Geothermal Resources: Ngawha Geothermal Field

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8.1 Ngawha: Main Points

Pressures

- The Ngawha springs are widely used for bathing. Baths have been excavated since 1908 in four separate areas. They have boarded sides and are fed through seepage in the bottom and/or sides. The bath waters have a small international and a large local reputation for their curative properties.
- Since July 1998, fluid from the Ngawha geothermal field has also been used for power generation.

State

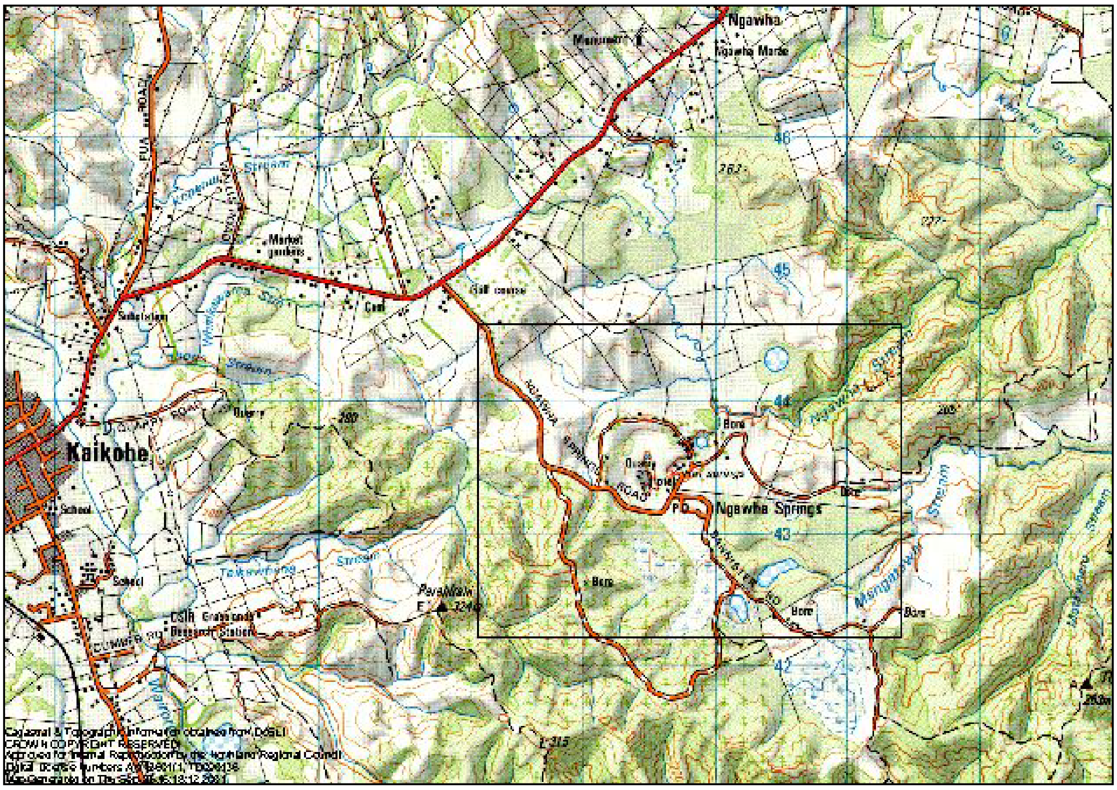
- Human impacts on the Ngawha springs have meant that the location of the features have changed little, but that the features themselves had been modified by bath excavation and mining operations in the early 20th Century.
- Monitoring required by the resource consent conditions has significantly increased the knowledge base of the Ngawha springs area.

Response

- The resource consents granted for the power station required the joint venture operators to undertake at least 12 months of further baseline monitoring in the Ngawha area before it could start abstracting geothermal fluid.
- Comprehensive ongoing monitoring of the environmental effects of the geothermal fluid take and power station.
- The establishment of a “peer review panel” and “community liaison committee” to increase both professional and community input into the monitoring of the resource and any effects of the power station.

8.2 Introduction to the Ngawha Geothermal Field

The Ngawha geothermal field is located approximately 5 km east of Kaikohe. It covers an area of between 25 to 50 km^2, and is the only high temperature geothermal field in New Zealand outside of the Taupo Volcanic Zone.



Map 14: Location of Ngawha Springs

The geothermal field lies within a small topographic basin and is centered on the town of Ngawha Springs. At the surface, the geothermal system consists of hot water springs and gas seepages. The productive reservoir consists of the permeable volume within the greywacke basement, which is thought to be more than 1,000 m thick (Gibson, 1992).

There are about 20 hot springs in the area, many of which are used as baths. Most of these occur in a small area in Ngawha Springs. They are a sacred taonga to the local hapu and all of Ngapuhi.

The waters in the springs are typically between 40 to 50°C, slightly acidic and give off a weak smell of hydrogen sulphide. The water chemistry includes high concentrations of boron, ammonia and bicarbonate, and mercury mineralisation. Given its water chemistry, and its geology, the Ngawha geothermal field is quite different to other geothermal fields in New Zealand.

The earliest phase of geothermal exploration at Ngawha concluded in 1964 with one deep bore being drilled (NG1) (Gibson, 1992). The former Ministry of Works drilled more exploration deep wells from 1977 to 1983. Some characteristics of these wells are given in Table 18.

Table 18: Characteristics of exploration deep wells drilled at Ngawha from 1977 to 1983 (Thain, 1985)

Year Drilled	Well Number	Total Depth m	Maximum Temperature ºC	Flowing Enthalpy kJ/kg	Flow Rate kg/s
1977	NG2	1253	236	980	30
1981	NG3	1470	228	980	30
1978/79	NG4	1353	237	970	110
1978	NG5	1281	250	-	-
1978	NG7	1316	189	-	-
1982	NG8	1184	218	890	65
1979	NG9	1000	227	970	65
1981/82	NG11	1209	225	960	90
1982	NG12	658	229	980	105
1982/83	NG13	2333	300	970	145
1982	NG15	431	175	-	-
1982	NG18	1362	244	950	30
1982	NG20	1644	260	2000	13

Most of the wells were discharged and tested for short periods, but were then left virtually untouched for a decade, before the existing power development was proposed.

8.3 Geothermal Issues

The Ngawha geothermal field is the only high temperature geothermal field in New Zealand outside of the Taupo Volcanic Zone, and is quite different to those other geothermal fields.

The key issue relating to the geothermal field is how much geothermal fluid can be used for power generation without significantly affecting the existing geothermal springs in the Ngawha Basin and the surrounding environment.

Aerial view of the Maori and Spa Baths with Lake Tuwhakino on the upper left **(Tricia Scott)**

8.4 Pressures Affecting Geothermal Resources

Historically, the thermal waters at Ngawha Springs were used for bathing. Maori history tells of the waters being used for bathing warriors. The spring system also attracted considerable scientific and commercial interest in the late 19th and early 20th centuries because of the accompanying mercury deposits, which were unprofitably mined during two periods. These mining operations substantially modified the landscape surrounding Ngawha springs (Sheppherd and Johnston, 1984).

Currently, the springs are still used for bathing. Baths have been excavated since 1908 in four separate areas. They have boarded sides and are fed through seepage in the bottom and/or sides. The bath waters have a small international and a large local reputation for their curative properties.

Since July 1998, fluid from the Ngawha geothermal field has also been used for power generation. The field is "tapped" by a single power station, which was constructed by a joint venture between Top Energy and the Tai Tokerau Maori Trust Board. Up to 10,000 tonnes of geothermal fluid per day can be taken from two "production wells" - NG9 and NG12, and is used to generate around 8MW (net) of electricity. The used fluid is then returned to the ground via two "reinjection wells" - NG11 and NG18.

Ngawha Geothermal power station during construction

The abstraction of geothermal fluid has the potential to result in physical and chemical changes to the existing geothermal features in the Ngawha Basin, and other adverse environmental effects such as land subsidence. Discharges from the geothermal power station also have the potential to have adverse effects on air quality and terrestrial and aquatic ecosystems.

Should the single existing power station prove to be commercially viable, with negligible environmental effects, then there may be increased pressure for further geothermal power development.

8.5 State of Geothermal Resources

The Ministry of Works asked the former Department of Scientific and Industrial Research (DSIR) to monitor the output and chemistry of the geothermal springs in the late 1970s/early 1980s to try to detect any effect of the exploration phase well discharge programme. This was due to concern that the exploration and possible use of the deep geothermal fluid beneath the Ngawha Basin could have adverse effects on the geothermal springs/baths at Ngawha Springs.

There had been several previous surveys of the springs and the chemistry of their waters. The surveys by Fleming (1945), Ellis and Mahon (1966) and Giggenbach

and Lyon (1977) indicated variability in spring and bath composition and the need to obtain more comprehensive data to determine the natural variability of the discharging system, and the parameters controlling it (Sheppherd and Johnston, 1984).

The monitoring done by the DSIR, and its review of the available scientific literature on the Ngawha thermal features, provided useful "background" data on spring output and chemistry. Some of the conclusions of this work are as follows:

- As far as could be judged, the location of the features had changed little, but that the features themselves had been modified by bath excavation and mining operations in the early 20th Century.

- The chemical composition of the bath waters reflected a hydrological balance between two supply waters – one a shallow extensive high magnesium-bicarbonate water, the other the high chloride-boron water derived from deep geothermal fluids. The compositions of the baths were influenced by various management practices on the baths, the rainfall of the preceding few days and surface drainage.

- The gases were similar in composition to the gases from the deep geothermal wells.

Jupiter and Universal Baths at Ngawha Springs
(Tricia Scott)

The resource consents granted for the power station in May 1994 required the joint venture to undertake at least 12 months of further baseline monitoring in the Ngawha area before it could start abstracting geothermal fluid. The joint venture actually ended up collecting more than 18 months of comprehensive baseline data before the production wells were purged and commissioning of the power station began. The following are some key findings from that baseline monitoring:

- More than 30 *Baumea complanata* populations were found in the Ngawha Basin. These populations covered an area of more than 3,000 m^2 and indications were that *B. complanata* plants were extending their boundaries at most locations.

- The vegetation in the area monitored could be broadly divided into two types: "gumland scrub", typified by abundant *Baumea teretifolia*, *Gleichenia dicarpa* and

Shoenus brevifolius, and drier vegetation types where *Dracophyllum lessonianus* and *Leptospermum scoparium* were prevalent.

Baumea complanata **growing amongst** ***Gleichenia dicarpa*** **(comb fern)** **Tricia Scott**

- One bittern (*Botarus poiciloptilus*) was heard in January 1997 and fernbirds (*Bowdleria punctata*) were present in small numbers.

- All mercury concentrations measured in soils at the "fixed station" monitoring sites chosen and in the Ngawha Springs township were higher than relevant environmental guideline values, particularly around the edge of Lake Waiparaheka. This is where the highest concentration of mercury was measured – 1,280 mg/kg, which compared with the Australian and New Zealand guideline for the protection of aquatic ecosystems maximum concentration at the time of 0.1 mg/kg (ANZECC, 1992).

- Water quality measured in streams draining the Ngawha Catchment was adversely affected (compromised) as a result of the discharges from the existing 'natural' geothermal surface features. For example, the boron concentrations measured at the Ngawha Stream weir and in the Mangatawai Stream exceeded the Australian and New Zealand guideline value for irrigation waters for sensitive plants (0.5 g/m^3) (ANZECC, 1992b).

- Mercury concentrations in stream and estuarine sediments were high, with some concentrations exceeding 500 mg/m^3 in stream sediments near the springs. Consistent with this finding was that mercury concentrations in eels in the Waiaruhe River were high compared with other sites in New Zealand and the control site in the Manaia Stream.

- Antimony concentrations in sediment in the Ngawha stream were also high.

- The hottest spring monitored was "Old Well" with a median temperature of 66.8ºC, although due to denied access, the temperature of the well was not measured between the cooler months of March to September. Therefore, the actual median well temperature may have been lower than this if the temperatures had been measured throughout the entire monitoring period.

- The hottest commercial bath was “Bull Dog” with a median temperature of 46.0ºC.

- The chloride/boron (Cl/B) ratio showed only small differences between the baths and the Cl/B ratio for each bath was similar to that recorded historically, indicating that there had been little change in the deep geothermal fluid component supplying the baths.

- The helium/nitrogen ratios in the gases in “Tiger Bath” were very different to those from the other baths.

- Lake Ngamokaikai, which has less surface geothermal manifestations and a smaller surface area than Lake Waiparaheka, showed greater fluctuations in water level than Lake Waiparaheka in response to rainfall.

- The half-hourly average hydrogen sulphide (H_2S) concentration in the air at the “permanent” monitoring site set up within Ngawha Springs township exceeded 100 µg/m^3 11 times during the monitoring period. This was somewhat unexpected, and the Ministry for the Environment’s ambient air quality guideline value of 7 µg/m^3 for half-hourly average H_2S concentration was exceeded regularly throughout the monitoring period.

- Median mercury concentrations in the air at monitoring sites ranged from 1.9 to 4.1 ng/m^3.

During the baseline monitoring period, a new species of mudfish was discovered at two sites in Northland – near Kerikeri airport and in the Ngawha Catchment. It is an ephemeral wetland species and was considered to be critically endangered because of low numbers. A population of this mudfish species was found in one of the catchments immediately adjacent to the geothermal power station site.

In March 2000, the Council assisted a masterate student from the University of Auckland to carry out a bathymetric survey of all three of the Ngawha geothermal lakes. It is understood to be the first such survey of the lakes and proved very interesting, with the main lake (Lake Waiparaheka) having a maximum depth of 40 metres, making it one of the deepest (if not the deepest) lakes in Northland.

8.6 Response to Geothermal Issues

The Revised Proposed Regional Water and Soil Plan for Northland places strict controls on the abstraction (taking) of geothermal water from the Ngawha Geothermal Field. It is only a permitted activity if the take is for reasonable domestic needs and, among other provisions (conditions), does not exceed 1 m^3 per day. Otherwise, the taking of geothermal water is a discretionary activity, which therefore requires a resource consent.

The Ngawha geothermal field is currently “tapped” by a single user - a joint venture between Top Energy and the Tai Tokerau Maori Trust Board, which operates a single small scale power station that generates around 8MW (net) of electricity.

As discussed in the previous section, the resource consents granted for the power station required the joint venture to undertake at least 12 months of further baseline

monitoring in the Ngawha area before it could start taking geothermal fluid. In addition to this baseline monitoring the resource consents also:

- Restricted the take to 10,000 tonnes per day instead of the 35,000 tonnes per day originally applied for by the joint venture.

- Required comprehensive ongoing monitoring of the environmental effects of the geothermal fluid take and power station.

- Required the establishment of a "Peer Review Panel". This panel is made up of three professionals with expertise in geothermal science, water quality, terrestrial and aquatic ecology, and a representative of the tangata whenua. The main purpose of the panel is to critically review reports on the various monitoring programmes required by the consents, consent compliance and the effects of the take/operation of the power station on the surrounding environment, and the sustainability and characteristics of the Ngawha geothermal field.

- Required the establishment of a "Community Liaison Committee" made up of representatives of the tangata whenua of Ngawha, thermal pool operators, local residents, downstream water users and the Far North District Council and Northland Regional Council.

The term of the consents was also reduced to ten years (from the commencement of the consents) from the 35 years applied for by the joint venture.

These strict requirements were imposed on the resource consents to:

- Protect the geothermal springs/features in the Ngawha Basin and the sustainability and characteristics of the Ngawha geothermal field.

- Minimise any environmental effects of the take and power station.

8.6.1 Monitoring

Monitoring has shown that no significant changes to the local environment have occurred in terms of air, water and soil quality as a result of discharges from the power station over the period of its operation.

Monitoring is currently conducted for:

- Ecosystems (including receiving water quality, eels, mudfish populations, vegetation surveys, fauna surveys).
- Springs and streams receiving thermal fluids (bath temperature and chemistry, stream flow variations).
- Groundwater (levels, temperature and chemistry).
- Lakes (levels, temperatures and chemistry).
- Air quality (chemistry).

An early survey of the wetland area immediately below the outlet from the NG9 holding pond (September 1999) established that some vegetation had been damaged or killed as a result of early discharges from the pond. These areas are now recovering.

Some Ngawha residents and geothermal pool operators have raised concerns that there had been some cooling of the pools. However, comparison of long-term records of temperature monitoring of those geothermal features did not show any abnormal cooling. Concerns have also been raised about offensive odour, which has been attributed to the power station. Continuous hydrogen sulphide monitoring records confirm that there have been high levels recorded, but that those levels were not outside the range recorded during the baseline monitoring period.