# SUSTAINABLE MANAGEMENT OF GEOTHERMAL RESOURCES, A NEW ZEALAND SCENARIO

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## ABSTRACT

New Zealand has a Resource Management Act for the purpose of promoting the sustainable management of natural and physical resources. The Act requires the country's regional councils to control the take and use of geothermal water and energy with the objective of sustainability. The Waikato Region contains most of New Zealand's high temperature geothermal systems, resulting in the Waikato Regional Council taking a leading role in sustainable management of geothermal resources.

The Council proposes to sustainably manage the region's total geothermal resource rather than managing individual systems sustainably. It supports unitization of designated development systems, where single tappers are given the exclusive right to take and multiple users are encouraged to utilize the extracted resource. This enables effective and accountable resource management, and responsible, efficient and secure resource development.

## 1. INTRODUCTION

New Zealand's Rcsource Management Act (RMA) (New Zealand Government, 1994) promotes the sustainable management of the country's natural and physical resources. The Act defines sustainable management as:

"managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while; meeting the needs of future generations, safeguarding the environment, and avoiding, remedying, or mitigating any adverse effects of activities on the environment."

The **New** Zealand Government is committed to devolving responsibility, encouraging transparency. and achieving accountability within all levels of government. Most of the responsibility for implementing the RMA has been placed upon regional councils, which have boundaries based on watersheds. Before enacting any policies or legal mechanisms, regional councils must identify the significant resource management issues, and outline objectives, policies, implementation methods, anticipated results, and monitoring **of** the sustainable management of the relevant natural or physical resource. In deciding objectives, policies, and methods, all possible options must be considered and the most efficient, effective, and equitable option selected.

The policies and methods must support an integrated and effects-based management approach that provides a community with:

- an understanding and appreciation of the environmental implications of sustainable natural and physical resource management;
- clear directions for all natural and physical resource developers and users to enable them to adequately cany out their **RMA** responsibilities; and
- a statement of intent outlining directions and activities to be undertaken by the regional council in fulfilling its **RMA** responsibilities.

Amongst other things, the **RMA** requires regional councils to control the take and use of geothermal water and energy (in geothermal water and surrounding material), and to control the quantity, level and flow of geothermal water in any water body. In exercising this control, regional councils are required to promote the sustainable management of the geothermal resource.

The Waikato Region has over 80% of New Zealand's identified high temperature geothermal systems including Wairakei and Ohaaki (see Figure 1). The Waikato Regional Council has identified geothermal resource management as a significant resource management issue, and recognizes that it has a major role in applying sustainable management to New Zealand's geothermal resource.

This paper describes how the Waikato Regional Council has approached sustainable management of the geothermal resource within the Waikato Region. Specifically, three geothermal resource management issues are considered; the needs of future generations, safeguarding the lifesupporting capacity of ecosystems, and dealing with adverse effects of activities.

## 2. DEFINITIONS

### 2.1 Regional Geothermal Resource

Sustainable resource management involves the integrated management of land, water, air, soil, minerals, energy, ecosystems, plants and animals. Since the **RMA** does not define geothermal resource, the Waikato Regional Council uses ***regional geothermal*** resource to mean all geothermal energy (including geothermal water), material containing heat or energy surrounding any geothermal water, and all plants, organisms, and features dependent on geothermal energy, located in the Waikato Region.

### 2.2 Geothermal System

The regional geothermal resource can be divided into natural units which are the geothermal systems. Generally a geothermal system consists of four subsystems:

- fluid recharge areas that are fed by rain water,
- a reservoir where heat and fluids are temporarily stored,
- surface discharge areas where geothermal fluids appear at or close to the surface, and

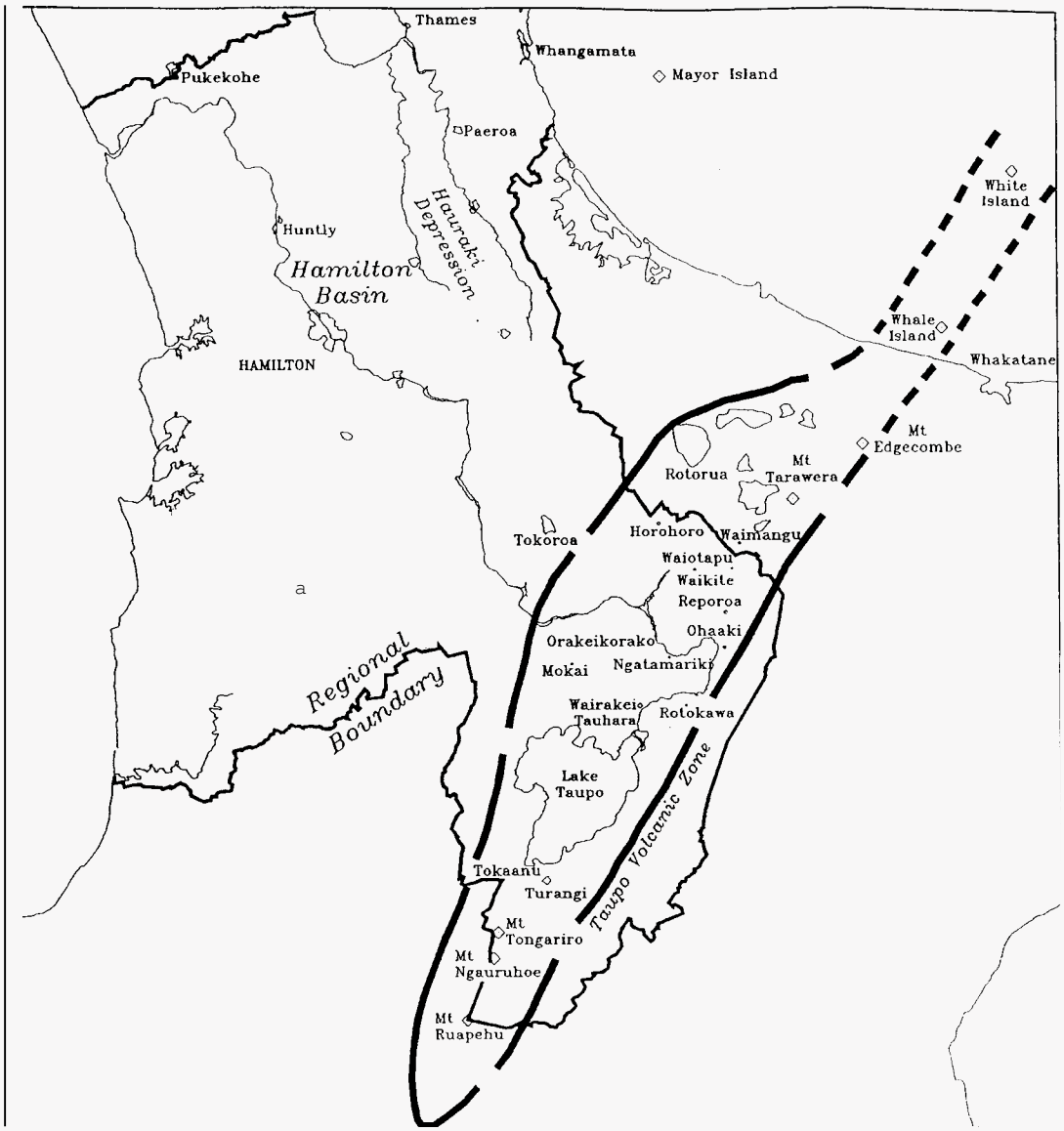


Figure 1. Geothermal systems in the Waikato Region and the Taupo Volcanic Zone

- a heat source (i.e., deep rocks heated by volcanic phenomena)

The major geothermal systems within the Waikato Region lie within the Taupo Volcanic Zone (TVZ). Since the natural recharge area of each major system covers a horizontal area of a few hundred square kilometres, the whole of the TVZ can be regarded, in terms of its hydrological setting, as one continuous recharge area.

### 2.3 Effect

The RMA has been described as "enabling" legislation, i.e., it does not contain explicit directions for managing natural resources. Instead, the Act is concerned with the *effects* of *activities.* The Act defines *effect* to include:

" (a) Any positive or adverse effect; and

(b) Any temporary or permanent effect; and

(c) Any past, present, or future effect; and

(d) Any cumulative effect which arises over time or in combination with other effects-

regardless of the scale, intensity, duration, or frequency of the effect, and also includes-

*(e)* Any potential effect of high probability; and

(f) Any potential effect of low probability which has a high potential impact. "

These effects are to be controlled indirectly by managing the activities through the adoption of the management objectives, policy statements, regional rules, or other methods.

The consideration of the environmental effects of activities, and the eventual pricing of these effects enables the accounting of the true costs of those activities, In this way the price of the goods or services reflects the environmental cost of their production or generation. The requirement to avoid, remedy, or mitigate adverse effects provides a costing framework.

### 2.4 Consent Conditions

The RMA allows regional councils to impose on resource consents, conditions:

- "that the regional council considers appropriate" provided that it: is for the purpose of resource management; is fairly and reasonably related to the consented activity; and has finality.

- requiring financial contributions, bonds, registered covenants, and payment of special administrative charges.
- requiring consent holders to supply information and to monitor their consents.

## 3. SUSTAINING THE POTENTIAL

The **RMA** defines sustainable management as the sustaining of the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations.

### 3.1 Uses and Values

Geothermal systems contain material with highly variable properties (e.g., temperatures and permeabilities) extending over areas of 10 - 100 square kilometres and to depths greater than five kilometres. They are naturally dynamic with fluid and heat flows changing continually and affecting surface features such as geysers, mud pools, hot springs, fumaroles, sinter terraces, and associated dependent ecosystems. Natural geothermal surface features are internationally rare and some of those features in the Waikato catchment are unique.

The nature of the geothermal resource is varied throughout the region and has a wide range of uses and values that meet community needs including; spiritual, cultural, recreational, aesthetic, intrinsic, therapeutic, energy (e.g. electricity generation, heating), biological diversity, economic, and intellectual stimulation. The Regional Council consider these needs will continue to be reasonably foreseeable needs of future generations, which the regional geothermal resource will be required to help meet.

At times the various uses and values of the geothermal resource can be conflicting. Utilization of a geothermal system for large scale fluid or heat production is physically impossible without significantly altering the system and affecting the natural surface features including ecosystems. Most of the international and local sites of natural geothermal surface features have been extensively modified, and many features destroyed.

The varied, possibly conflicting, uses and values of the geothermal resource can be provided for if the regional geothermal resource is managed as a single, regional resource rather than as a series of individual systems. Different geothermal systems within the region can be managed to sustain the potential of the resource to meet the different values and needs of the community.

### 3.2 Renewable or Sustainable?

Mining of a geothermal system occurs when the total outflow (natural and artificial) of fluid or heat exceeds total inflow, i.e. the rate of extraction exceeds the rate of renewal. If this situation prevails the local resource will eventually be exhausted. However, the potential of the geothermal fluid or heat resource is sustained if knowledge of the accessible geothermal resource (the amount of reserve) is maintained or increased. For example, as the fluid or heat is mined, new deeper production wells might be drilled into the system to tap more of the resource without affecting other systems. In this manner knowledge of reserves can be provided to future generations, and the physical potential of the resource can be sustained.

Sustainable management of the geothermal resource requires knowledge of the complex physical and biological structures and interactions within the systems. To keep this knowledge current requires long-term planning for its acquisition and archiving. It requires sustained integrated input from many spccialised technical disciplines, and a good understanding of both modified and unmodified systems.

Sustaining the potential of the regional geothermal resource requires: the endorsement of Tangata Whenua (the indigenous people), continuing security of investment, maintenance of the public geothermal resource knowledge-base (including skills, quality assured data, peer reviewed interpretations, and accessible information), and public confidence in the responsible management of the resource.

Policy must be equitable to allow fair and reasonable use of resources and to minimise **risk** of judicial review of policy. Fairness is also important in gaining community support for the policy, support fundamental to sustainable management.

### 3.3 Efficiency

The efficient use and development of the geothermal resource involves the efficient extraction (take) from the resource and the efficient application (use) of what is taken. Efficient and responsible take of fluid and energy requires;

- integrated and cooperative development of a whole system,
- the absence of competitive extraction of data, fluid or energy from a geothermal system,
- conditions that reduce environmental and investment risk,
- effective and efficient monitoring and evaluation of the resource state,
- a publicly agreed staged-development plan for the resource spanning short, medium and long term time frames, (including phasing out development) and
- public access to peer reviewed resource models, predictions, and data.

Efficient use of the taken resource is encouraged by:

- the competitive sale of the fluid and energy, and
- security of supply.

## 4. SAFEGUARDING THE LIFE-SUPPORTING CAPACITY

The **RMA** also defines sustainable management as safeguarding the life-supporting capacity of air, water, soil, and ecosystems.

### 4.1 Life-supporting Capacity

The life-supporting capacity of geothermal ecosystems is their ability to buffer the biosphere from geothermal discharges. Geothermal plants and animals have evolved by adapting to and reducing the toxicity of geothermal discharges. The plants and animals make significant contributions to: biotic diversity, intellectual stimulation, the gene pool, scenery, and aesthetic enjoyment. Geothermal plants and animals also have intrinsic values.

Many significant geothermal ecosystems have already been extensively modified or destroyed by development. In particular, geysers, natural sinter terraces and their dependent ecosystems have been extensively damaged by modification of their feed systems, physical surroundings, and life-forms. There is no documented evidence to suggest the inflicted damage is reversible, instead new flow regimes occur, and introduced plants and animals invade the modified habitats. Where new surface outflows have occurred, existing land use has prevented or effectively retarded the establishment of geothermal ecosystems. As a result, natural geothermal ecosystems are becoming increasingly rare.

### 4.2 Safeguarding

The life-supporting capacity of geothermal ecosystems can be safeguarded by identifying the remaining geothermal habitats, understanding their nature, avoiding or remedying adverse effects on existing habitats, and by propagating and breeding geothermal plants and animals.

These ecosystems and their life-supporting capacity will be further protected if the public are better informed of their value and fragility.

## 5. DEALING WITH ADVERSE ENVIRONMENTAL EFFECTS

The RMA further defines sustainable management as including the avoidance, remediation, or mitigation of any adverse effects of activities on the environment.

### 5.1 Environmental Effects

Most artificial activities that occur within a geothermal system will have adverse effects on that system. Activities range from walking through natural surface features and ecosystems, through changes in land drainage, to massive extraction of fluid and heat. The subsequent adverse effects range from the crushing of fragile sinters and rare native plants and animals, through the demise of unique geysers, to huge increases in heat flow and land subsidence. Discharges of fluid, heat, and biophysical substances adversely affect geothermal systems. These adverse effects must be either avoided, remedied or mitigated.

### 5.2 How to avoid, remedy or mitigate?

Geothermal features can be ranked in order of significance on their occurrence, resilience to activities, and ability to continue in an altered environment. Some adverse effects, such as the demise of geysers and the modification of some ecosystems, appear to be irreversible.

Where surface features are considered to be significant, activities that could possibly produce adverse effects can be prohibited. For example, adverse effects on surface geothermal features caused by fluid and heat extraction activities can be avoided in some geothermal systems if fluid and heat takes are specifically prohibited.

Remediation of surface features, affected by heat and fluid extraction, may occur once the extraction stops. Ecosystems may be revitalised once fluid flows are re-established. However, it is unlikely that remediation, let alone restoration, will occur.

Destruction of features of one type should not be mitigated by the enhancement of features of a different type (e.g., the destruction of geysers is not mitigated by the enhancement of steam features). Steam features are relatively common to exploited geothermal systems, whereas geysers and associated hot chloride springs are normally the first casualties. Hence, geysers, chloride springs, and their ecosystems are becoming increasingly rare.

Where avoidance of adverse effects is Impossible, e.g., the modification of fluid and heat flows to surface features in exploited geothermal systems, similar types of surface features in other geothermal systems should bc secured for protection. This could be acceptable as mitigation.

Mitigation might also be appropriate for the use of the public geothermal knowledge base. The knowledge base is part of the resource. For example, within the Waikato catchment their exists geothermal systems with characteristics that make them suitable for large scale exploitation, and information about them is publicly available. These system could be considered resources for future generations. If they are developed, then mitigation may be the public identification of an equivalent additional new geothermal rcsource. This could also include the development of the technology necessary for tapping this resource.

The New Zealand government used to dominate geothermal exploration and exploitation, and considerable reserves were identified. With the withdrawal of government involvement from exploration, New Zealand's reserves are decreasing. Short term competitive commercial practices are threatening the sustainable management of the resource, by failing to replenish the reserves. These short comings could be partly countered by consent conditions that encouraged collaboration amongst geothermal developers, e.g., by establishmg a research programme funded by imposing a resource levy.

## 6. ENVIRONMENT WAIKATO METHODS

### 6.1 Developer Responsibilities

Regional councils are resource policy and regulatory agencies; they are not, and cannot be, expected to provide information and expertise necessary to prescribe to resource users the ways in which specified environmental outcomes are to be achieved. Rather, individual users as part of their operations should establish the most cost-effective and appropriate methods and techniques for achieving council requirements. The onus is on users to demonstrate to the regional council that their proposals meet council goals and objectives. This can be achieved by the developers carrying out an assessment of effects on the environment and developing management plans to avoid, mitigate or remedy impacts. In addition, regional council and developers jointly need to develop and deploy monitoring systems capable of measuring effects of resource development.

This approach is endorsed in the RMA, which requires applicants for resource consents to document actual or potential effects that the activity may have on the environment, and the ways in which any adverse effects may be avoided, remedied, or mitigated. This outcome driven approach, rather than one of setting detailed processes, rules and regulations, gives users flexibility to develop projects so that individual site characteristics, innovation and the necessary best practicable methods can be used. Monitoring and enforcement of policy becomes critical to ensure these stated outcomes are met.

### 6.2 Geothermal Policy

To provide for the possibility of future adverse effects caused by the interconnection of superficially distinct geothermal systems, the Regional Council proposes to designate zones containing systems whose reservoirs can be developed (Reservoir Development Zones) and zones containing systems whose reservoirs will be protected (Reservoir Protection Zones). The distinction is applied to the reservoir subsystems because of the difficulty in defining and controlling uses of the discharge subsystem.

Council proposes that, different restrictions on activities will apply within the different zones. The Reservoir Development Zones will contain geothermal systems in which reservoir development effects will be allowed, i.e., fluid and energy production will be allowed. Any effects of activities on the discharge subsystem will need to be either remedied or mitigated. However, they will not need to be avoided. The Reservoir Protection Zones will contain geothermal systems in which the effects of fluid and energy production will be avoided. This will help prevent adverse effects on the discharge features and ecosystems. Systems outside these zones will be subject to precautionary zoning - cvidcnce will be required that no detrimental effects will arise from any proposed activity.

The Waikato Regional Council propose the identification of the priority of values and uses of zones and individual geothermal systems within zones. This process has already started with the publication of a listing of geothermal systems, ranked on geological and geophysical values (Houghton *et al.*, 1980), arid botanical values (Given, 1989). However, microfauna values and values ascribed by Tangata Whenua (the indigenous people) have yet to be adequately identified. These will

need to be achieved before zones and systems are satisfactorily categorised.

In the mean time, geothermal resource consents have been issued for geothermal systems that are widely recognised as having characteristics that make them suitable for optimising values associated with the large scale take and use of geothermal fluid and energy within the constraints of biology, ecology, and physics. Specifically, consents have been issued for the development of a 14MW electrical power station at Rotokawa, and consents for a 50MW electrical power station at Mokai are being considered.

The Waikato Regional Council considers the sustainable development of a geothermal system for fluid and heat values is best pursued by a single commercial body (the single tapper), regulated by requirements for efficient take, but enabled to provide maximum public benefit of use through commercial mechanisms.

Single tappers will be given the exclusive right to execute at least one stage of development of a geothermal system. They will be required to:

- Establish a Waikato Regional Council endorsed peer review panel to help the regional council ensure the sustainable development of the geothermal system.
- Provide public access to quality assured environmental data and information relating to the geothermal system.
- Describe and record the state of the geothermal system before, during and after the exercise of a consent.
- Develop and maintain a development plan for the geothermal system.

To monitor compliance with these resource consent conditions, the Regional Council applies gknerally accepted methods of project management. It is: providing **a** brief descriptive background for the consent condition; clearly stating the objective; identifying the key expected results; setting the parameters of quality, time and priority (costs are obviously under the direct control of the consent holder); and defining the reporting procedures.

The composition of single tappers will not be restricted by the Regional Council, however the New Zealand Commerce Act restricts monopolistic practices. It is anticipated single tappers could be joint ventures selling fluid to competing users.

## 7. CONCLUSIONS

A geothermal resource, consisting of multiple geothermal systems, can be managed in a manner that meets the needs of future generations, safeguards the lifesupporting capacity of geothermal ecosystems, and takes account of the adverse effects of activities.

The varied, possibly conflicting community uses and values of the geothermal resource can be provided for, if the different, individual geothermal systems of the resource are managed to protect or enhance complementary uses and values.

The sustainable large scale development of a geothermal system for its fluid and heat values is optimally pursued by a single, commercial body with the exclusive rights to take, regulated by requirements for efficient take, but enabled to provide maximum community benefit of use through commercial mechanisms.

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