud pools off Ohakuri Road, Atiamuri**

| Date | Pool | T(°C) | pH | Flow (l/s) | Water level | Diameter (m) | Depth (m) | Ebullition | Colour |
|---|---|---|---|---|---|---|---|---|---|
| 16 Jan 2012 | West | 32.0 | 7 | - | Ground level | - | 1 | Small, constant bubbles on left | Brown, murky |
| 24 Jan 2013 | West | 97 | 6 | - | 0.8m below ground level | - | nd | Constant gas discharge | Brown |
| 16 Jan 2012 | East | 32.2 | 5 | - | Ground level | - | nd | Occasional bubble in centre | Brown, murky |
| 24 Jan 2013 | East | 96 | - | - | Dry | - | nd | - | Brown mud |


**Figure 10: Mud pools off Ohakuri Rd, Atiamuri, A Jan 2012; B Jan 2013**

The infrared photos show the two hot areas where the mud pools are situated.

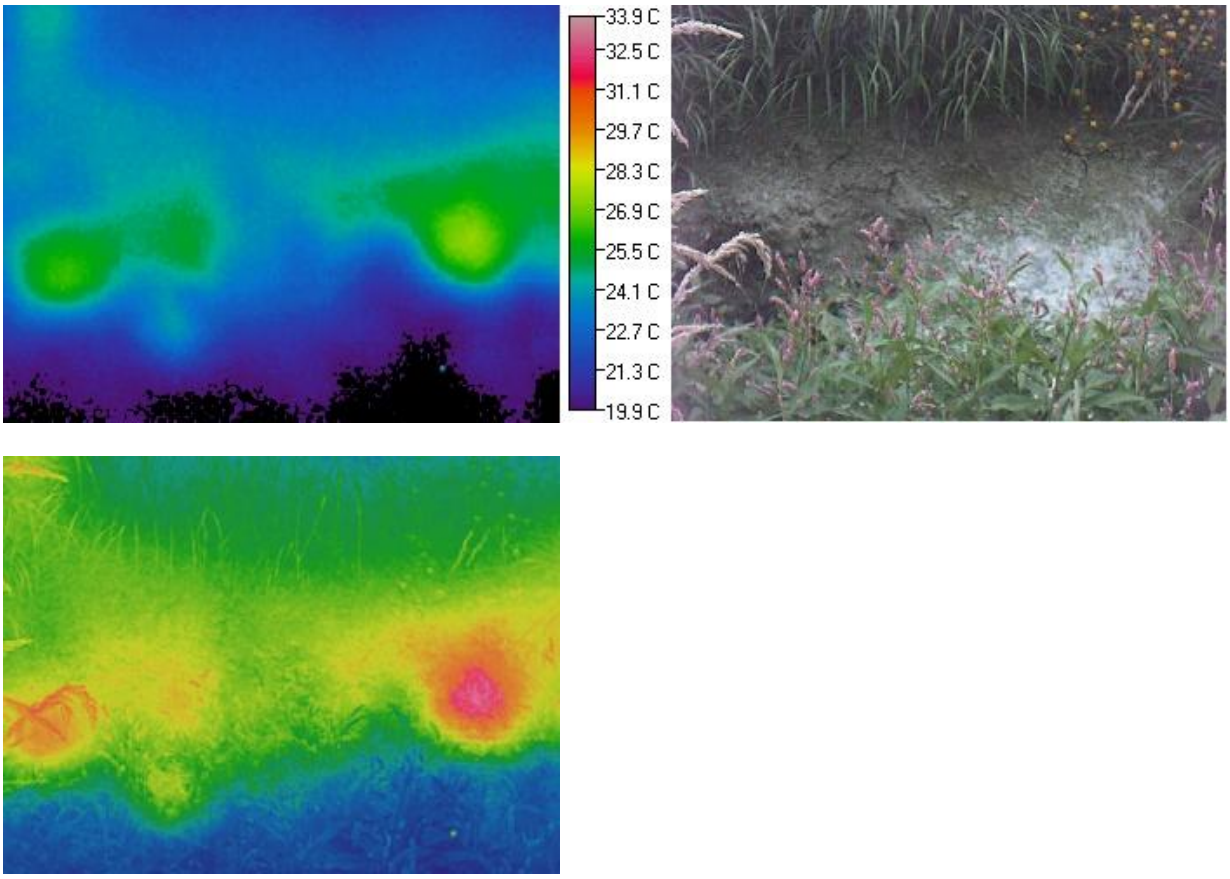


**Figure 11: Infrared photo of mud pools off Ohakuri road, Atiamuri, in Jan 2013**

- **Berg's Crater**
  E1866162 N5749496

This feature has been filled with logs. During the Jan 2013 visit it was noted that the feature was warm. It reached a temperature of 50°C in the centre of the crater.


**Figure 12: Berg's Crater, A Oct 2011); B Jan 2013**

The infrared photos show that there is a hot area in the centre of the crater.

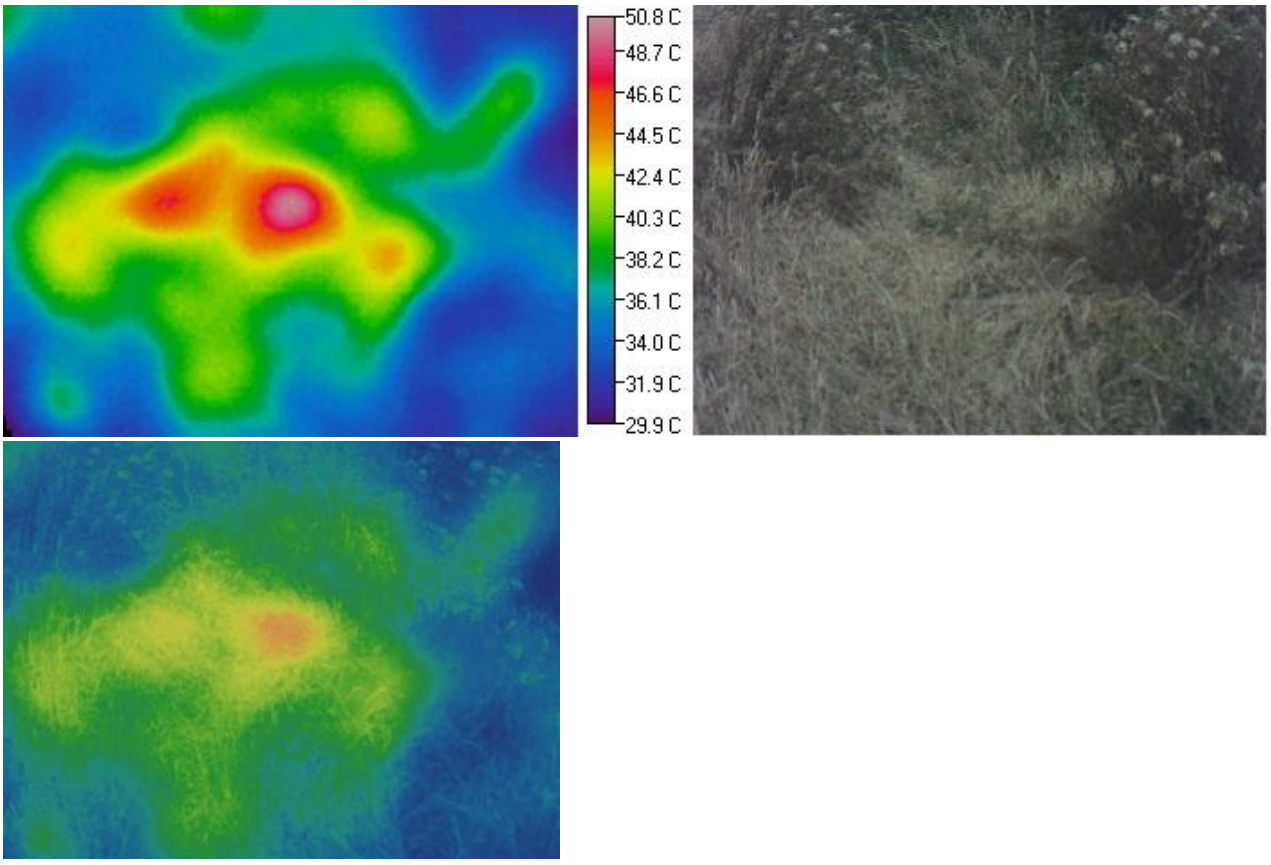


**Figure 13: Infrared photos showing Bergs Crater, Atiamuri in Jan 2013**

# 3 Golden Springs

## 3.1 Pools in stream through the Golden Springs Motel

- **North Pool**
  E1888747 N5736983

A new weir, planter boxes and steps leading into the pool have been installed at the site since the last visit. The water temperature has increased by 6.1°C from 34.1°C to 40.2°C. There were no bathers at 12:00.

**Table 5: Data from the North Pool, Golden Springs Motel**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 18 Jan 2012 | 34.1 | 7 | 30 | Overflowing | - | Beige, cloudy |
| 23 Jan 2013 | 40.2 | 7-8 | 20 | Overflowing | - | Green/grey, cloudy |


**Figure 14: North Pool, Golden Springs Motel in Jan 2012 (A), Jan 2013 (B)**

The infrared photos show that the hottest part of the pool appears to be where it flows over the weir. This could be due to the infrared camera only showing the surface temperature, which is cooler than within the pool due to its exposure to air. The water going over the waterfall includes the deeper warmer water mixed with the cooler surface water, so it appears hotter than the surface water above and below the waterfall.

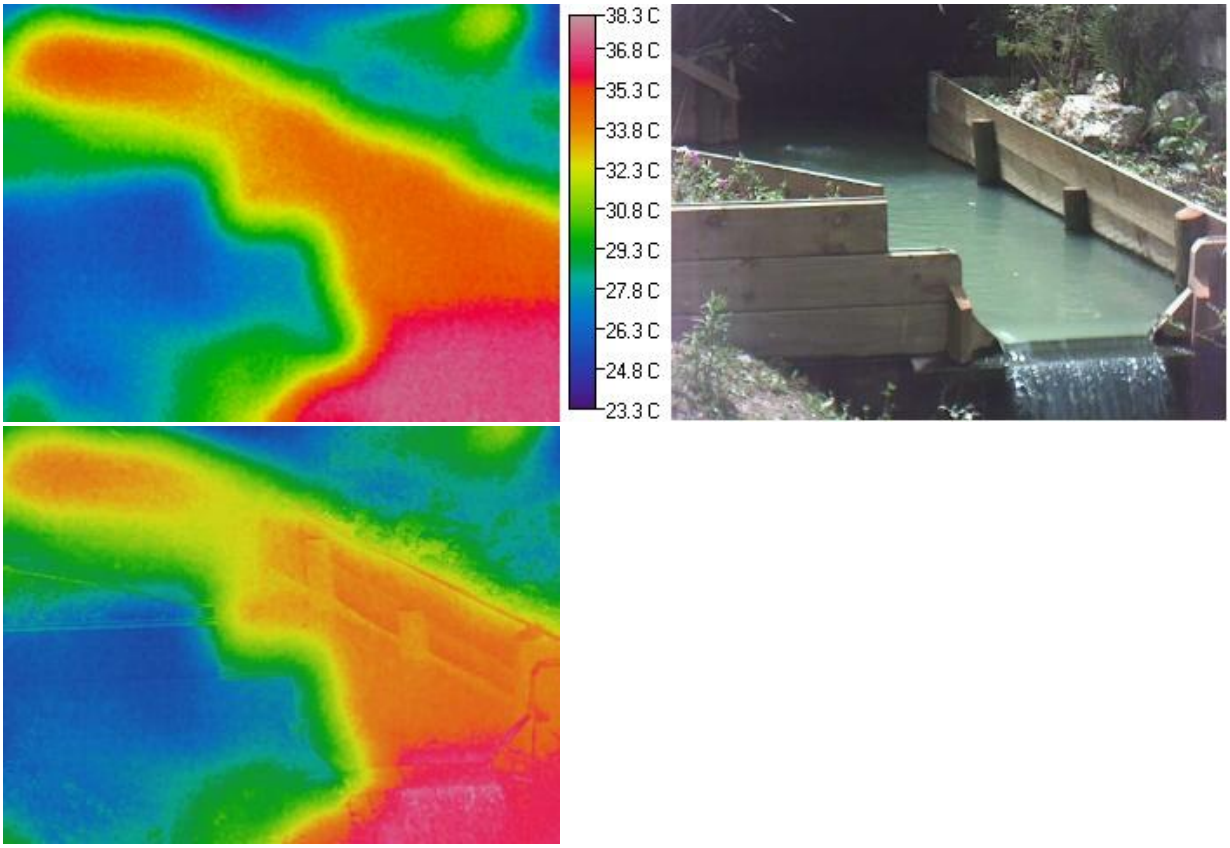


**Figure 15: Infrared photos, North Pool, Golden Springs Motel in Jan 2013**

- **South Pool**
  E1888681 N5736843

There was a new hand rail leading into the pool. The colour has changed from beige in Jan 2012 to a green/grey colour in Jan 2013. There were no bathers at 12:11.

**Table 6: Data from the South Pool, Golden Springs Motel**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 18 Jan 2012 | 36.7 | 7 | 40 | Overflowing | - | Beige, cloudy |
| 23 Jan 2013 | 37.5 | 7 | 30 | Overflowing | - | Green/grey, cloudy |


**Figure 16: South Pool, Golden Springs Motel in Jan 2012(A), Jan 2013 (B)**

The infrared photo shows that the hottest area of the pool is in the vicinity of the waterfall.

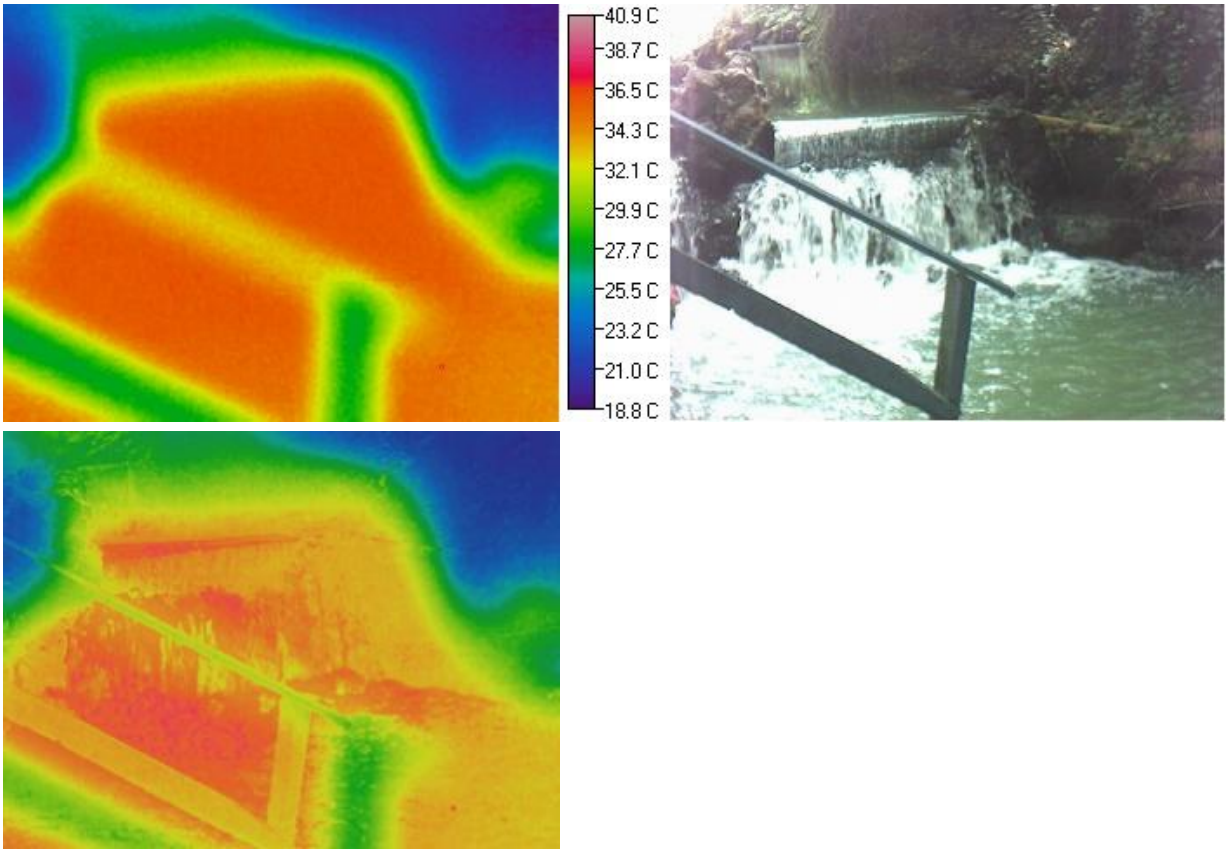


**Figure 17: Infrared photos, South Pool, Golden Springs Motel, Jan 2013**

## 3.2 Pools across the road from the Golden Springs Motel

- **Feature 3**
  E1888846 N5737375

There were no discernible changes since the previous visit in Jan 2012.

**Table 7: Data from Feature 3, Golden Springs**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 18 Jan 2012 | 41.3 | 7 | nd | nd | Gas discharge, small constant bubbles in centre | Milky green |
| 23 Jan 2013 | 42.6 | 7 | nd | nd | Effervescing | Murky, green |


**Figure 18: Feature 3, Golden Springs in Jan 2012 (A), Jan 2013 (B)**

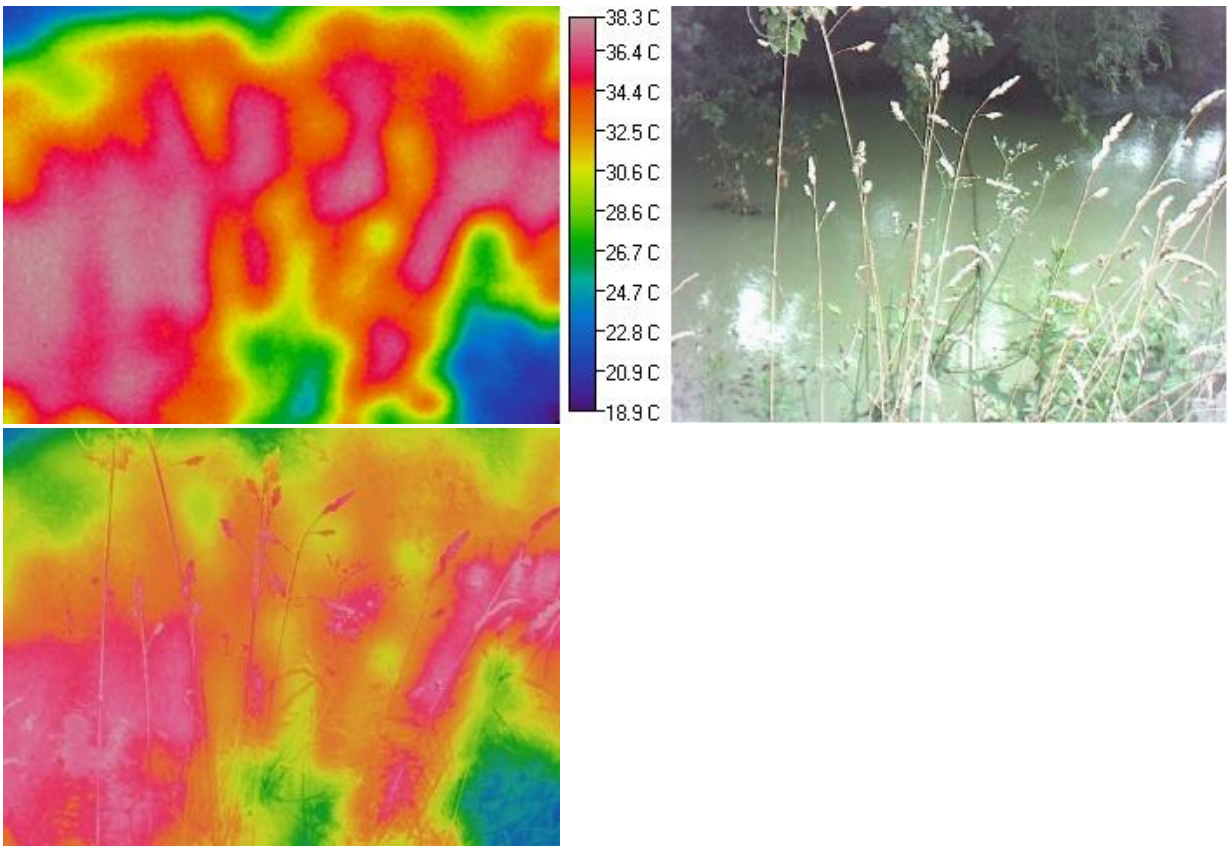


**Figure 19: Infrared photo of Feature 3, Golden Springs in Jan 2013**

- **Feature 4**
  E1888827 N5737465

The feature was covered in algal mats and the colour of the water has changed from a blue-green to a light grey.

**Table 8: Data from Feature 4, Golden Springs**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 18 Jan 2012 | 42.1 | 7 | nd | nd | Calm | Cloudy, blue-green |
| 23 Jan 2013 | 39.1 | 7 | nd | nd | Calm | Clear, light grey |

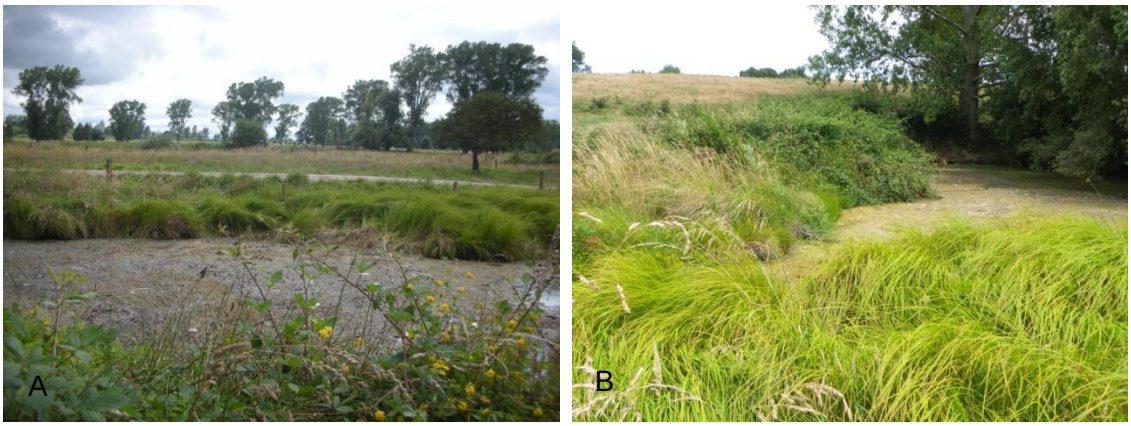


**Figure 20: Feature 4, Golden Springs in Jan 2012 (A), Jan 2013 (B)**

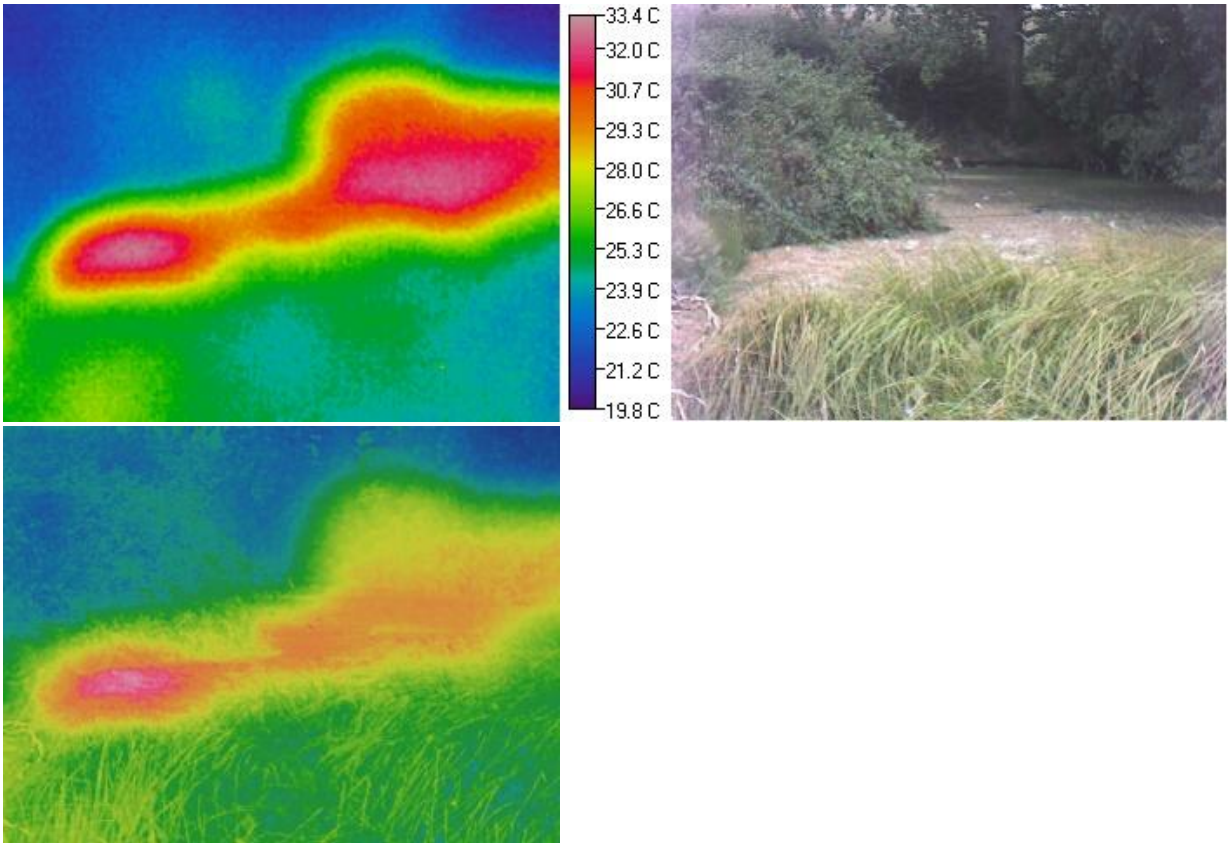


**Figure 21: Infrared photos of Feature 4, Golden Springs in Jan 2013**

# 4 Horohoro

## 4.1 Waipupumahana Pool

1878253E 5761598N; Located number 72.3006
There was less flow in Jan 2013 than in the previous year. The colour had also changed to a clear green from being a murky dark green. The pool appears to have warmed slightly (2.5°C increase).

**Table 9: Data from Waipupumahana Pool, Horohoro**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 18 Jan 2012 | 47.9 | 7 | ± 5 | Overflowing | Gentle effervescence near centre of pool and outflow | Dark green, murky |
| 24 Jan 2013 | 50.4 | 7-8 | ± 0.5 | Overflowing | Upwelling | Clear, green |

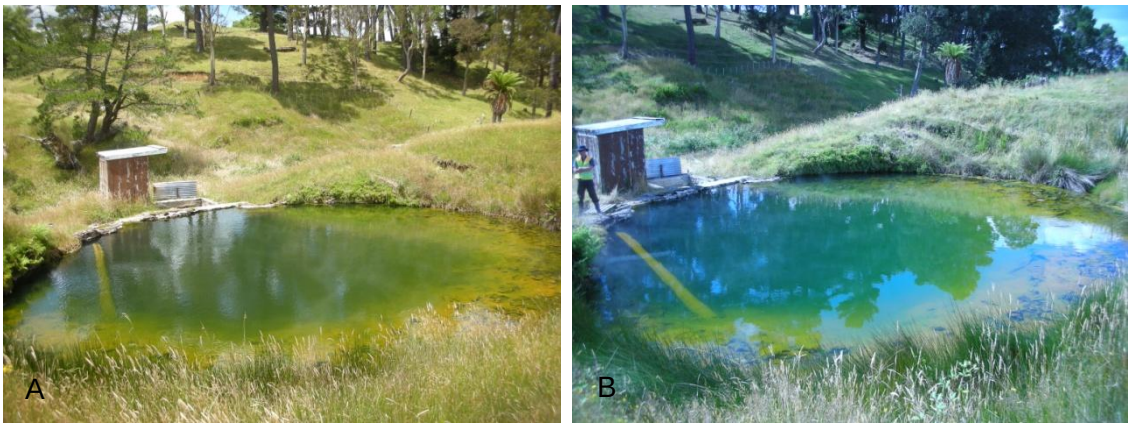


**Figure 22: Waipupumahana Pool, Horohoro in Jan 2012 (A), Jan 2013 (B)**

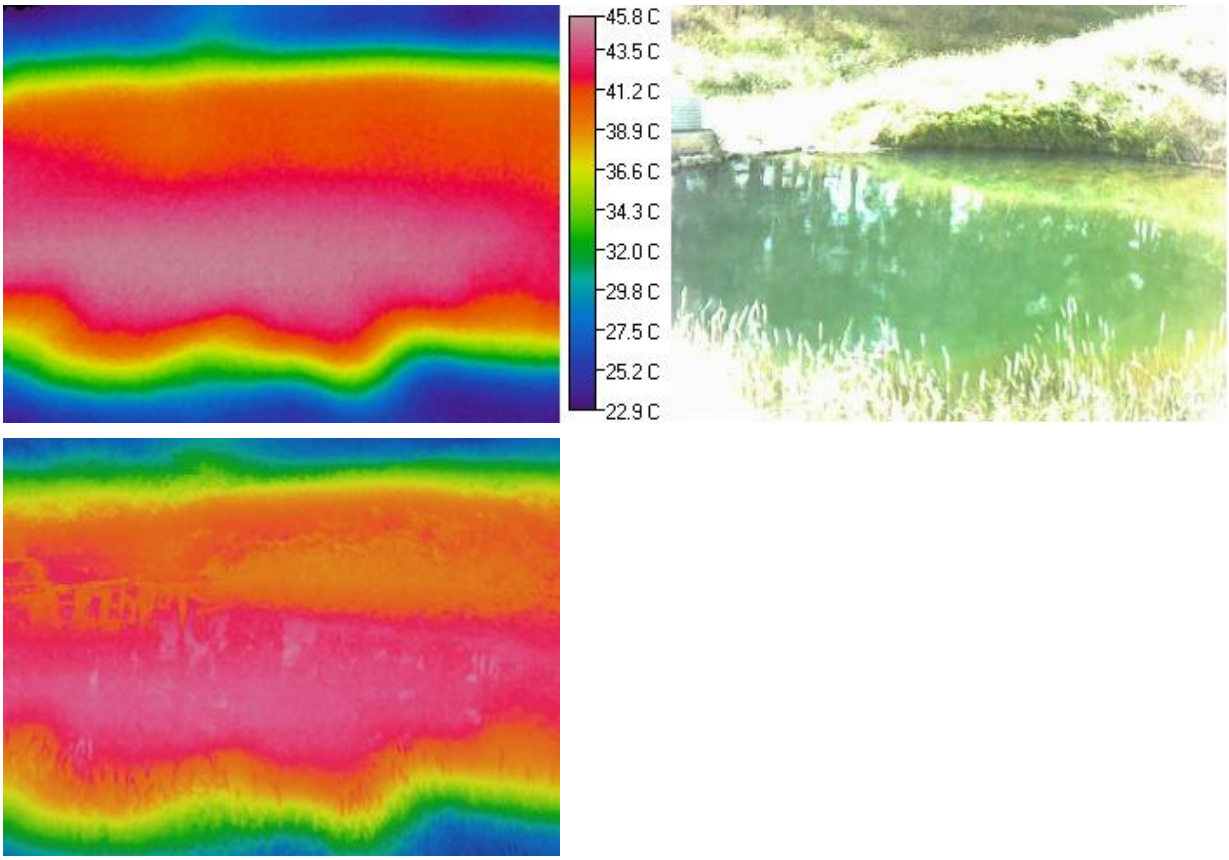


**Figure 23: Infrared photos, Waipupumahana Pool, Horohoro in Jan 2013**

# 5 Ngatamariki

## 5.1 Hydrothermal Eruption Crater

- **Large pool occupying the crater**
  E1876505 N5730230; Located number 72.2098

There was an eruption at this location in Apr 2005, with a large amount of sediment deposited in the area. There is a large pool within the hydrothermal eruption crater, with a small mud pool alongside it. There is a lot of steam coming from the far side of the pool. Most of the pool is calm, with some areas of small bubbles, mostly around the edges. The extent of the yellow/green algae growing around the edges has been consistent at each visit throughout the year. The temperature appears to be increasing, with a 9.7°C increase in the period from Apr 2012 through to Jan 2013. The level of the pool has also increased, with an initial ESG reading of 0.100m in Apr 2012 to 0.110m in Jan 2013. The colour and clarity of the pool have also fluctuated throughout the year (see Table 10 for details).

**Table 10: Data from Ngatamariki Hydrothermal Eruption Crater Pool**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 43.8 | 7 | ~10 | Overflowing, ESG 0.100m | Calm, occasional gas discharge | Dark green |
| 2 July 2012 | 45 | 7-8 | 5-10 | Overflowing, ESG 0.100m | Small areas of discharge around edges | Murky grey/green |
| 20 Sept 2012 | 50.2 | 6 | ~5 | Overflowing, ESG 0.112m | Small areas of discharge around edges with the whole pool effervescing. | Cloudy grey/ green |
| 23 Jan 2013 | 53.5 | 7 | ~6 | Overflowing, ESG 0.110m | Effervescing | Green, cloudy |


**Figure 24: Large Pool: Overview, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C) Jan 2013 (D)**

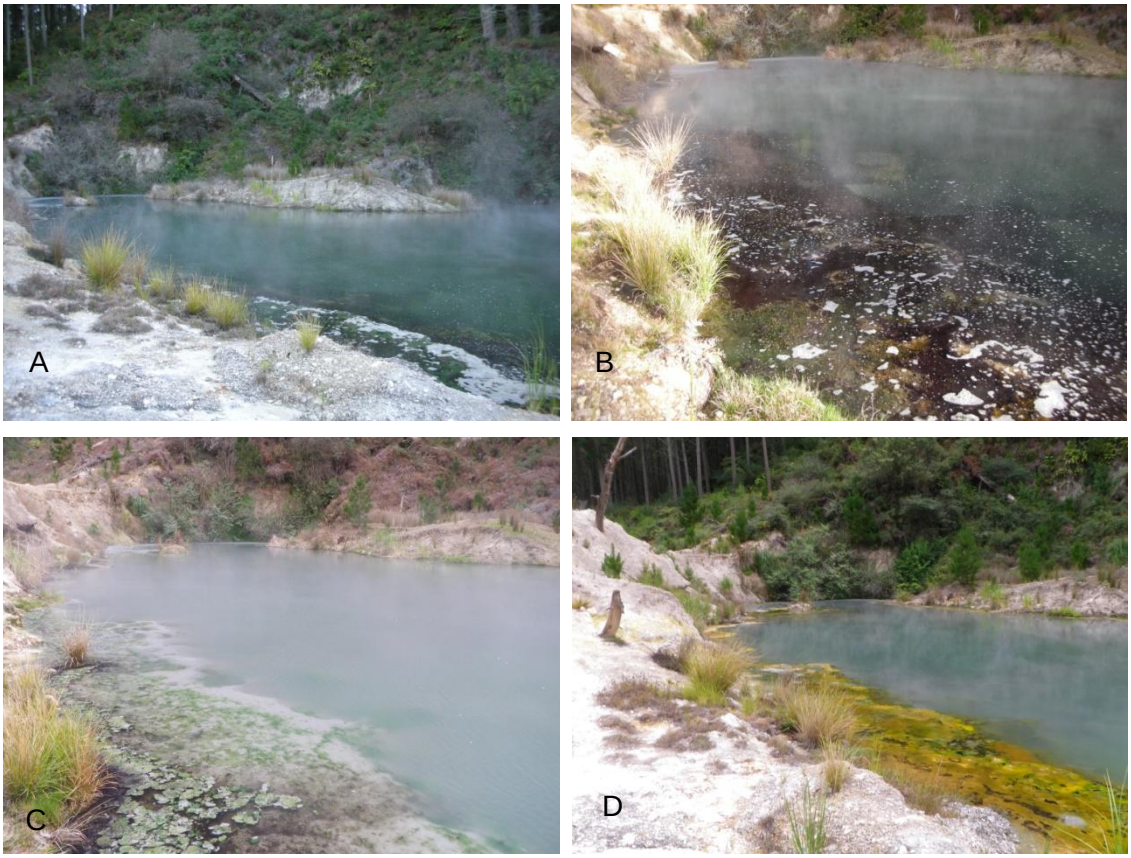


**Figure 25: Large pool gas discharge, Apr (A), Jul (B), Sep 2012 (C), Jan 2013 (D)**


**Figure 26: Steam at large pool, Apr 2012 (A), Jul 2012 (B), Sept 2012, (C) Jan 2013 (D)**


**Figure 27: Large Pool outflow in Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

The Infrared photos in Figure 28 show the warm areas of the Ngatamariki Eruption Crater. Photo A depicts the area to the left of the crater, indicating that the water is cooler around the island and algal mats. Photo B depicts the steaming area at the back of the pool, and shows the heat in this area. Photo C depicts the outlet, and shows that the water is hottest along the front edges and towards the centre of the pool.

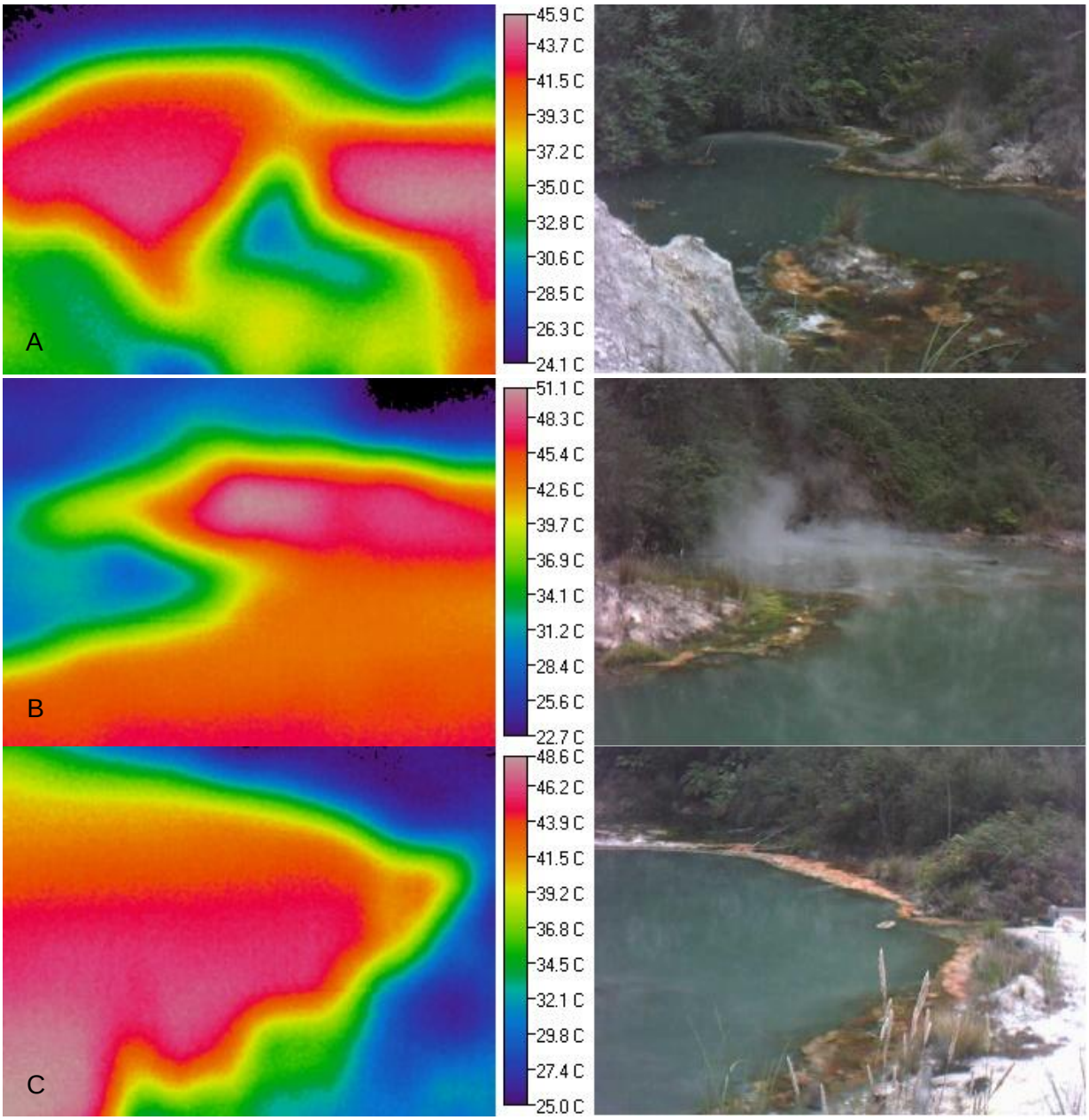


**Figure 28: Infrared photos, Ngatamariki Hydrothermal Eruption Crater in Jan 2013**

- **Mud pool beside large pool**

There is a log in the pool, which has been there for some time. Although discoloured, there is no visual evidence of the log rotting or being dissolved. The level has fluctuated over the year, and the temperature seems to be increasing, from 34.5°C in Apr 2012 to 69.3°C in Jan 2013.

**Table 11: Data from Mud pool beside Ngatamariki Hydrothermal Eruption Crater Pool**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 34.5 | 3 | nd | 0.5m below outflow | Moderate, continuous gas discharge | Murky grey, mud |
| 2 July 2012 | 34.7 | 3 | nd | 0.5m below outflow | Small areas of gas discharge | Murky grey, mud |
| 20 Sept 2012 | 39 | 3 | nd | 0.3m below outflow | Effervescing | Cloudy/ Grey |
| 23 Jan 2013 | 69.3 | 4 | nd | 0.7m below o/f | Small bubbles of gas discharge | Grey |


**Figure 29: Mud Pool, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

The infrared photos show that the pool is hottest in the centre of the pool, which is also where the gas discharge originates.

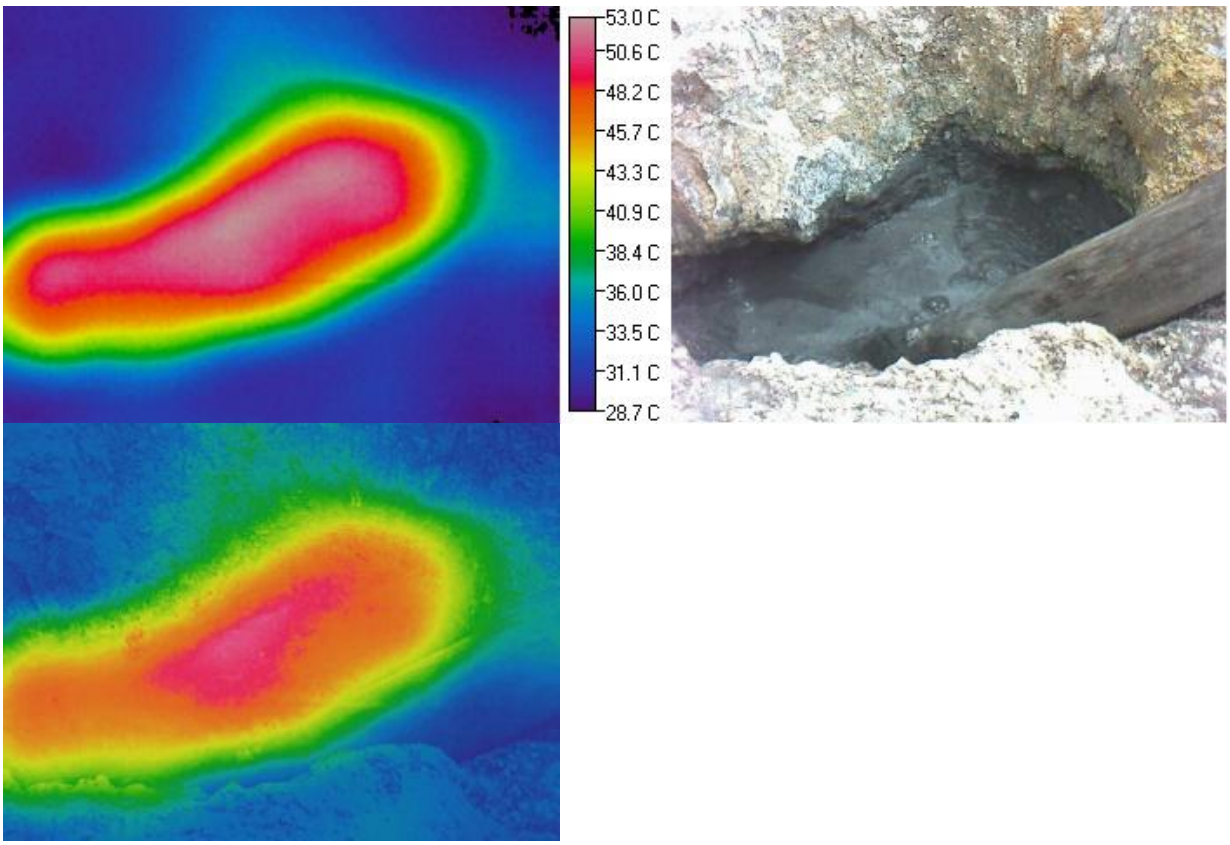


**Figure 30: Infrared photos showing the mud pool, Ngatamariki in Jan 2013**

- **Northwest Pool**

The pool appears to have warmed slightly since the previous visit in October 2011. It was mostly covered in duckweed at the time of the Jan 2013 visit. There are no infrared photos for this site.

**Table 12: Data from Northwest Pool, Ngatamariki**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 26 Oct 2011 | 25.7 | 7 | nd | 2.5m below rim | Calm | Cloudy, dark green |
| 23 Jan 2013 | 32.8 | 7 | nd | 3.5m below rim | Calm | Black |


**Figure 31: Northwest Pool, Ngatamariki October 2011 (A), Jan 2013 (B)**

- **Biodiversity Pool**

This pool is located amongst the trees to the right of the track leading to the hydrothermal eruption crater, just before the clearing. There were yellow algal mats on the pool at the time of the visits. The temperature of the pool seems to be reasonably consistent, with a maximum difference of 5°C over the four monitoring visits. The pH changes at each visit with the lowest being pH6-7 and the highest pH9. There are no infrared photos for Jan 2013.

**Table 13: Data from Biodiversity Pool, Ngatamariki**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 67.6 | 9 | nd | nd | Constant discharge all over pool | Murky grey |
| 2 July 2012 | 65.5 | 8 | nd | nd | Constant discharge all over pool | Clear, light grey mud base |
| 20 Sept 2012 | 69.5 | 6-7 | nd | nd | Constant effervescing in the centre with smaller areas around the edges of the pool | Clear, light grey mud base |
| 23 Jan 2013 | 66.3 | 7-8 | nd | nd | Constant discharge all over pool | Clear, light grey mud base |


**Figure 32: Biodiversity Pool, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C) and Jan 2013 (D)**

# 6 Orakei Korako

## 6.1 Orakei Korako Springs

Located number 72.2107

- **Diamond Geyser**
  E1874515 N573694


**Figure 33: Diamond Geyser, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

The temperature increased from 74.2°C in Apr 2012 up to 86°C in July 2012. It has been more consistent in the subsequent visits. The pH changed from pH7 to pH9 between Apr and July; however it had changed back to pH7 in Sept. The flow varies throughout the monitoring period.

**Table 14: Data from the Diamond Geyser, Orakei Korako**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 74.2 | 7 | ~0.05 | Overflowing | Constant upwelling on far side of pool | Clear, dark grey |
| 2 July 2012 | 86 | 9 | seep | Overflowing | Upwelling at outlet | Clear, dark grey |
| 20 Sept 2012 | 85.6 | 7 | 0.5l/s | Overflowing | Upwelling at outlet | Clear, dark grey |
| 22 Jan 2013 | 86.2 | 7 | seep | Overflowing | Upwelling at outlet | Clear, grey |

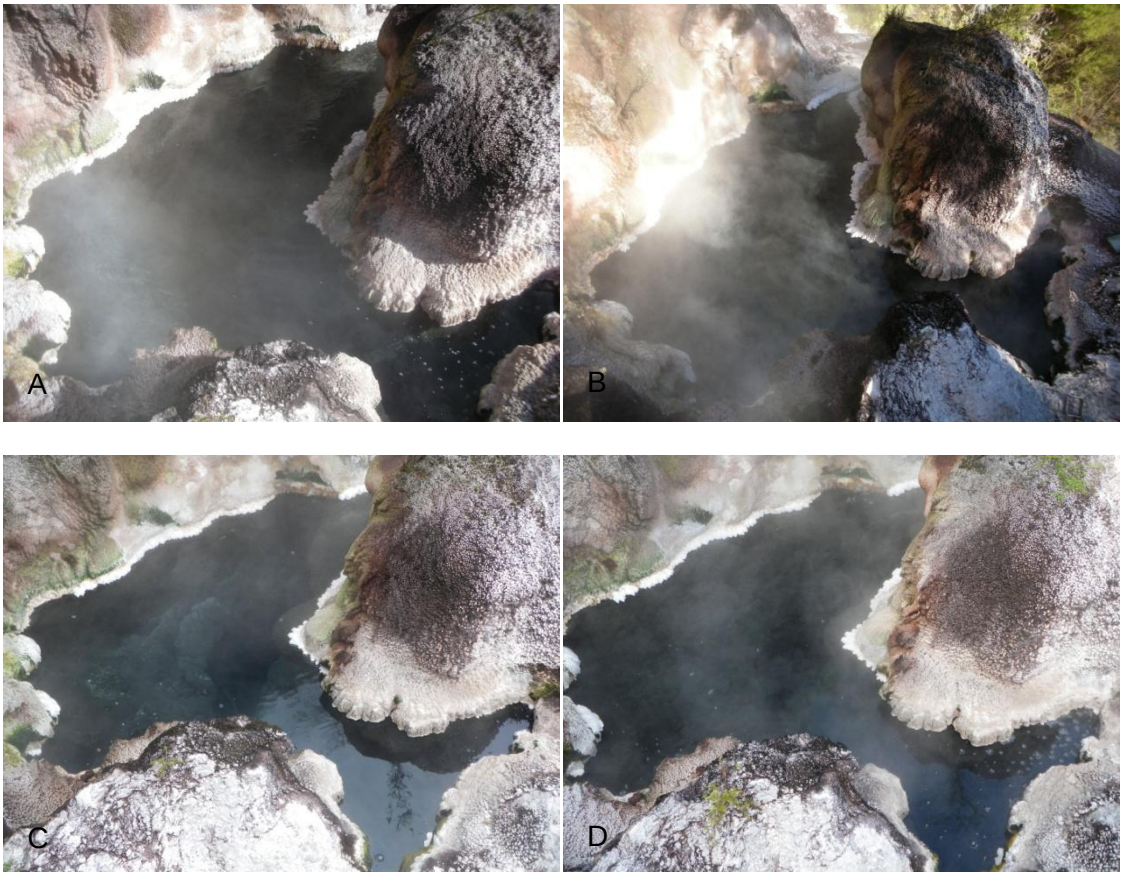


**Figure 34: Diamond Geyser, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

The infrared photo below appears to show that the areas where the sinter are growing is quite hot compared to the surrounding surfaces. The warmest areas are near the outlet and along the Eastern side of the pool.

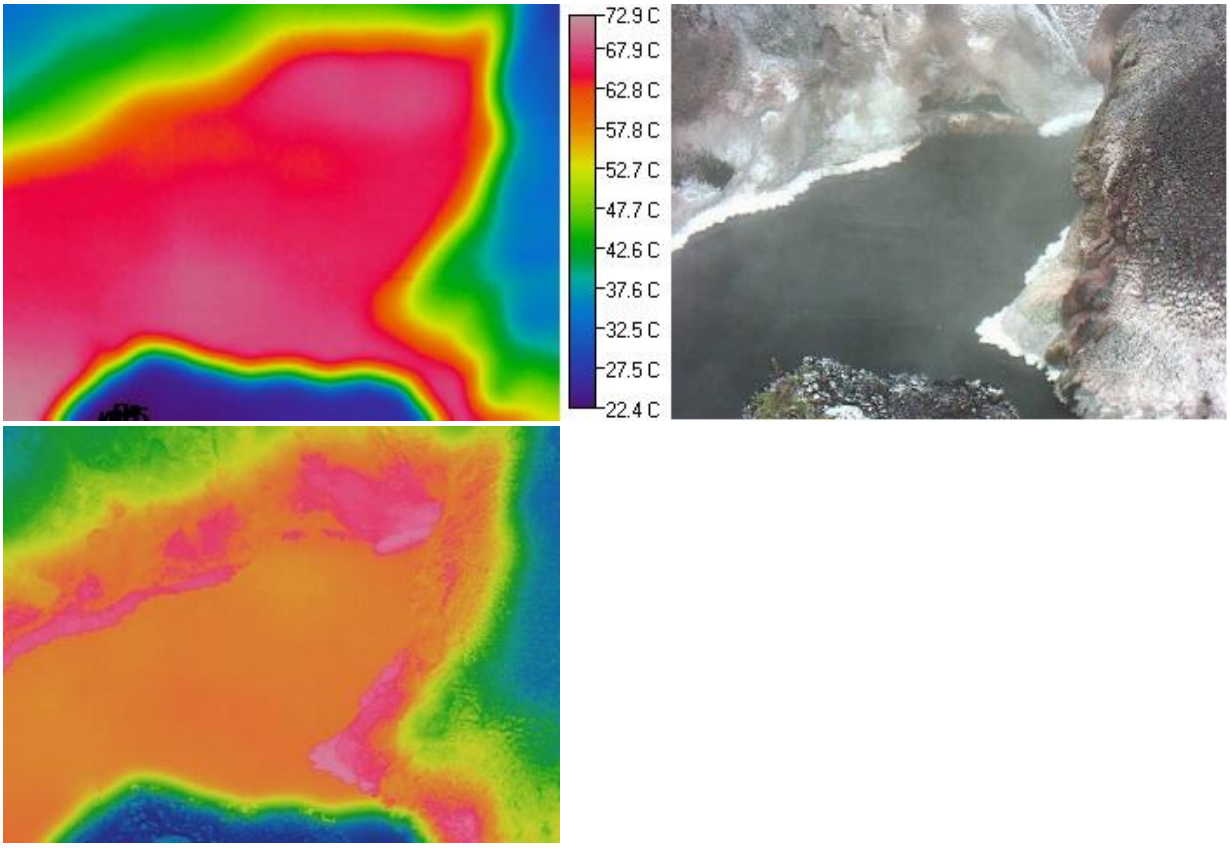


**Figure 35: infrared photo, Diamond Geyser, Orakei Korako in Jan 2013**

- **Pool beside Diamond Geyser**

In Sept 2012 there was a small amount of new sinter noticeable around the edges. The pH of the pool was reasonably consistent until Jan 2013, where it had increased from pH5 to pH7. There was a temperature increase from 71.9°C in Apr 2012 to 83°C in July 2012 (which is consistent with the Diamond Geyser pool heating up over the same period), after which there was only a 1°C increase through to Jan 2013. In Jan 2013 it was noted that there was scum on the pool.

**Table 15: Data from the pool beside the Diamond Geyser, Orakei Korako**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 71.9 | 5 | 0 visible | Top of rim | Occasional discharge | Cloudy grey |
| 2 July 2012 | 83 | 4 | 0 visible | Top of rim | Calm | Clear, dark grey |
| 20 Sept 2012 | 84.2 | 5 | Seep | Overflowing | Constant bubbles on the far side of the pool and occasionally from the middle | Cloudy Grey/Blue |
| 22 Jan 2013 | 84 | 7 | 0 visible | Top of rim | Calm | Cloudy, grey |

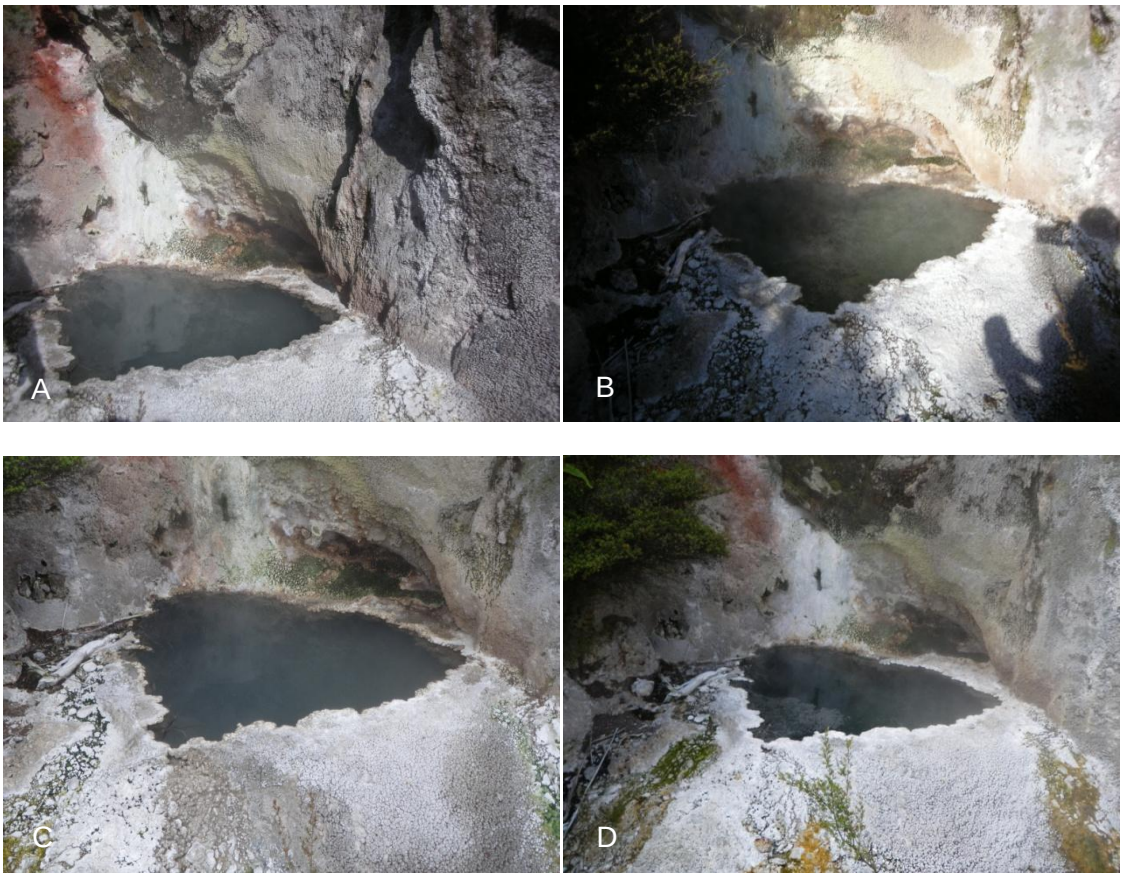


**Figure 36: Pool beside Diamond, Apr 2012 (A), Jul (B), Sept 2012 (C) Jan 2012 (D)**

The infrared photo below shows that the pool appears to be the hottest near the back of the pool, and at the outlet where the ground is hot. It also shows (similar to the Diamond Geyser) that the areas of sinter are quite warm compared with the surrounding sinter. It also looks like steam may be affecting the photo or the rocks behind the pool are warm.

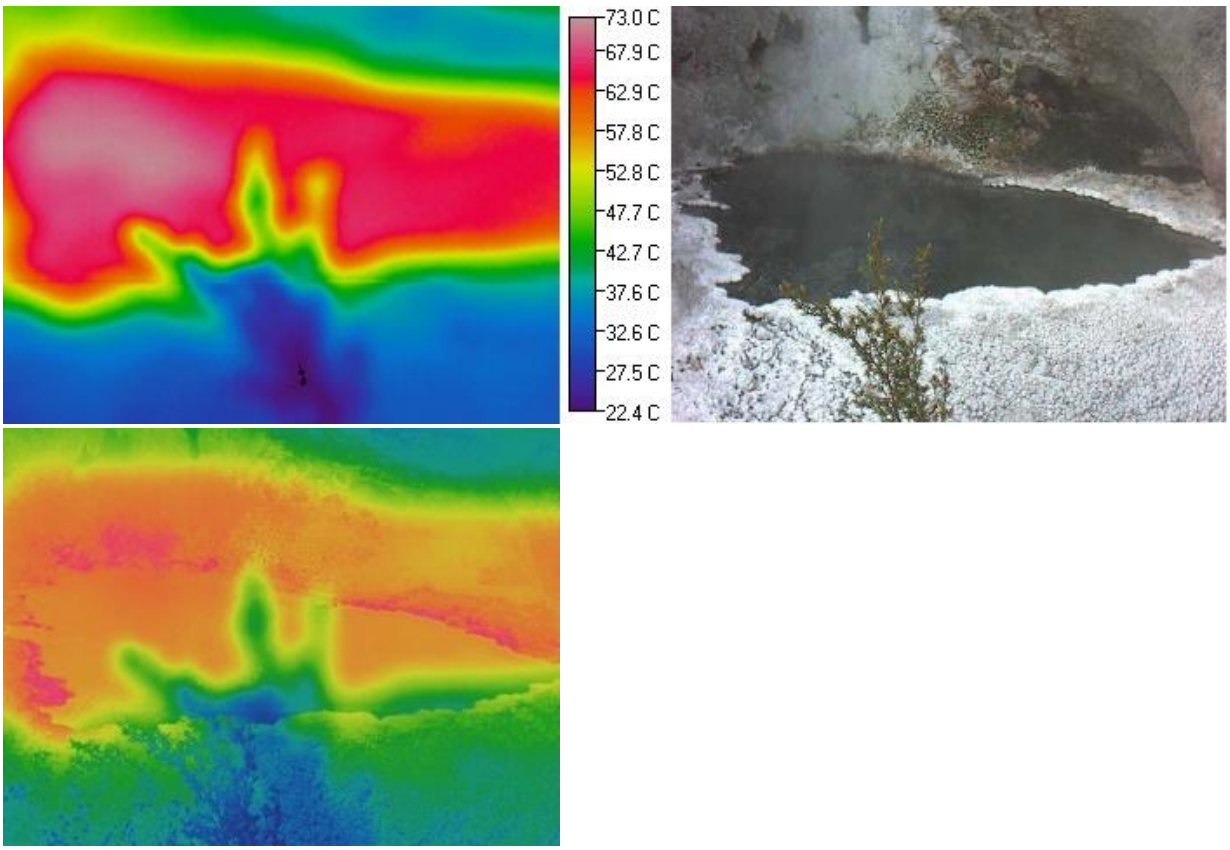


**Figure 37: Infrared photos, pool beside the Diamond Geyser, Orakei Korako in Jan 2013**

- **Bush Geyser**

During the Apr 2012 visit it was noted that there were fresh nodules present and signs of a recent eruption (no eruption was witnessed). In Jan 2013 the eruption reached a height of 0.2m above the rim. The water level of 1m was taken after an eruption, before the eruption no water was present in the vent. In July 2012 the temperature of 57°C was taken before the eruption, with 92.1°C measured after the eruption.

**Table 16: Data from the Bush Geyser, Orakei Korako**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 64.4 | - | nd | 1.5m below rim | Audible gas discharge, steam | Clear |
| 2 July 2012 | 57 – 92.1 | 9 | nd | 1.0m below rim | Erupted at 11:10am | Clear |
| 20 Sept 2012 | 90.6 | 8 | nd | 1.0m below rim | Erupted at 10:48 for 1 minute | Clear |
| 22 Jan 2013 | 96 | 8-9 | nd | 1.0m below rim | Erupted at 09:08 for 5 minutes | Clear |


**Figure 38: Bush Geyser, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013**

The infrared photos below were taking during a quiescent stage. The hottest area appears to be the vent on the right side of the geyser.

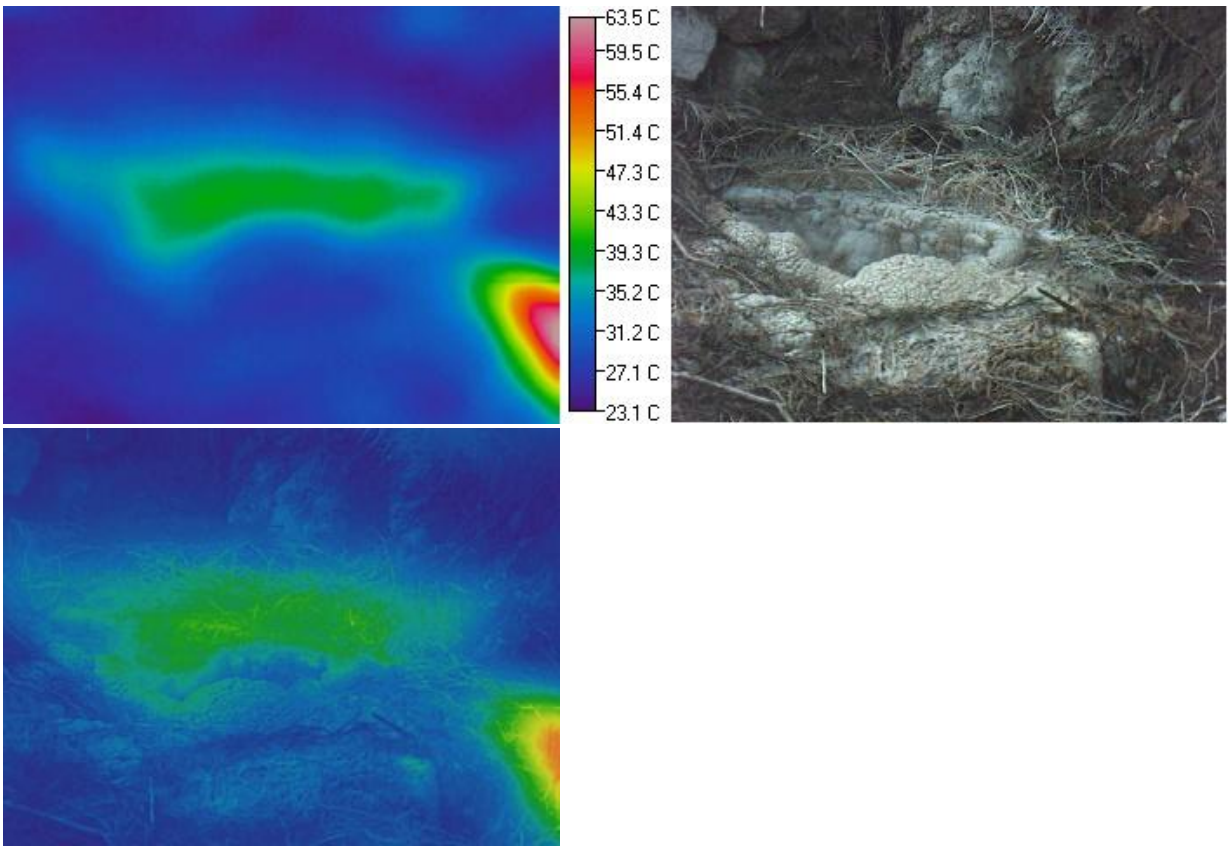


**Figure 39: Infrared photos, Bush Geyser, Orakei Korako in Jan 2013**

- **Cascade Geyser**

Apr 2012: geyser erupted twice, with an eruption length of three and a half minutes, with an interval of approximately 3 minutes between eruptions. Eruption height was approximately 0.5m.

July 2012: geyser erupted twice, at 11:05am and 11:20am. The eruption at 11:20am lasted 2 minutes and the eruption height was ~0.2m.

Sept 2012: geyser erupted three times during the period of observation, at 10:45, 10:51 and 10:57 for 1 minute, 1 minute and 4 minute durations respectively.

Jan 2013: geyser erupted once at 09:20 for approximately one minute.


**Figure 40: Cascade Geyser, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

The infrared photos in Figure 41 were taken during an eruption, and show the flow path of the water during an eruption. There are also a couple of hot spots to the right of the geyser.

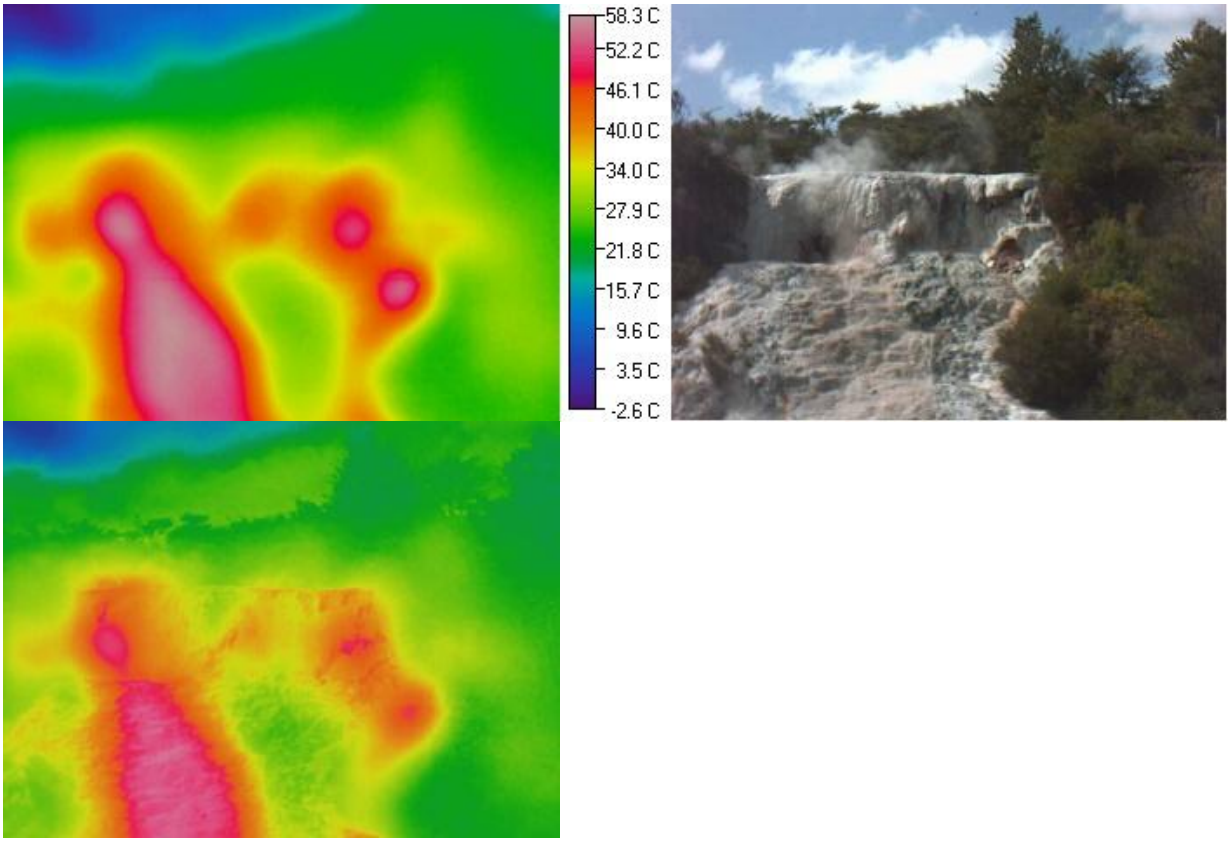


**Figure 41: Cascade Geyser at Orakei Korako during an eruption**

- **Sapphire Geyser**

The geyser erupted twice during the visit observation period at 10:35 and 10:43 in Sept 2012. It did not erupt during the Apr 2012, July 2012 or Jan 2013 visits, however it was steaming in Jan.

**Figure 42: Sapphire Geyser, Orakei Korako in Jul 2012**

- **Map of Africa**
  E1874578 N5736954

Various coloured algal mats were observed on the water surface during all of the monitoring visits. The area that the mats cover tends to vary at each visit. There was a slight amount of bubbling noticeable during the Sept 2012 visit compared to the calm surface of the other visits. The pH seems to vary from pH7 to pH9. The pool could not be reached to obtain a pH result on the Jan 2013 visit. The temperature seems to vary between monitoring periods, with the lowest being 30°C during the Jan 2013 visit and highest of 46°C during the Sept 2012 visit.

**Table 17: Data from the Map of Africa Pool, Orakei Korako**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 40.8 | 7 | nd | nd | Calm, some steam | Clear, dark green |
| 2 July 2012 | 36.3 | 8 | ~0.5 (inflow) | nd | Calm | Clear, green tinge |
| 20 Sept 2012 | 46 | 9 | n/d | nd | One small area bubbled consistently. | Clear, dark green |
| 22 Jan 2013 | 30 | nd | ~0.5 (inflow) | nd | Calm | Clear, dark green |


**Figure 43: Map of Africa, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

The infrared photos below show that the warmest area around The Map of Africa appears to be in the vicinity of the algal mats surrounding the pool.

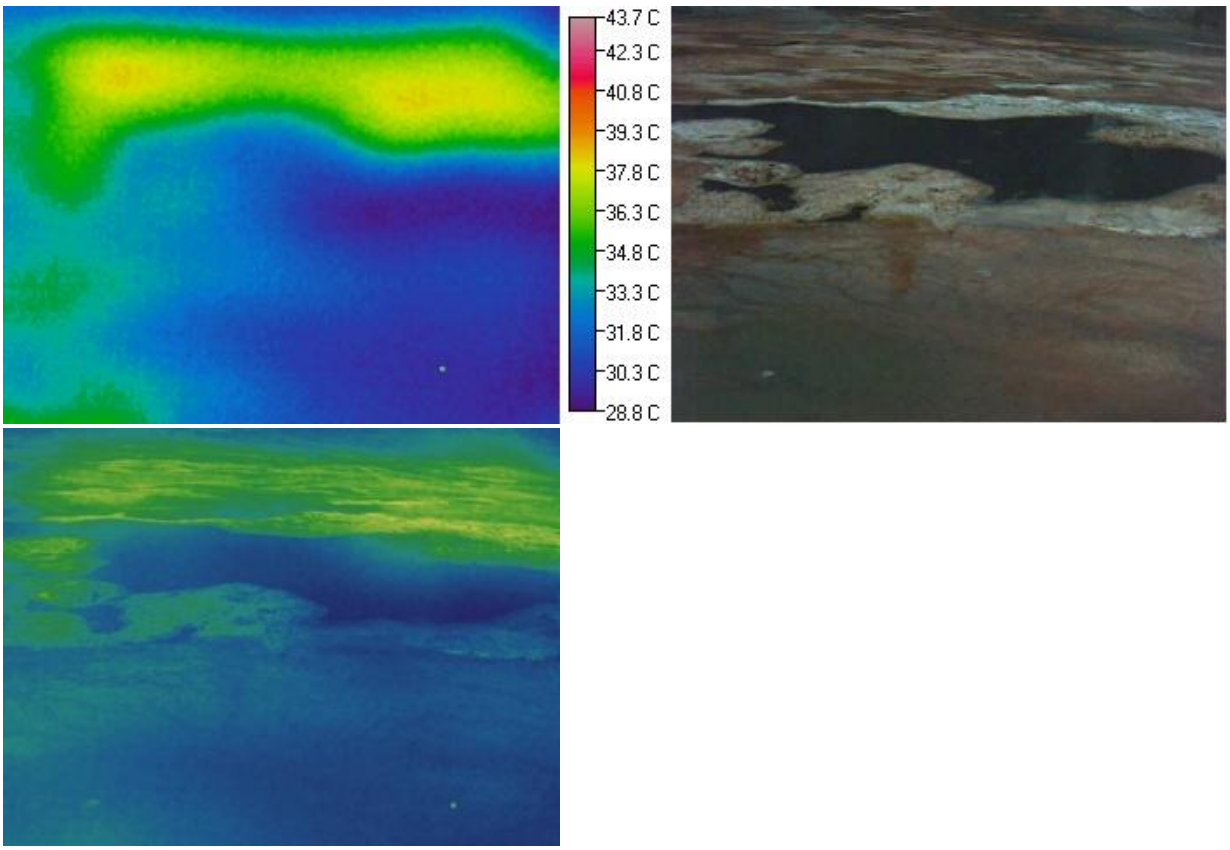


**Figure 44: Infrared photos, Map of Africa, Orakei Korako in Jan 2013**

- **Devil's Throat**
  E1874599 N5736996

The vent appeared to be surging at three minute intervals with constant bubbling during the Sept 2012 visit. The bubbling becomes more vigorous as it surges, with the flow changing from <0.5l/s to 1l/s when surging, which was noted in the July 2012, Sept 2012 , Jan 2013 monitoring visits. The pH seems to have altered from pH9 in Apr 2012 to pH7 in Jan 2013. The temperature was lower in the Apr 2012 visit. There is no infrared photo for the Devil's Throat.

**Table 18: Data from the Devil's Throat, Orakei Korako**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 92.1 | 9 | ±0.5 | Overflowing | Bubbling vigorously, surging | Clear |
| 2 July 2012 | 97 | 8 | ~0.5-1.0 | Overflowing | Constant bubbling, boiling, surging | Clear |
| 20 Sept 2012 | 97.4 | 8-9 | <0.5 – 1.0 | Overflowing | Constant bubbling, boiling, stronger when surging | Clear, dark grey |
| 22 Jan 2013 | 98.8 | 7 | <0.5 – 1.0 | Overflowing | Constant bubbling, surging vigorously | Clear |


**Figure 45: Devil's Throat, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

- **Fred and Maggie's Pool**
  E1874648 N5736981

There were no major changes at Fred and Maggie's pool throughout the visits, apart from minor temperature fluctuations.

**Table 19: Data from Fred and Maggie's Pool, Orakei Korako**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 94.8 | 7 | ±0.5 | Overflowing | Boiling near outflow | Clear, grey-blue |
| 2 July 2012 | 98.3 | 6 | <0.5 | Overflowing | Boiling near outflow | Clear, blue-green |
| 20 Sept 2012 | 98 | 7 | <0.5 | Overflowing | Boiling vigorously | Clear, dark grey |
| 22 Jan 2013 | 96.6 | 7 | ±0.5 | Overflowing | Boiling near outflow | Clear, grey |


**Figure 46: Fred and Maggie, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

The infrared photos below show that the hottest part of the pool is the area in front of the upwelling.

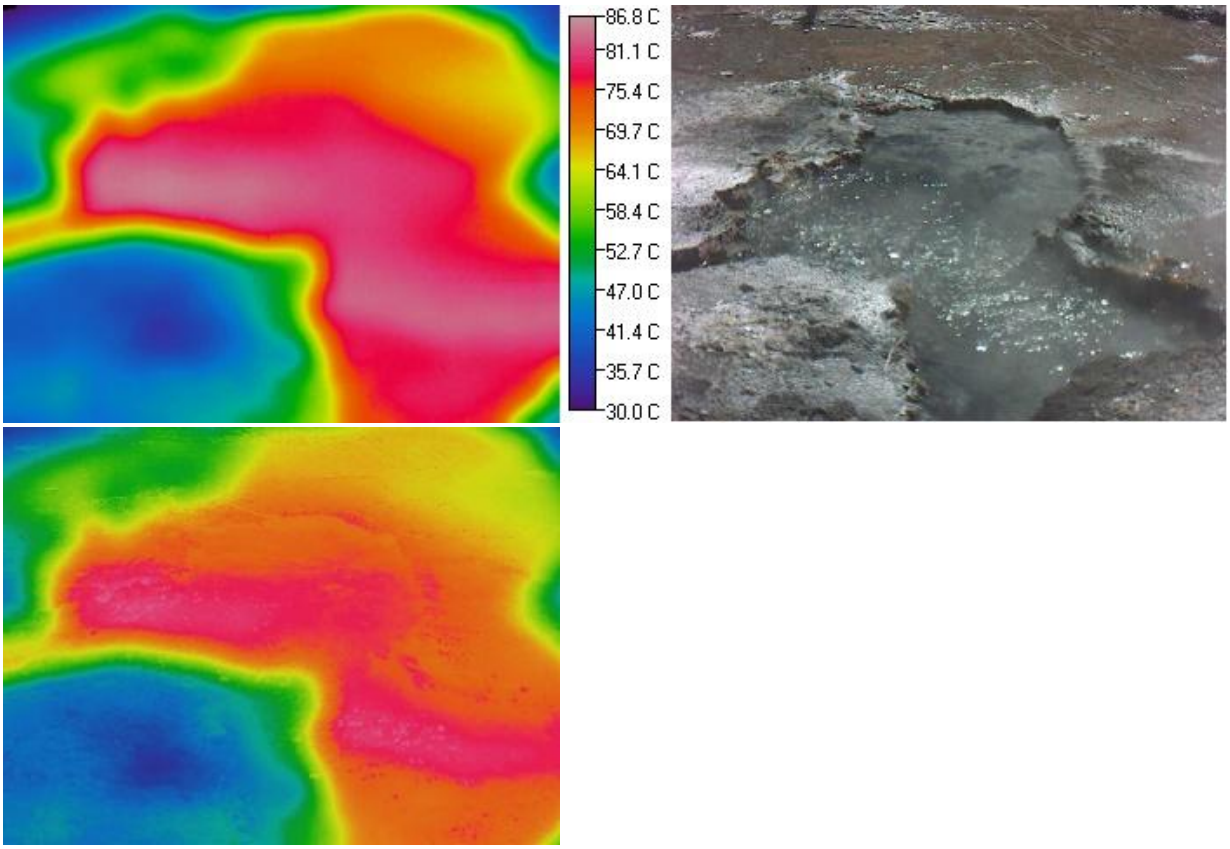


**Figure 47: Infrared photos of Fred and Maggie's Pool**

- **Wairiri Geyser**
  E1874643 N5736951

In Jan 2013 there was water flowing into the pool from the Terrace. There was no photo taken for the Wairiri geyser in Sept 2012.

There was a significant drop in water level in Jan 2013; it was at least 1m below the outflow. After an initial increase in temperature (9.7°C) from Apr 2012 to July 2012, the temperature decreased significantly (by 27.1°C) between Sept 2012 , Jan 2013.

**Table 20: Data from the Wairiri Geyser, Orakei Korako**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 75.5 | 7 | nd | 0.9m below surface | Calm | Clear, blue-grey |
| 2 July 2012 | 85.2 | 6 | nd | 0.5m below outflow | Occasional gas discharge | Clear, blue-green |
| 20 Sept 2012 | 88.1 | 7 | n/d | 0.4m below outflow | Occasional upwelling | Clear, blue-green |
| 22 Jan 2013 | 61 | 6-7 | seep (inflow) | nd | Calm | Clear |


**Figure 48: Wairiri Geyser at Orakei Korako in Apr 2012 (A), Jul 2012 (B), Jan 2013 (C)**

The Infrared photos (Figure 49) show that the warmest part of the pool is at the back of the pool, which appears to be a dry area.

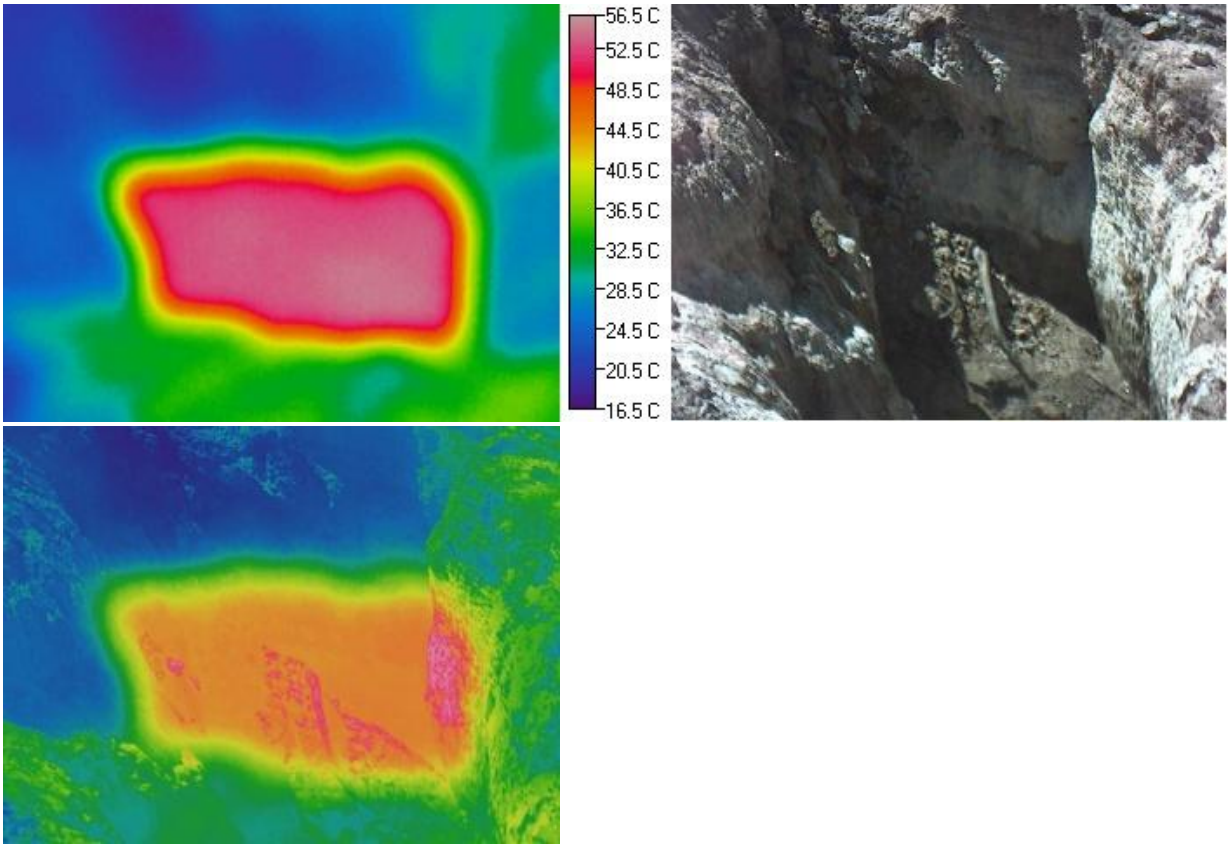


**Figure 49: Infrared photos, Wairiri Geyser, Orakei Korako in Jan 2013**

- **Steaming ground on the Western edge of Artists Palette.**
  E1874661 N5736910

The ground was only steaming in the area towards the rear of the photo (Figure 50) in Sept. In Jan 2013 the area was flooded. The infrared photos have not been included as there is only a small temperature difference shown.

**Table 21: Data from steaming ground, Western edge, Artists Palette, Orakei Korako**

| Date | T(°C) |
|---|---|
| 19 Apr 2012 | 30-54 |
| 2 July 2012 | 13.4-70 |
| 20 Sept 2012 | 25-60 |
| 22 Jan 2013 | 27-30 |


**Figure 50: Steaming ground in Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

- **Fumarole to left of boardwalk**
  E1874662 N5736878

The fumarole was dry during all visits. It has an average depth of 0.7m and a diameter of ~0.65 x 1m. There are large temperature fluctuations in the fumarole over the monitoring period, ranging from 19.4°C to 58°C.

**Table 22: Data for the Fumarole to the left of the boardwalk, Orakei Korako**

| Date | T(°C) | pH | Flow (l/s) | Ebullition | Diameter | Depth |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 45.8 | nd | nd | Weak steam | 0.60 x 1m | 0.6m |
| 2 July 2012 | 19.4 | nd | nd | - | 0.65 x 1m | 0.7m |
| 20 Sept 2012 | 37 | nd | nd | Steaming | 0.65m x 1m | 0.7m |
| 22 Jan 2013 | 58 | nd | nd | Steaming | 0.60m x 1.1m | 0.7m |


**Figure 51: Fumarole, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

The infrared photos below show the heat originating along the back of the fumarole, with various warm spots, most likely from steam.

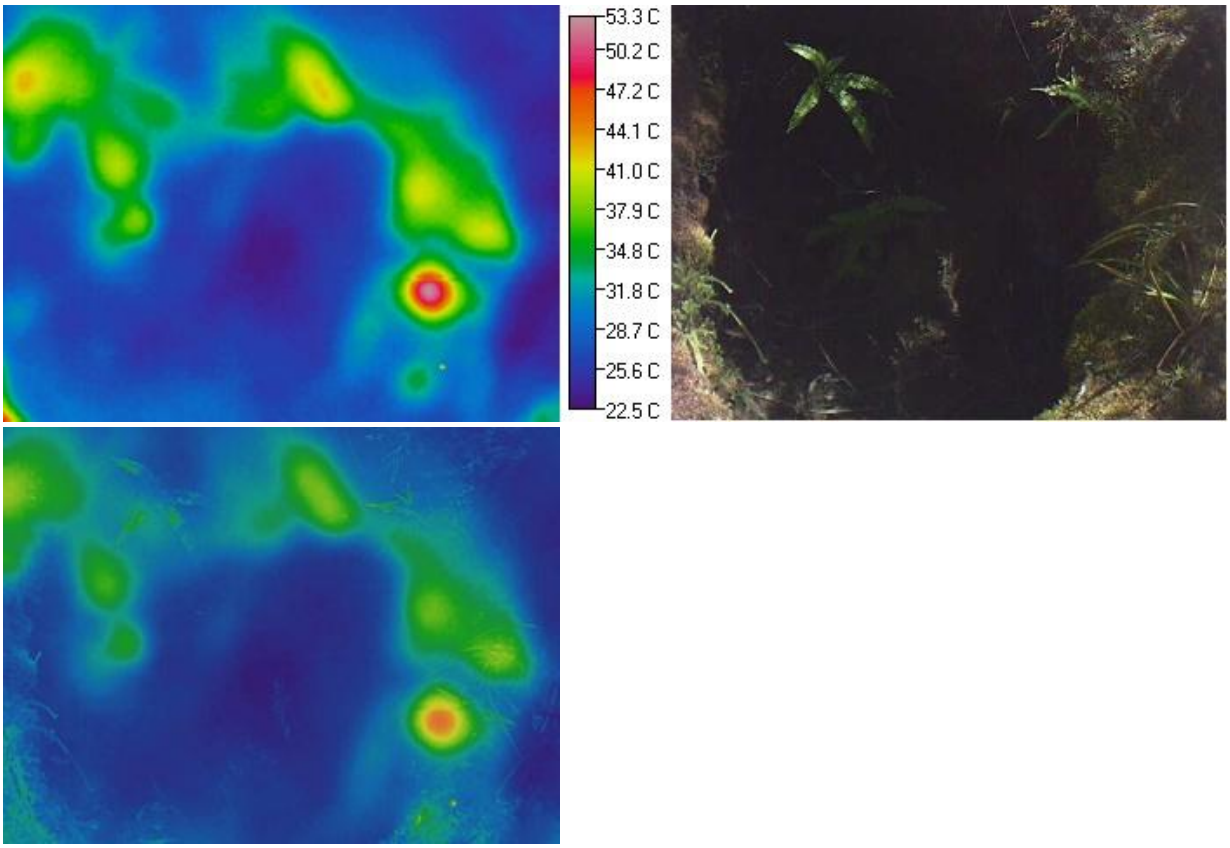


**Figure 52: Fumarole to the left of the boardwalk, Orakei Korako**

- **Two pools by the boardwalk**
  E1874670 N5736770

The water temperature at the South Pool fluctuates throughout the year, and the pH has changed from having a neutral pH7 in Apr 2012 to pH 3-4 in Jan 2013. The water level had risen to 0.7m from 2m below the surface. The clarity had altered from clear to murky, with a visibility of about 1m, between Sept 2012 , Jan 2013.

**Table 23: Data from the South Pool by the boardwalk, Orakei Korako**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 73.3 | 7 | nd | 2m below surface | Occasional gas discharge. | Clear, grey |
| 2 July 2012 | 85 | 8 | nd | 2m below surface | Calm | Clear, light beige mud base |
| 20 Sept 2012 | 69.4 | 6 | nd | 1.4m below surface | Calm | Clear, light beige mud base |
| 22 Jan 2013 | 61.8 | 3-4 | nd | 0.7m below surface | Calm | Murky, blue grey. Visibility ~1m. |


**Figure 53: South Pool, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

The infrared photos (Figure 54) show that the warmest area appears to be in the centre of the pool.

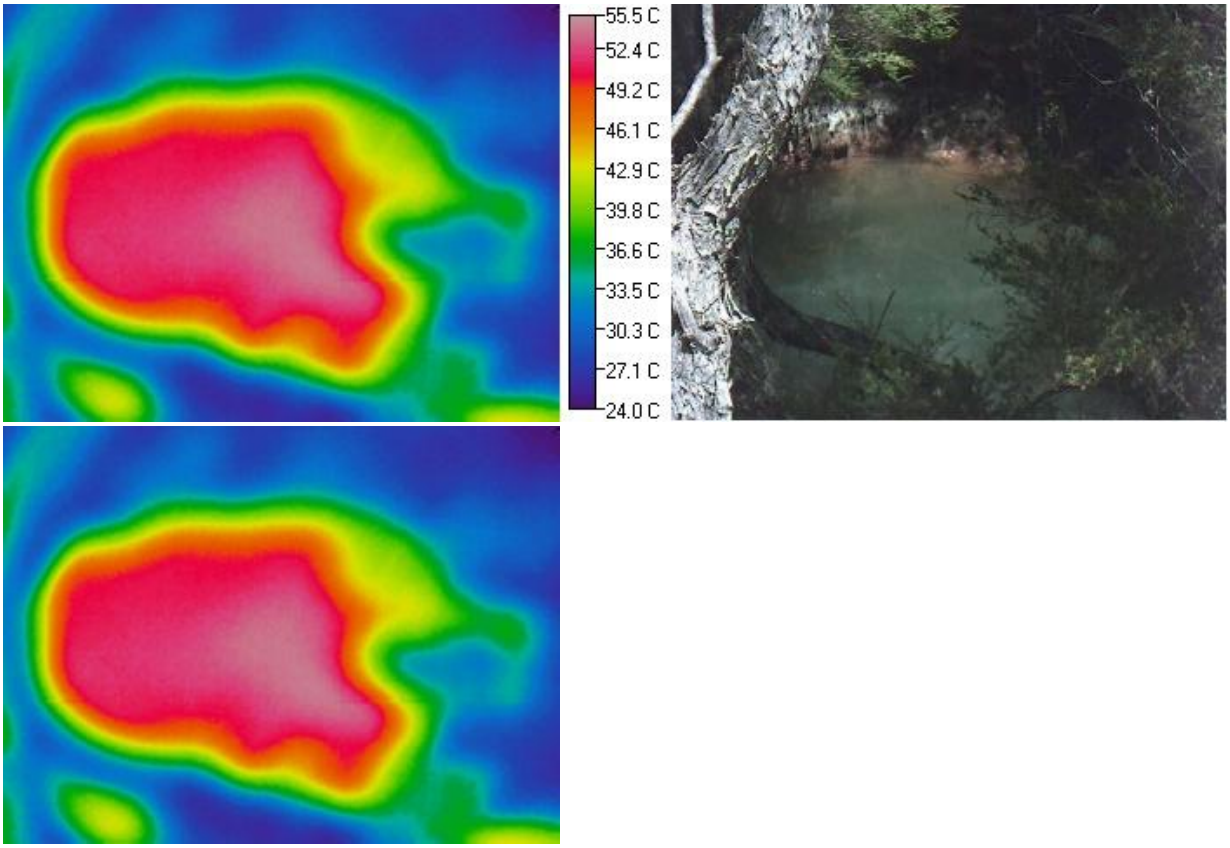


**Figure 54: Infrared photos, South Pool by the boardwalk, Orakei Korako in Jan 2013**

The water temperature at the North Pool has decreased markedly (24.3°C) from 79°C in Apr 2012 to 54.7°C in Jan 2013. The pH seems to have remained reasonably constant; however, the water level has risen.

**Table 24: Data from the North Pool by the boardwalk, Orakei Korako**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 79.0 | 7 | nd | 2.5-3m below surface | Calm | Clear, grey |
| 2 July 2012 | 77.7 | 6 | nd | 1.5m below surface | Constant streams of discharge on left | Clear, dark grey |
| 20 Sept 2012 | 68.5 | 6 | nd | 1.2m below surface | Effervescing on the left with occasional small upwellings | Clear, light brown |
| 22 Jan 2013 | 54.7 | 6 | nd | 1.10m below surface | Constant, small bubbles | Clear, brown mud base |


**Figure 55: North Pool, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

The heat seems to be evenly spread throughout the pool.

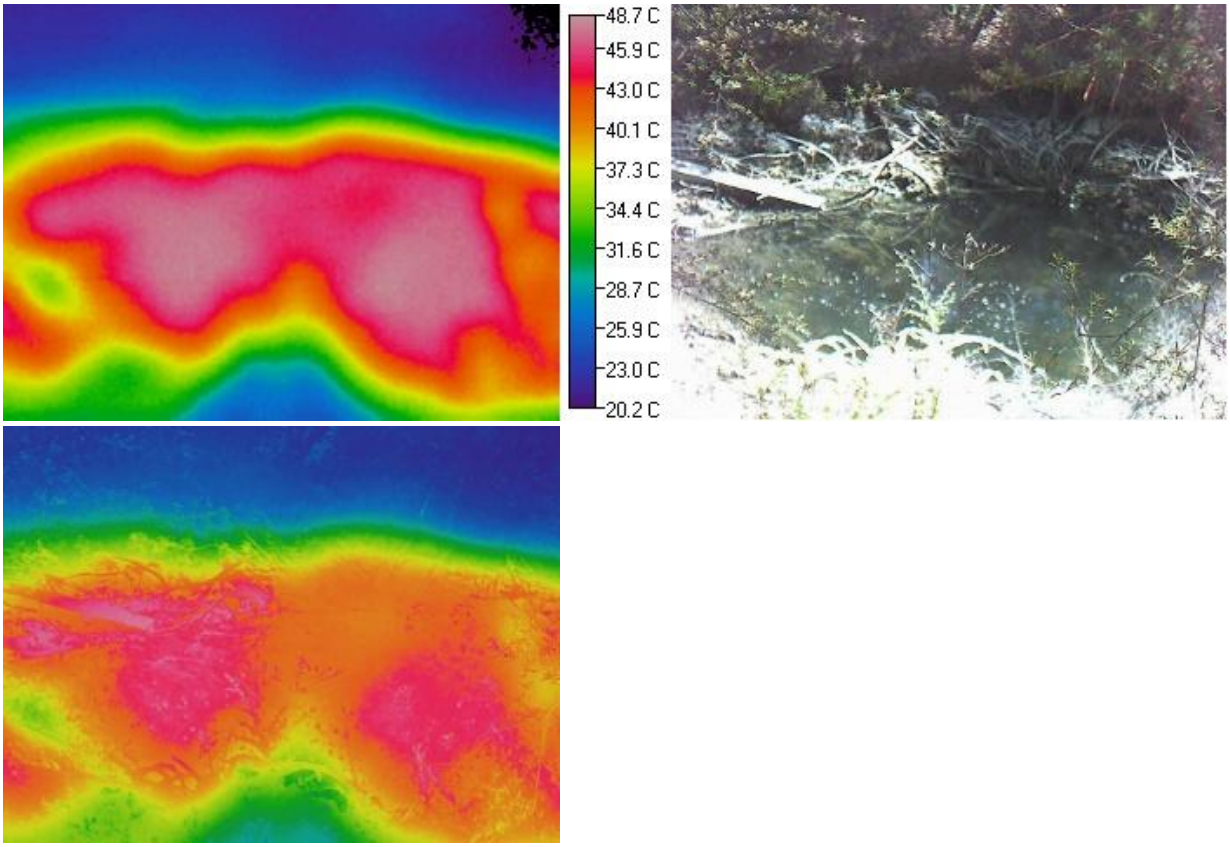


**Figure 56: Infrared photos, North Pool by the boardwalk, Orakei Korako in Jan 2013**

- **Artists Palette and Pyramid of Geysers**

**Figure 57: Artists Palette, with the Pyramid of Geysers in the background in Jan 2013**

Apr 2012: water level has dropped in the pools on the left of the boardwalk. The pyramid geyser is erupting to a height of approximately 0.5-1.0m. The two small pools in the centre are surging.

July 2012: pools to the left of the viewing platform appear to be steaming and bubbling, however no water can be seen. A small vent in line with the corner of the platform erupted from 12:00 – 12:04 to a height of 0.5m. There is no visible water in the large centre crate. The main geyser is constantly erupting to a height of ~0.5m.

Sept 2012: pool at the front corner of the lookout was erupting to a height of ~1m, with the main geyser erupting to ~0.5m. Many of the pools were either dry or much lower than normal.

Jan 2013: pool in front of the lookout was almost full, with blue water. The pools to the left of the lookout were blue, overflowing and bubbling continuously. The rest of the pools appeared dry. The main geyser was erupting.


**Figure 58: Composite photo, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

- **Ruatapu Cave**
  E1874752 N5736770

Due to a rock fall some years ago there is no access to Ruatapu Cave; therefore the temperature was taken from the viewing platform with the IR gun. There did not appear to be any changes over the period, the temperature remained relatively consistent.

**Table 25: Data from the Ruatapu Cave, Orakei Korako**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | nd | nd | nd | - | Calm | Clear, Blue-green |
| 2 July 2012 | 38 | nd | nd | - | Calm | Clear, blue |
| 20 Sept 2012 | 40.8 | nd | nd | - | Calm | Clear, blue/green |
| 22 Jan 2013 | 37 | nd | nd | - | Calm | Clear, blue |

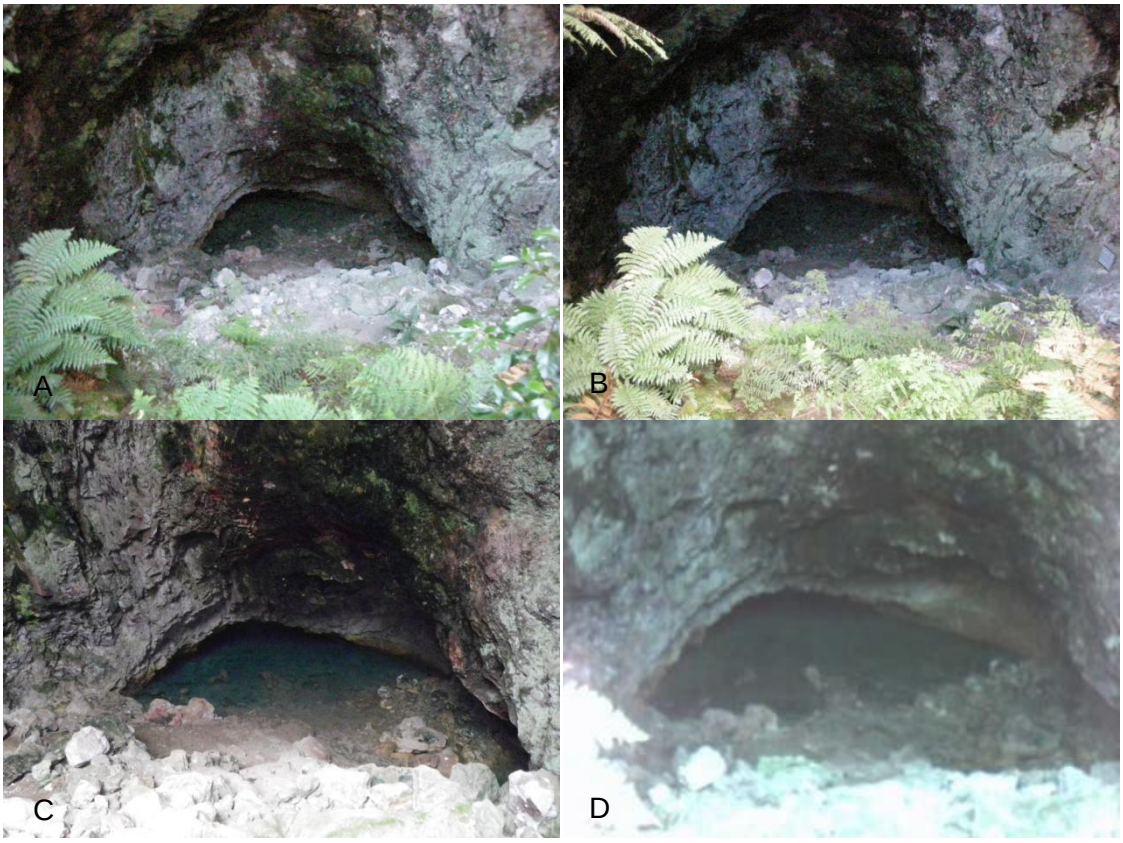


**Figure 59: The Ruatapu Cave, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

The heat seems to be evenly spread across the pool, although it is slightly warmer towards the back of the pool. The Infrared photo (Figure 60) is taken from the viewing platform, which is some distance from the pool.

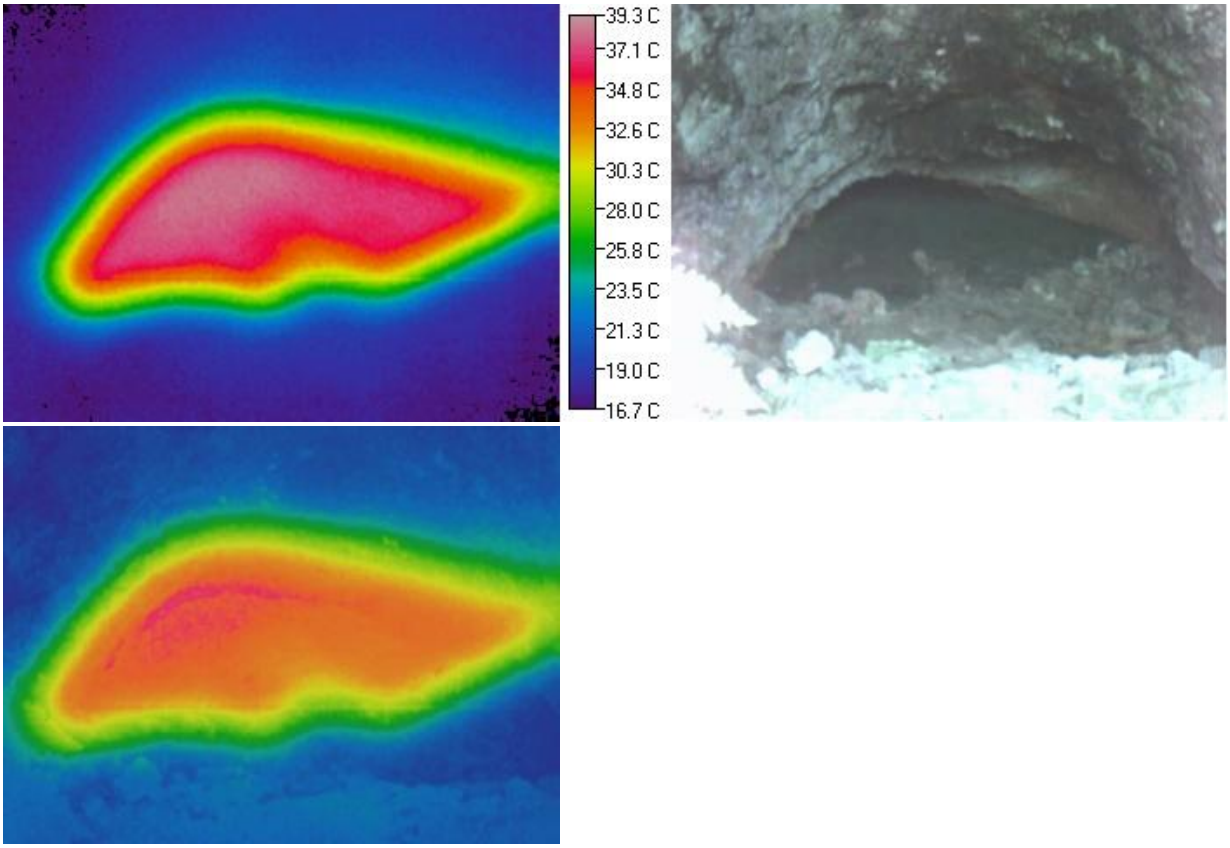


**Figure 60: Infrared photo, Ruatapu Cave, Orakei Korako in Jan 2013**

- **Soda Fountain**
  E1874555 N5736924

The water level has changed several times from Apr 2012 to Jan 2013. The pH has also dropped from pH9 to pH7. There was too much steam to take an accurate Infrared photo.

**Table 26: Data from the Soda Fountain, Orakei Korako**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 97.9 | 9 | 0 visible | 0.8m below outflow | Vigorous boiling | Clear |
| 2 July 2012 | 92.6 | 8 | 0 visible | 1.2m below outflow | Constant gas discharge | Clear |
| 20 Sept 2012 | 99.8 | 8 | 1 l/s | Overflowing | Boiling vigorously from far side, surging up to 0.2m | Clear light blue/grey |
| 22 Jan 2013 | 102.2 | 7 | 0.5-1l/s | Overflowing | Boiling | Clear, grey |


**Figure 61: Soda Fountain, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

- **Map of Australia**
  E1874160 N5736976; Located number 72.2998

There were no major changes throughout the monitoring period. There was most likely flow in the Apr and July visits, we were looking at the wrong outlet. There are two outlets; we were reading the one near the level marker, however, we have since determined that the main outlet is out to the side. There was too much steam in Jan 2013 to get a good infrared photo. The steam is cooler than the pool, and the Infrared Camera picks up on the temperature of the steam instead of the pool, giving an inaccurate reading.

**Table 27: Data from the Map of Australia, Orakei Korako**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 81.5 | 9 | 0 visible | 250mm below top of ruler | Constant, slow bubbling on right side of pool | Clear, blue (turquoise) |
| 2 July 2012 | 74.2 | 8 | 0 visible | 245mm below top of ruler | Constant, upwelling on right side of pool | Clear, blue-green |
| 20 Sept 2012 | 76 | 8 | <0.5 l/s | 245mm below top of ruler | Constant upwelling in 2 parts of the pool | Clear, turquoise/ green |
| 22 Jan 2013 | 82.5 | 8 | 0.5 l/s | 245mm below top of ruler | Constant upwelling | Clear, turquiose |


**Figure 62: Map of Australia, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

## 6.2 Waihunuhunu Inlet

- **Inlet 1**
  E1875427 N5739204

There were no bathers at the time of the survey in Sept 2012. In Jan 2013 there were 8 bathers in the vicinity of the Inlet. There was a temperature decrease of 10.7°C between Sept 2012 , Jan 2013. The site was not monitored in Apr 2012 and July 2012.

**Table 28: Data from Inlet 1, Waihunuhunu Inlet, Orakei Korako**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 20 Sept 2012 | 63.7 | 6-7 | ~15 | - | - | Clear |
| 22 Jan 2013 | 53 | 7 | 10-12 | - | - | Clear |

**Figure 63: Waihunuhunu Inlet 1, Orakei Korako in Sept 2012 (A), Jan 2013 (B)**

- **Inlet 2**
  E1875395 N5746213

There were no bathers at the time of the survey in Sept 2012 or Jan 2013. The site was not monitored in Apr and July 2012. There were no discernible changes other than slight fluctuations in pH and flow.

**Table 29: Data from Inlet 2, Waihunuhunu Inlet, Orakei Korako**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 20 Sept 2012 | 46.4 | 6 | 3 | - | - | Clear |
| 22 Jan 2013 | 46 | 7 | 4 | - | - | Clear |


**Figure 64: Waihunuhunu Inlet 2, Orakei Korako in Sept 2012 (A), Jan 2013 (B)**

# 7 Reporoa

## 7.1 Butcher's Pool

- E1891720 N5738576

There was an oily, yellow film and algae floating on top of the water, at the time of both visits in Jan 2012 , Jan 2013; however there was a smaller amount in Jan 2013. There were no bathers at either monitoring visit.

**Table 30: Data from Butcher's Pool, Reporoa**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 18 Jan 2012 | 39.1 | 7 | - | 0.5m below rim | Effervescing all over pool | Murky, light green |
| 31 Jan 2013 | 38.6 | 6 | ~1 | o/f | Effervescing all over pool | Murky, green |

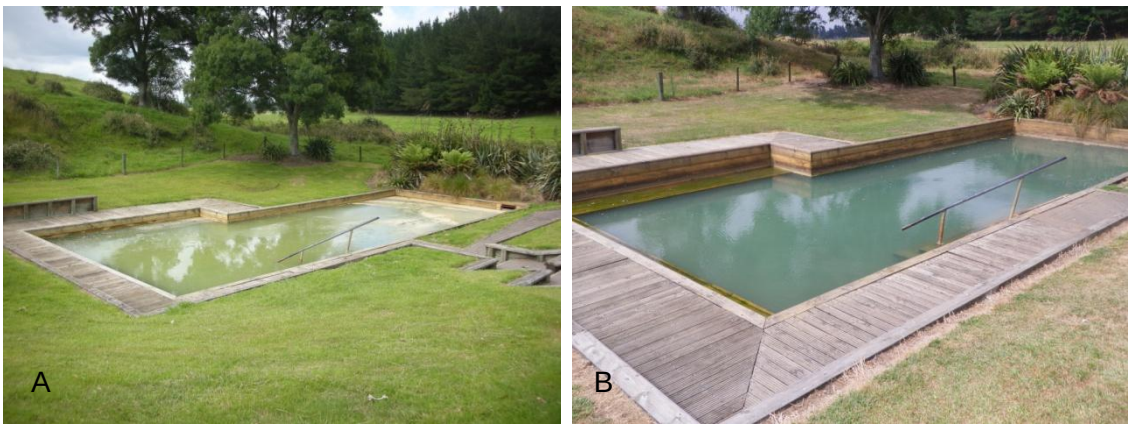


**Figure 65: Butcher's Pool, Reporoa in Jan 2012 (A), Jan 2013 (B)**

The warmest area of the Butchers pool appears to be at the far end of the pool near the outlet.

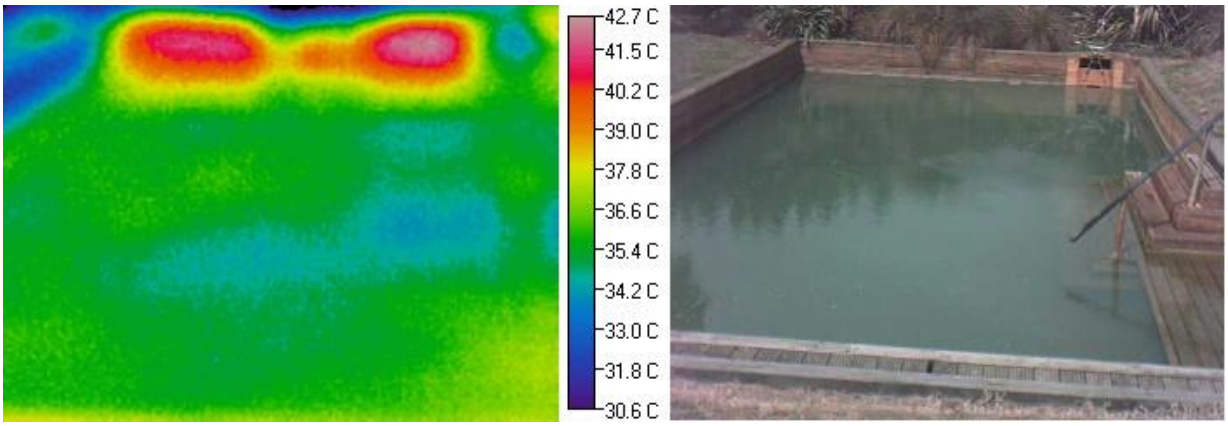


**Figure 66: Infrared photo of Butcher's pool, Reporoa in Jan 2013**

# 7.2 Wharepapa Road

- **Fumaroles**
  E1890802 N5742769

In Jan 2013 Vent 5 was blocked off with grass clumps. Vent 6 is dry ground. There is a notable temperature change in each of the vents, apart from Vent 4.

**Table 31: Data from Fumaroles, Reporoa**

| Date | Vent | T(°C) | Flow | Depth (m) | Diameter (m) | Ebullition | Colour |
|---|---|---|---|---|---|---|---|
| 18 Jan 2012 | 1 | 49.8 | steam | ~0.8 | ~0.2 | Audible gas discharge | Black mud |
| 23 Jan 2013 | 1 | 71.4 | nd | ~1.5 | ~0.23 | Audible gas discharge | Black mud |
| 18 Jan 2012 | 2 | 60.1 | steam | ~1.0 | ~0.5 | Audible gas discharge, bubbling mud | Black mud |
| 23 Jan 2013 | 2 | 71.2 | Steam | ~1.7 | ~0.6 | Audible gas discharge | Black mud |
| 18 Jan 2012 | 3 | 70.1 | steam | ~1 | ~0.3 | Audible gas discharge, bubbling mud | Black mud |
| 23 Jan 2013 | 3 | 76.2 | nd | ~1.6 | ~0.5 x 0.66 | Audible gas discharge | Black mud |
| 18 Jan 2012 | 4 | 61.1 | steam | ~1.5 | ~1.0 x 0.5 | Audible gas discharge | Black mud |
| 23 Jan 2013 | 4 | 61 | nd | ~3 (angled) | ~0.67 x 1 | Audible gas discharge | Black mud |
| 18 Jan 2012 | 5 | 61.1 | steam | ~0.3 | ~0.3 | Audible gas discharge, bubbling mud | Black mud |
| 23 Jan 2013 | 5 | 65 | nd | ~0.6 | ~0.6 x 0.7 | nd | nd |
| 18 Jan 2012 | 6 | 79.9 | steaming ground | ground level | ~0.3 | nd | nd |
| 23 Jan 2013 | 6 | 91.1 | nd | ground level | ~0.6 | nd | nd |


**Figure 67: Jan 2012: A) Overview of Fumaroles; B) Vents 1 & 2; C) 3; D) 4; E) 5; F) 6**

**Figure 68: Jan 2013 Fumaroles. A) Overview; B) Vents 1 & 2; C) 3; D) 4; E) 5; F) 6**

- **Figure 8 shaped pools**
  E1890786 N5742843

In Jan 2012 the water level had risen and the pools had merged. The larger pool was more active, and the pH appeared to be different between the pools. In Jan 2013 the water level was lower so the pools were separate.

**Table 32: Data from Figure 8 shaped pools, Reporoa**

| Date | Pool | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|---|
| 18 Jan 2012 | Large | 86.7 | 7 | nd | 0.2m below ground | Upwelling, gas discharge | Clear, dark grey/brown mud base |
| 23 Jan 2013 | Large | 96.6 | 8 | nd | 0.8m below ground | Vigorous discharge, surging | Dark brown,0 visibility |
| 18 Jan 2012 | Small | 81.5 | 9 | nd | 0.2m below ground | Calm | Clear, grey/brown mud base |
| 23 Jan 2012 | Small | 81.2 | 8 | nd | 0.8m below ground | Calm | Dark brown,0 visibility |

**Figure 69: Figure 8 shaped pools, Reporoa**

The infrared photos below show the large and the small pool separately. The hottest area of both pools is in the centre of each pool. The large pool is hotter than the small pool.

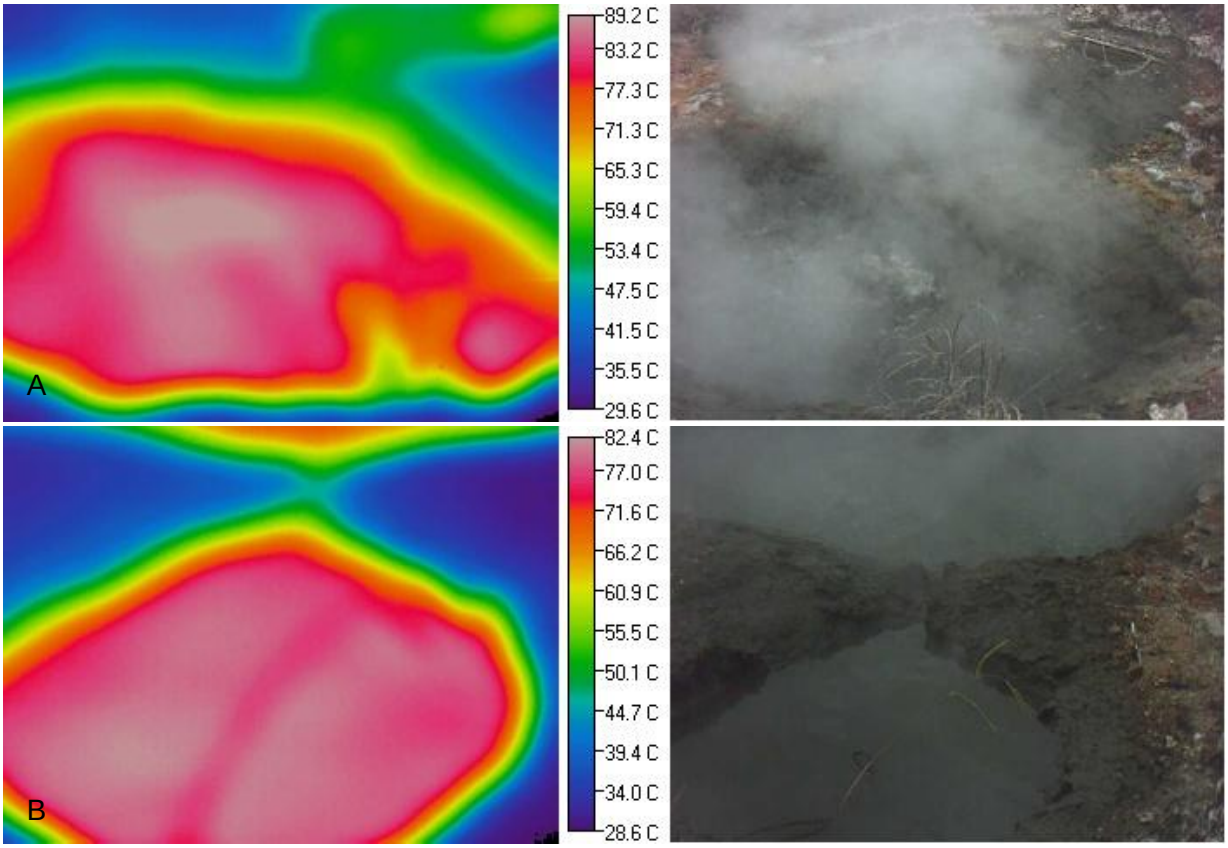


**Figure 70: Infrared photos, Figure 8 pools, Jan 2012; Large pool (A) and Small pool (B)**

- **Hot Pool 3**
  E2800959 N6304325

This pool has been fenced off. The temperature had increased by 6.3°C and the pH had dropped from pH9 to pH7 since Jan 2012. The flow has also decreased over the monitoring period. There was too much steam to take an infrared photo.

**Table 33: Data from Hot Pool 3, Reporoa**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 18 Jan 2012 | 86.7 | 9 | ~5 | o/f | Slow, constant upwelling | Clear, blue |
| 23 Jan 2013 | 93 | 7 | ~1.5 | o/f | Calm, some steam | Clear, blue |


**Figure 71: Hot pool 3, Reporoa in Jan 2012 (A&B), Jan 2013 (C&D)**

- **Hot Pool 4**
  E1891154 N5743025

The pool appears to have a muddy base, with several areas of steaming ground around the pool. The water level has dropped significantly and the temperature has increased by 13.2°C since the previous visit in Jan 2012.

**Table 34: Data from Hot Pool 4, Reporoa**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 18 Jan 2012 | 67.8 | 4 | nd | 0.1m below rim | Constant bubbling, audible gas discharge | Murky, grey |
| 23 Jan 2013 | 81 | 5 | nd | 1.5m below rim | Constant gas discharge | Murky, brown |

**Figure 72: Hot Pool 4, Reporoa in Jan 2012 (A), Jan 2013 (B)**

## 7.3 Longview Road

- **Lake**

A large part of the lake surface was covered in a foamy substance. Matt Stott from GNS says that their understanding is that it is a eutrophic water body, which has lots of organic matter. The 'scunge' on top is most likely a combination of aerobic bugs and plant biomass that is being blown around the lake. The appearance of 'scunge' would change depending on the wind velocity and direction.

There was more 'scunge' in Jan 2013 than there had been in Apr 2012. The temperature had also increased by 8.5°C.

**Table 35: Data from Lake, Longview Road, Reporoa**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 20 Apr 2012 | 23.2 | 3 | nd | nd | Effervescing | Emerald green, murky |
| 23 Jan 2013 | 31.7 | 3 | nd | nd | Effervescing | Green, murky |


**Figure 73: Lake, Longview Road, Reporoa in Apr 2012 (A&B), Jan 2013 (C&D)**

- **Mud Pool**

There were various mud pools in the area, we chose to sample the large one close to the lake. We could not get an accurate reading of the pH with the pH paper, nothing matched it so we determined that it was <3. We also took photos of the other mud pools beside the large one. The water level in Jan 2013 was lower than it had been in Apr 2012.

**Table 36: Data from Lake, Longview Road, Reporoa**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 20 Apr 2012 | 18.3 | <3 | nd | 0.3m below rim | Effervescing | Murky, brown with mud base |
| 23 Jan 2013 | 23.2 | <3 | nd | 1m below rim | Gas discharge | Murky, brown |


**Figure 74: Mud pool, Longview Road, Reporoa in Apr 2012 (A&B), Jan 2013 (C&D)**

The infrared photo shows that the warmest area of the mud pools is a vent next to the large pool. The mud pool itself seems to be the coolest.

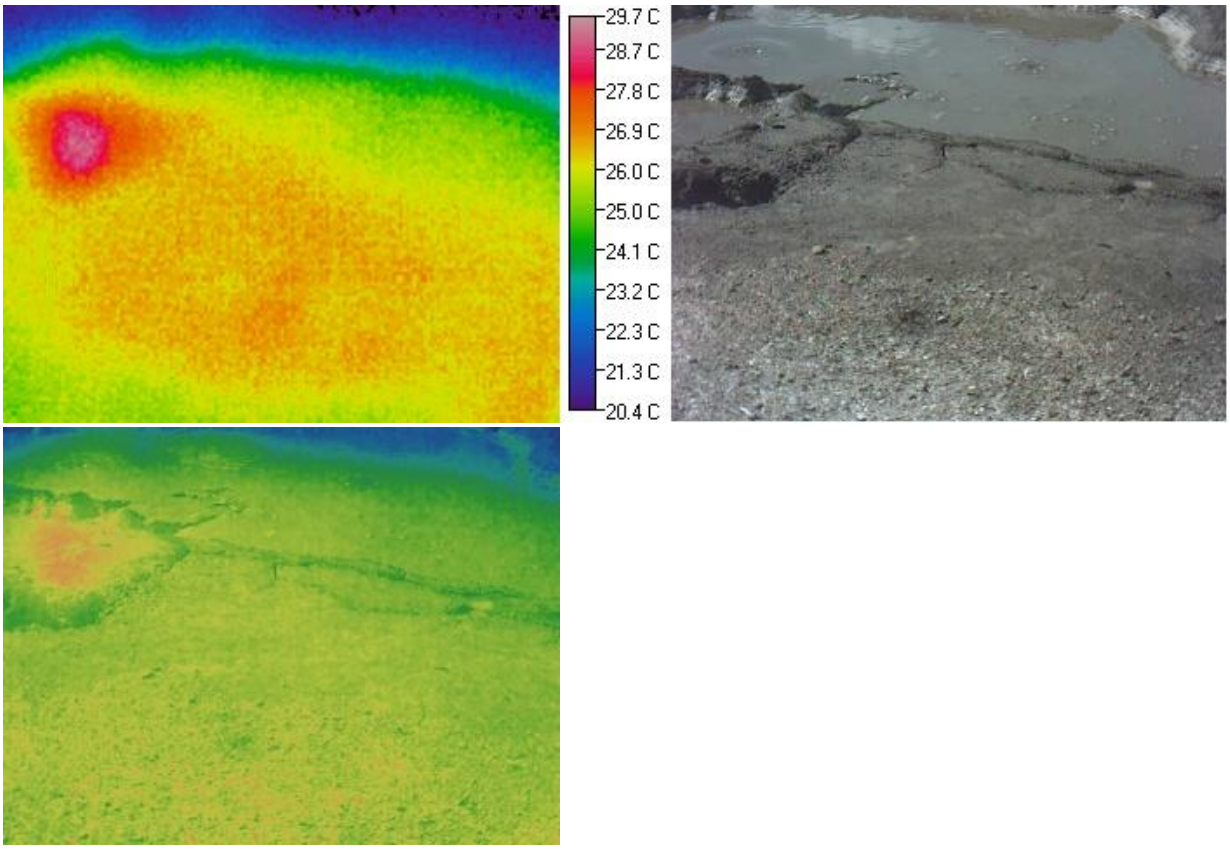


**Figure 75: Infrared photo, mud pool, Longview Road, Reporoa in Jan 2013**


**Figure 76: Small mud pool, Longview Road, Reporoa in Apr 2012 (A), Jan 2013 (B)**

# 8 Rotokawa

In Jan 2013 we were only able to visit RK3 at Rotokawa due to high gas levels. Apr 2012 was our first visit to the area.

## 8.1 Parariki Stream

**Table 37: Data from Parariki Stream, Rotokawa**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 20 Apr 2012 | 77.9 | 3 | 20 | - | Calm | Clear, green |

**Figure 77: Parariki Stream, Rotokawa**

## 8.2 Lagoon Springs

- **RK3**

The temperature had decreased slightly (3.9°C) from Apr 2012 to Jan 2013. There have also been changes in ebullition and colour (see Table 38).

**Table 38: Data from RK3, Rotokawa**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 20 Apr 2012 | 57.9 | 3 | nd | o/f | Several areas of gas discharge | Pale, cloudy green. Areas of yellow. |
| 29 Jan 2013 | 54 | 3 | nd | nd | Calm | Murky, blue |

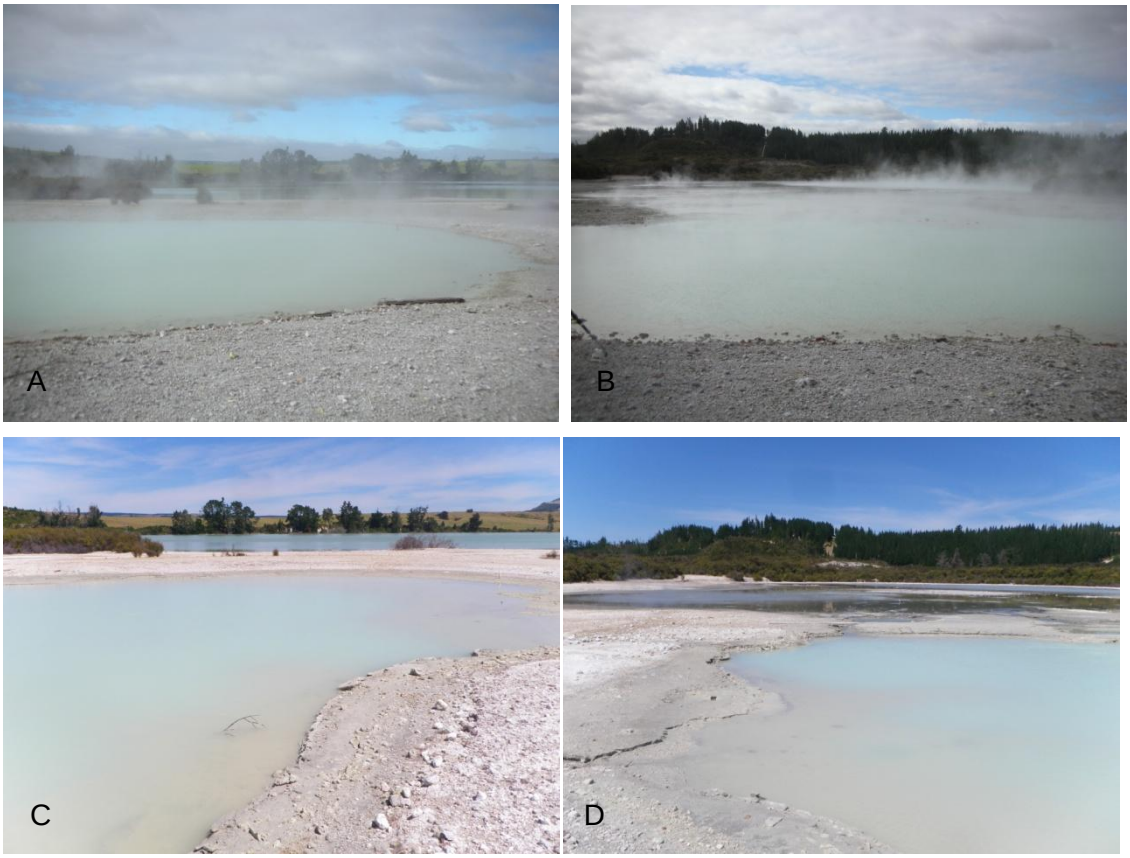


**Figure 78: RK3, Rotokawa in Apr 2012 (A&B), Jan 2013 (C&D)**

- **RK4**

RK4 a & b were overflowing into each other. We could nott get close enough to RK4k to sample from it.

**Table 39: Data from RK4, Rotokawa**

| Pool | Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|---|
| a | 20 Apr 2012 | 59.3 | 3 | - | o/f | Constant gas discharge | Pale, cloudy green. Pale yellow mud. |
| b | 20 Apr 2012 | 45.9 | - | - | o/f | Small areas of discharge | Pale, cloudy green |

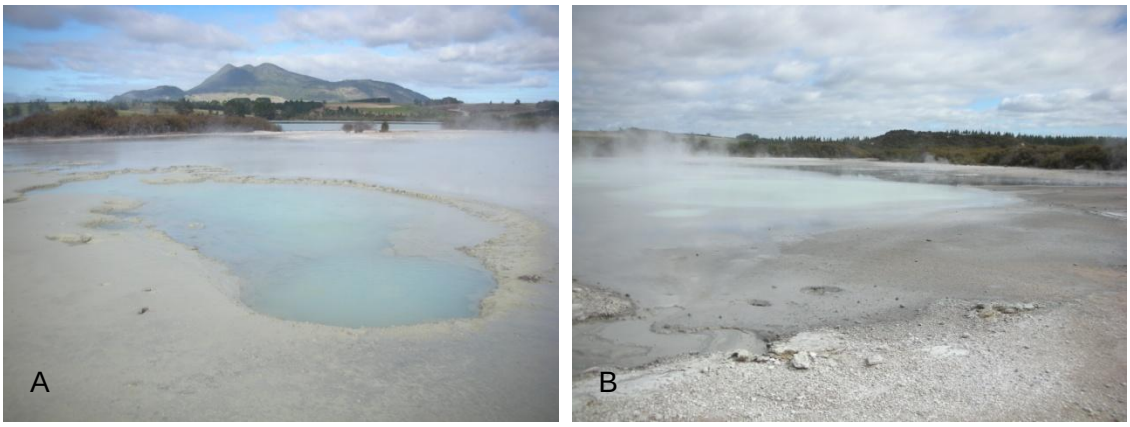


**Figure 79: RK4a&b (A) and RK4k (B), Rotokawa**

- **RK6**

**Table 40: Data from RK6, Rotokawa**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 20 Apr 2012 | 50.7 | - | seep | o/f into lake | Numerous areas of discharge | Pale, cloudy green |

**Figure 80: RK6, Rotokawa**

# 8.3 Pools on other side of track

- **Closest pool**

**Table 41: Data from pool on left of track, Rotokawa**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 20 Apr 2012 | 33.7 | 7 | - | 5cm below rim | Constant vigorous discharge | Dark grey, murky |

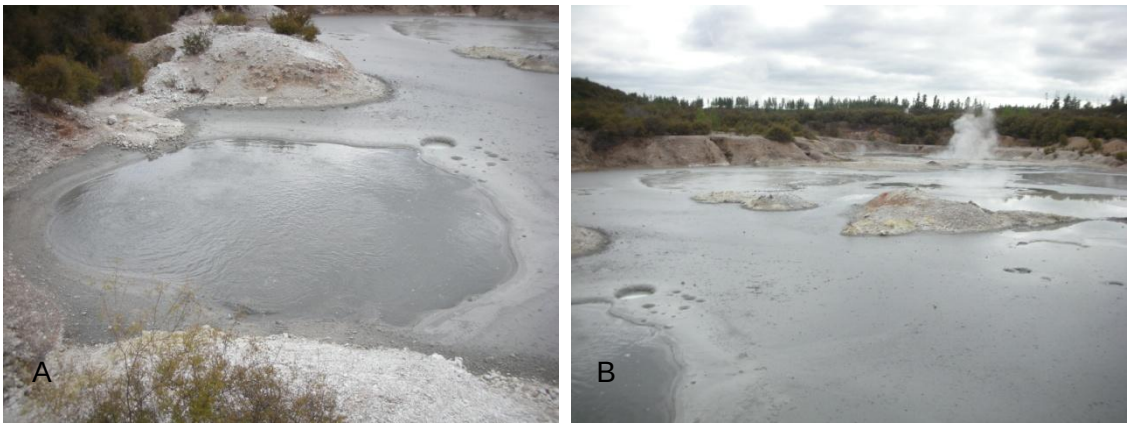


**Figure 81: Pool sampled (A) and overview of area (B)**

# 8.4 Craters

- **RK1001**

The temperature was read from the top of the crater with the IR Gun.

**Table 42: Data from RK1001, Rotokawa**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 20 Apr 2012 | 62.9 | - | nd | - | Gas discharge around edges, some discharge in main pool | Milky turquoise |

**Figure 82: RK1001, Rotokawa**

- **Second crater near RK1001**

The temperature was read from the top of the crater with the IR Gun.

**Table 43: Data from crater near RK1001, Rotokawa**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 20 Apr 2012 | 89.9 | - | nd | - | Vigorous steaming, boiling | Clear, light green |


**Figure 83: View towards second crater (A) and photo of crater (B), Rotokawa**

# 9 Tauhara

## 9.1 Lake Taupo Shore

- **Tharepa Spring**
  E1882989 N5733159; Located number 1197.1

Apart from the main Tharepa Spring, there are several small springs feeding into the main pool. The spring temperature had decreased in Sept 2012, andcreased again in Jan 2013. There was an oily film on the surface in Apr 2012 , Jan 2013.

There were no bathers present during any of the monitoring visits.

**Table 44: Data from the Tharepa Spring, Tauhara**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 4 Apr 2012 | 65.5 | 7 | seep | nd | No gas | Clear, oily slick in pools |
| 2 July 2012 | 64.3 | 6 | <0.5 | nd | No gas | Clear |
| 19 Sept 2012 | 51.0 | 7 | Seep | overflowing | No gas | Clear with an oily film on the surface |
| 31 Jan 2013 | 64.6 | 7 | Seep | o/f | No gas | Clear |


**Figure 84: Tharepa Spring, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

The infrared photos show the heat emanating from the spring as it flows out of the rock and makes its way into Lake Taupo.

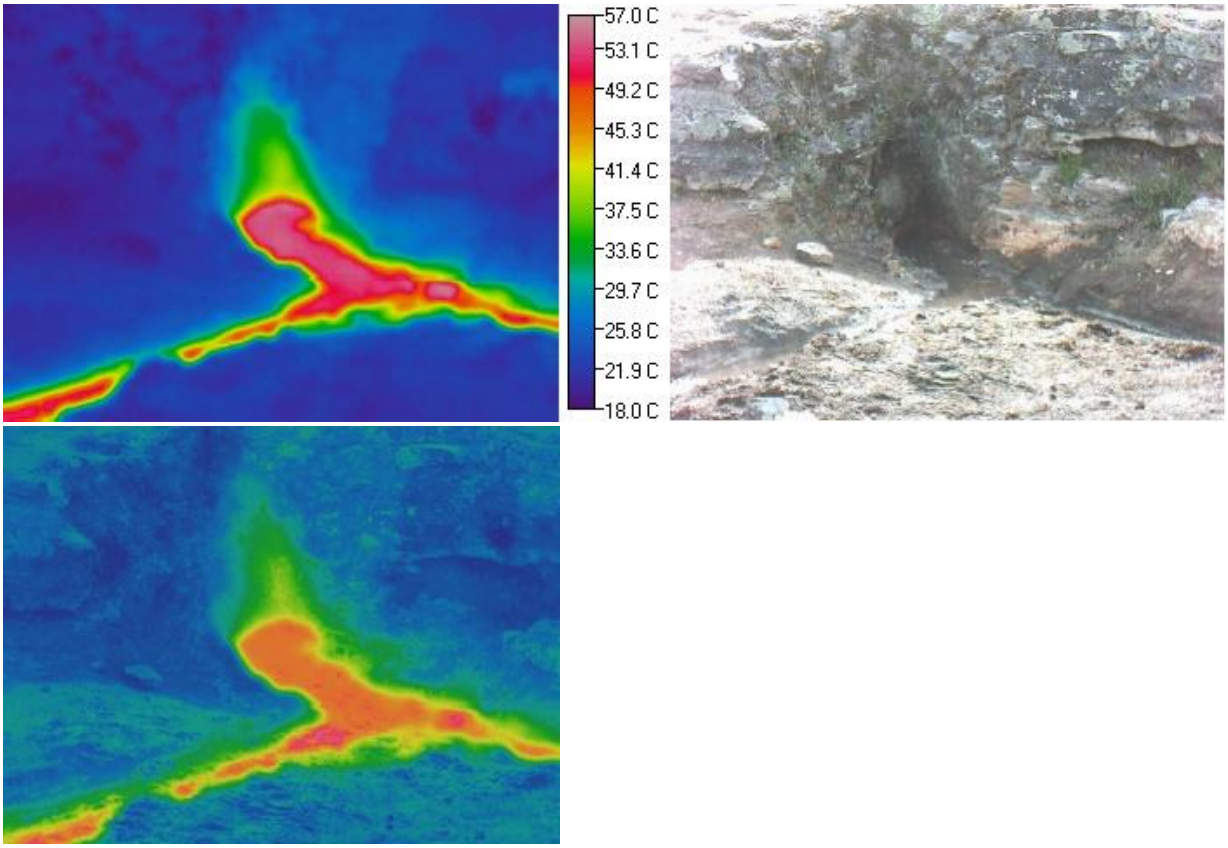


**Figure 85: Infrared photos showing the Taharepa Spring in Jan 2013**

- **Rocky Point Spring**
  E1868286 N5711795; Located number 72.2988

There were no bathers near the spring in Apr, July and Sept 2012. It was not possible to take an accurate reading from the spring in Sept 2012 due to the lake level being higher than the spring.

**Table 45: Data from the Rocky Point Spring, Tauhara**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 4 Apr 2012 | 65.0 | 7 | - | o/f | Constant bubbles | Clear |
| 2 July 2012 | 65.3 | 6 | <0.5 | o/f | Calm | Clear |
| 19 Sept 2012 | 30 | - | - | Lake overflowing into the spring | - | Clear |
| 31 Jan 2013 | 62 | 6-7 | <0.5 | o/f | Calm | Clear |

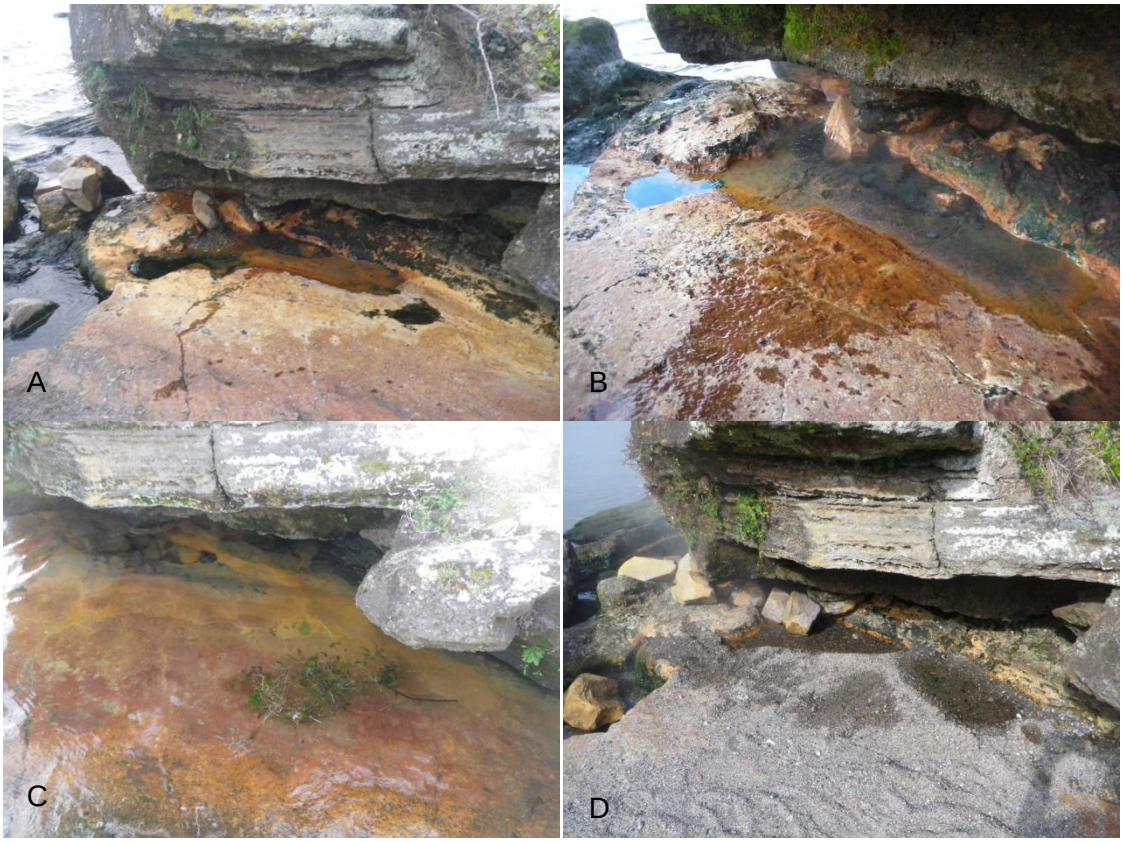


**Figure 86: Rocky Point Spring, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

The infrared photos in Figure 87 show the origin and path of the water from the spring as it flows into Lake Taupo.

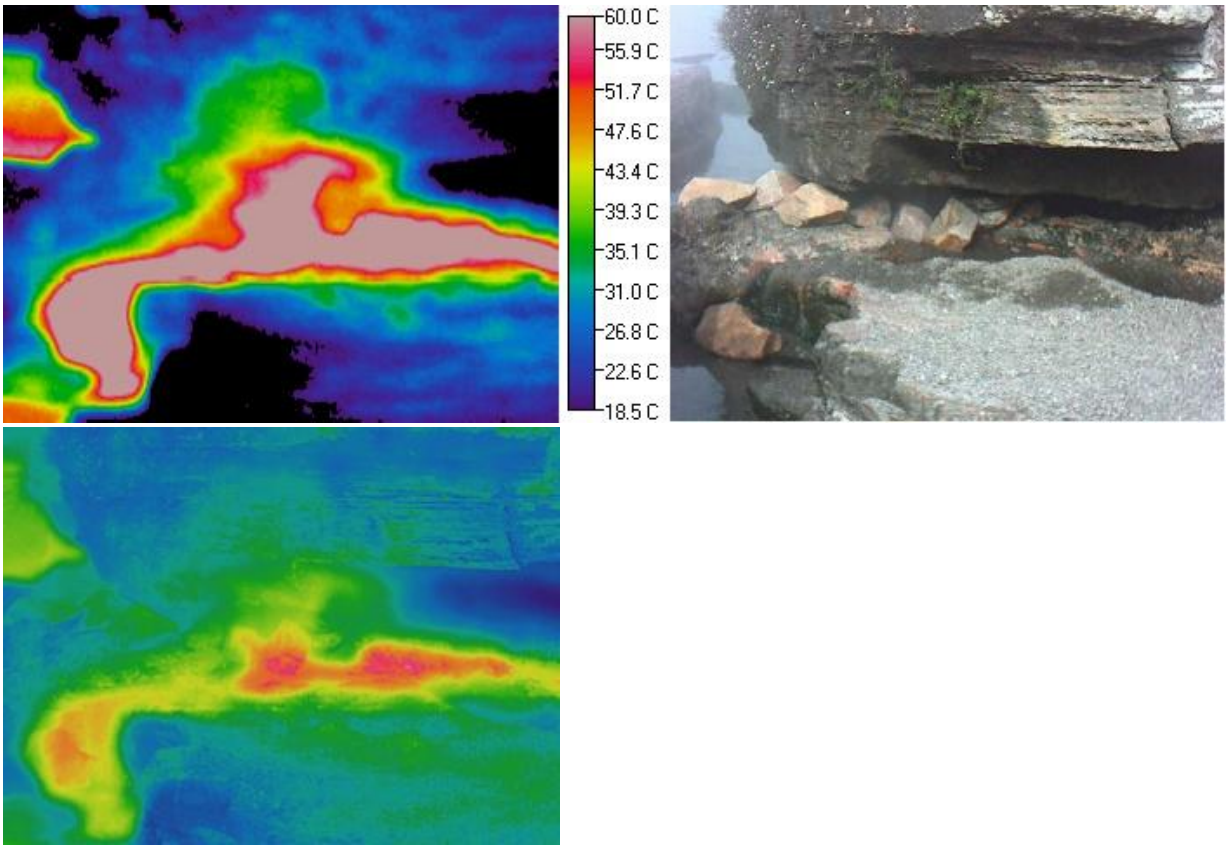


**Figure 87: Infrared photos of Rocky Point Spring in Jan 2013**

# 9.2 Otumuheke

- **End of Ponga**
  E1869102 N5715081

The site is at the end of the ponga fence next to the Spa Hotel. There was green algae on the stream bed during all visits. The temperature has remained fairly consistent at all the visits. No infrared photos are included in this report.

**Table 46: Data from the Otumuheke Stream, the end of the Ponga fence, Tauhara**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 4 Apr 2012 | 50.4 | 6 | ±30-40 | nd | No gas | Clear |
| 2 July 2012 | 48.6 | 5-6 | ~40 | nd | No gas | Clear |
| 19 Sept 2012 | 50.5 | 7 | 20-30 | nd | No gas | Clear |
| 21 Jan 2013 | 53.7 | 7 | 40 | - | - | clear |


**Figure 88: Otumuheke Stream, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

- **Confluence under bridge**

The site is located on the bridge next to the Spa Hotel. There was algae on the bed of both streams with brown/yellow sediment on the bed of the right tributary. The temperature was hotter in Jan 2013 than any of the previous monitoring visits. No infrared photos are included in this report.

**Table 47: Data from the right tributary to the Otumuheke Stream by the bridge, Tauhara**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 4 Apr 2012 | 49.4 | 7 | ±2 | nd | No gas | Clear |
| 2 July 2012 | 48.8 | 5 | ~1 | nd | No gas | Clear |
| 19 Sept 2012 | 47.9 | 7 | ~2 | nd | No gas | Clear |
| 21 Jan 2013 | 52.5 | 7 | 2-3 | nd | No gas | Clear |

**Table 48: Data from the Otumuheke Stream by the bridge, Tauhara**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 4 Apr 2012 | 50.3 | 7 | ±30-40 | nd | No gas | Clear |
| 2 July 2012 | 47.5 | 5 | ±30-40 | nd | No gas | Clear |
| 19 Sept 2012 | 48.0 | 7 | ±20-30 | nd | No gas | Clear |
| 21 Jan 2013 | 53.6 | 7 | 40 | nd | No gas | Clear |


**Figure 89: Otumuheke Stream, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

- **Spa Thermal Park**

The Otumuheke Stream runs into the Waikato River in Spa Thermal Park. Table 49 details the number of bathers present at the time of visiting the area.

**Table 49: Data from Spa Thermal Park, Tauhara**

| Date | Time | No. Of Bathers | No. Of Bystanders |
|---|---|---|---|
| 4 Apr 2012 | 16:00 | 19 | 0 |
| 26 June 2012 | 15:38 | 14 | 0 |
| 19 Sept 2012 | 14:42 | 4 | 3 |
| 21 Jan 2013 | 12:10 | 5 | 11 |

**Figure 90: Otumuheke Stream, Spa Thermal Park (Tauhara)**

# 9.3 Waipahihi Source

- **Source Spring**
  E1869804 N5711669; Located number 72.2989

The temperature was cooler in Sept 2012, and the flow had increased. The temperature was back up in Jan 2013.

**Table 50: Data from the Waipahihi Source Spring, Tauhara**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 4 Apr 2012 | 69.7 | 7 | <0.5 | Overflowing | Calm, steam | Clear, grey |
| 26 June 2012 | 71.4 | - | 0.5-1.0 | Overflowing | Calm, steam | Clear |
| 19 Sept 2012 | 63 | 7 | 1-2 | Overflowing | Calm, steam | Clear |
| 31 Jan 2013 | 69.6 | 7 | <1 | Overflowing | Calm | Clear |


**Figure 91: Waipahihi Source, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

The infrared photos in Figure 92 show the hot area where the spring is situated and the flow path into the stream.

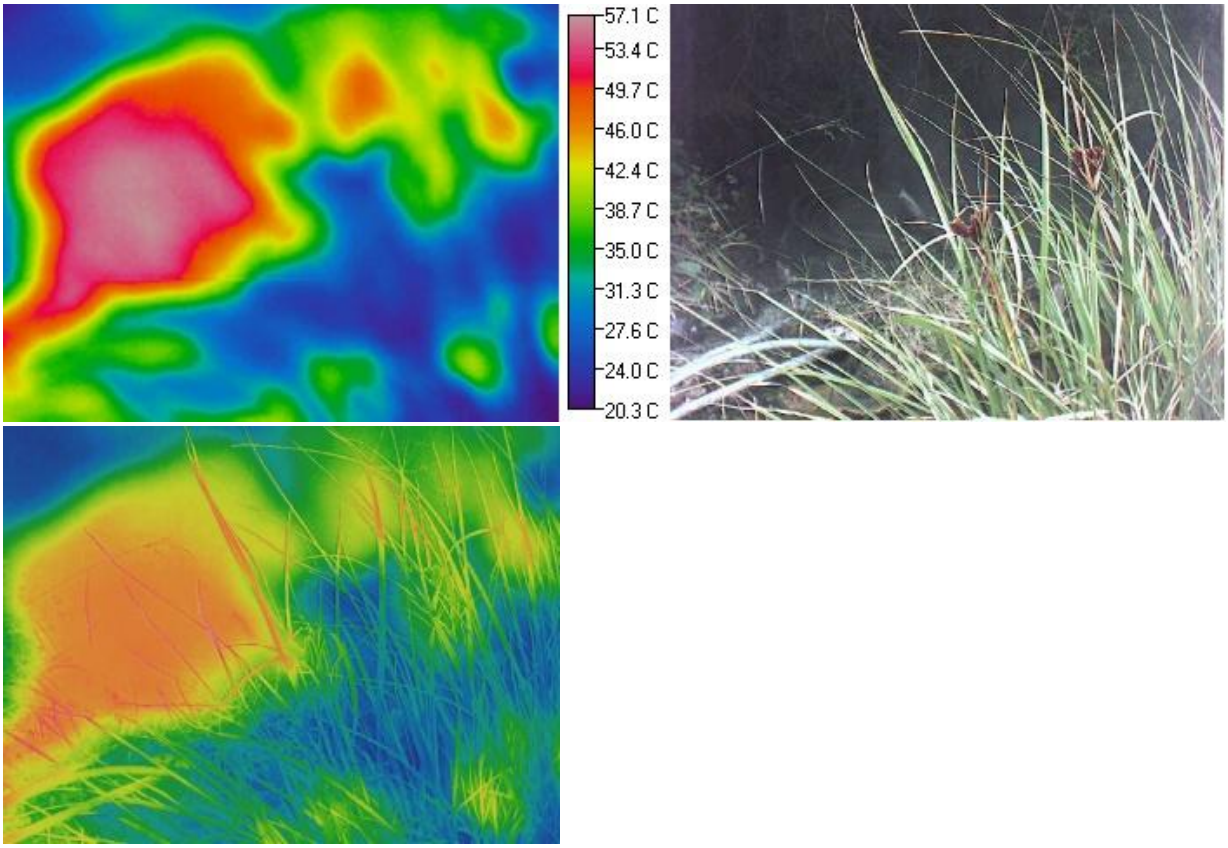


**Figure 92: Infrared photos, Waipahihi Spring in Jan 2013**

- **New Spring**

This is a spring that has formed near the weir. There are new deposits of exposed sinter and the stream appears to be widening. Yellow/green algae is growing on the streambed and on the sinter.

**Table 51: Data from the New Spring, Waipahihi, Tauhara**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 4 Apr 2012 | 69.2 | 7 | ~1 | Overflowing | Calm | Clear |
| 26 June 2012 | 68.1 | - | <0.5 | Overflowing | Calm | Clear |
| 19 Sept 2012 | 66.7 | 7 | <0.5 | Overflowing | Calm | Clear |
| 31 Jan 2013 | 67 | 7 | <0.5 | Overflowing | Calm | Clear |


**Figure 93: New Spring, Apr 2012 (A), June 2012 (B), Sept 2012 (C), Jan 2013 (D)**

# 10 Te Kopia

Located number 72.2117

## 10.1 Mud Geyser and associated pools

- **Large pool and mud volcano**
  E1880802 N5744756

We could not access the large pool and mud volcano in Jan 2013. While we were at the Mud Geyser on Geyser Ridge we could see an eruption in the vicinity of the mud volcano.

- **Large Pool and Mud Geyser on Geyser Ridge**
  E1880758 N5744696

During the Jan 2013 monitoring visit it was noted that the temperature was 77°C (down from 79.1°C in the previous visit in Jan 2012). The water level was approximately 3m below the rim. The colour of the water was brown/beige and cloudy. There was constant discharge in several areas of the pool.

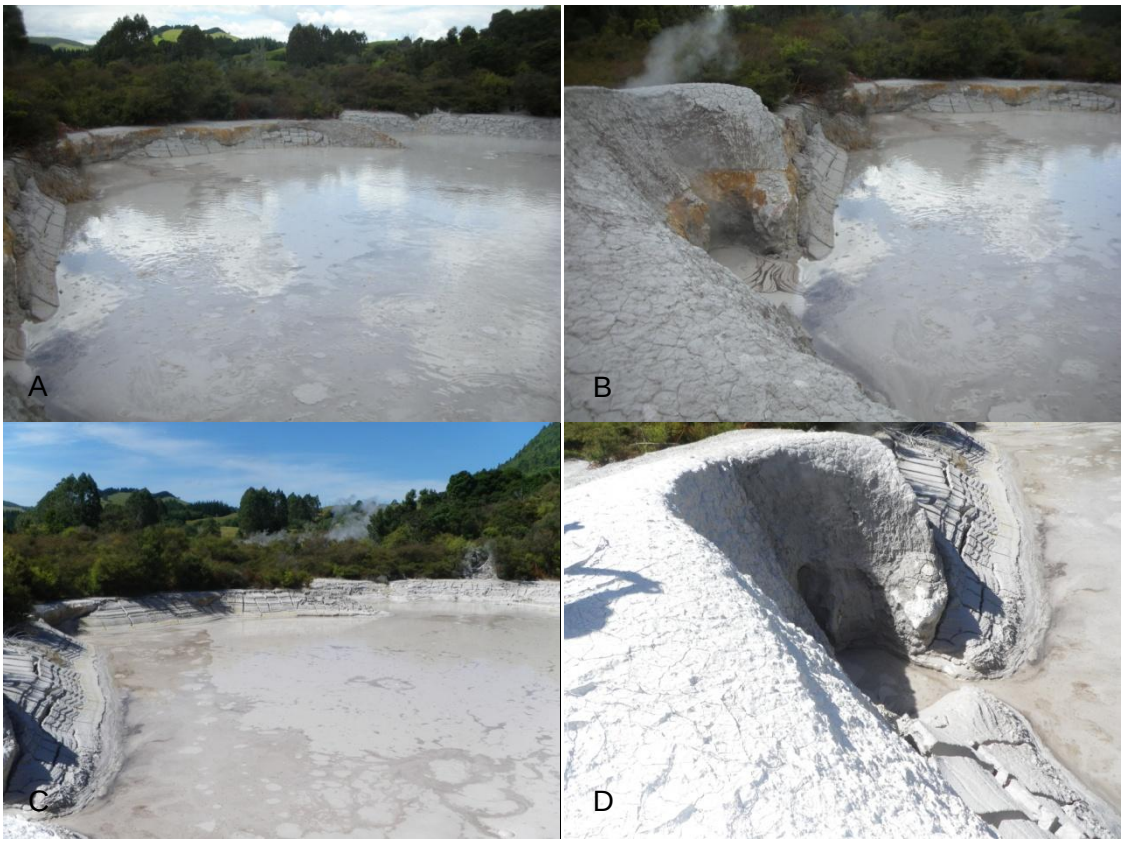


**Figure 94: Large Pool (A) and Mud Geyser (B), Jan 2012. (C) and (D), Jan 2013**

The infrared photos in Figure 95 show the heat in the vicinity of the Mud Geyser, and well as a vent just above the geyser.

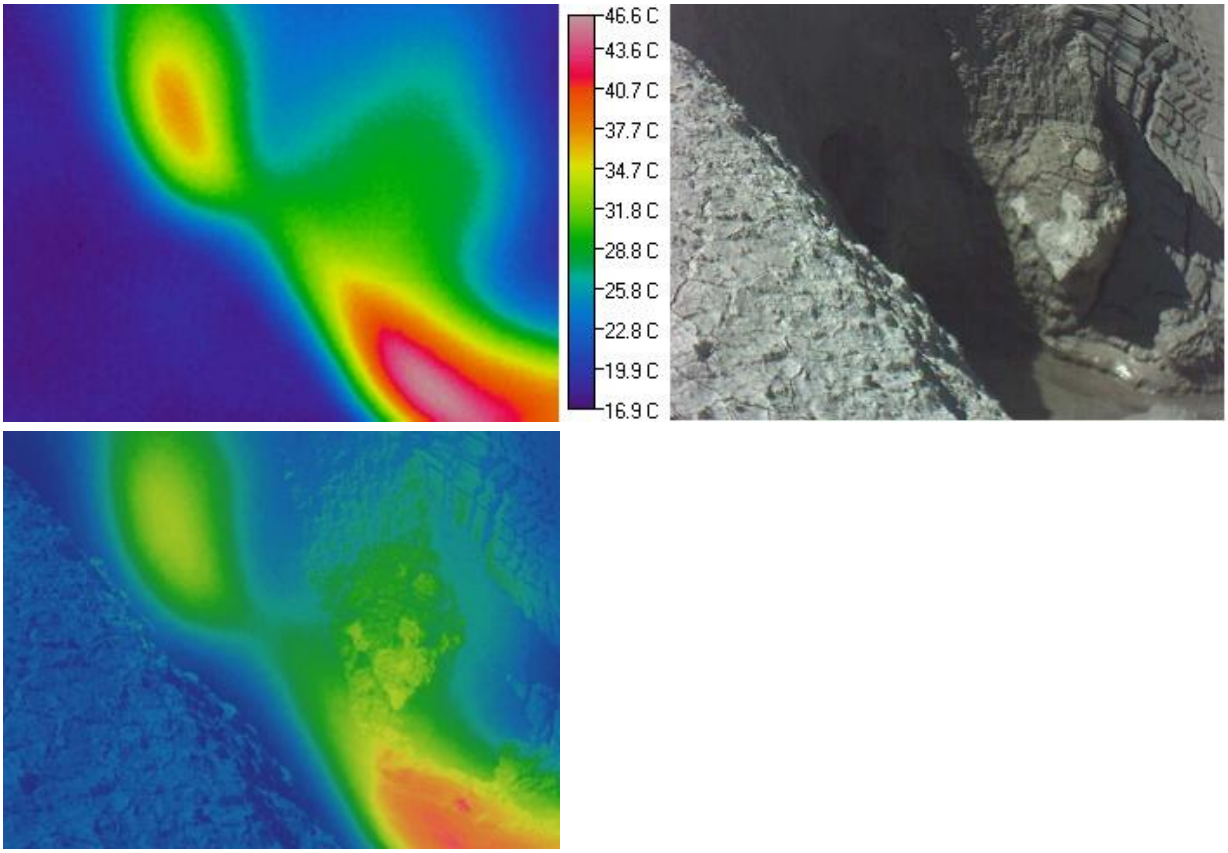


**Figure 95: Infrared photo, Mud Geyser on Geyser Ridge, Te Kopia in Jan 2013**

The Large pool on Geyser Ridge appears to be warmest where it is closest to the mud geyser.

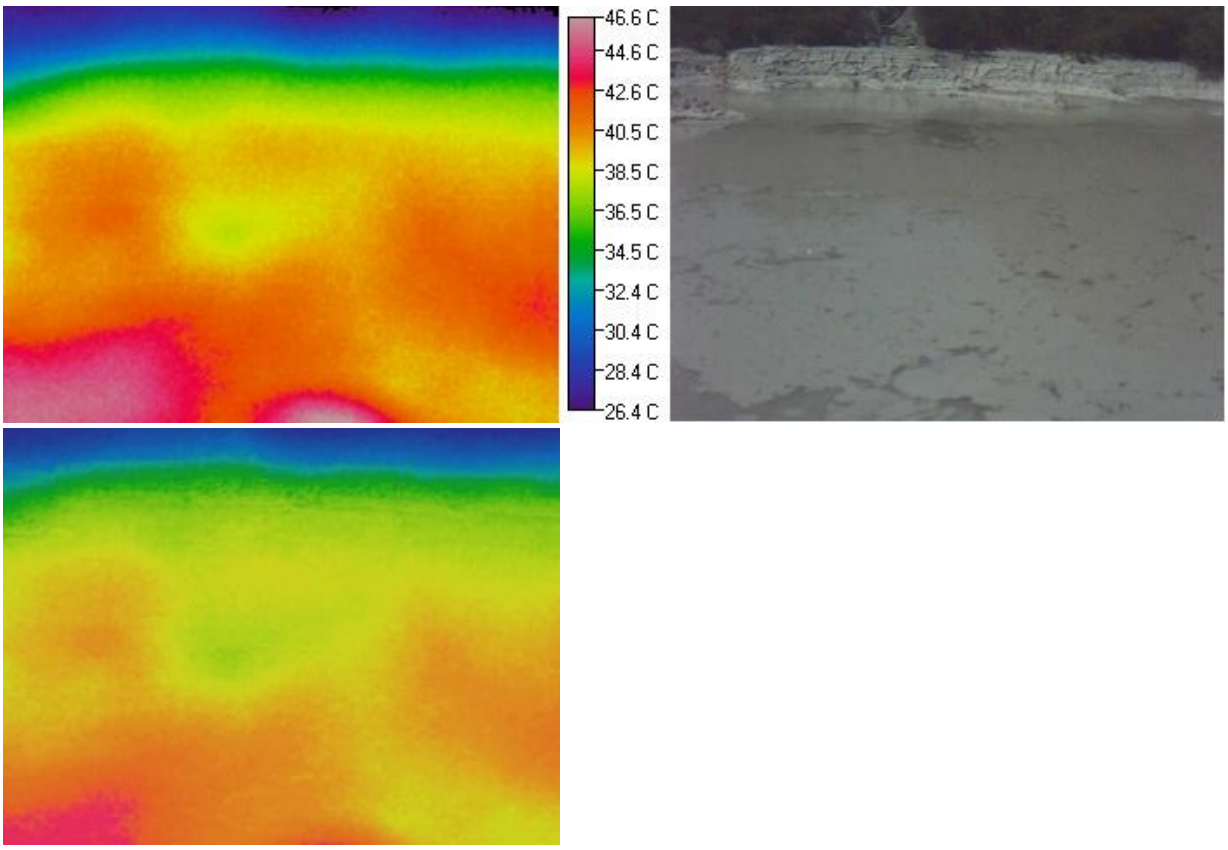


**Figure 96: Infrared photo, Large Pool on Geyser Ridge, Te Kopia in Jan 2013**

- **Small Mud Pool on Geyser Ridge**
  E1880750 N5744694

There was evidence of a recent eruption in both Jan 2012 and Jan 2013. There was a temperature increase of 21.9ºC over the monitoring periods.

**Table 52: Data from the small mud pool on Geyser Ridge, Te Kopia**

| Date | T(°C) | Flow (l/s) | Depth (m) | Diameter (m) | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 17 Jan 2012 | 61.1 | Steam | 0.5 | ~1.5 x 2 | Gas discharge | Light grey mud |
| 22 Jan 2013 | 83 | Steam | 1.1 | ~1.3 x 2.2 | Calm | Light grey mud |

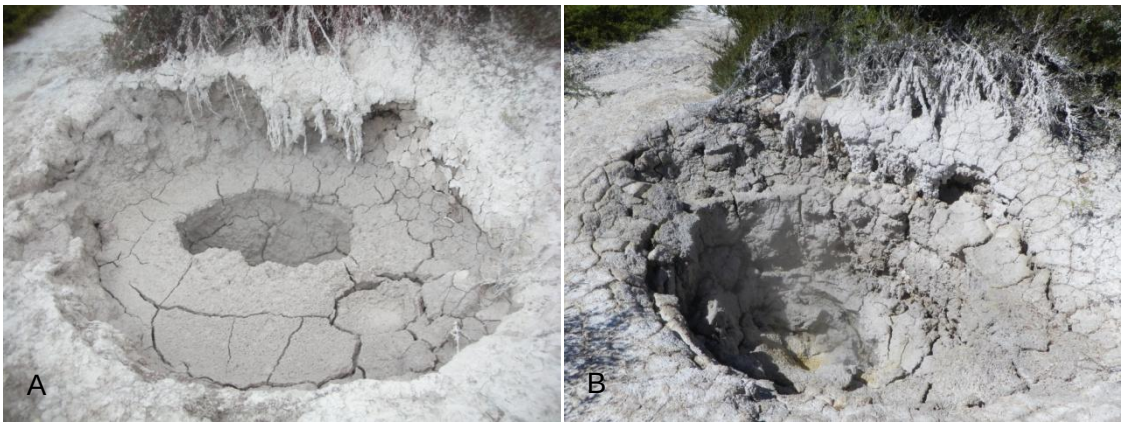


**Figure 97: Small mud pool on Geyser Ridge, Te Kopia in Jan 2012 (A), Jan 2013 (B)**

The hottest part of the mud pool appears to be near the front of the pool.

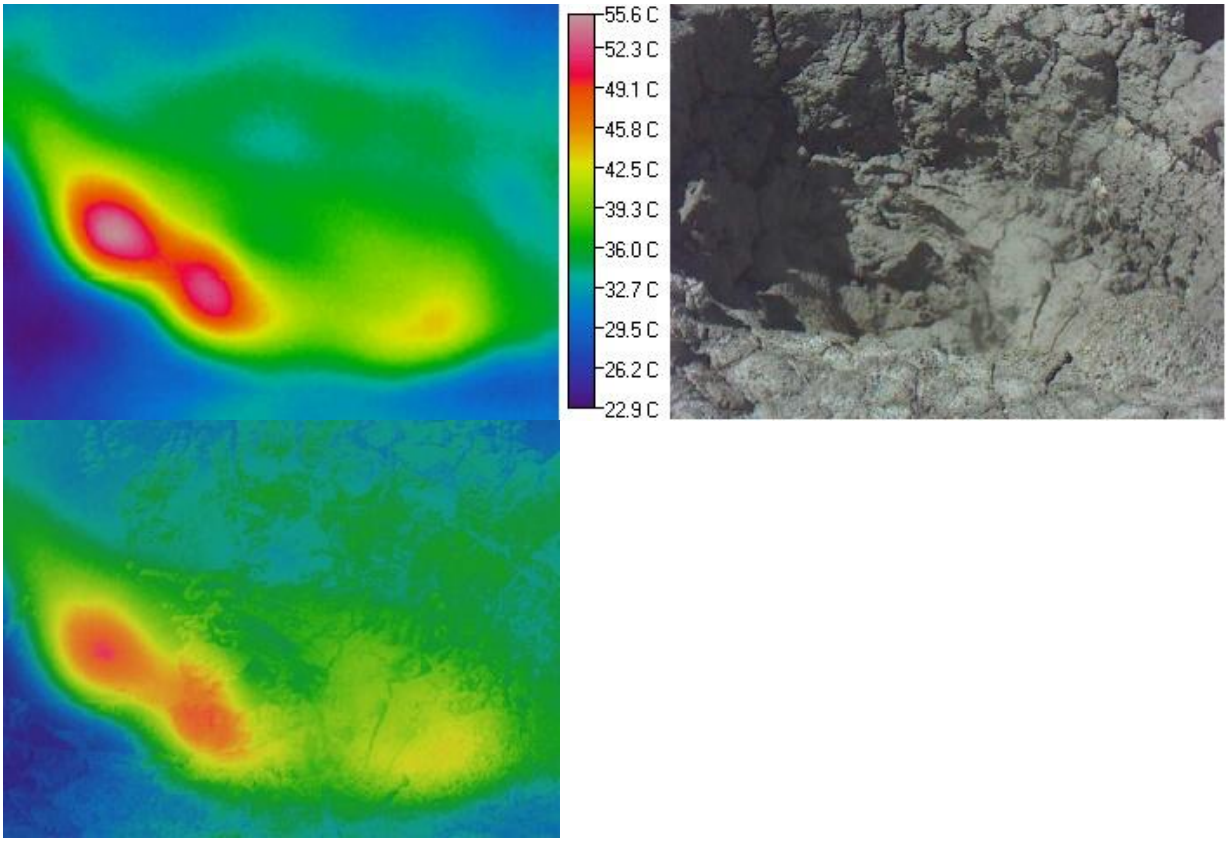


**Figure 98: Infrared photos, small mud pool on Geyser Ridge, Te Kopia in Jan 2013**

## 10.2 Mud Pools (Tomos) on west of Te Kopia Road

- **TK8**

There was dried mud at the base of the vent with a little steam. The IR gun measured 45.6°C.

**Table 53: Data from TK8 on Te Kopia Road**

| Date | T(°C) | pH | Flow (l/s) | Depth to water | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 20 Apr 2012 | 45.6 | - | Little steam | - | Calm | Brown-grey mud at base |
| 22 Jan 2013 | 60 | - | Steam | Dry | Audible discharge | Brown-grey mud at base |

**Figure 99: TK8, Te Kopia in Apr 2012 (A), Jan 2013 (B)**

The hottest area of TK8 appears to be at the base of the vent.

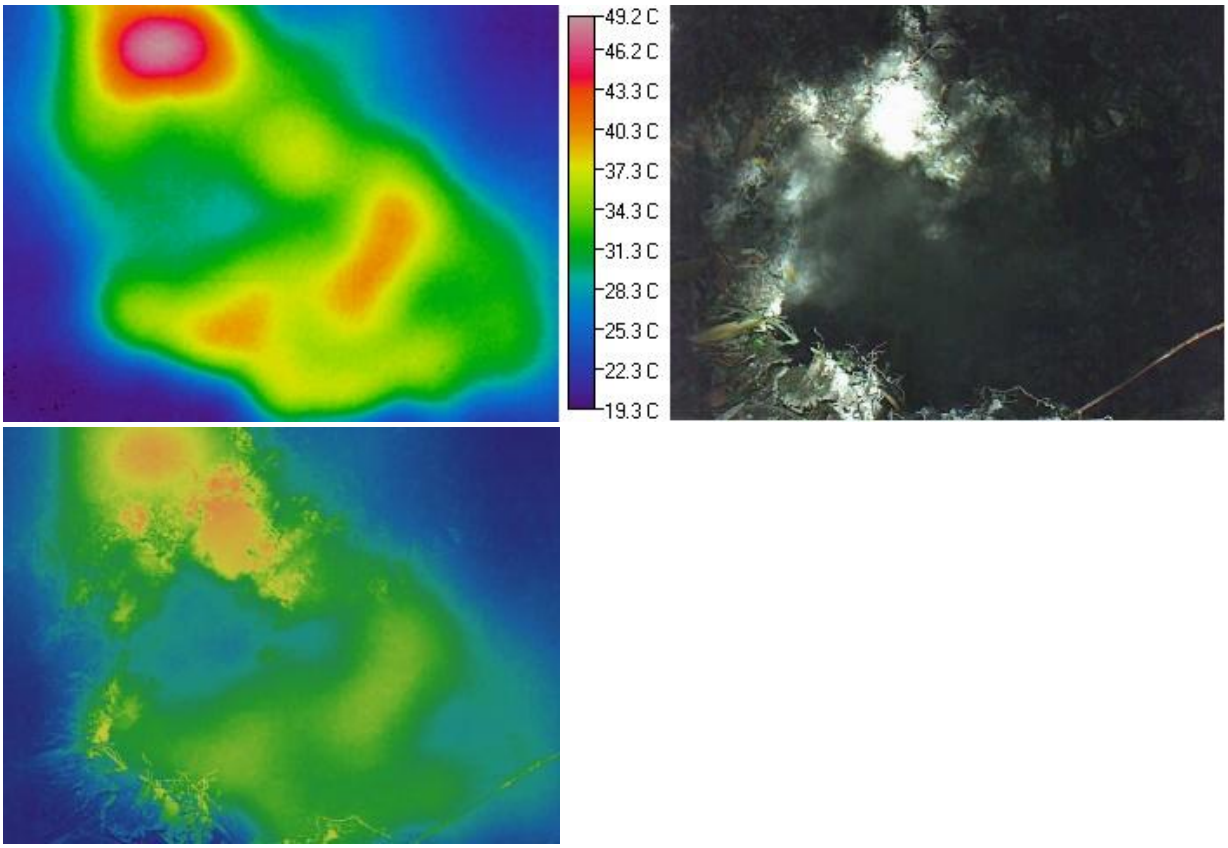


**Figure 100: Infrared photos of TK8, Te Kopia in Jan 2013**

- **Doom**

We did not find Doom in Apr 2012. In Jan 2013 there did not appear to be any activity in the vent. There was no infrared photo taken of Doom

**Table 54: Data from Doom on Te Kopia Road**

| Date | T(°C) | pH | Flow (l/s) | Depth to water | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 22 Jan 2013 | 20 | - | - | Dry | Calm | nd |

**Figure 101: TK8, Te Kopia in Jan 2013**

- Pools by the stream

The temperature has increased by 18.9ºC since the previous visit in Apr 2012.

**Table 55: Data from Mud pools by the stream on Te Kopia Road**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 20 Apr 2012 | 73.4 | - | - | Dry | Vigorous bubbling | Grey mud |
| 22 Jan 2013 | 92.3 | - | - | Dry | Bubbling mud | Grey mud |

**Figure 102: Mud pools by stream, Te Kopia in Apr 2012 (A), Jan 2013 (B)**

# 11 Tokaanu

We could not monitor Tokaanu in October 2012 or Jan 2013.

## 11.1 Tourist Walk

Located number 72.2119

- **Hydrothermal Eruption Pool beside Te Waihoto Pool**
  E1839504 N5683191

The temperature had dropped by 5.9°C between Apr 2012 and June 2012.

**Table 56: Data from the Hydrothermal Eruption Pool beside Waihoto Pool, Tokaanu**

| Date | T(°C) | pH | Flow (l/s) | Water level | Diameter (m) | Ebullition | Colour |
|---|---|---|---|---|---|---|---|
| 4 Apr 2012 | 59.5 | 7 | 0 visible | 0.4m below ground level | ~1.5 | Calm | Clear, green |
| 26 June 2012 | 53.6 | nd | 0 visible | 0.6m below ground level | nd | Calm | Clear, greenish |

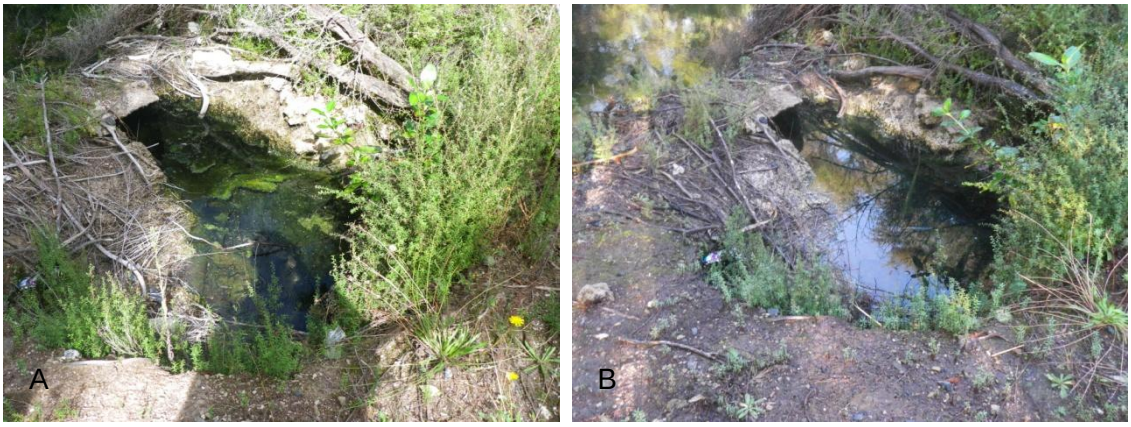


**Figure 103: Hydrothermal Eruption Pool by Waihoto Pool, Apr 2012 (A), June 2012 (B)**

- **Matewai Pool**
  E1836520 N5683146

The temperature had decreased by 3.1°C from Apr 2012 to June 2012. The inflow from Hoani A pool had decreased.

**Table 57: Data from the Matewai Pool, Tokaanu**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 4 Apr 2012 | 72.6 | 7 | 2 (inflow) | 0.4m below rim | Calm | Clear, green-blue |
| 26 June 2012 | 69.5 | nd | <1 (inflow) | 0.5m below rim | Calm | Clear, green tinge |

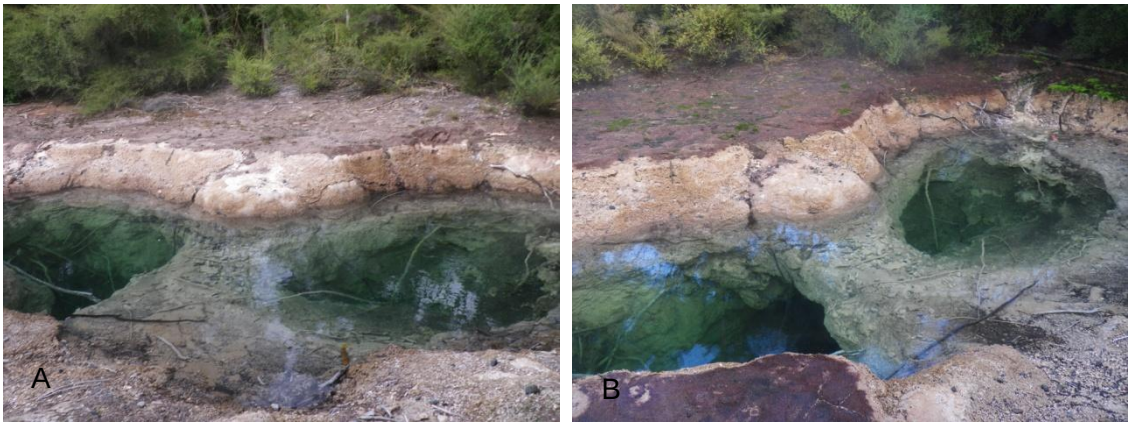


**Figure 104: Matewai Pool, Tokaanu in Apr 2012 (A) and June 2012 (B)**

- **Hoani Pool A**
  E1839510 N5683138

The outflow to Matewai Pool is a long standing artificial channel that has been dug under the path. The water level had increased since the Apr visit, however the flow to Matewai pool had decreased.

**Table 58: Data from the Hoani Pool A, Tokaanu**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 4 Apr 2012 | 87.0 | 7 | 2 | Ground level | One area of upwelling | Clear, green-blue |
| 26 June 2012 | 84.6 | nd | <1 | o/f | Constant small bubbles at centre and far end of pool | Clear, blue |


**Figure 105: Hoani Pool A, Tokaanu in Apr 2012 (A) and June 2012 (B)**

- **Hoani C Pool**
  E1839499 N5683134

The colour of the pool had changed from a light brown to a darker brown from Apr 2012 to June 2012. The temperature had also decreased by 21.6°C.

**Table 59: Data from Hoani Pool C, Tokaanu**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 4 Apr 2012 | 50.0 | 5 | 0 visible | 0.2m below outflow | Clusters of gas discharge | Murky, light brown |
| 26 June 2012 | 28.4 | nd | 0 visible | 0.2m below outflow | Occasional bubbles | Murky, brown |

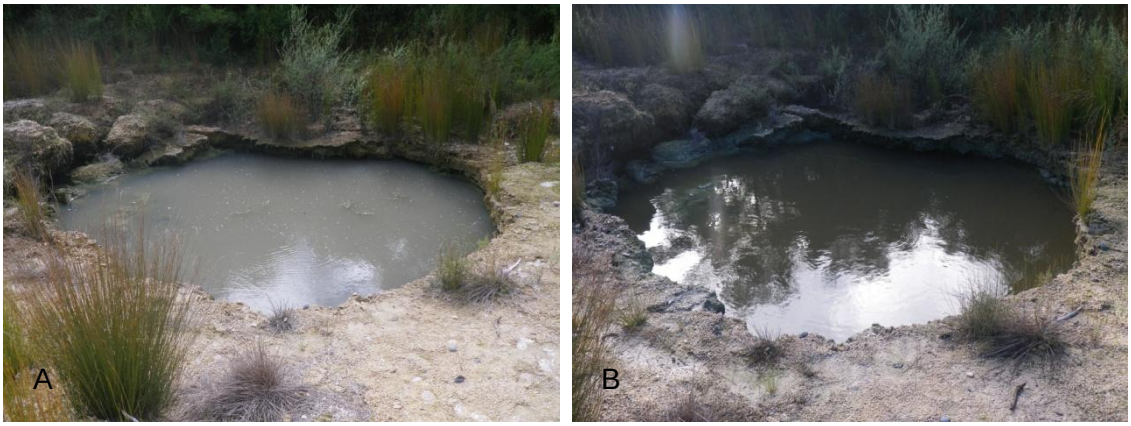


**Figure 106: Hoani Pool C, Tokaanu in Apr 2012 (A) and June 2012 (B)**

- **Takarea 6 Pool**
  E1839676 N5683088; Located number 72.2985

There were yellow and green algal mats present at both monitoring visits. The temperature of the pool had decreased by 7.3°C between Apr 2012 and June 2012.

**Table 60: Data from Takarea 6 Pool, Tokaanu**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 4 Apr 2012 | 62.8 | 5 | 0 visible | Ground level | Occasional clusters of vigorous discharge | Clear, slightly green |
| 26 June 2012 | 55.5 | nd | 0 visible | nd | Occasional small column of bubbles | Clear |

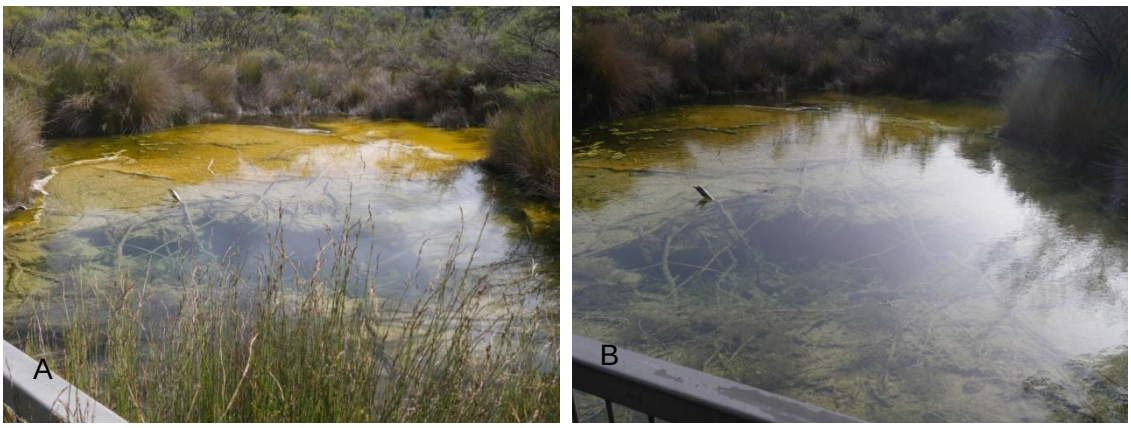


**Figure 107: Takarea 6 Pool, Tokaanu in Apr 2012 (A) and June 2012 (B)**

Mud Pools close to Paurini E1839332 N5683066

- **Mud Pool 1**

There were no significant differences between Apr 2012 and June 2012

**Table 61: Data from Mud Pool 1, Tokaanu**

| Date | T(°C) | Liq discharge (l/s) | Depth (m) | Diameter (m) | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 4 Apr 2012 | 90 | 0 | 0.5m below rim | 1 x 0.5m | Two areas of discharge on the left | Dark brown mud |
| 26 June 2012 | 88 | 0 | 0.4m below rim | 1 x 0.5m | Constant large bubble, small bubble on left | Dark brown mud |

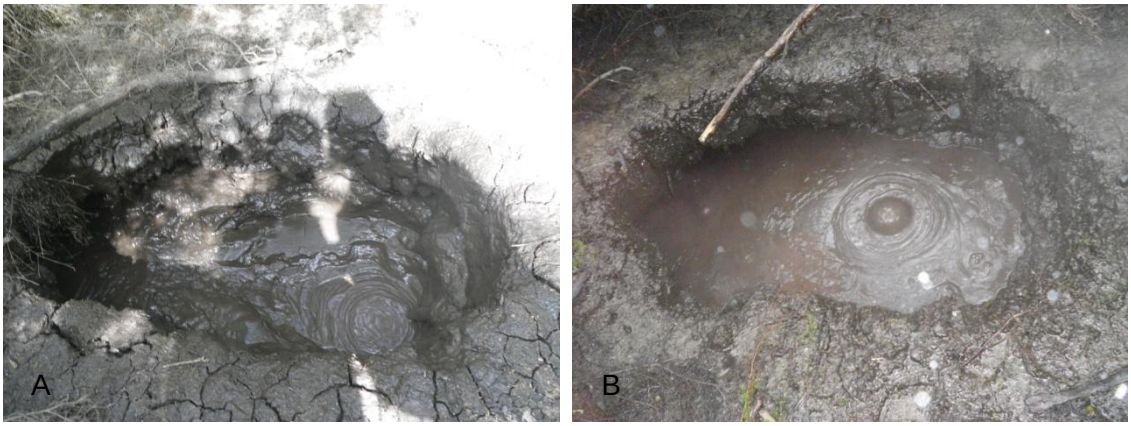


**Figure 108: Mud Pool 1, Tokaanu in Apr 2012 (A) and June 2012 (B)**

- Mud Pool 4, North and South

In June 2012 there was a log in the South pool.

**Table 62: Data from Mud Pool 4, Tokaanu**

| Date | Pool | T(°C) | Liq discharge (l/s) | Depth (m) | Diameter (m) | Ebullition | Colour |
|---|---|---|---|---|---|---|---|
| 4 Apr 2012 | North | 92 | 0 | 0.2m below rim | 1m x 0.5m | Constant, small discharge | Dark grey, brown mud |
| 4 Apr 2012 | South | 90 | 0 | 0.5m below rim | 0.4m | Gas discharge erratic | Dark grey, brown mud |
| 26 June 2012 | South | 95 | 0 | 0.08m below rim | 0.8m | Gas discharge constant | Dark grey, brown mud |


**Figure 109: Mud Pool 4, Tokaanu**

- **Paurini Pool**
  E1839330 N5683049

In June 2012 there was a 3°C decrease in temperature. Rainfall made it difficult to tell if ebullition was present.

**Table 63: Data from Paurini Pool, Tokaanu**

| Date | T(°C) | pH | Flow (l/s) | Depth to water | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 4 Apr 2012 | 64.0 | 7 | nd | 1.2m below boardwalk | Continuous vigorous discharge in centre | Clear, green |
| 26 June 2012 | 61.0 | nd | nd | 1.2m below boardwalk | nd | Clear, green |


**Figure 110: Paurini Pool, Tokaanu in Apr 2012 (A) and June 2012 (B)**

- **Hydrothermal Eruption Crater Pool**
  E1839318 N5683119

The kanuka in front of the fence had grown approximately 20-30cm between October 2011 and June 2012.There was a temperature decrease of 7.1°C between Apr and June 2012.

**Table 64: Data from Hydrothermal Eruption Crater Pool, Tokaanu**

| Date | T(°C) | pH | Flow (l/s) | Depth to water | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 4 Apr 2012 | 28.1 | 7 | nd | 0.2m below ground | Calm | Black |
| 26 June 2012 | 21 | nd | nd | 0.2m below ground | Calm | Black |

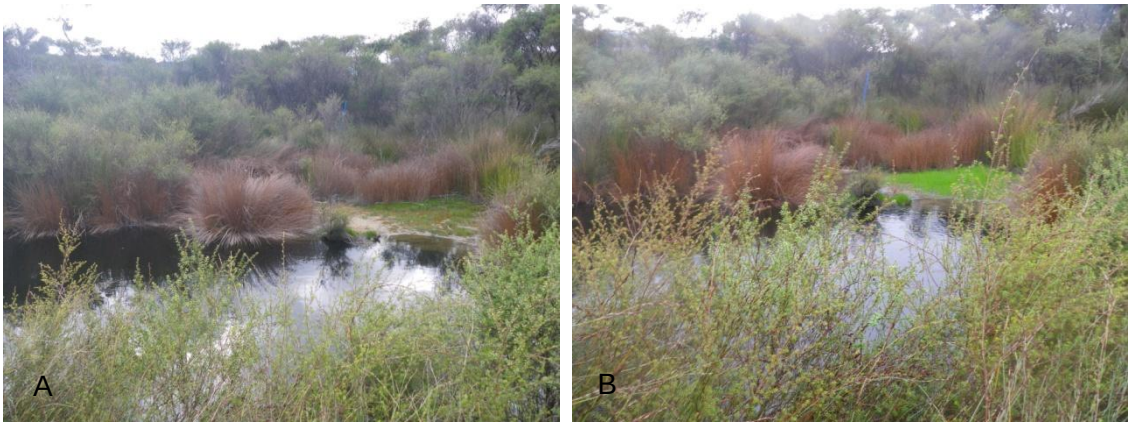


**Figure 111: Hydrothermal Eruption Crater Pool, Apr 2012 (A) and June 2012 (B)**

## 11.2 Cooking area

- **Taumatapuhipuhi**
  Located number 72.2984

Apr 2012 visit: artificial outflow is now approximately 0.5m deep from the highest point of the sinter terrace 1.5m downstream of the pool. Taumatapuhipuhi discharged from the mid vent for approximately 25 seconds to a height of ~0.5m. The same vent boiled again 5 minutes later for approximately 28 seconds, to a height of ~0.5m. The temperature was taken during the quiescent stage. It was in use when we were there, with flax being laid in the geyser. The flax was being softened so it could be used for weaving.

June 2012 visit: Taumatapuhipuhi discharged for approximately 15 seconds at 14:05. The same vent erupted again 5 minutes later for ~ 20 seconds. The temperature was taken during the quiescent stage.

**Table 65: Data from Taumatapuhipuhi, Tokaanu**

| Date | T(°C) | pH | Height (m) | Eruption interval | Eruption duration | Colour |
|---|---|---|---|---|---|---|
| 4 Apr 2012 | 98 | 7 | 0.5 | 5 min | 25s and 28s | Clear |
| 26 June 2012 | 92 | nd | 0.5 | 5 min | 15s and 20s | Clear |


**Figure 112: Taumatapuhipuhi, Tokaanu in Apr 2012 (A&B) and June 2012 (C&D)**

- **Hot vents at entry to cooking area (Apr 2012 )**
  - Feature no. 1 is vigorously bubbling light brown mud at 92°C.
  - Feature no. 2 is brown mud/water with a vigorous discharge at 80°C.
  - Feature no. 3 appears to have disappeared.

- Feature no. 4 is about 0.3 x 0.12m in diameter. It has a temperature of 80°C, and there is audible bubbling. Water level cannot be seen.


**Figure 113: Photos showing Features 1 and 2, 3 and 4, Tokaanu in Apr 2012**

- **Hot vents at entry to cooking area (June 2012 )**
  - Feature no. 1 is vigorously bubbling at 90°C. It is brown and murky.
  - Feature no. 2 appears to have disappeared.
  - Feature no. 3 appears to have disappeared.
  - Feature no. 4 has a depth of 0.7m; there is a small puddle of hot water at the bottom of the vent, at 60°C.


**Figure 114: Photos showing Features 1 and 4, Tokaanu, June 2012**

- **Main cooking area (Apr 2012)**
  - Feature no. 5 is vigorously bubbling at 98.3°C. It has a diameter of 1m x 0.7m and a depth of 0.6m below the rim. The colour is brown.
  - Feature no.6 is a boiling mud pool, temperature is 97.9°C. Water level is 0.4m below overflow, diameter is 0.5m x 0.5m. There is vigorous discharge.
  - Feature no.7 had a temperature of 96.0°C. Water level is 0.4m below ground level, diameter is 0.3m. There is a small area of vigorous bubbling at the edge.
  - Feature no.8 is a small pool of brown mud at a temperature of 90°C. It has a diameter of 0.3m and a depth of 0.2m. There is some steam.


**Figure 115: Photos showing the Cooking Area Features 5 and 8, Tokaanu in Apr 2012**

- **Main cooking area (June 2012)**
  - Feature no. 5 is boiling vigorously at 98.4°C. It is seeping out and the water is murky and light brown.
  - Feature no.6 is a boiling mud pool, temperature is 88.9°C. Water level is 0.2m below overflow, diameter is 0.8m x 0.8m. There is a constant discharge.
  - Feature no.7 had a temperature of 90.0°C. There is an audible (bubbling and hissing) gas discharge. There is a black, oily film on top - the colour of the water cannot be seen.
  - Feature no.8 is a small pool of brown mud at a temperature of 87°C. It has a diameter of 0.4m and is at ground level. There are constant bubbles and it is seeping.


**Figure 116: Photos showing Cooking Area Features 5,6,7 and 8, Tokaanu, June 2012**

# 12 Waikite

## 12.1 Waikite Swimming Pool area

There was too much steam to take infrared photos at the Waikite Swimming pool area.

- **Manaroa Pool**
  E1888904 N5752722; Located number 72.4227

Apr and July 2012: main area of upwelling is vigorous, with surges occurring every few minutes, up to 0.5m in height. The sinter is brown. There is a lot of steam, making it difficult to get a clear photograph of the pool.

October 2012:re are three main areas of upwelling, with surges occurring every few minutes. The sinter is brown. There is a lot of steam, making it difficult to get a clear photograph of the pool or estimate the flow. There are no major changes since the last site visit.

Jan 2013: main area of upwelling is on the far side of the pool. It surges every few minutes to a height of 0.5 - 1.0m. There are also several areas of effervescence. The sinter is brown.

**Table 66: Data from Manaroa Pool, Waikite**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 5 Apr 2012 | 98.9 | 9 | 40-50 | overflowing | Boiling, vigorous upwelling. Surging up to 0.5m | Clear, deep blue |
| 3 July 2012 | 99.9 | 8-9 | 30-40 | overflowing | Boiling, surging in centre. Bubbling vigorously on the left | Clear, dark blue |
| 17 Oct 2012 | 97.2 | 8 | - | overflowing | Boiling and surging in 3 separate areas centre. | Clear, dark blue |
| 25 Jan 2013 | 98.7 | 7 | 50 | o/f | Upwelling, surging | Clear, deep blue |


**Figure 117: Manaroa Pool, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

## Hot Pool Supply Gully

- **Upper Supply Spring**
  E1888866 N5752705; Located number 72.4227

The temperature fluctuates with each visit. The pH was consistent until Jan 2013 when the pH dropped slightly.

**Table 67: Data from Upper Supply Spring, Waikite**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 5 Apr 2012 | 95.5 | 9 | piped | o/f | Vigorous discharge, boiling | Clear |
| 3 July 2012 | 85 | 9 | piped | o/f | Vigorous discharge, boiling | Clear |
| 17 Oct 2012 | 93.6 | 9 | piped | o/f | Vigorous discharge, boiling | Clear |
| 25 Jan 2013 | 94.2 | 7-8 | Piped | o/f | Vigorous discharge, boiling | Clear |


**Figure 118: Upper Supply Spr, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

- **Lower Supply Spring**
  Located number 72.4228

There are two areas of discharge associated with this spring, which flow into the same pool. There are no major fluctuations with the spring.

**Table 68: Data from Lower Supply Spring, Waikite**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 5 Apr 2012 | 95.9 | 8 | Piped | Overflowing | Vigorous discharge, boiling | Clear |
| 3 July 2012 | 95.9 | 8 | piped | Overflowing | Vigorous discharge, boiling | Clear |
| 17 Oct 2012 | 95.8 | 8 | piped | Overflowing | Vigorous discharge, boiling | Clear |
| 25 Jan 2013 | 97.6 | 7 | Piped | Overflowing | Vigorous discharge, boiling | Clear |

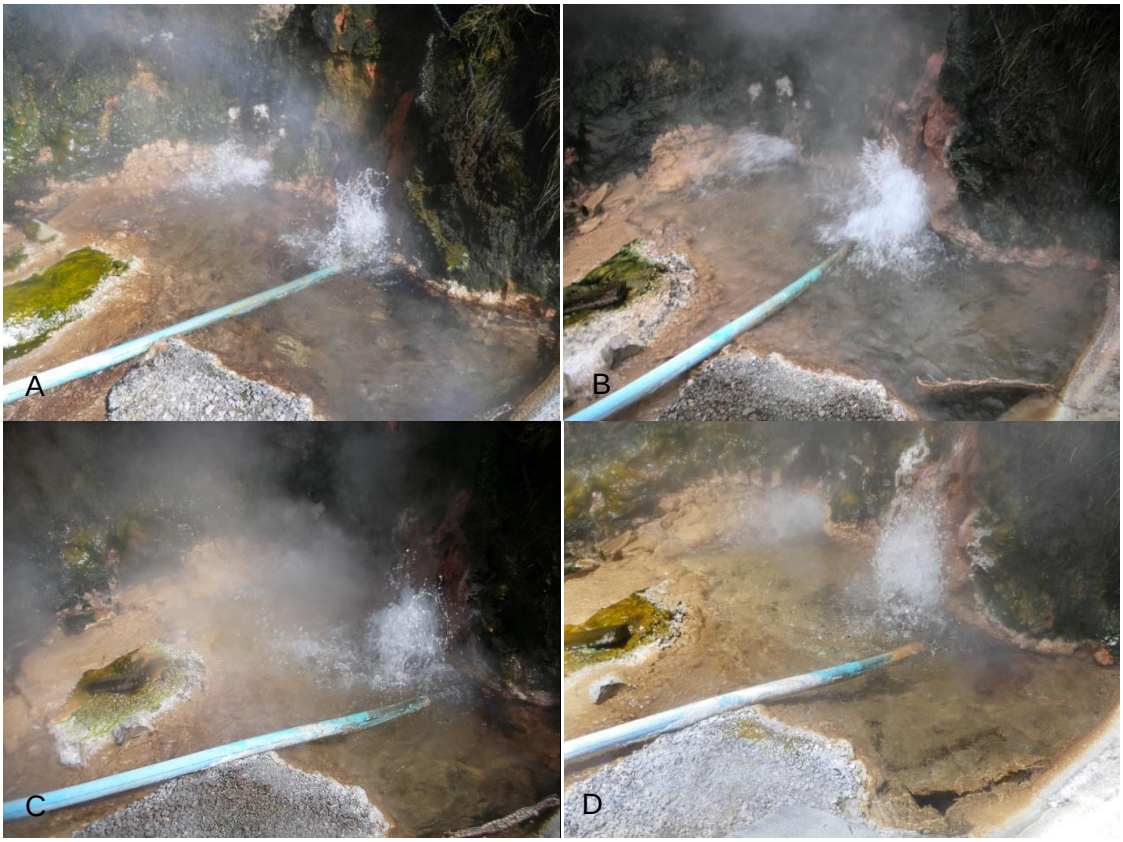


**Figure 119: Lower Supply Spr, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

- **Pool adjacent to Lower Supply Spring**

The pH dropped from pH 9 at the previous visits to pH7 in Jan 2013. The temperature increased markedly at the July visit, and then returned to a normal level by the October visit.

**Table 69: Data from Pool adjacent to Lower Supply Spring, Waikite**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 5 Apr 2012 | 81 | 9 | ~2 | Overflowing | Continuous streams of small bubbles | Clear, grey |
| 3 July 2012 | 92.5 | nd | <0.5 | Overflowing | Continuous upwelling in centre | Clear, grey |
| 17 Oct 2012 | 80 | 9 | <0.5 | Overflowing | Continuous upwelling in centre | Clear, grey |
| 25 Jan 2013 | 80 | 7 | ~0.5 | Overflowing | Upwelling | Clear |


**Figure 120: Pool adjacent Lower Supply, Apr (A), Jul (B), Sep 2012 (C), Jan 2013 (D)**

# 12.2 DOC Reserve on Landcorp Farm

- **Scalding Spring**

This spring is fenced off. It appears to be a deep pool, with a shelf of sinter extending about 1m from the edge of the pool before it drops off. The sinter shelf is a few centimetres under water. The pool flows on to a sinter terrace which leads into the Otamakokore Stream.

In Sept 2012 it was noticed that the spring was surging randomly during the visit. Prior to a surge the flow from the spring was a seep increasing to a flow of 0.5l/s during a surge. The temperature of the spring fluctuated between 95.2$^{o}$C when not surging, and 96.3$^{o}$C during a surge.

There was a temperature increase from Apr 2012 to July 2012, after which it remained reasonably consistent. The pH has reduced over the period from pH9 down to pH7.

**Table 70: Data from Scalding Spring, Waikite**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 81.5 | 9 | 1 | Overflowing | Upwelling | Clear, blue |
| 3 July 2012 | 97.6 | 8 | <0.5 | Overflowing | Vigorous upwelling near outlet | Clear, blue |
| 17 Oct 2012 | 95.2 | 8 | Seep – 0.5 | Overflowing | Surging | Clear, blue |
| 25 Jan 2013 | 95.4 | 7 | ~0.5 | 0/f | Upwelling near outlet | Clear, grey/blue |

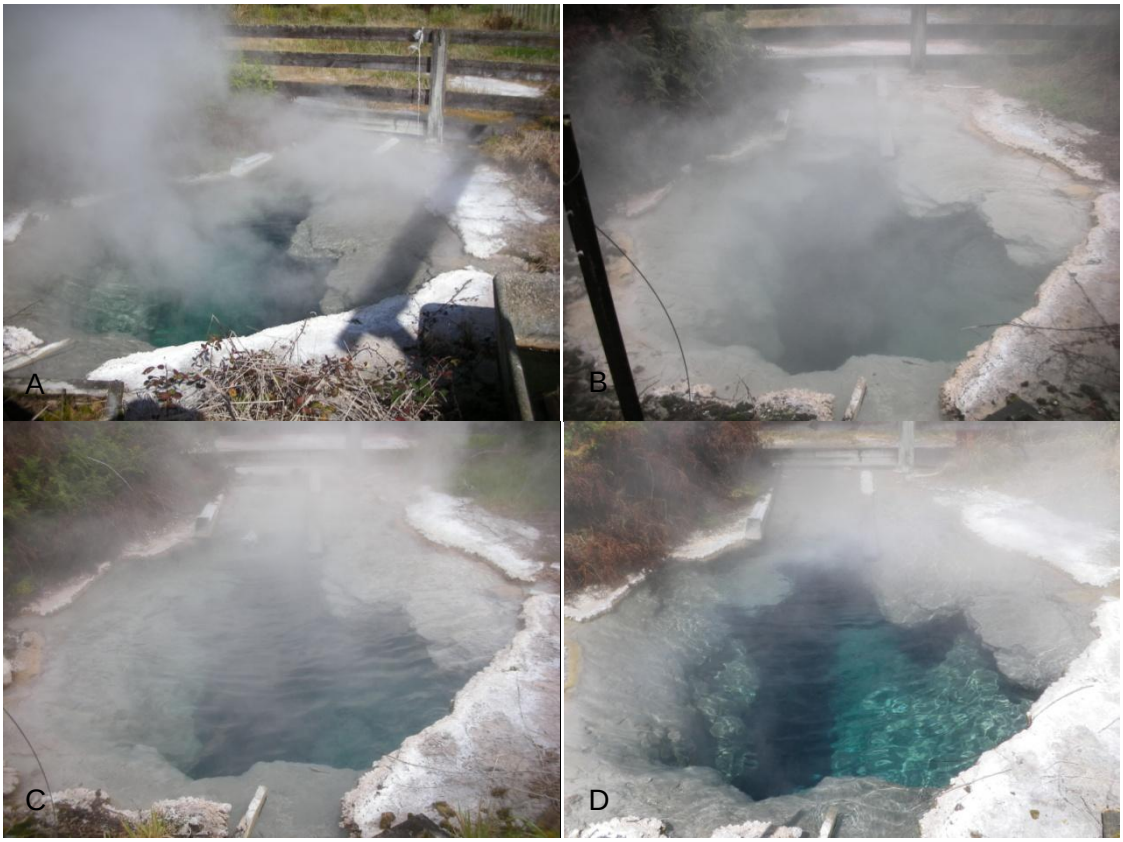


**Figure 121: Scalding Spring, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

- **Waikite Scarp and Spring**
  Located number 72.4393

The spring discharges into a small stream which flows onto the sinter terraces. There is new sinter both in the channel and on the margins of the stream. The terrace that the stream flows onto appears to have green and yellow algae growing on it.

In Apr 2012 and July 2012 we were unable to get up to the spring itself as the stream seems to have widened and we did not think it would be safe. The measurements were taken near the fence line where the stream comes out of the bush area. In July 2012 the flow appeared to be the same as the previous visit, however there was more surface water around due to the weather leading up to the visit.

At the October 2012 site visit we were able to access the spring as the blackberry had been sprayed and had died back. There has been no change to the temperature, pH or flow since the last site visit.

We were also able to access the spring in Jan 2013. There was a temperature increase between the October and January visits of 22.2°C.

**Table 71: Data from Spring, Waikite Scarp**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 63.5 | 9 | 1 | - | Calm, steam | Clear |
| 3 July 2012 | 75.1 | 9 | ~0.5 | - | Calm, steam | Clear |
| 17 Oct 2012 | 75.1 | 9 | <0.5 | - | No Gas | Clear |
| 25 Jan 2013 | 97.3 | 9 | ~0.5 | o/f | - | Clear |


**Figure 122: Hot stream (A), and discharge area onto terraces (B), (C) and (D), Apr 2012**


**Figure 123: Hot stream (A), and discharge area onto terraces (B), (C) and (D), Jul 2012**


**Figure 124: Hot stream (A), and discharge area onto terraces (B), (C) and (D), Oct 2012**


**Figure 125: Hot stream (A), and discharge area onto terraces (B), (C) and (D), Jan 2013**

The infrared photo below shows the two areas where the springs are situated, above and below the fern branch.

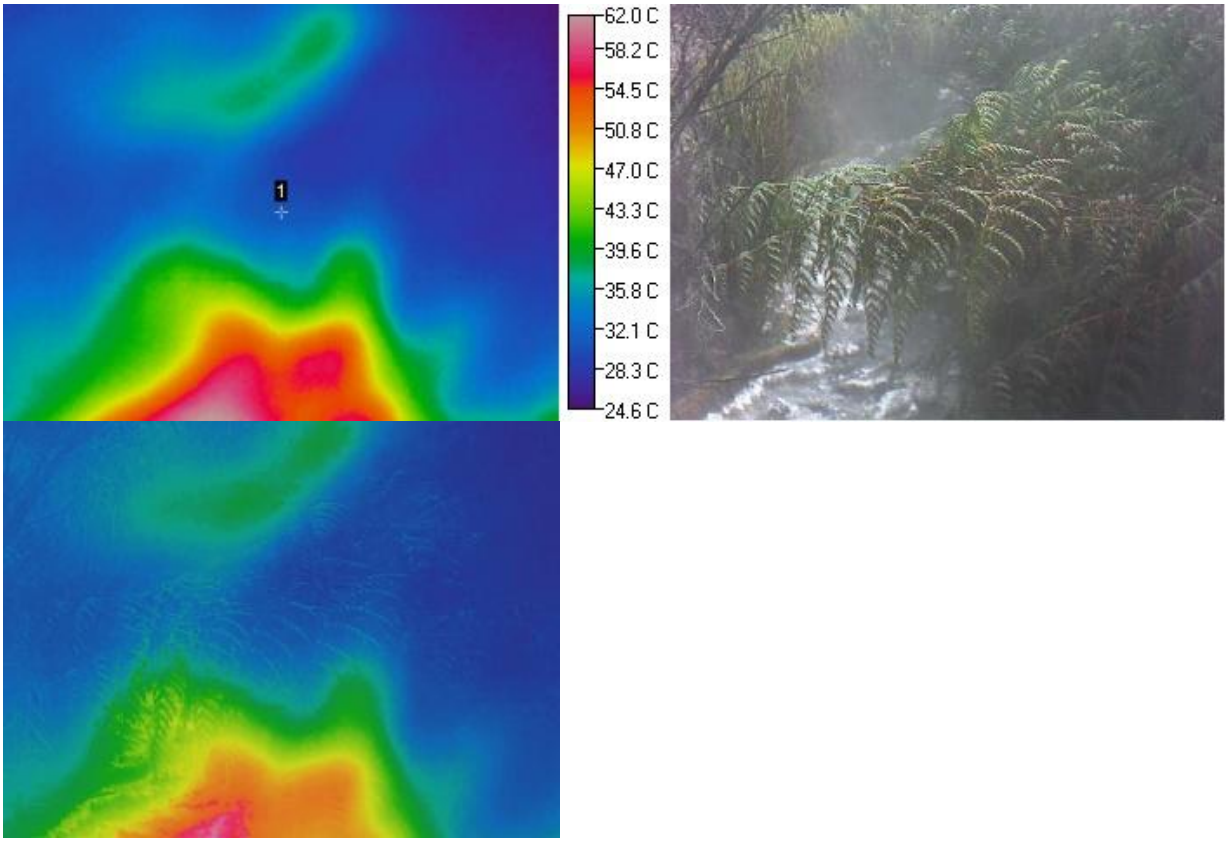


**Figure 126: Infrared photos, springs, Waikite scarp**

The infrared photo below show the path of the hot water as it flows over the terrace.

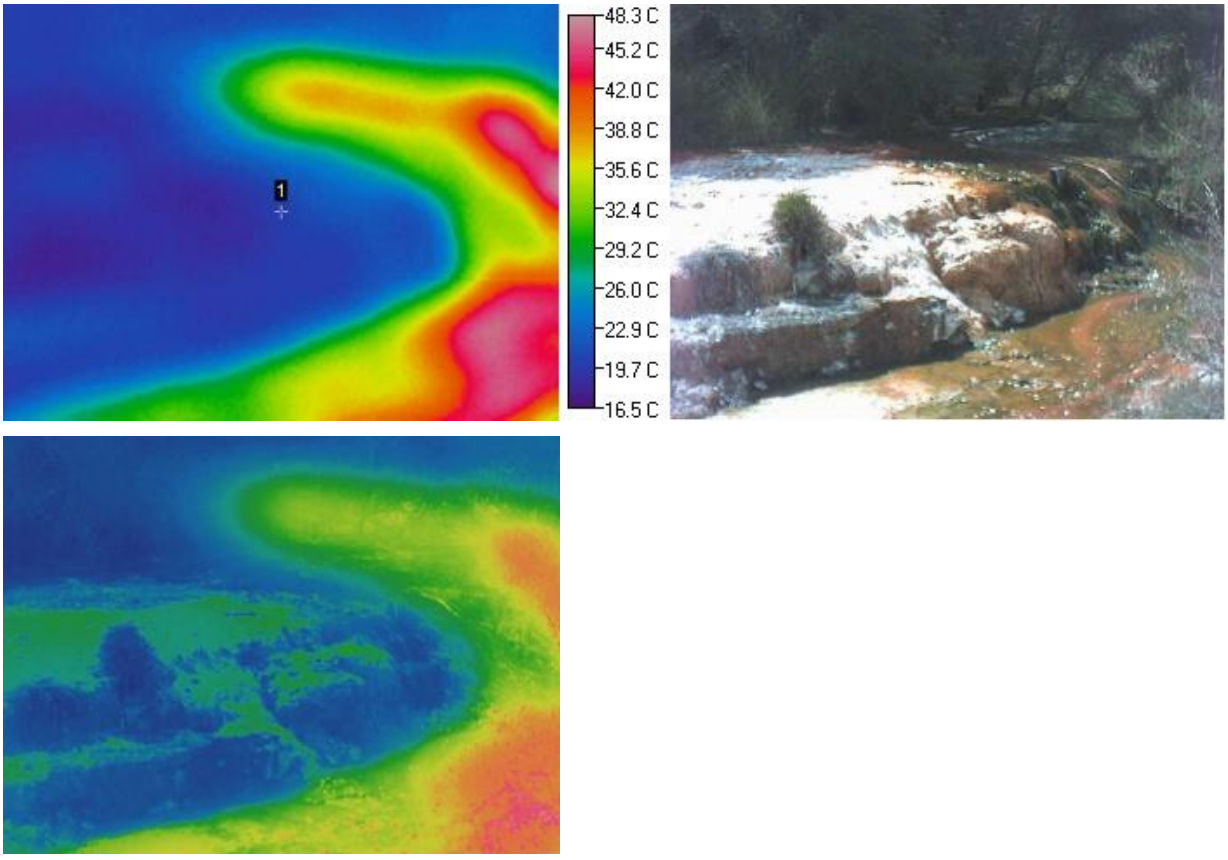


**Figure 127: Infrared photos, Waikite scarp terraces**

# 13 Waiotapu

## 13.1 Tourist Walk

- **Weather Pool**
  E1894318 N5749245

The temperature in Apr and July 2012 was taken using an IR gun from the path, which is some distance from the pool. The temperature reading can be adversely affected by steam and is therefore indicative only. We could not get a reading in October 2012 or Jan 2013.

**Table 72: Data from Weather Pool, Waiotapu**

| Date | T(°C) | Water level | Ebullition | Colour |
|---|---|---|---|---|
| 5 Apr 2012 | 50 | Overflowing | Calm | Murky, turquoise |
| 3 July 2012 | 42 | Nd | Calm | Cloudy, pale green |
| 17 Oct 2012 | - | Not overflowing | Calm | Cloudy, blue/green |
| 30 Jan 2013 | - | Overflowing | Calm | Murky, blue/green |


**Figure 128: Weather Pool in Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

- **Pool north of Jean Batten Geyser**

The pool appears to be thermally inactive, and has not been warmer than 26.5°C throughout the monitoring period. The pH, colour and level have varied widely during the period.

**Table 73: Data from Pool north of Jean Batten Geyser, Waiotapu**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 5 Apr 2012 | 25.1 | 3 | 0 visible | 0.3m below ground level | Calm | Murky, blue-green |
| 3 July 2012 | 11.9 | 4 | Seep | o/f | Calm | Cloudy, blue |
| 17 Oct 2012 | 17.4 | 6 | - | Submerged | Calm | Cloudy, blue/green |
| 30 Jan 2013 | 26.5 | 4 | Seep | o/f | Calm | Clear |

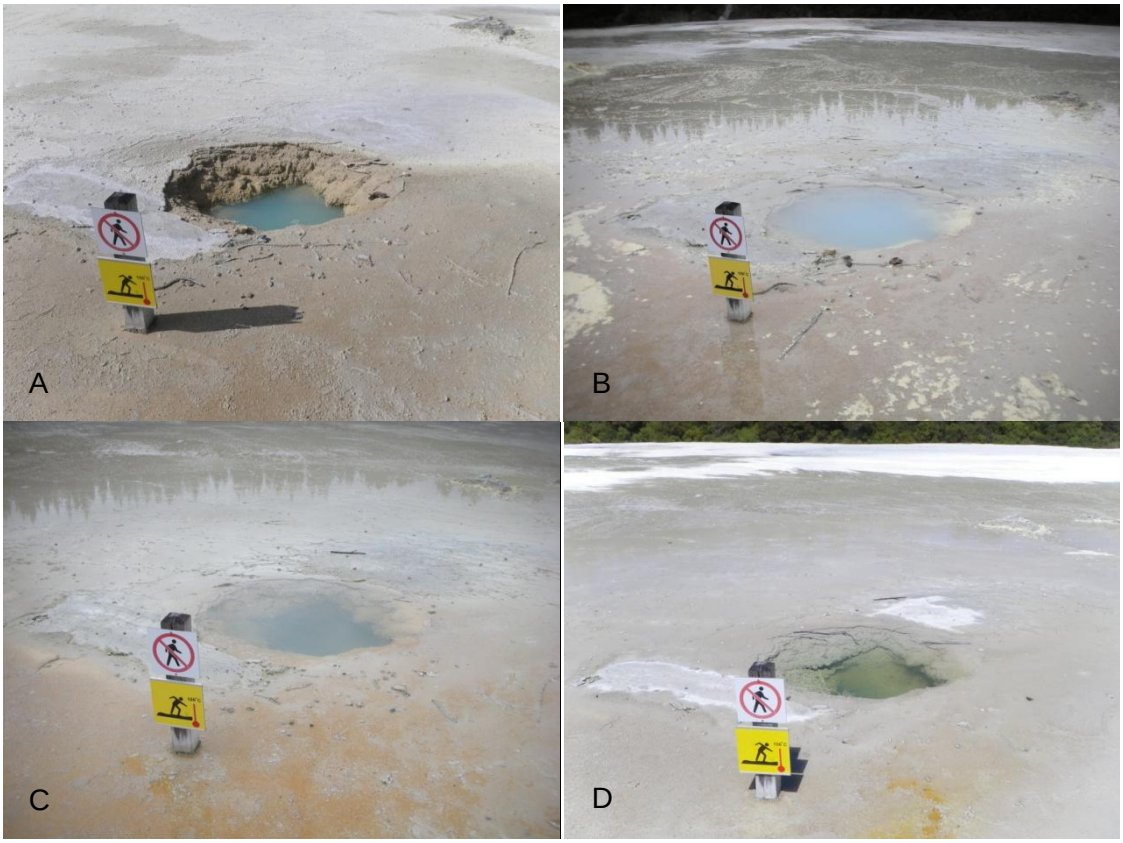


**Figure 129: Pool N of Batten, Apr 2012 (A), Jul 2012 (B), Sep 2012 (C), Jan 2013 (D)**

The infrared photos in Figure 130 show that the pool itself is cold; however there is an area of warm ground directly behind the pool.

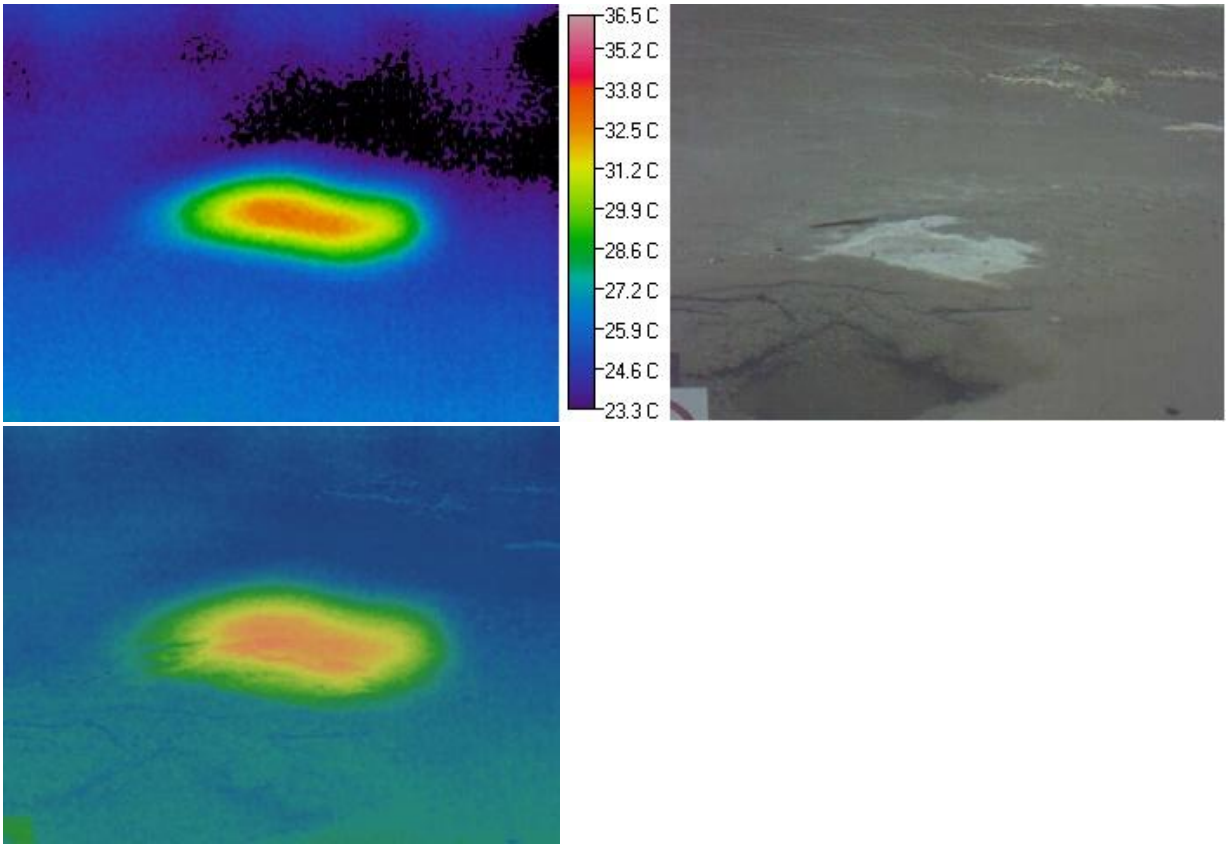


**Figure 130: Infrared photos, pool next to the Jean Batten Geyser in Jan 2013**

- **Jean Batten Geyser**

There have been no visible changes during the reporting period.

**Table 74: Data from Jean Batten Geyser, Waiotapu**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 5 Apr 2012 | 98.0 | nd | 0 visible | No visible water | Steam, audible bubbling | - |
| 3 July 2012 | 97.4 | nd | 0 visible | No visible water | Steam, audible bubbling | - |
| 17 Oct 2012 | 97.8 | nd | 0 visible | No visible water | Steam, audible gas discharge | - |
| 30 Jan 2013 | 98 | nd | 0 visible | No visible water | Steaming, audible gas discharge | - |

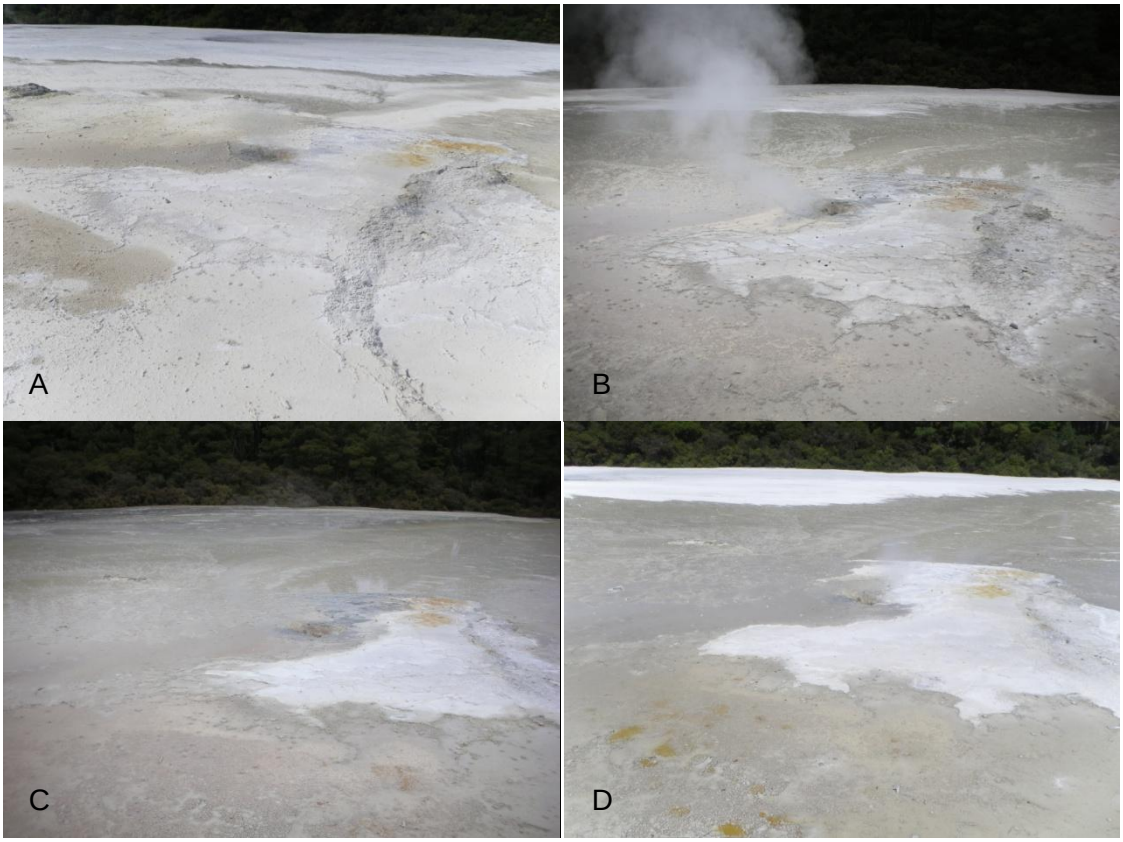


**Figure 131: Jean Batten Geyser, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

- **Sinter Terraces**

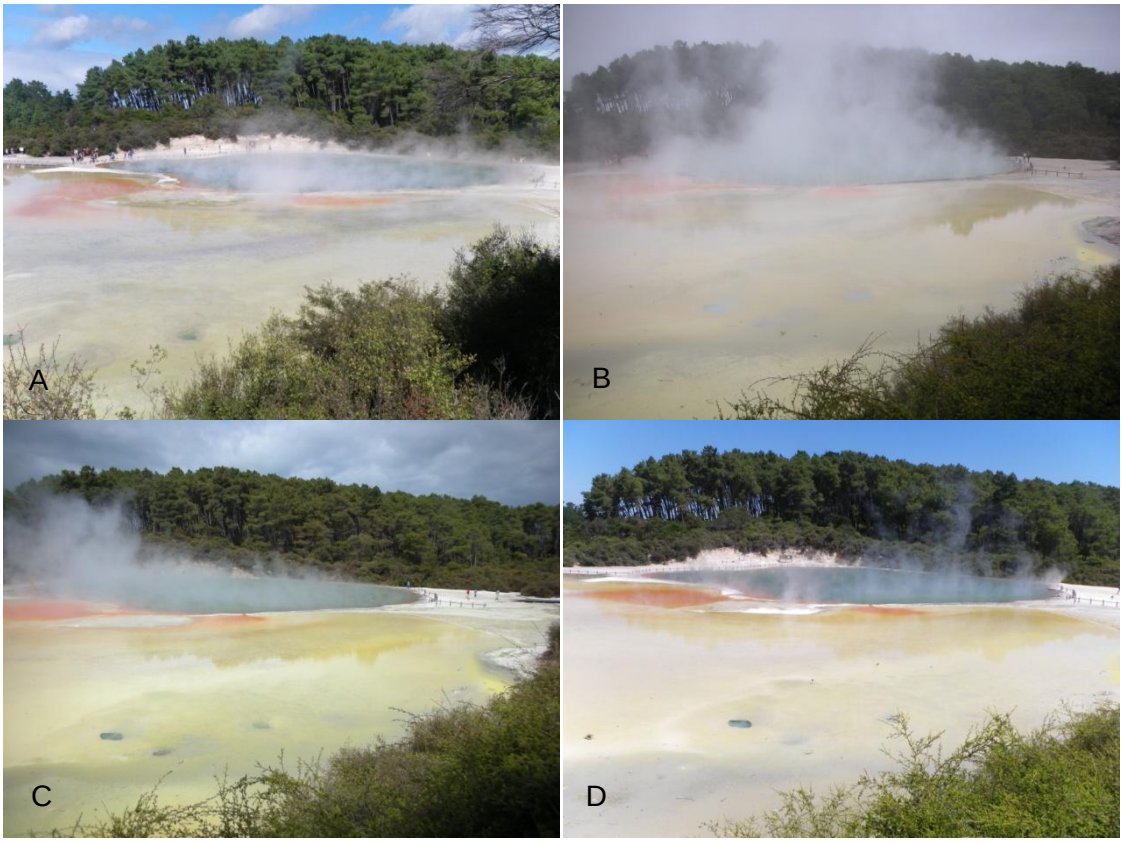


**Figure 132: Sinter Terraces, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

- **Sinter Terraces – Yellow coloured vent**

In Jan 2013 there was yellow precipitate around the edges of the pool. The colour is quite variable.

**Table 75: Data from Sinter Terraces – Yellow coloured vent, Waiotapu**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 5 Apr 2012 | nd | nd | - | submerged | Calm | Cloudy green/yellow |
| 3 July 2012 | nd | nd | - | submerged | Calm | Cloudy green |
| 17 Oct 2012 | nd | nd | - | submerged | Calm | Pale green/ yellow |
| 30 Jan 2013 | nd | nd | - | submerged | Calm | Murky green/blue |


**Figure 133: Yellow coloured vent, Apr (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

- **Sinter Terraces – Foreground Pool**

The temperature is taken using the IR gun from the platform, which is some distance away so may not be accurate. The temperature was significantly lower in July 2012. The colour and ebullition have been inconsistent.

**Table 76: Data from Sinter Terraces – Foreground Pool, Waiotapu**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 5 Apr 2012 | 67 | nd | - | Submerged | Vigorous gas discharge | Cloudy green/yellow |
| 3 July 2012 | 52.5 | nd | - | Submerged | Calm | Cloudy, pale green |
| 17 Oct 2012 | 65 | nd | - | Submerged | Constant Upwelling on far side | Murky, light green |
| 30 Jan 2013 | 65 | nd | - | Submerged | Calm | Green, Murky |

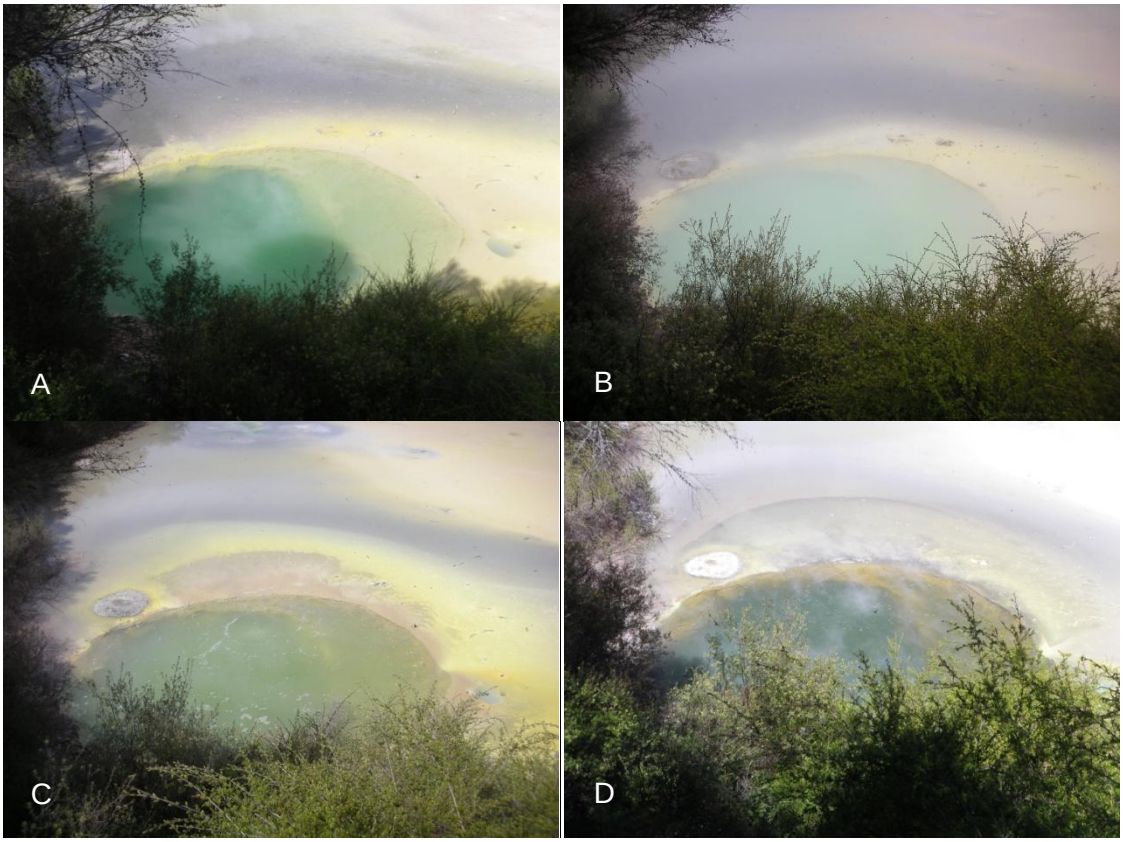


**Figure 134: Foreground Pool, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

The pool heat seems to be evenly spread throughout the pool. The differences in temperature observed in the infrared photo are most likely due to the steam distorting the temperature reading of the pool itself.

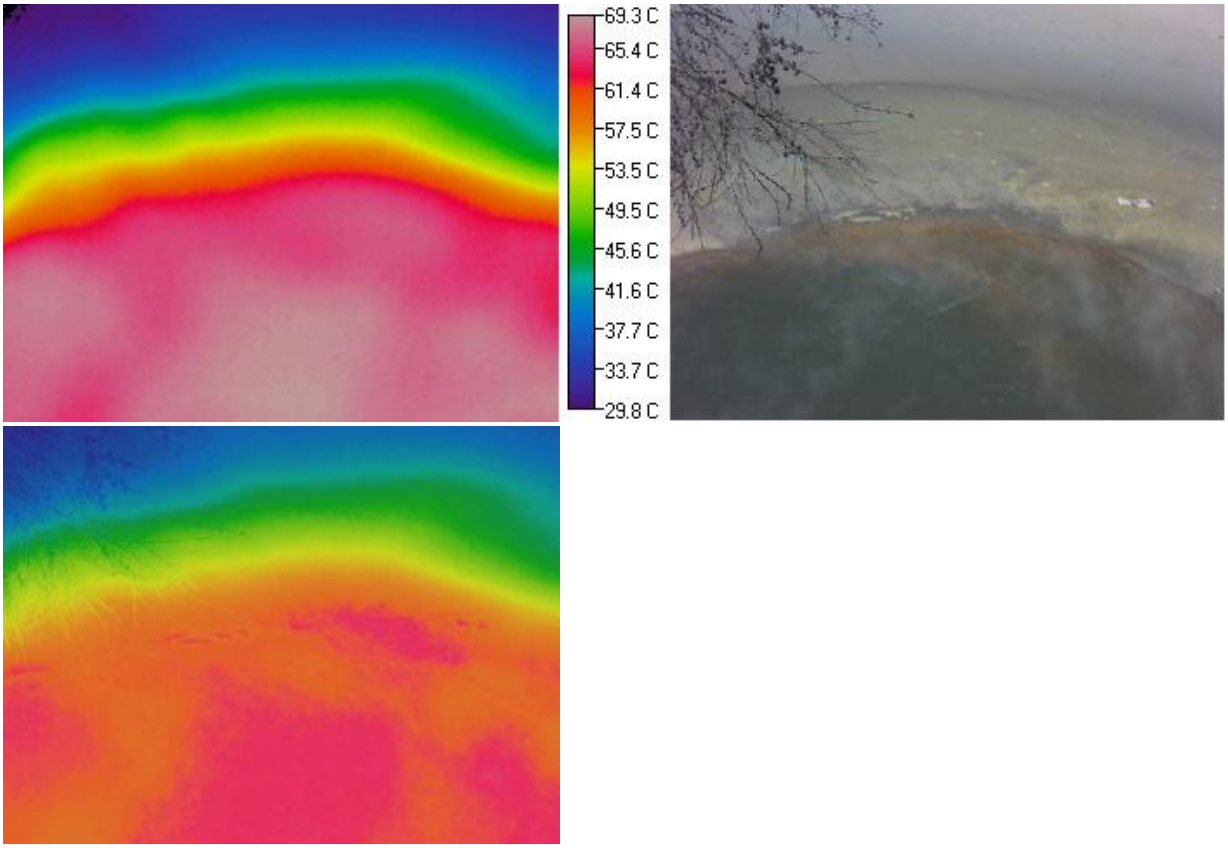


**Figure 135: Infrared photos of Sinter Terraces – Foreground Pool, Waiotapu, Jan 2013**

- **Waiotapu Geyser**
  E1894389 N5748720; Located number 72.3007

The pH has changed markedly from pH7 in Apr 2012 to pH3 in Jan 2013. It is normal for geysers to decrease in pH between eruptions due to the oxidation of $H_2S$ to $H_2SO_4$. This may be the case here – we may have observed it at different stages of the eruptive cycle. The clarity was also different in Jan, changing from clear and grey to murky and grey. The temperature had decreased by 6°C. There is no photo for the Waiotapu Geyser for July 2012.

**Table 77: Data from Waiotapu Geyser**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 5 Apr 2012 | 86.1 | 7 | - | 0.1m below overflow | Calm, weak steam | Clear, grey |
| 3 July 2012 | 83.8 | 5 | Nd | 0.05m below outflow | Calm | Clear, grey |
| 17 Oct 2012 | 81.9 | 6 | Nd | 0.2m below outflow | Calm | Clear, grey |
| 30 Jan 2013 | 80 | 3 | 0 visible | 0.3m below outflow | Calm, some steam | Murky, grey |


**Figure 136: Waiotapu Geyser in Apr 2012 (A), Sept 2012 (B), Jan 2013 (C)**

- **Oyster Pool**
  E1894414 N5748668; Located number 72.4225

There do not appear to be any significant changes, apart from the temperature fluctuations.

**Table 78: Data from Oyster Pool, Waiotapu**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 5 Apr 2012 | 63.8 | 3 | seep | Overflowing | Constant discharge | Cloudy pale green |
| 3 July 2012 | 68.1 | 4 | seep | Overflowing | Constant upwelling in several area | Murky, pale green |
| 17 Oct 2012 | 63 | 4 | seep | Overflowing | Constant upwelling in centre | Cloudy/ pale green/ blue |
| 30 Jan 2013 | 64.3 | 4 | Seep | Overflowing | Constant upwelling in centre | Murky, green |

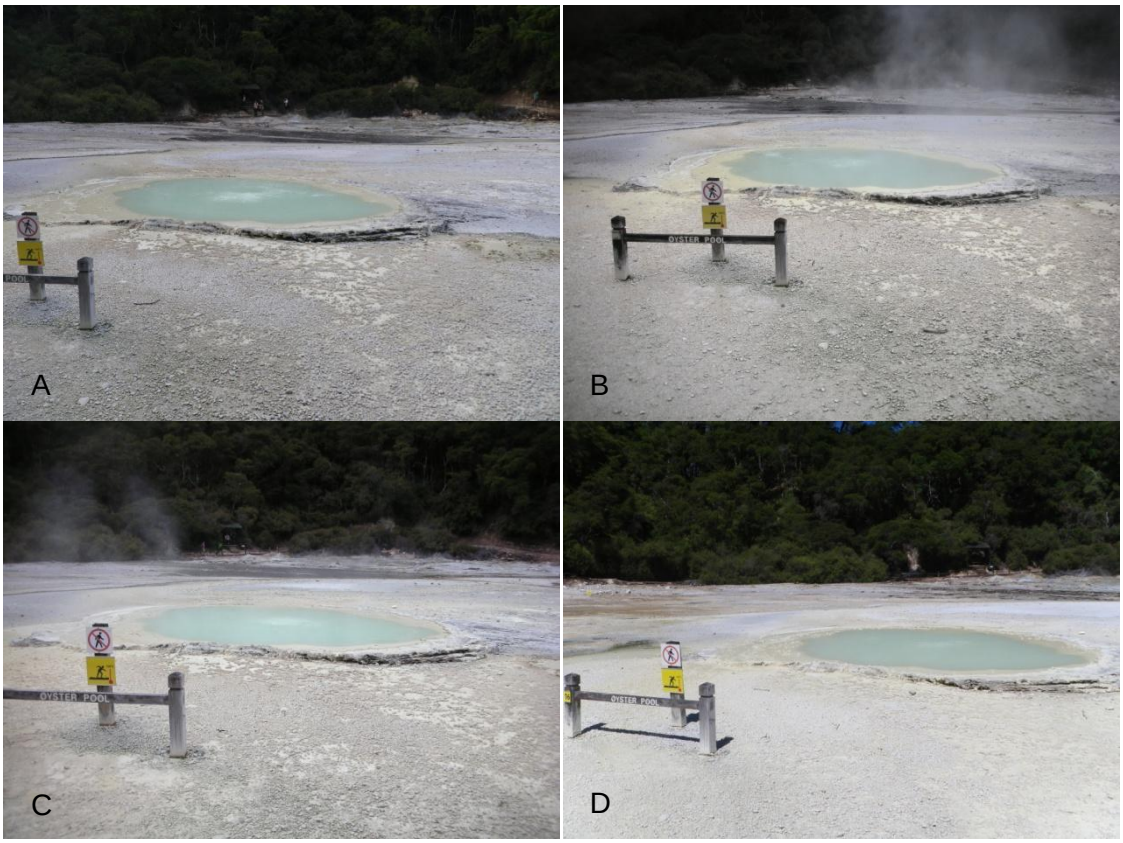


**Figure 137: Oyster Pool, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

The infrared photos below illustrate the heat in the Oyster pool. The hottest part of the pool appears to be in the centre and front of the pool. The majority of the upwelling is in the centre of the pool.

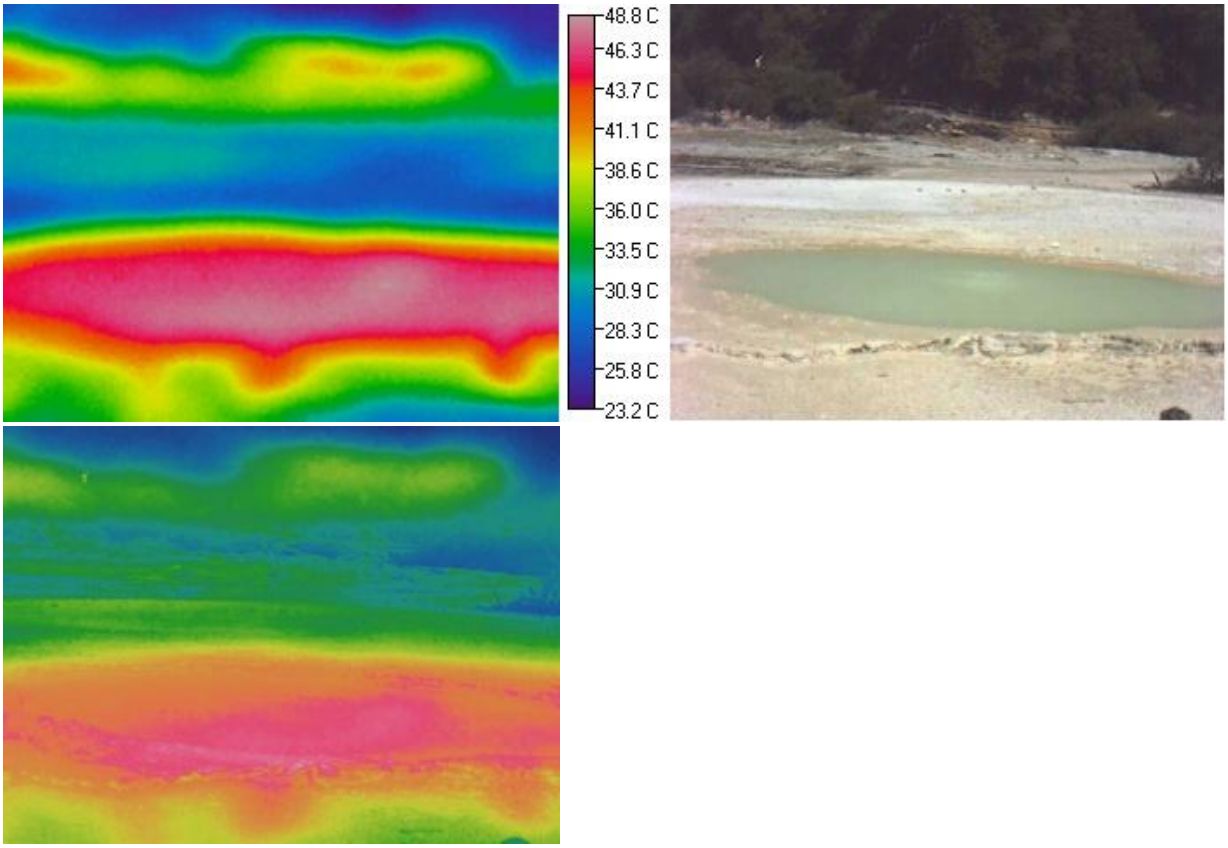


**Figure 138: Infrared photos of Oyster pool, Waiotapu in Jan 2013**

- **Lake Ngakoro**
  Located number 72.4226

There was no photo taken in Apr 2012. The colour and clarity of the lake changed between monitoring visits. The inflow into the lake has decreased over the period. The temperature and pH readings in Jan 2013 were taken from the stream entering the lake, which is why the temperature is higher than in previous visits.

**Table 79: Data from Lake Ngakoro, Waiotapu**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 5 Apr 2012 | 23 | nd | Inflow 20l/s | nd | Calm | Mid green |
| 3 July 2012 | 22.9 | nd | - | nd | Small bubbles around edges | Murky, green |
| 17 Oct 2012 | 25 | nd | 9-10 inflow | nd | Calm | Murky, green |
| 30 Jan 2013 | 43.8 | 2 | 5 (inflow) | o/f | Calm | Murky, yellow |

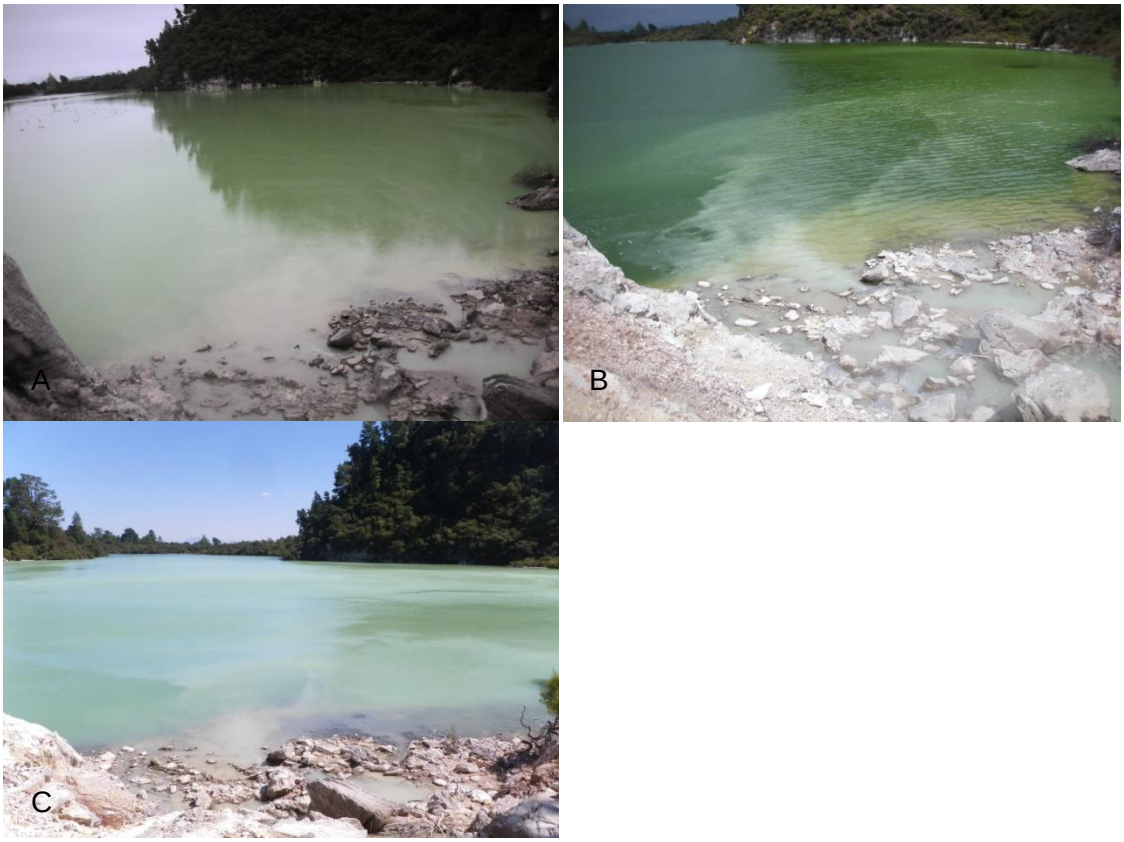


**Figure 139: Lake Ngakoro, Waiotapu in Jul 2012 (A), Sept 2012 (B), Jan 2013 (C)**

The infrared photos below illustrate the heat entering the lake from the stream, and then dissipating further away from the stream where it cools down.

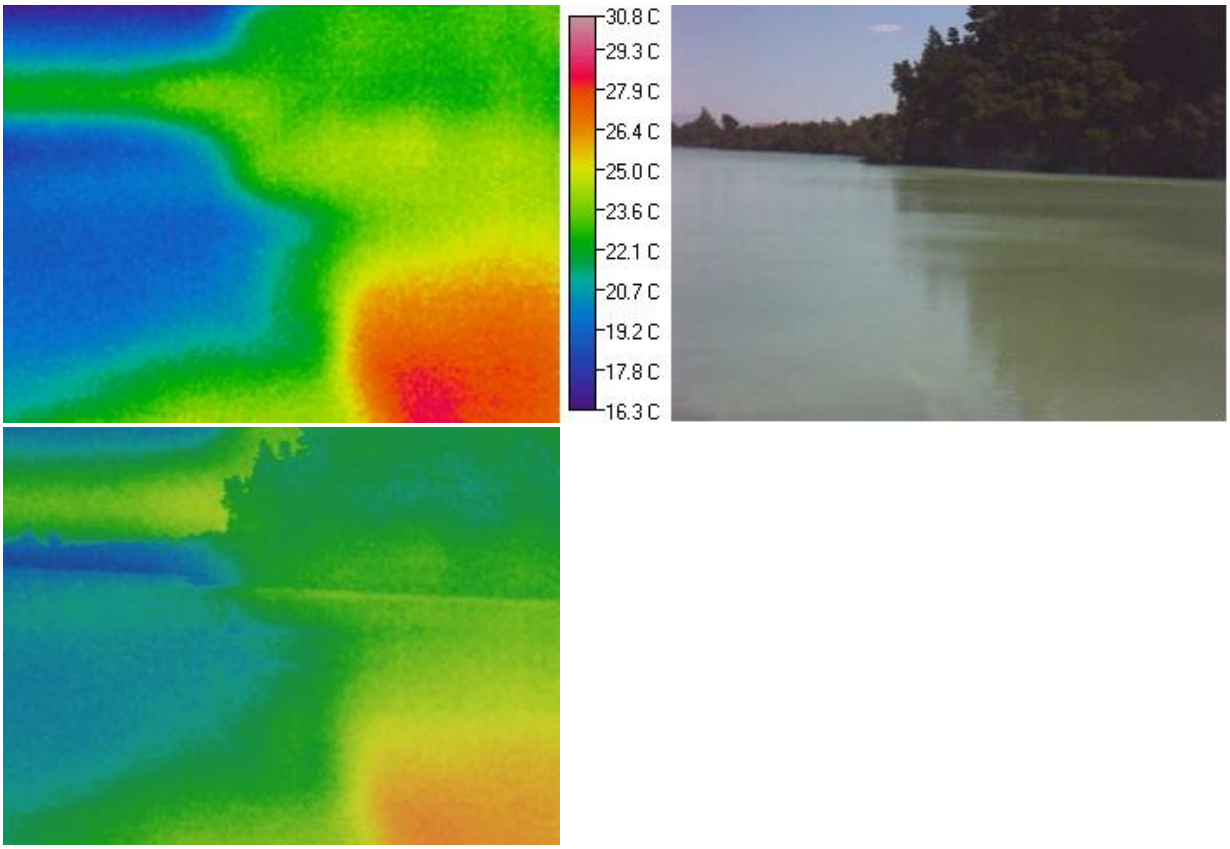


**Figure 140: Infrared photos of Lake Ngakoro, Waiotapu in Jan 2013**

- **Champagne Pool**
  E1894414 N5748950

The pool seems to be reasonably consistent, with slight fluctuations in the pH and temperature.

**Table 80: Data from Champagne Pool, Waiotapu**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 5 Apr 2012 | 75.3 | 5 | - | 0.1m below rim | Effervescing | Murky green |
| 3 July 2012 | 75 | 5 | nd | 0.1m below rim | Effervescing around edges | Murky green |
| 17 Oct 2012 | 73.4 | 6 | nd | 0.1m below rim | Effervescing around edges, steaming | Murky green |
| 30 Jan 2013 | 77.3 | 7 | nd | o/f | Effervescing | Murky, green |


**Figure 141: Champagne Pool, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

- **Devil's Bath**

Apr – July 2012: water temperature dropped by 10.5ºC between the Apr 2012 and July 2012 monitoring periods

October 2012: water temperature had increased from 13.5$^{o}$C in July 2012 to 26.7$^{o}$C during this visit. The water level had dropped significantly from being level with the high water mark in July to 5m below it at the time of this visit. The proprietor indicated that there had been a sudden drop followed by a slow lowering in water level since ~two weeks before the visit. He indicated that the water level was slightly higher on the day of the visit. There had been no change at the inlet to the Champagne pool.

In Jan 2013 the water level had increased slightly.

**Table 81: Data from Devil's Bath, Waiotapu**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 5 Apr 2012 | 24 | nd | - | High water mark | Occasional gas discharge | Bright green |
| 3 July 2012 | 13.5 | nd | - | High water mark | Calm | Bright green, murky |
| 17 Oct 2012 | 26.7 | nd | - | ~5m below high water mark | Effervescing small bubbles | Yellow/ Green, cloudy |
| 30 Jan 2013 | nd | nd | - | ~4.5m below high water mark | Calm | Yellow/ Green, cloudy |


**Figure 142: Devil's Bath, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

# 13.2 Knox Geyser area

We were unable to visit the Know Geyser area in Jan 2013.

- **Lady Knox Geyser**

The Lady Knox Geyser erupts at ~10:15am daily, after a surfactant is dropped into the opening of the vent by the staff of Waiotapu. The eruptions we witnessed were all over 30 minutes in length. The pH is from the run off of the geyser, and the temperature iss read from about 5m away using the IR Gun, so may not be representative of the water temperature as it erupts from the geyser, due to rapid atmospheric cooling.

**Table 82: Data from Lady Know Geyser, Waiotapu**

| Date | T(°C) | pH | Height | Eruption duration | Colour |
|---|---|---|---|---|---|
| 5 Apr 2012 | 90 | 5 | 12 | Over 45 mins | Clear |
| 3 July 2012 | 66 | 6 | 5 | Over 30 mins | Clear |
| 17 Oct 2012 | 77-91 | 6 | 6-7 | Over 30 mins | Clear |

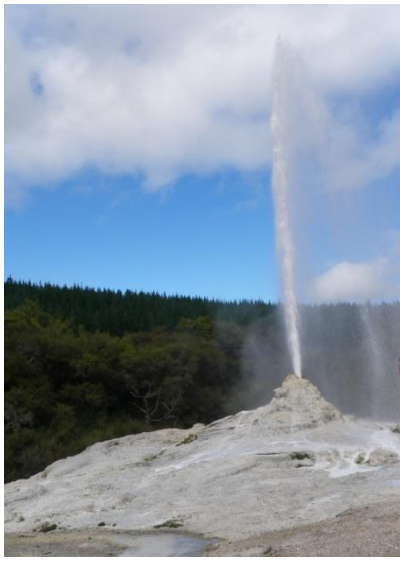

**Figure 143: Lady Knox Geyser, Waiotapu in Apr 2012 (A), Jul 2012 (B), Sept 2012 (C)**

- **Knox Hole Spring and Channel**
  E1895123 N5749869

The spring was dry. There was water discharging into the channel about 3m from the spring, this had a pH of 3 and was 76.5°C. It was clear, with a dull yellow precipitate. The temperature fluctuates over the monitoring periods.

**Table 83: Data from Know Hole Spring, Waiotapu**

| Date | T(°C) | pH | Flow (l/s) | Level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 5 Apr 2012 | 71 | nd | <0.5 (from below spring) | dry | Audible discharge | nd |
| 3 July 2012 | 53.1 | 3 | Seep (from below spring) | Small pool | Audible discharge | Clear |
| 17 Oct 2012 | 67.4 | 3 | Seep (from below spring) | Small pool | Audible gas discharge | Clear with a yellow base |

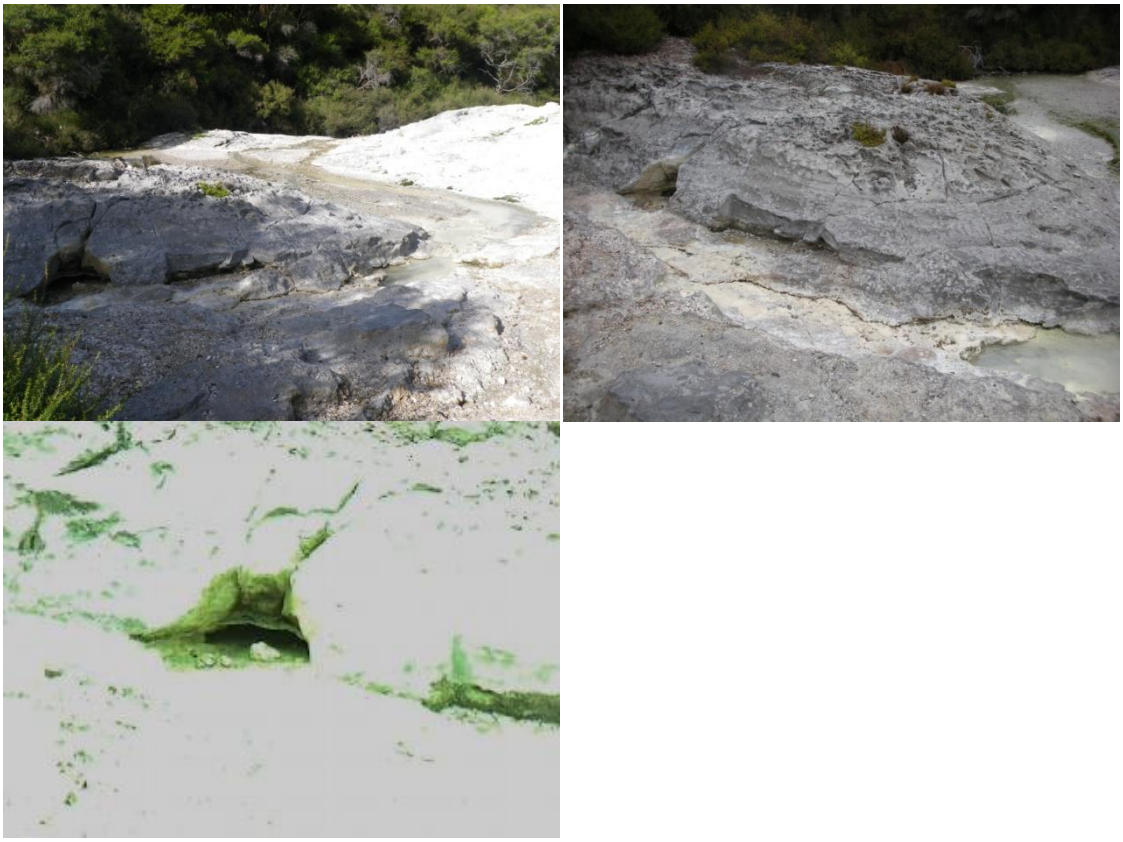

**Figure 144: Knox Spring Hole and Channel, Apr 2012 (A), Jul 2012 (B) Sept 2013 (D)**

- **Hidden Pool**
  E1894833 N5749981

There were no bathers in the pool in Apr, July or Sept 2012.

Algae was present on the walls, with a pale yellow substance oozing from areas where water seeps from the rocks. There is no photo for the Hidden pool in Sept 2012.

**Table 84: Data from Hidden Pool, Knox Geyser area, Waiotapu**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 5 Apr 2012 | 41.5 | 3 | 6 | Overflowing | Calm, some steam | Murky, grey |
| 3 July 2012 | 35.6 | 3 | ~5 | Overflowing | Calm | Murky, grey/brown |
| 17 Oct 2012 | 38 | 2-3 | 6-7 | Overflowing | Calm | Murky, grey/brown |


**Figure 145: Hidden Pool, Knox Geyser area, Waiotapu in Apr 2012 (A) and Jul 2012 (B)**

- **Venus Pool in creek on Lady Knox Road**
  E1895377 N5749891

This is a warm stream on Lady Knox Road. There is no photo for the Hidden pool in Sept 2012.

In July 2012 the vegetation around the stream appears to have died back. As far as I can tell it is most likely caused by weed spray, not by an increase in temperature because the vegetation close to the stream is unaffected and the vegetation close to the road is dying. However, it does appear to be one particular species of plant that is affected which does not occur lower down, therefore it is possible that it has been affected by heat. Later consultation with a member of staff confirmed that broom may have been sprayed in the area.

In Sept 2012: Flow has diminished from 30l/s during the previous visit to 5l/s. Green algae is noticeable on the stream bed. New growth of ferns can be seen on the bank, although the grasses have not recovered from the die back of the bank vegetation noted during the last visit.

**Table 85: Data from Venus Pool, Knox Geyser area, Waiotapu**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 5 Apr 2012 | 48.0 | 4 | ±12 | nd | Calm | Clear, light brown |
| 3 July 2012 | 41.9 | 4 | ~30 | nd | Calm | Clear |
| 17 Oct 2012 | 43.4 | 3-4 | 5 | nd | Calm | Clear |

**Figure 146: Venus Pool, Waiotapu in Apr 2012 (A) and Jul 2012 (B)**

# 13.3 Waiotapu Loop Road Pools

- E1893976 N5749319

Along Waiotapu Loop Road is a bridge, underneath which is a tributary of the Waiotapu Stream. There are two pools, one either side of the road. At 09:10 on 3rd July 2012 there was one bather. At 13:00 on 17 October 2012 there were no bathers.

# 13.4 Kerosene Creek Area

- **Kerosene Creek Pool**
  E1896006 N5751572

The temperature has fluctuated over the monitoring period, with the warmest temperature being in Jan 2013 and the coolest in July 2012. There was green algae growing on some of the rocks around the pool

In Jan 2013 there were two bathers in the large pool further downstream at 11:50. The water was flowing over the rocks on the side of the pool. In Apr 2012 there were no bathers at 10:40; at 11:30 there were six bathers in the large pool further downstream. In Sept 2012 there were no bathers in the stream between the small and the large pool at 09:00. Green algae were growing on some of the rocks around the pool. At 15:10 on July 2012 there were five bathers in the stream between the small and the large pool. On our way back from the steaming ground at 15:34 there were four bathers in the large pool.

**Table 86: Data from Kerosene Creek Pool, Waiotapu**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 19 Apr 2012 | 36.4 | 3 | 150 | 0.3m below rock rim | - | Slightly cloudy |
| 3 July 2012 | 31.7 | 3-4 | 150 | 0.5m below rock rim | - | Clear |
| 17 Oct 2012 | 34.3 | 3 | ~150 | 0.3m below rock rim | - | Slightly Murky Brown |
| 30 Jan 2013 | 41.3 | 3 | 130 | 0.5m below rock rim | - | Murky, brown |


**Figure 147: Kero Creek Pool, Apr 2012 (A), Jul 2012 (B), Sep 2012 (C), Jan 2013 (D)**

- **Kerosene Creek Steaming Ground**
  E1896014 N5751240

Apr 2012: There appears to have been flooding in the area recently. The pools may have been covered in sediment. The stream temperature was 36.4°C. Two small pools next to the stream were measured at 28.9°C and 34.9°C. The temperature of these may have been affected by the stream. There were small areas of vigorous gas discharge.

July 2012: stream temperature was 31.9°C. The temperature of the small vents next to the stream ranged from 21.9°C to 32.8°C. The water was clear, and there was constant bubbling from the vents.

Sept 2012: stream temperature was 33.9°C (2 degrees warmer than the last site visit) at pH4. Although temperatures were ~7$^{o}$C cooler (15$^{o}$C-27$^{o}$C compared to 21.9°C to 32.8°C) the temperature variation between the pools was very similar between this visit and the one in June-July 2012.The water was clear, and there was constant bubbling from the vents with an accompanying smell of kerosene.

Jan 2013: vents that we measured were all pH4. The temperatures ranged from 28.9-34°C. Most of the vents were clear, however one contained murky water.


**Figure 148: Steaming ground, Apr 2012 (A), Jul 2012 (B), Sept 2012 (C), Jan 2013 (D)**

# 14 Whangairorohea

## 14.1 Tahunaatapu Pool

An incident at the pool in Apr 2012 resulted in the bank breaching. This incident has caused the level to drop by approximately one metre or 1m. There are areas of exposed mud where the water level has dropped. Three pipes have been placed at the outlet to control the outflow, and water was flowing from of all of the pipes. We could not visit the site in Apr due to the risk of a hydrothermal eruption.

There has been a slight increase in temperature (5.7°C) from June 2012 to Jan 2013

**Table 87: Data from Tahunaatapu Pool, Whangairorohea**

| Date | T(°C) | pH | Flow (l/s) | Water level | Ebullition | Colour |
|---|---|---|---|---|---|---|
| 25 June 2012 | 48.3 | nd | ~3.5 | o/f (piped) | Effervescing with occasional large bubbles | Clear, brown muddy base |
| 17 Oct 2012 | 51.1 | 8-9 | ~4 | o/f (piped) | Upwelling in the deep area, effervescing near the outflow | Clear, blue in the deepest area |
| 23 Jan 2013 | 54 | 7-8 | ~2 | o/f (piped) | Upwelling | Clear, blue in the deepest area |

**Figure 149: Tahunaatapu Pool, Whangairorohea, June 2012**

**Figure 150: Tahunaatapu Pool, Whangairorohea in October 2012**

**Figure 151: Tahunaatapu Pool, Whangairorohea in Jan 2013**

The infrared photos show that the hottest area of the pool is in the centre, which is also the deepest part where the upwelling originates. There appear to be some hot spots on the bank on the far side of the pool.

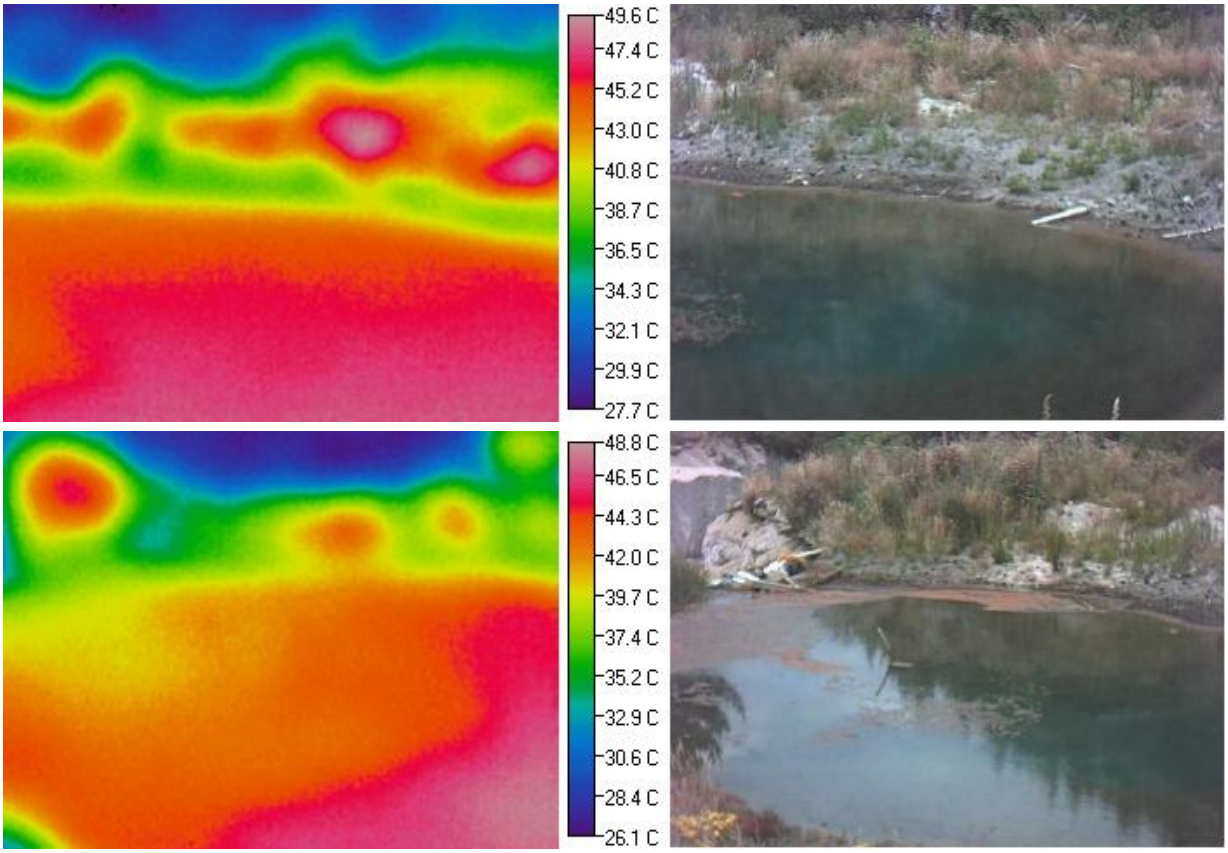


**Figure 152: Infrared photos, Tahunaatapu pool, Whangairorohea in Jan 2013**

# 15 Appendix 1

The appendix for this report is an Excel spreadsheet of the observations contained in this and previous reports, Waikato Regional Council document number 2142693. This may be obtained upon request from the Waikato Regional Council.