Rotorua Geothermal System

Intrinsic Values and Surface Features

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Geothermal

What is it?
How does it originate?
Where is it found?
Can we exploit it?
What are the problems?
Geothermal energy is heat within the Earth

Three sources:
1. Radioactive decay of minerals in the crust
2. Primordial heat from the centre
3. Volcanism

Two transport mechanisms:
1. conduction
2. convection
Classification of geothermal resources

Temperature: range encountered 20-500 °C

Enthalpy (heat content): ranges from 150-2700 kJ/kg

High-temperature: above 100 °C, enthalpy >1000 kJ/kg
Low-temperature: < 100 °C, enthalpy <1000 kJ/kg
Origin of a high-temperature system

Geothermal field

- Magma body
- Cold groundwater

Rainwater flow:
- Approx. 1 km

Heat transfer region

Geothermal field:
- 100°C
- 200°C
- 300°C

Diagram scale: approx. 1 km
Location of Geothermal Systems
Origin of thermal features

Geothermal Reservoir
(180 - 300 °C)

Fractures with hot water + steam

Outflow

Hot spring

Hot pool

Geyser

Fumarole

Zone of low permeability

Boundary Zone

cold groundwater
Hot springs and Warm pools

Hot Ground Fumarole

Acid Pools and Collapse Holes

Mixing

Steam feeding

Boiling Zone

Hot water feeding

fractures

cold groundwater
Natural Thermal Features:

- Geysers
- Hot springs
- Hot pools
- Mud pools
- Sinter terraces
- Areas of thermal ground
- Algal mats
- Thermophyllic plants
Worth preserving?

rare - worldwide tourist attraction
cultural value
intrinsic beauty
dynamic
Effects on natural thermal features

Pre-development

Champagne Cauldron
Wairakei (NZ)

Activity almost dead
overgrown with vegetation

1997
A Crow’s Nest Geyser, the Spa geyser basin (Lloyd photo);
B Waipikirangi Geyser, the Spa (Lloyd photo);
C Prince of Wales Feather Geyser, Geyser Valley (Isles photo);
D Twins Geyser, Geyser Valley (photographer unknown);
E Porangi Geyser, Orakeikorako (Lloyd photo);
F Waikite Geyser, Whakarewarewa (Lloyd photo)

All lost by the 1070’s
Ohaaki Pool (NZ)

Effects of reservoir pressure drawdown

before development (1952)
during well testing (1969)

Water level (m)

Time (year)
History of changes to natural thermal features in NZ

- **Rotomahana** - Pink & White Terraces totally destroyed by volcanic eruption in 1886
- **Orakeikorako** - about 2/3 features submerged by L. Ohakuri in 1961
- **Tauhara (Spa sights)** - affected by lowering of river level in 1942, then killed by development of Wairakei field in early 1960’s
- **Wairakei** - most features dead by 1965 as a result of development
- **Rotorua** - many features severely affected by drilling 1930-70’s as a result of withdrawal of hot water
- **Ohaaki** - Ohaaki Ngawha affected by development in 1968
Rotorua Geothermal Field

• Unique in that it lies beneath a major city

Three major time periods;
• Traditional use and natural state - 1800’s to 1950
• Intensive extraction of fluid and heat from the field – 1950 to 1986
• Bore closure and post closure recovery – 1986 to present
Rotorua Geothermal System
Rotorua Geothermal System
Distribution of bores
• 1953 Geothermal Energy Act. Bores deeper than 61m needed to be licenced.
• 1967 Rotorua Empowering Act. No bores are licenced, exploitation progressed in an unplanned manner with no regard to sustainability or protection of the values
• 1970’s large decline in surface activity, public concern starts
• 1980 Ministry of Energy announces guidelines, no new drilling
• 1982 agreement is reached for a monitoring programme
• Establishes fluid is wasted through inefficient use and that aquifer levels continued to decline
• 1986 Rotorua Empowering Act revoked, bore closures ordered within 1.5km of geysers
• Recovery starts ……
Results from the Monitoring Programme (1984-86)

Geothermal aquifer pressure

Average air temperatures
Distribution of bores

Before closures

After closures
Monitor Bore - results

Ground water levels
Usage
Rotorua Geothermal Field
A Success Story ?
Hot Springs

- Kuirau and Ohinemutu
  - Springs have recovered
- Govt Gardens, Ngapuna
  - Springs have recovered
- Whakarewarewa (Te Puia)
  - Some springs have recovered
  - Some geysers have, others have stopped

Borefield

- Bore field aquifer levels are up
- Net use is down
- Management Plan in place
- Monitoring in place
Chloride Springs
some have recovered

Parekohoru

Korotiotio
Chloride Springs - Geysers
Problems ........ A couple

- Lack of acceptance control was/is needed
- Building over failed springs
- Building over abandoned wells
- No management of soak bores
Built over warm ground
Built over failed springs
Hydrothermal eruptions
Soak Bores
Mitigation
Controlled development
Acid Sulphate - discoloured pools
Acid Sulphate - collapses