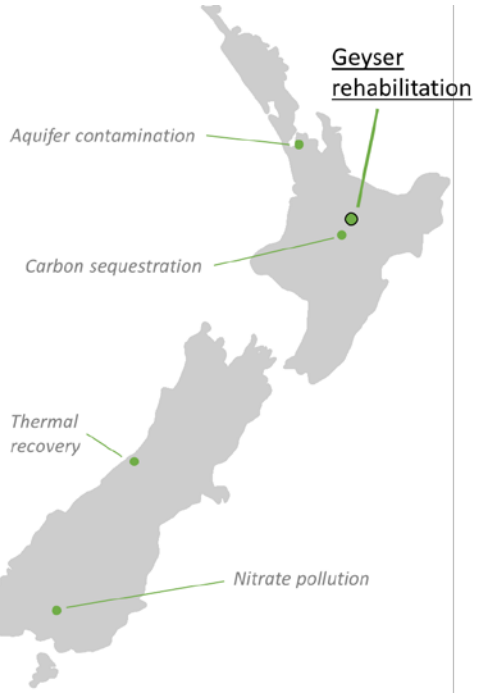
Rehabilitation of Waikite Geyser



Geysers, spectacular explosions of hot water and steam, are valued for their natural beauty and as an indicator of the health of a geothermal field. They erupt because of abrupt boiling of superheated water in an underground chamber. Afterward, the geyser "resets" by slow refilling of the chamber with a mixture of hot and cold groundwater. However, if the proportion of hot water decreases or the rate of refilling slows, geyser eruptions can become less frequent or disappear altogether.

The city of Rotorua was built atop the Rotorua geothermal system and, for decades, residents drilled shallow bores so they could use free hot water for heating and bathing. Over time however, pressure (and groundwater level) in the field declined, and the geysers it supported stopped erupting. The Waikite Geyser at Whakarewarewa, the third largest in the country with eruptions reaching more than 20 m high, last erupted in 1967. To arrest the decline and rehabilitate the geothermal system, a borehole closure program was begun in 1986. By 1990, the total production from the system had decreased by 70%, reinjection had increased, and pressures were recovering. Geothermal temperatures are still recovering having declined a small amount due to cold (30°C) water being drawn into the reservoir. Thermal features have steadily returned, although there is considerable uncertainty about the early pressure conditions of the field and the connectedness of different rock types from which hot water is drawn. As such, predicting when a particular thermal feature will return can be difficult.

The Bay of Plenty Regional Council are hearing submissions on an application by Rotorua City Council (RCC) to extend the borehole moratorium. Currently, there is some limited production from existing bores in the city, and a borehole exclusion zone around Whakarewarewa. RCC have proposed to continue the moratorium in its current form. This is opposed by the Tūhourangi Ngāti Wāhiao people of Whakarewarewa Village, who wish to see all bores closed in an effort to speed recovery of their geysers. The application is also opposed by the local chamber of commerce representing local hotels that wish to install geothermally heated baths (requiring new bores.)

You have been retained by Tūhourangi Ngāti Wāhiao to undertake a computer modelling study of the Rotorua Geothermal Field and recovery of the Waikite Geyser. To support your study, the following data are available:

- Total extraction rate data from the Rotorua geothermal system, and a partition corresponding to a Rhyolite formation that has seen continuing extraction post borehole closure.
- Pressure and temperature monitoring data from near Whakarewarewa.

- Reservoir engineering reports which indicate that the supply of hot water (rate and temperature) into the geysers has been disrupted but is recovering. The supply of cold water is unchanged.

Project expectations:

You should undertake a computer modelling study that will assist decision-making during the resource consent hearing, in particular addressing the noted concerns of other stakeholders where they are relevant to the study. The model you develop should be defensible, reflective of reality, and take appropriate account of uncertainty. You will be required to communicate the model findings in both oral and written formats.

Recommended literature:

For a model of the Rotorua geothermal system

Ratouis, TMP, MJ O'Sullivan, SA Alcaraz, JP O'Sullivan, (2017). The effects of seasonal variations in rainfall and production on the aquifer and surface features of Rotorua geothermal field. *Geothermics 69*, 165-188.

For an eruptive history of the Waikite Geyser and other surface features

Scott, BJ, DA Gordon, AD Cody, (2005). Recovery of Rotorua geothermal field, New Zealand: Progress, issues and consequences. *Geothermics 34*, 161-185.

For a model linking geyser style to flow rate and temperature conditions (Section 3.5)

Rinehart, J, (1980) Fundamentals of Geyser Operation. In: Geysers and Geothermal Energy. Springer, New York, NY.