Rotorua Geothermal System

Intrinsic Values and Surface Features

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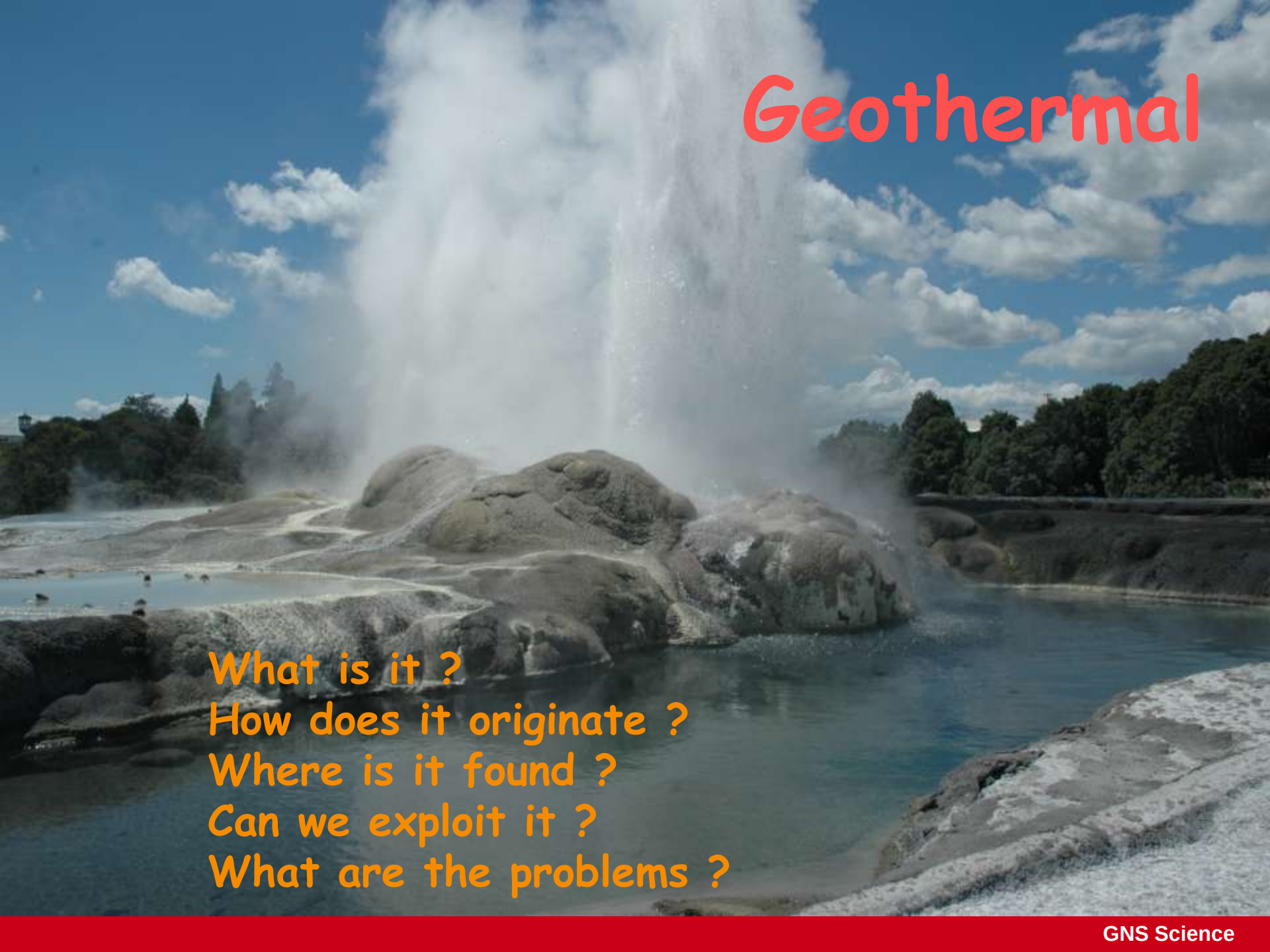


Geothermal

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:

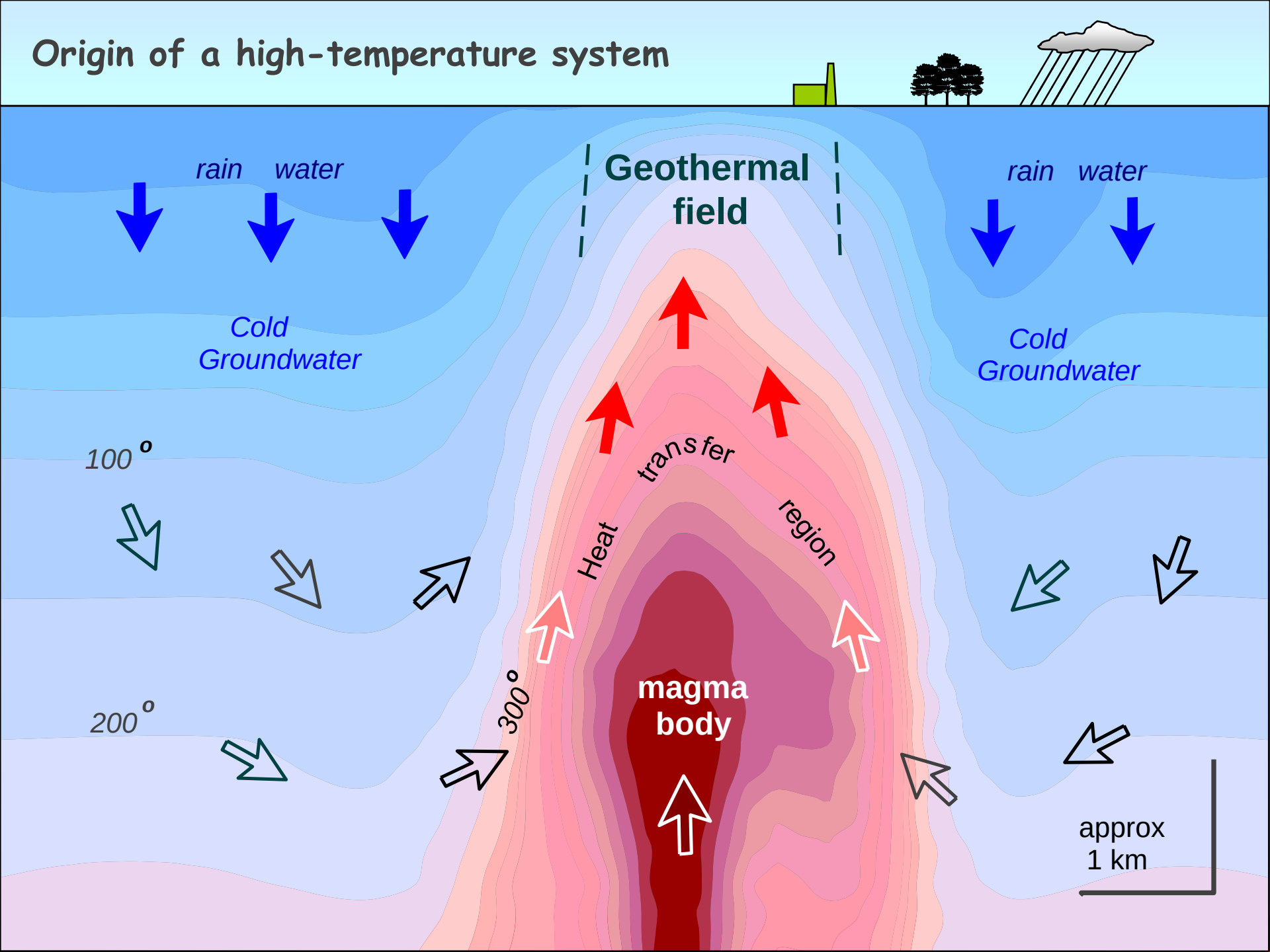
1. conduction
2. convection

Classification of geothermal resources

Temperature: range encountered 20-500 ºC

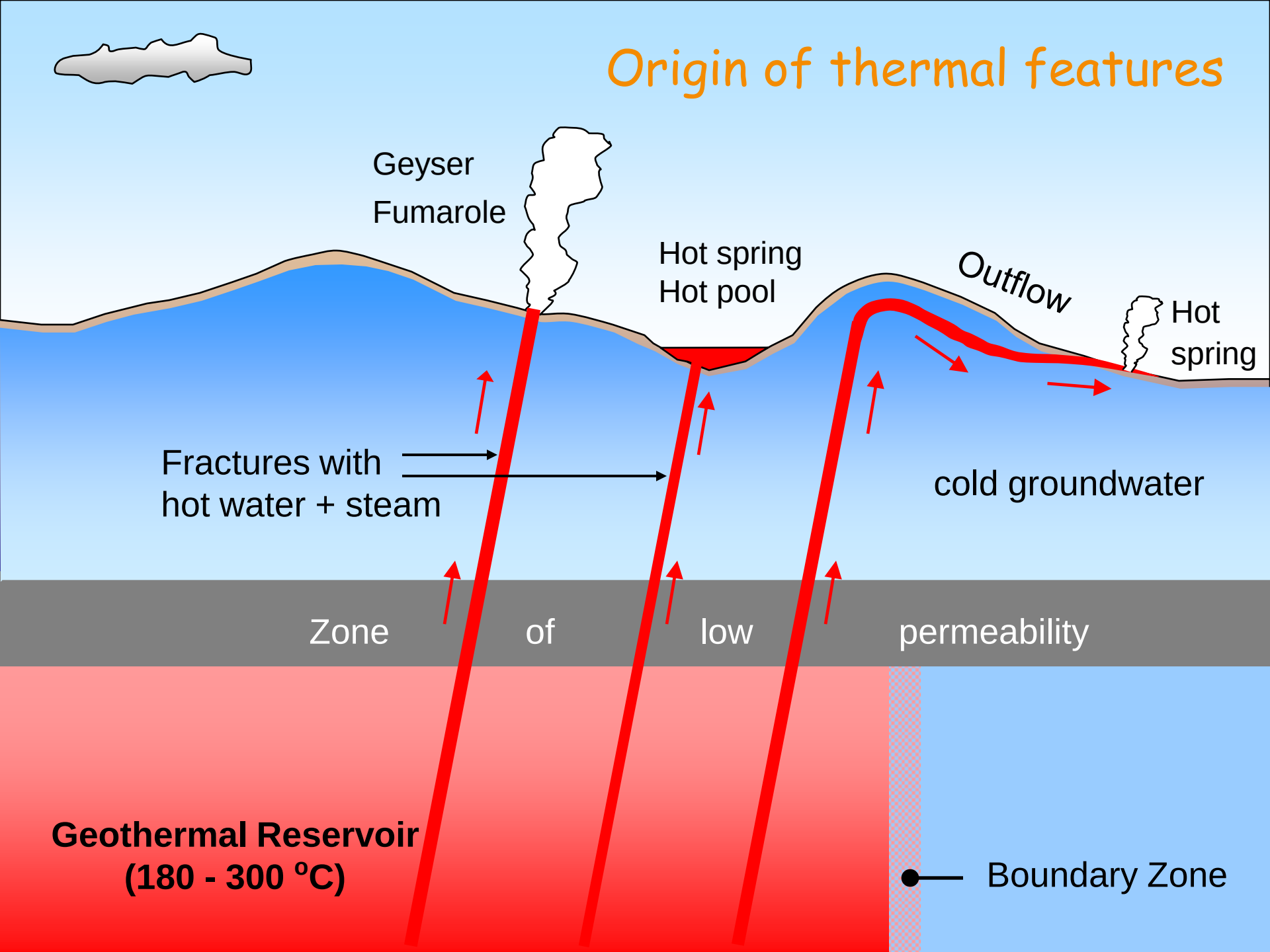
Enthalpy (*heat content*): ranges from 150-2700 kJ/kg

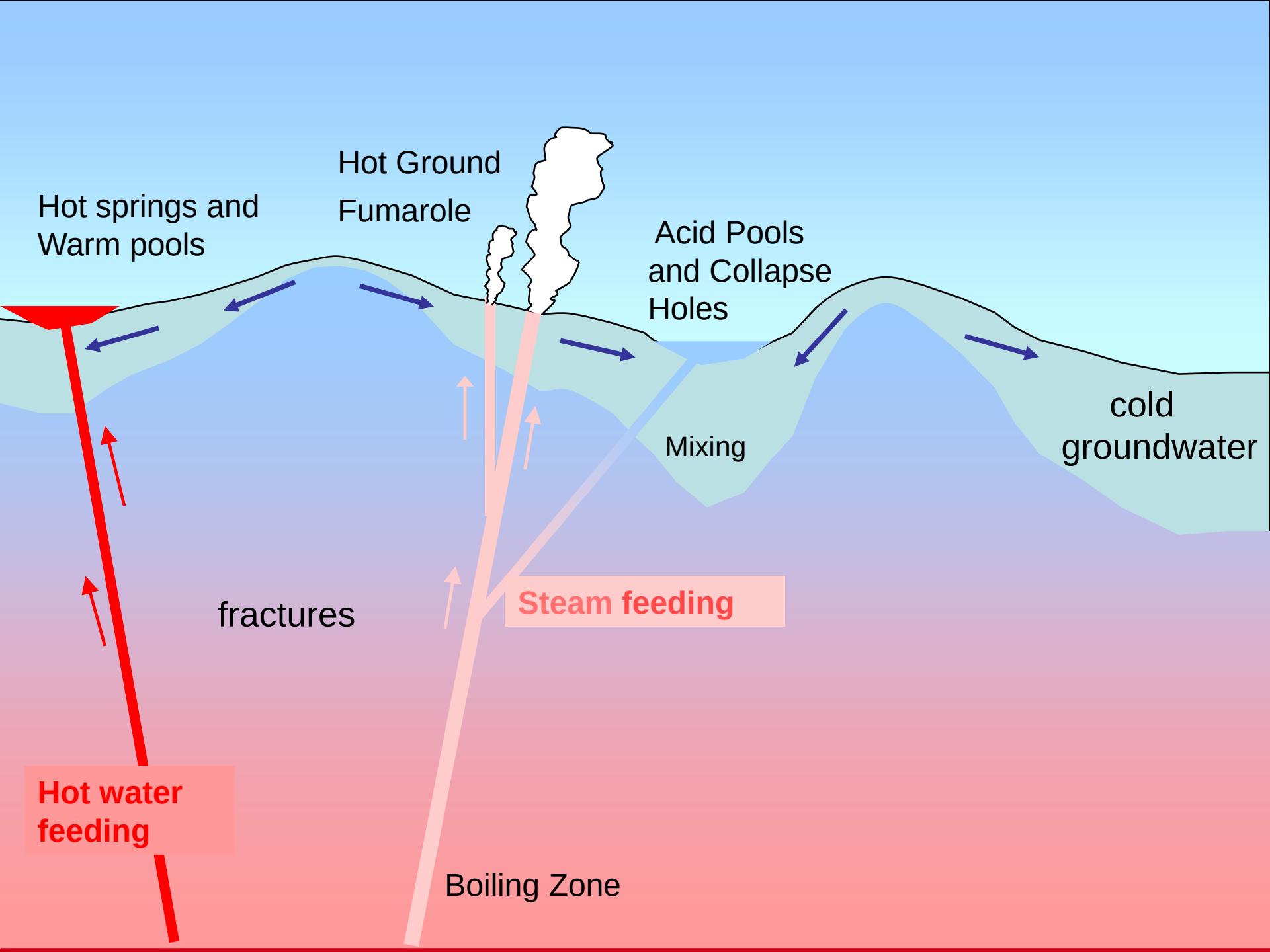
High-temperature: above 100 ºC, enthalpy >1000 kJ/kg
Low-temperature: < 100 ºC, enthalpy <1000 kJ/kg


Origin of a high-temperature system
rain
water
rain
water
Geothermal field
Cold Groundwater
Cold Groundwater
100 °
200 °
300 °
Heat transfer region
magma body
approx 1 km


Raoul Island
Bay of Islands
N
Auckland
Mayor Island
White Island
Edgecumbe
Okataina
Tarawera
Maroa
Taupo
Tongariro
Ngauruhoe
Taranaki/ Egmont
Ruapehu
active in the past 300 years
active in the past 10 000 years
0
100 km

Location of Geothermal Systems


Origin of thermal features
Geyser
Fumarole
Hot spring
Hot pool
Outflow
Hot
spring
Fractures with
hot water + steam
cold groundwater
Zone of low permeability
Geothermal Reservoir
(180 - 300 °C)
Boundary Zone


Hot springs and
Warm pools
Hot Ground
Fumarole
Acid Pools
and Collapse
Holes
cold
groundwater
Mixing
fractures
Steam feeding
Hot water
feeding
Boiling Zone

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)

1997

Activity almost dead
overgrown with vegetation

Eagles Nest
Geyser
Wairakei

Papakura Geyser
Rotorua

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)

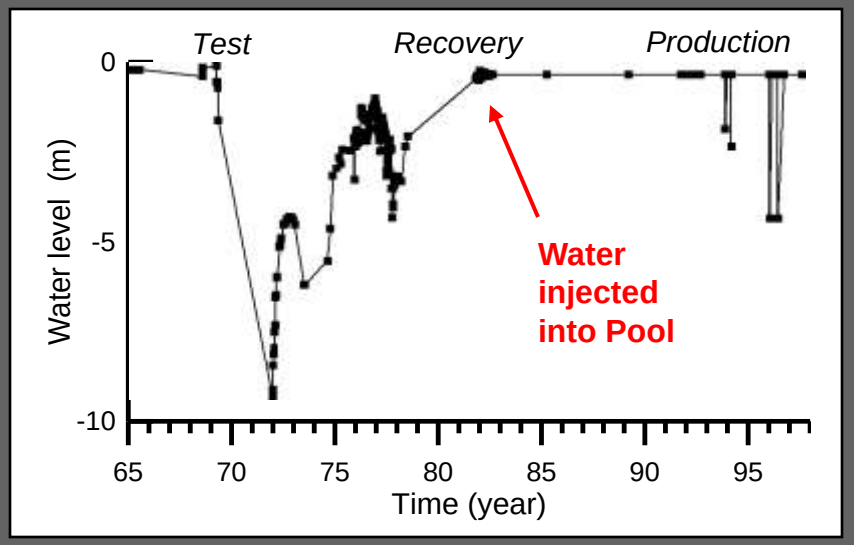
All lost by the 1070's

Ohaaki Pool (NZ)

before development (1952)

during well testing (1969)

Effects of reservoir pressure drawdown



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

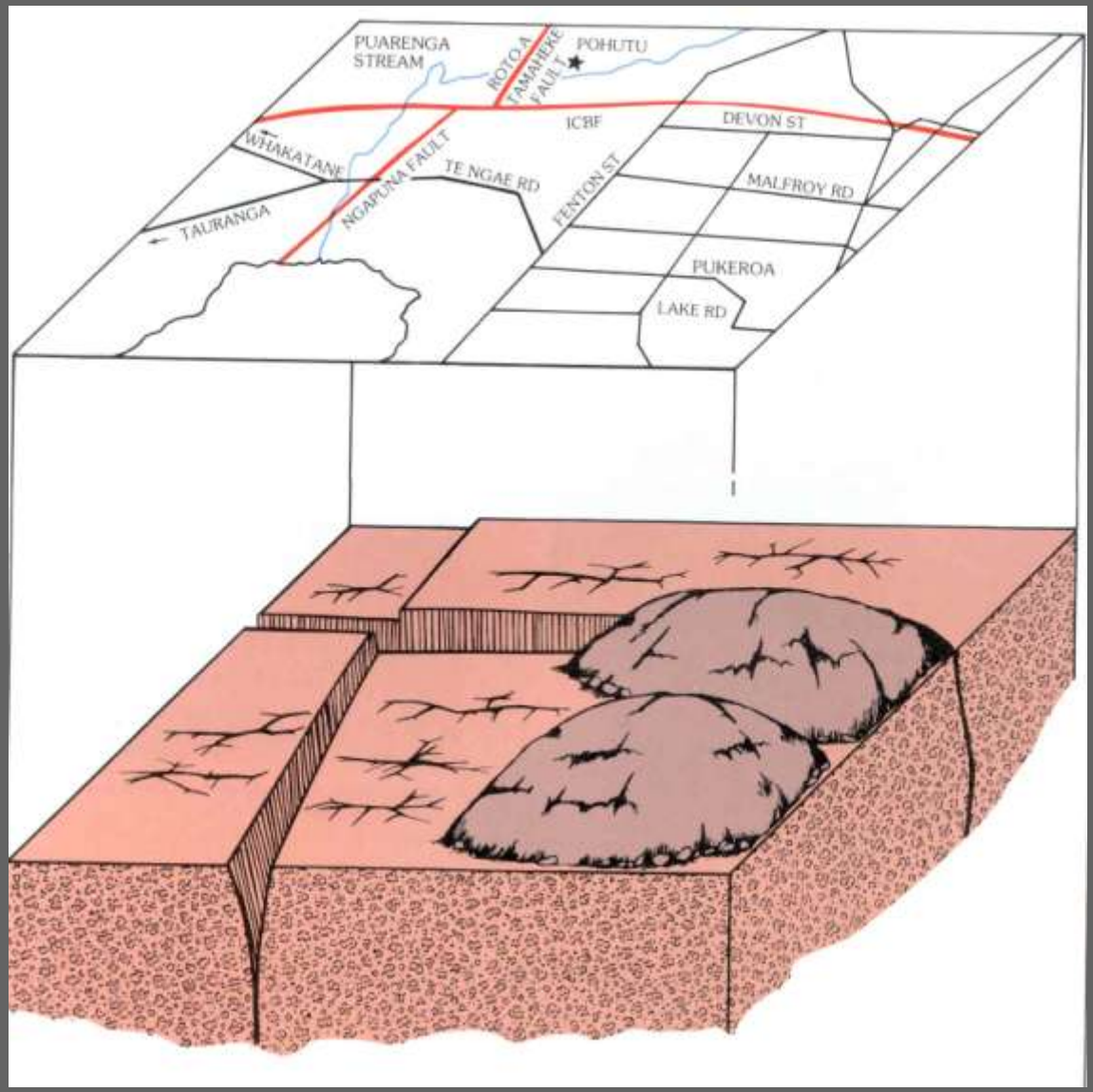
Rotorua Geothermal Field

- **Unique in that it lies beneath a major city**

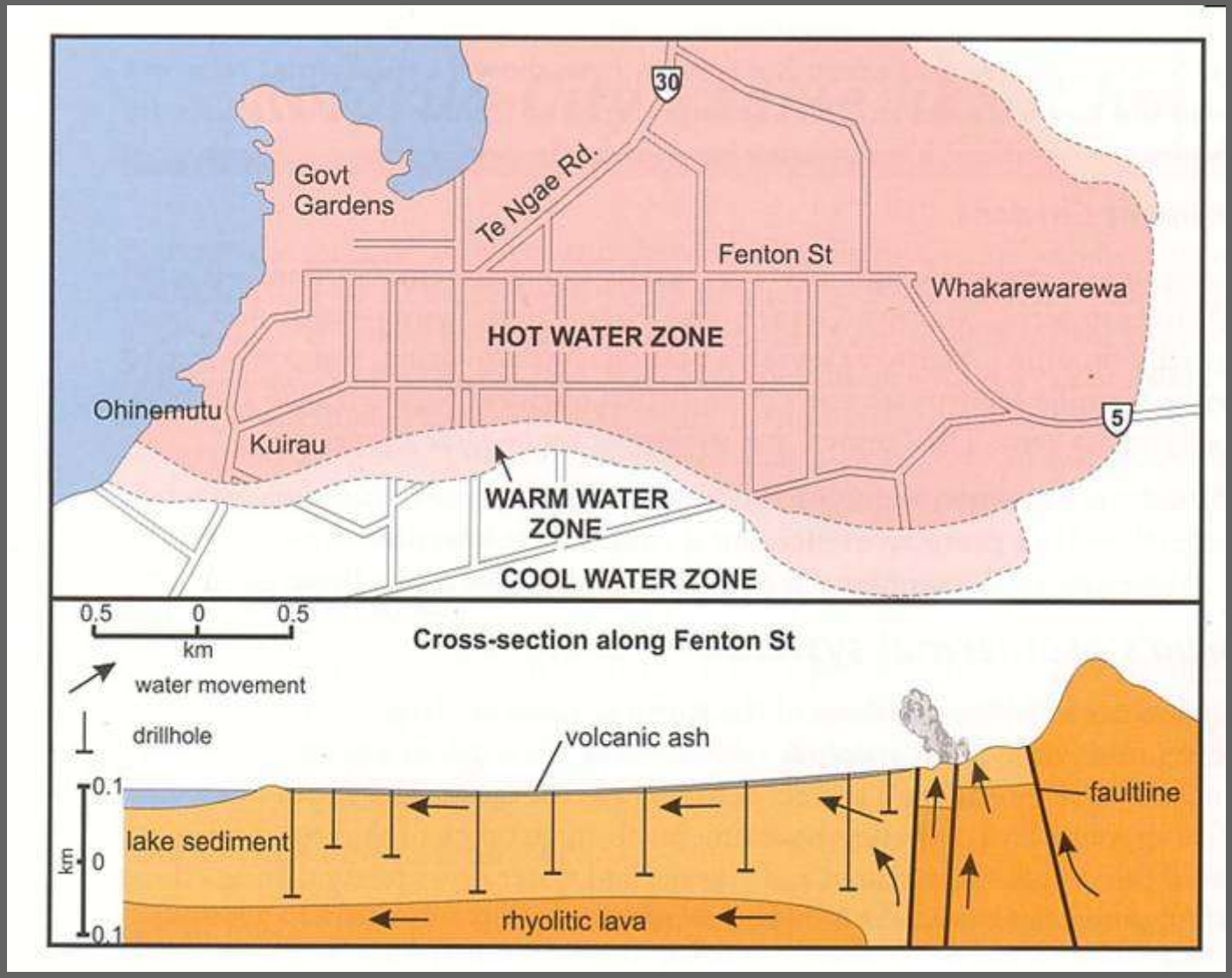
Three major time periods;

- **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**

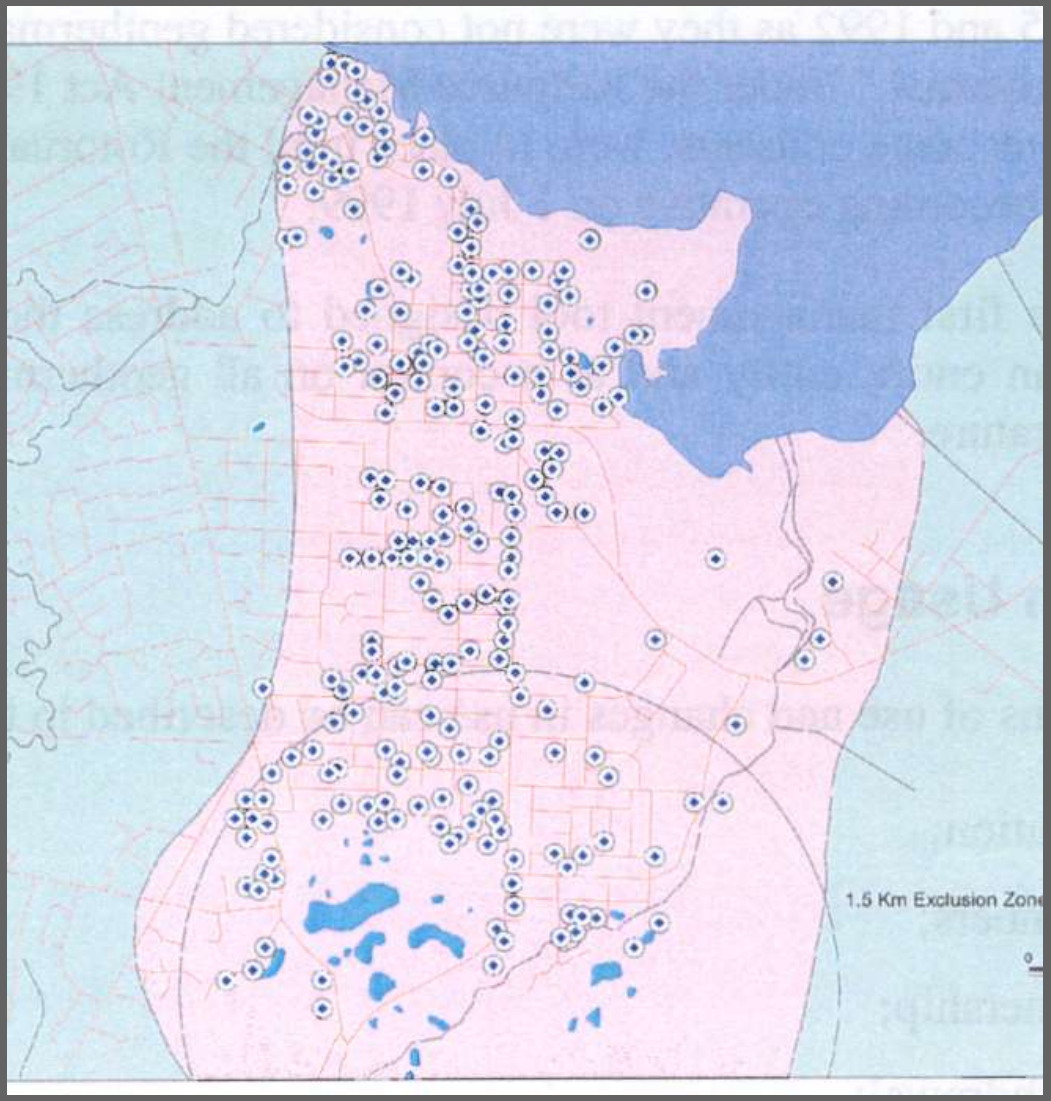
Rotorua Geothermal System



Rotorua Geothermal System



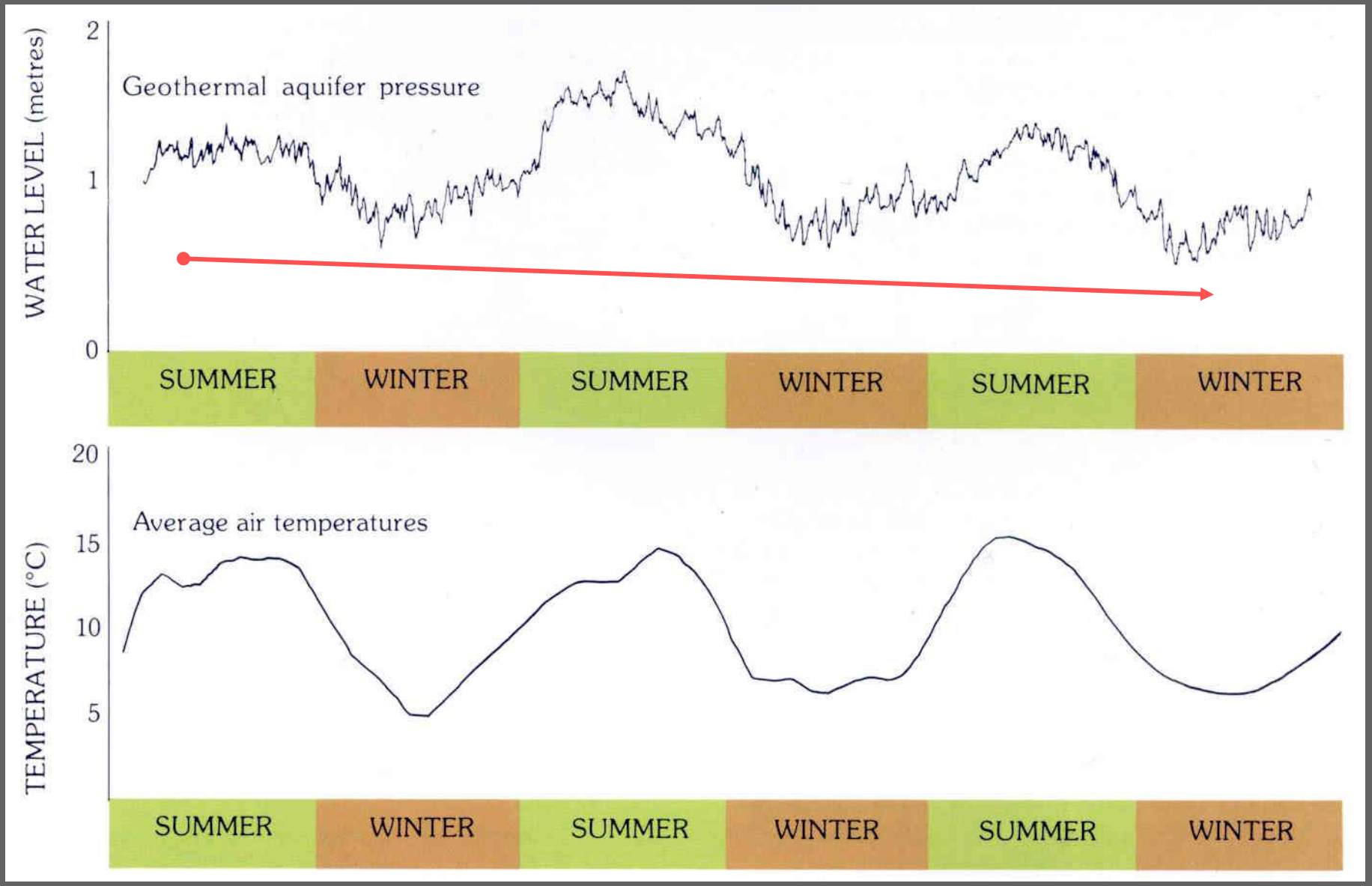
Distribution of bores



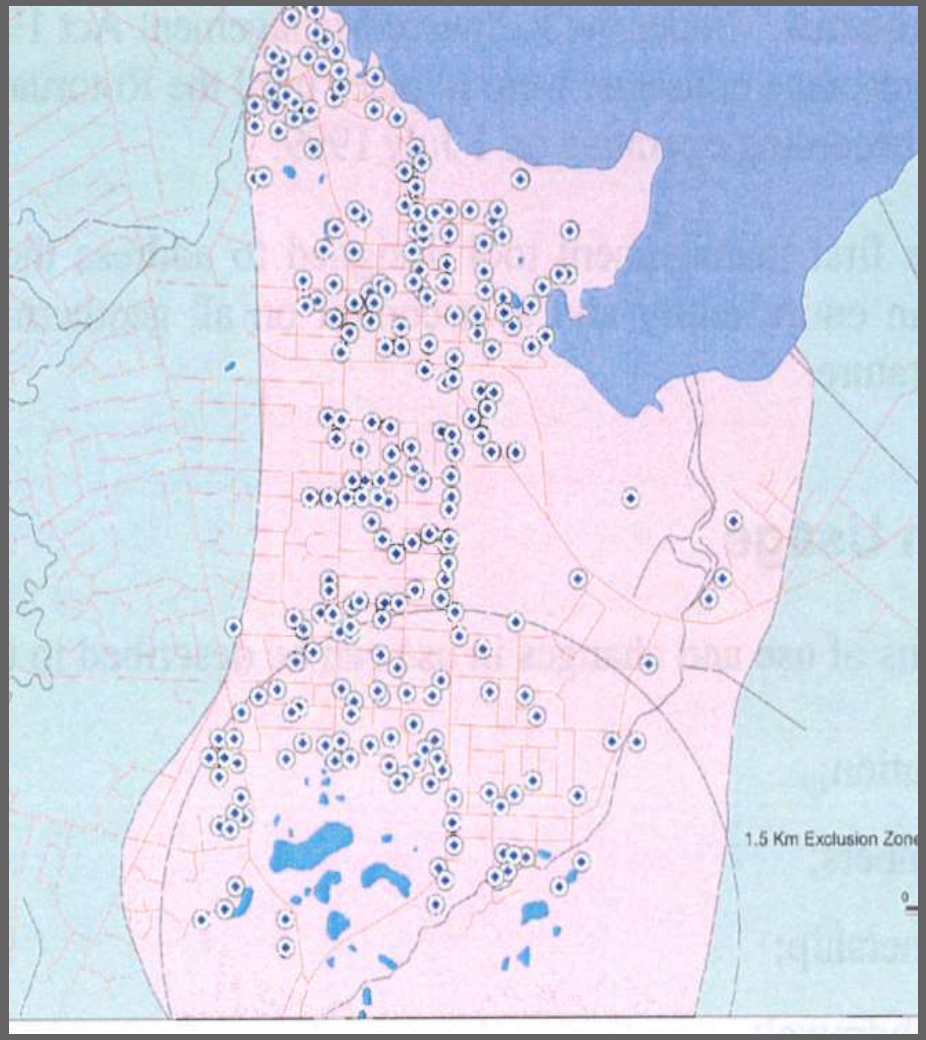
History

- 1953 Geothermal Energy Act. Bores deeper than 61m needed to be licenced.
- 1967 Rotorua Empowering Act. No bores are licened, 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)

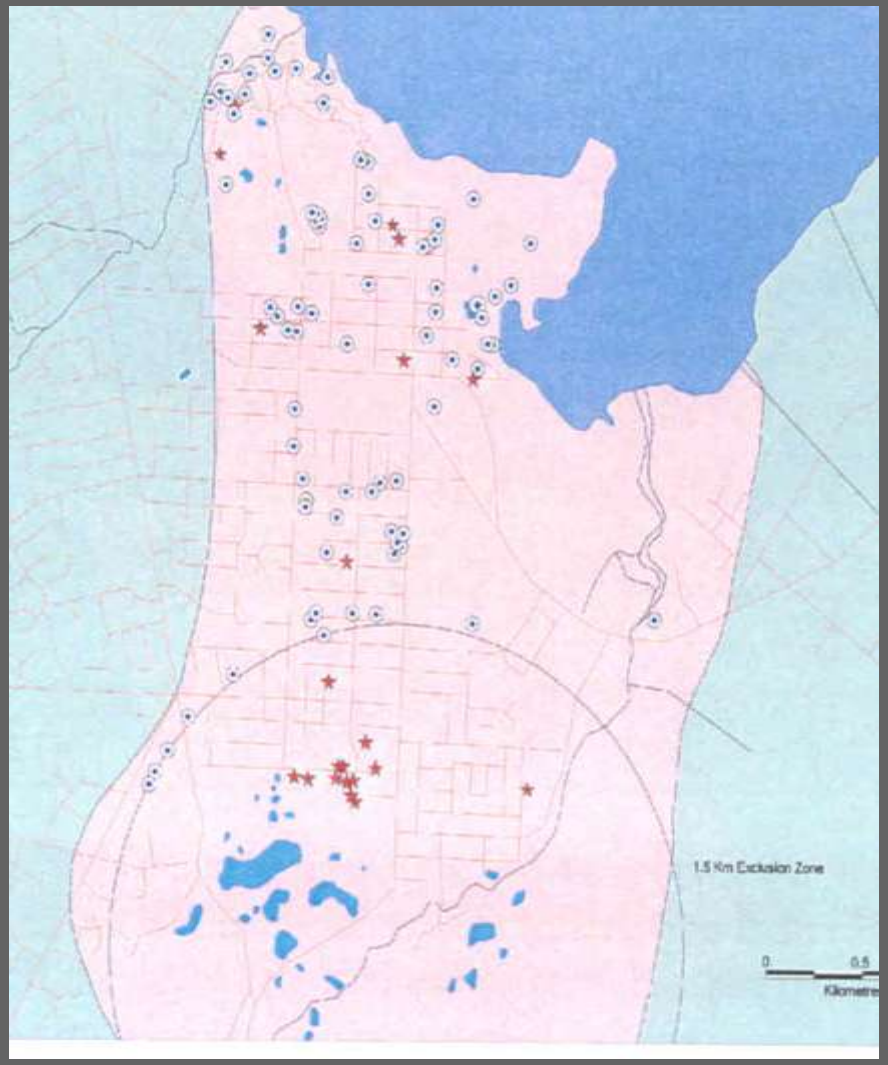


Distribution of bores

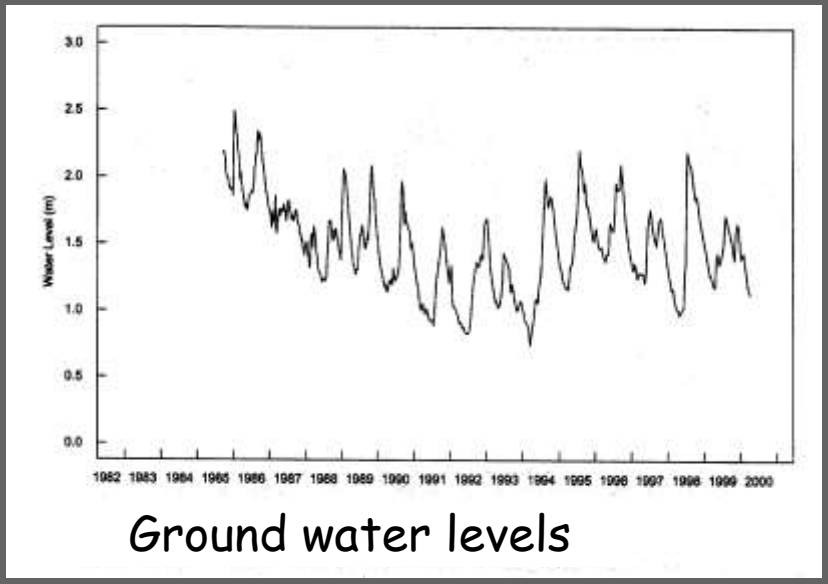


Before closures

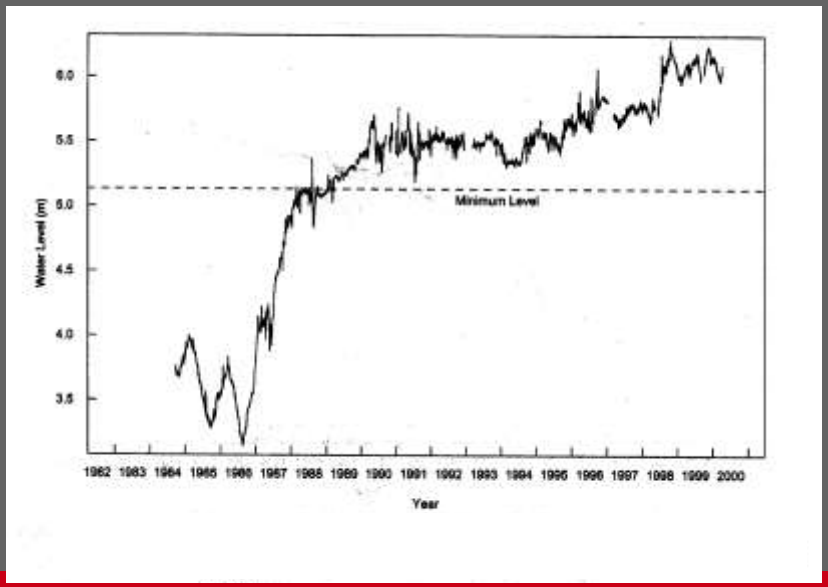
After closures

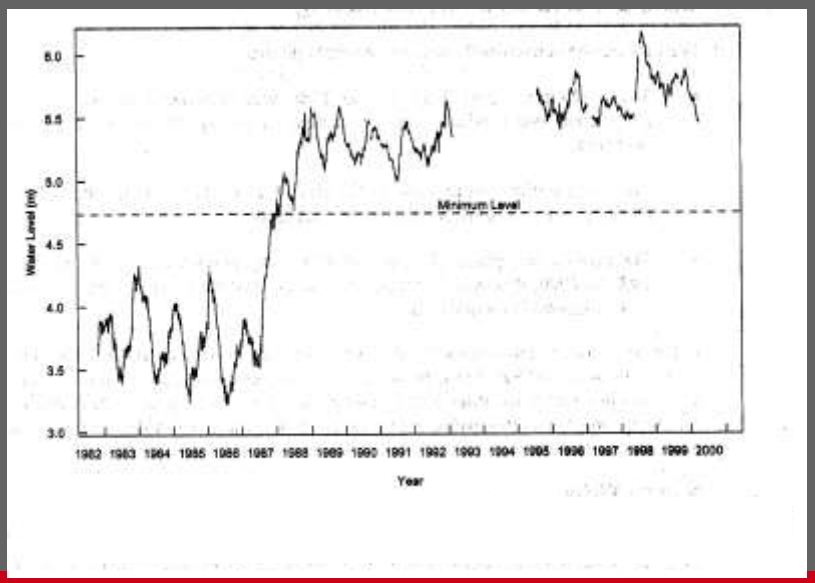


Monitor Bore - results

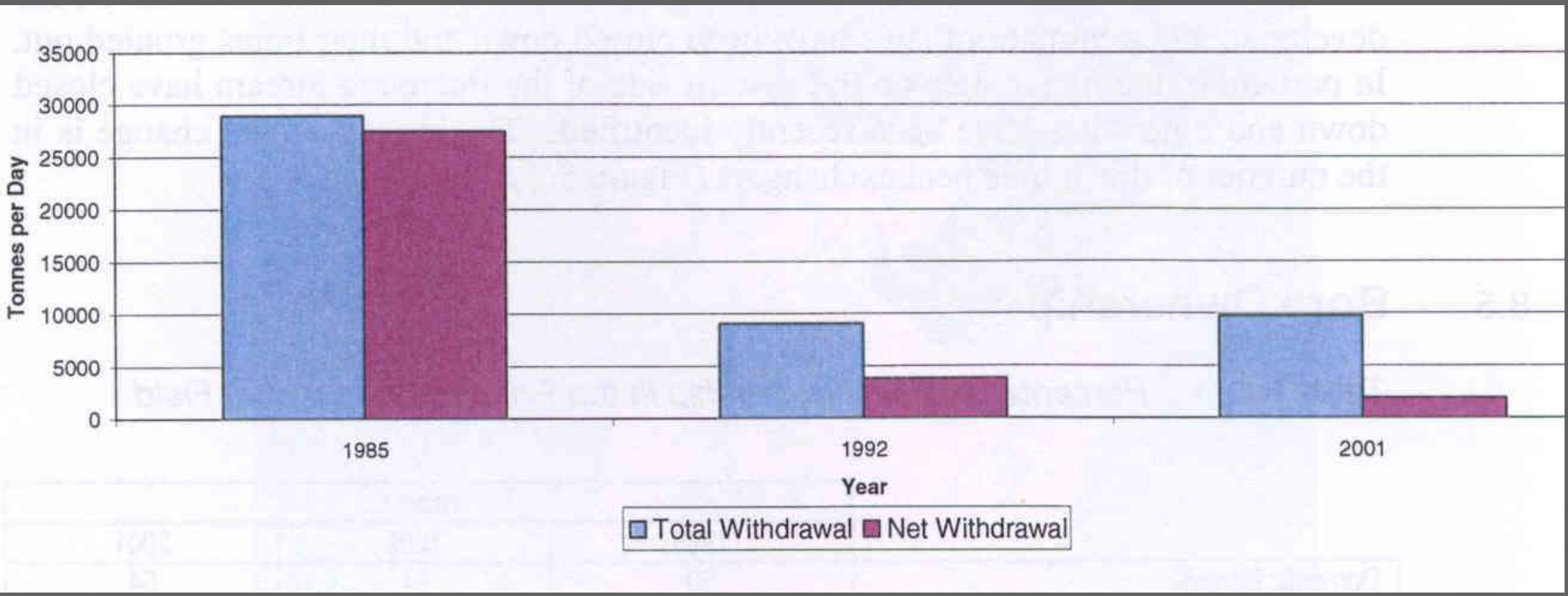


Ground water levels





Useage


35000
30000
25000
20000
15000
10000
5000
0
Tonnes per Day
1985
1992
2001
Year
Total Withdrawal
Net Withdrawal

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

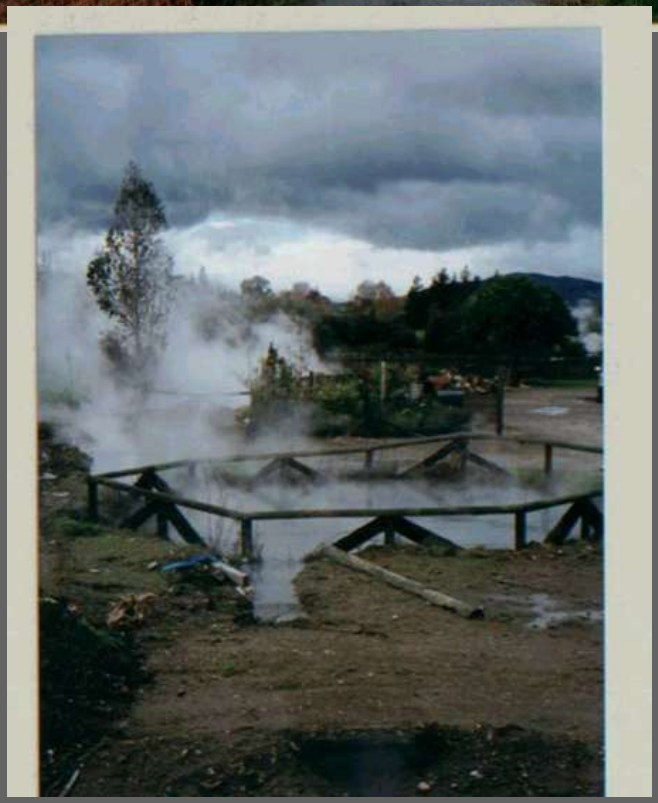
some have recovered

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

GNS Science

Hydrothermal eruptions


IT & VEG

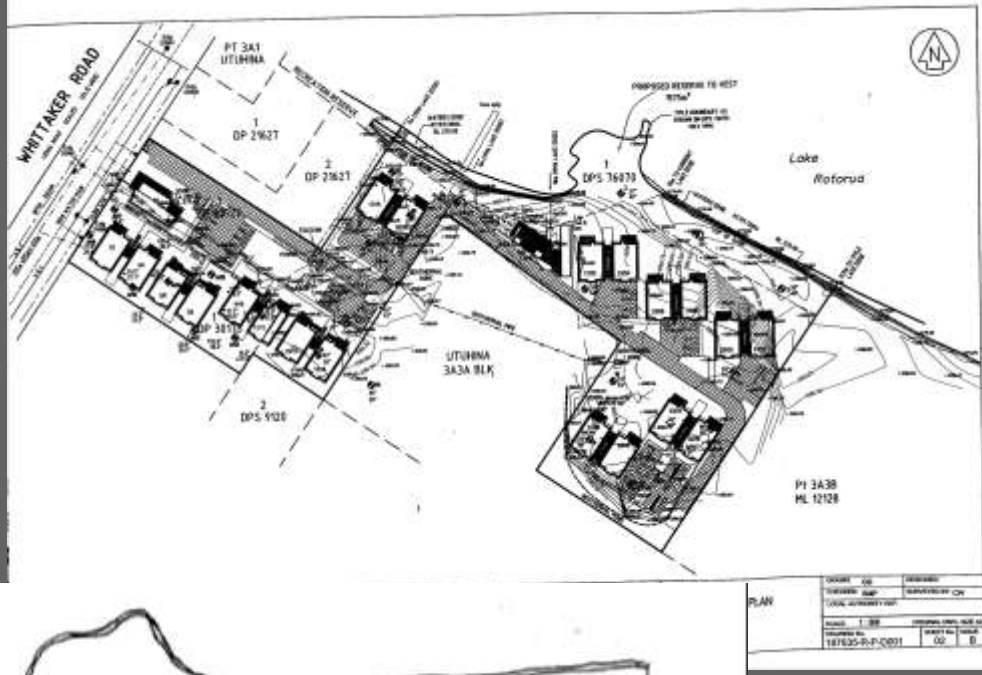

DANGER
NO ENTRY

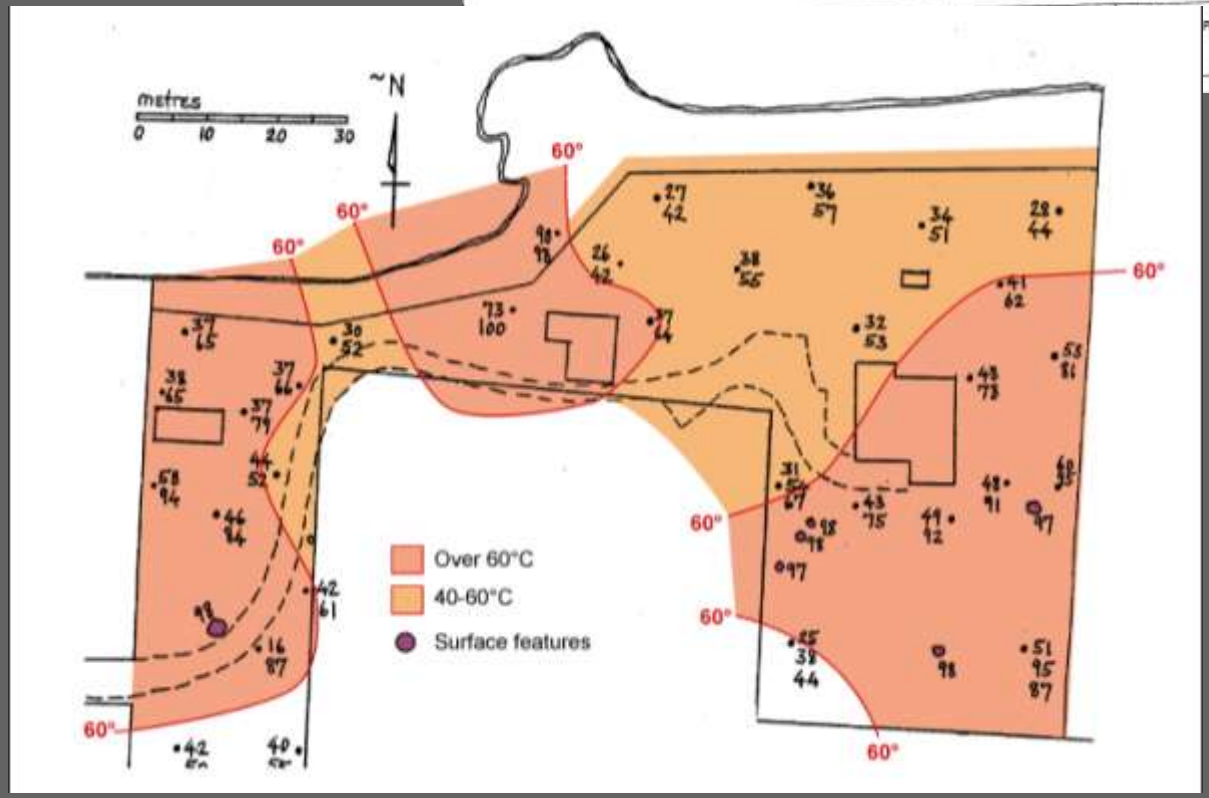

27/3/2001 18:48

Soak Bores

Mitigation

Controlled development





Acid Sulphate - discoloured pools

Acid Sulphate – collapses