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Sustainable Management of Geothermal Resources in the Waikato Region, New Zealand

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ABSTRACT

New Zealand's environmental legislation devolves the management of most environmental matters to sub-national units of local government known as regional councils. Accordingly, since 1991 the Waikato Regional Council (Environment Waikato) has been developing, implementing and reviewing policy that promotes the sustainable management of geothermal resources. This policy divides the regional geothermal resource (80% of the national resource) into five types of geothermal systems; Development, Limited Development, Research, Protected and Small Geothermal Systems.

Geothermal energy is defined in New Zealand legislation as renewable. However, requiring large-scale use in Development Systems to be at a renewable rate is overly restrictive. The policy provides for extractive use that can be sustained over a number of generations by requiring a social discount rate to be applied as an alternative to the conventional use of a financial discount rate. It is accepted that at the conclusion of the extraction period, the resource may be depleted.

Significant Geothermal Features (including thermophilic ecosystems) are defined by assessment of cultural significance, rarity, vulnerability to changes in heat and fluid flow, and vulnerability of key characteristics to external factors such as other land uses and weathering. Policies, rules and non-regulatory methods protect Significant Geothermal Features.

1. INTRODUCTION

New Zealand's situation as an island archipelago nation is not unique but it is uncommon. New Zealand does not share many natural resources with other nation states. Apart from migratory fauna, and global oceanic and atmospheric resources, New Zealand is too isolated to be affected by the activities of neighbouring countries. In turn New Zealand is too far away for activities occurring internally to affect other countries.

Because we have few internationally shared natural resources, the management of these resources has been devolved to locally elected Councils instead of a central government bureaucracy as is the case in most other countries.

2 INDIGENOUS PEOPLE'S PERSPECTIVE

The relationship Maori people have with natural resources is recognised in New Zealand law. The competing concepts of protection and development are compatible with the views of Maori, who regard the geothermal resource as *taonga* (i.e. highly valued resources). These *taonga* have metaphysical as well as physical characteristics, and their management is based on a set of beliefs about the relationship of humans to the natural world.

The legend of Ngatotoirangi describes how geothermal energy arrived in New Zealand and gives a basis for understanding the relationship Maori people in geothermal areas have with the resource. The concept of *kaitiakitanga*, loosely translated as 'guardianship' requires Maori people to respect the environment and to ensure resources are maintained and handed to future generations in a healthy condition.

3 LEGISLATIVE ENVIRONMENT

New Zealand is world leading in concentrating most of its environmental legislation within a single statute - the Resource Management Act (1991) (RMA). Its prime purpose is to promote the sustainable management of natural and physical resources. It is hierarchical in operation and ties together the activities of Central government, Regional, City and District Councils. It is concerned with the management of air, water, soil, land, geothermal, some minerals (e.g. shingle and sand) and coastal resources out to the 12 nautical mile limit of the territorial sea.

3.1 Local Government Management Role

Local government underwent a radical transformation in 1989 with a reform process that slashed the number of locally elected agencies from over 700 to less than 100 including 12 Regional Councils and 74 City and District Councils. City and District Councils are collectively referred to as 'Territorial Councils'.

Regional Councils are primarily responsible for achieving integrated management of natural and physical resources within the region, the co-ordination of natural hazard management and land transport planning, and undertaking flood protection, biosecurity and land transport activities within each region. RMA responsibilities include the integration of regional and district activities and regulating water, air, soil, geothermal, some minerals and coastal resource use. Regions are defined by the boundaries of large river system catchments and extend to the limit of the 12 nautical mile territorial sea.

The primary role of territorial Councils is to provide services for communities such as water supplies, wastewater treatment, roads, parks, libraries etc. Their RMA responsibilities include land-use planning and regulation. The jurisdiction of territorial councils is land and the boundaries are politically defined by 'communities of interest' rather than any physical criteria, although some boundaries coincide with parts of regional boundaries. Three District Councils and one City Council also have regional functions. They are known as Unitary Authorities.

There are 12 territorial councils wholly or partially within the Waikato Region.

3.2 The Resource Management Act (1991)

The RMA is enabling of activities and is concerned with the management of adverse effects from the use of resources. It is best described as 'meta-policy' as it is legislation that allows sub-national agencies to create their own objectives, policies, rules and other methods for managing publicly owned resources. The machinery for implementing the RMA relies on the relationship between central government and the two-tier local government structure of regional and territorial councils.

The Act provides a comprehensive suite of policy, planning and regulatory instruments to manage the local effects of using resources and at the same time giving effect to the national interest.

Regional and District Plans contain rules that consent activities and cover the entire spectrum of approvals starting at *Permitted* as not requiring a consent through *Controlled* where a consent must be granted but conditions may be applied, then on to *Restricted Discretionary* where the consent authority restricts its discretion to nominated matters. *Discretionary* activity is the next level and is followed by *Non-Complying* and finally *Prohibited* where the activity has unsustainable effects and an applicant may not even apply for a consent.

3.3 Relationship Between Government Agencies

Regional Councils are required to produce a Regional Policy Statement (Environment Waikato 2004a) with the primary purpose of achieving integrated management of natural and physical resources within each region. They may develop Regional Plans (Environment Waikato 2004b), containing rules to regulate the use of particular resources. In practice all Regional Councils have used this option as the alternative is *ad-hoc* case-by-case management with little guidance for decision-making. Regional Plans must not be inconsistent with the Regional Policy Statement.

District councils are required to develop District Plans to regulate land use activities. Like the policy statements and plans of Regional Councils, District Plans must not be inconsistent with national planning instruments. Additionally District Plans must not be inconsistent with either the policy statement or regional plans of their Region.

3.4 The National Interest

There are several mechanisms for ensuring the national interest is adequately provided for in this devolved management structure.

1. The legislation itself includes a specific section identifying matters of national importance, which must be recognised and provided for in the development of policies and plans and in decision-making.

2. The Minister for the Environment has the ability to 'call-in' and process applications from developers to use resources. This has been used only twice in the 13 year life of the Act.

3. The Minister for the Environment may develop a National Policy Statement when the issues are national in scope or are common to all or most councils. To date there have been no National Policy Statements other than the legislatively mandated New Zealand Coastal Policy Statement. At the time of writing a draft National Policy Statement for Biodiversity has been prepared but it has gone no further.

4. Any Minister of the Crown may request a change to the local government planning instruments: Regional Policy Statement, Regional Plan or District Plan. This is a lengthy public process and there would be no guarantee what the outcome would be.

5. The Minister for the Environment may develop environmental standards for managing resources that would apply nationally as a minimum threshold. This mechanism has been used to develop and apply national air quality standards.

6. The final and most flexible approach is to make submissions on policy statement and plan hearings and on applications for resource use. This is the most commonly used method of communicating the national interest.

4 GEOTHERMAL RESOURCES

New Zealand is recognised world-wide as an area of outstanding geothermal attractions. The Waikato Region contains most of New Zealand's geothermal areas (See Figure 1 below). The regional geothermal resource can be divided naturally into management units known as geothermal systems. A geothermal system is an individual body of geothermal energy and water not believed to be hydrologically connected to any other in the upper few kilometres of the Earth's crust.

Figure 1: Geothermal Resources of the Waikato Region

At lower depths, it is accepted that there is a common heat source, and this is consistent with Maori understanding of the geothermal resource. In some cases there is doubt over the near-surface hydrological separation between particular geothermal systems.

Geothermal systems may have several heat upflows supporting separate geothermal fields that are linked to each other by subsurface lateral flow. A geothermal system may support an isolated hot spring, a group of surface features, or several groups of features. Alternatively, there may be no visible expression at the surface.

There is a clear distinction between the region's large geothermal systems and its small geothermal systems. The large systems are all found in the Taupo Volcanic Zone, the triangular-shaped active volcanic zone stretching from an apex at Mt Ruapehu out to White Island (Whakaari) and beyond. These systems cover a large area, and contain large volumes of heated rock and geothermal fluid of temperatures of up to 350°C.

The small geothermal systems are scattered throughout the region, including the Taupo Volcanic Zone. They generally produce water of less than 100°C, and are small in area and volume of water discharged. Figure 1 shows the geothermal resources of the Waikato Region.

5 THE MANAGEMENT CHALLENGE

Sustainable management of the geothermal resource relies on the maintenance of the different characteristics of the resource. However, some applications are incompatible with others. For example, to continue to exist, sinter-depositing springs and geysers require surface outflows of mineralised hot liquid (sourced from deep within the earth), and cannot co-exist with the artificial extraction of large quantities of hot liquid from the same source. In contrast, mud pools, fumaroles and steaming ground do not require a surface outflow of this hot liquid and can therefore co-exist with extraction activities.

Geothermal surface features are restricted in size and distribution, and some of these features are considered to be internationally rare. Different activities affect different characteristics of the geothermal resource. For example, adverse effects can result from walking on natural surface features, changing land drainage patterns, modifying fluid feed systems, physical surroundings and life forms, and large-scale extraction of fluid and heat. These adverse effects range from crushing fragile sinters and rare native plants and animals, to the demise of rare geysers and large-scale increases in heat flow and land subsidence.

The time lag between an activity taking place and any noticeable degradation of the resource can vary from seconds to decades. There is little historical evidence of surface features being able to be re-established once damaged. Instead, new flow regimes occur and introduced plants and animals invade the modified habitats. Where new surface outflows occur, existing land use tends to prevent or retard the establishment of new geothermal ecosystems. As a result, natural geothermal ecosystems are extremely rare.

Therefore, within the Region, the depletion or degradation of the remaining rare features of the geothermal resource must be avoided but, equally, recognition must be given to the development potential of the resource.

5.1 Current use of Geothermal Energy

In 2000, New Zealand's total primary energy supply was 814 petajoules (PJ). Eighteen percent (143 PJ) of this came from geothermal sources (MED 2001). The major portion of this energy is stored as heat within rocks and is presently accessible through the controlled inflow and extraction of fluid. The Waikato Region provides 90% of the primary geothermal energy extracted in New Zealand. While most of this is taken for electricity generation, approximately 40 separate industries within the Region, including accommodation and tourist facilities, also take small amounts of heat for direct uses.

In 2000, New Zealand's total electrical energy supply was 126 PJ per year (MED 2001). Geothermal energy from the country's seven geothermal power stations, five of which are in the Waikato Region, provided around seven percent of the national electricity supply. In electricity production, only approximately 10% of the geothermal energy extracted can be converted to a useable form. The rest is re-injected or disposed of into the environment as heat. Modern plants, and in particular those using binary technology, are more efficient than older plants.

5.2 Geothermal –A Renewable Resource

When discussing the renewability of any energy source, the timeframe for renewability needs to be specified. For example, coal deposits are renewable over geological ages, but not over a human timeframe. For an energy source to be renewable, the rate of input of energy must be the same or greater than the rate of extraction over the specified timeframe. Most energy sources generally classed as renewable are either unaffected by use (solar, wind, wave, tidal) or take no more that a few years to recover their energy-producing capacity (hydro, biomass).

Studies show that the durations of typical hydrothermal systems range from 5,000 to 1,000,000 years (Thain 2003). During this time repeated pulses of heat may pass through the system for a time, and the area may retain some heat continuously for longer periods. These conditions may lead to temperature fluctuations and hydrodynamic variations during the life of the system. During a period of 1,000,000 years, erosion, deposition, and tectonic processes may also affect the hydrology of a geothermal system. On a geological timescale high temperature individual geothermal systems are essentially ephemeral.

The New Zealand government has defined geothermal energy sources as renewable . However, extraction of the fluid and energy in a geothermal system beyond the natural rate of discharge depletes the useable resource found within the upper aquifers. Recovery of a severely depleted aquifer by the replenishment of fluid and energy from lower depths to a point where production can be resumed is expected to take tens or hundreds of years. Recovery of surface outflow of heat and fluid to near pre-production rates will take longer, probably thousands of years (Pritchett 1998). Therefore the period of renewability of geothermal energy can be orders of magnitude greater than that for other energy sources defined as renewable.

Extraction of energy from a geothermal system at a rate at which the energy source is renewed on a timeframe similar to that of biomass and hydro-electricity would mean than only extremely small developments could proceed. Much of the resource would therefore not be available for extractive use by the current and the next few generations.

Renewability and sustainability are two different concepts. For an energy source, renewability describes a property of the resource, whereas sustainability relates to how the source is used (Stefanson, 2000 and Thain, 2003).

Sustainability can refer to either weak or strong sustainability. Strong sustainability requires no loss of natural resources, and thereby provides future generations with at least the opportunities of today's generation. However, weak sustainability allows the depletion of some natural resource stocks, as long as future generations will still be at least as well off as today's generation, through technological change and the like.

Geothermal resources can be used sustainably (using a definition of weak sustainability) over any given period through controlled depletion. As with renewability, the timeframe for sustainability must be specified. To sustain the energy-producing potential of a geothermal system to meet the reasonably foreseeable needs of future generations, extraction must be at a rate that can be maintained by those future generations. The depletion of the available energy and fluid in a geothermal reservoir within one or two generations, leaving the reservoir in a state where recovery of natural outflows will take hundreds or thousands of years, falls short of sustainable management of the resource.

The principles of sustainable management applied to a geothermal system take into account a great deal more than the ability to extract particular amounts of heat and fluid over a particular period. They also require that the effects of the take and discharge of energy and fluid on the system and on other natural and physical resources be avoided, remedied, or mitigated. In addition, they take into account issues of economic efficiency.

5.3 Efficiency

Efficient use of energy is required by the RMA and includes several dimensions:

1. Productive efficiency (output at a low cost);
2. Allocative efficiency (allocating resources to production that society values the most); and
3. Dynamic or innovative efficiency (where technological change is encouraged and used to produce productivity gains).

Wasteful take and discharge lead to greater loss of heat and fluid than is required for the purpose. This is inconsistent with sustainable management and the principle of productive efficiency. Wasteful use can also occur, with geothermal resources being used in the place of more appropriate sources of heat, water, or minerals. This can deprive current and future generations of the ability to use the resource appropriately, and is inconsistent with the principle of allocative efficiency.

When energy and fluid are extracted from a geothermal reservoir, the geothermal fluid transports energy during the extraction and replenishment processes. The fluid is replenished by natural upflows, reinjection, and sometimes by an artificial increase in fluid flow as a result of extraction. It can also be replenished by injection of water from other sources. Conservation of energy, in-situ fluid, and fluid flow are usually greatly assisted by reinjection into the geothermal system of the used fluid, which still contains a great deal of energy in the form of heat.

5.4 Information and use of the Precautionary Approach

Sustainable management of a resource requires understanding of the characteristics of that resource. Management of the resource is improved by greater availability of relevant information.

The nature of the geothermal resource is such that there is considerable lack of knowledge. Surface features, where they exist, provide only a very small indication of the extent of the resource and its hydrodynamic characteristics. Geophysical and geochemical techniques, as well as an understanding of the local geology, must be applied to enable understanding of the resource.

Much data and information about the regional geothermal resource that was collected by the government using public funds is now retained in confidence by the government as a commercial asset. The unavailability of this data and information to regional and local authorities and resource users creates uncertainty in decision-making, limiting the opportunities for use of the regional geothermal resource. It also can lead to higher costs for ratepayers and resource users through duplication.

5.5 Effects of use on Geothermal Surface Features and other Land uses

At times, and in various locations, particular uses of geothermal resources have adverse effects on surface features, some other characteristics of the geothermal resource, and on other land uses. For example, large-scale geothermal fluid and heat extraction at Wairakei-Tauhara and Ohaaki, between Taupo and Rotorua, has led to land subsidence.

Over the 50 year life of the Wairakei Power Station, at least 1.8 billion tonnes of geothermal fluid have been removed from the Wairakei-Tauhara system and discharged to surface waters. Natural recharge has replaced some of this loss but not completely as the ground water level has been lowered by some 200m. The system underlies most of Taupo township (population of 21,000) which is subject to differential subsidence in some areas. Subsidence in borefield areas outside the township has already reached 15m and is continuing.

Extraction can also increase the rate of steam discharge, increasing land instability and leading to hydrothermal eruptions, landslides, and the creation of sink holes. Extraction has destroyed or adversely affected geothermal surface features and connected ecosystems.

In some cases large-scale extraction of energy and fluid has led to the demise of geysers, and to large scale increases in heat flow. Many significant geothermal ecosystems have been extensively modified or destroyed as a consequence. Although reinjection can reduce the damage and sometimes partially reverse it, there is no documented evidence to suggest all damage is reversible. Instead new flow regimes occur, and introduced species invade the modified habitats. Where new surface outflows have occurred, existing land use has prevented or retarded the establishment of geothermal ecosystems. As a result, natural geothermal ecosystems are extremely rare.

Discharges of geothermal energy and fluid into other natural and physical resources can cause adverse effects depending upon the receiving environment (e.g. hot mineralised geothermal water discharged into fresh water). Although there is some natural discharge of geothermal energy and fluids into the Waikato River, artificial discharge has increased the concentrations of mercury, arsenic and boron in the water, and increased its temperature. This has long-term and short-term adverse effects on water quality and the riverine ecosystem, affecting uses such as contact recreation, crop irrigation, and provision of drinking water.

Provided that appropriate technology is used to avoid significant land disruption, reservoir cooling and other adverse effects, reinjection can be beneficial by minimising land subsidence, reducing the discharge to other natural and physical resources, and helping to sustain the natural flow to geothermal features.

5.6 Land uses near Geothermal Features

Some land uses in close proximity to Significant Geothermal Features have adverse effects. For example, at Reporoa, land drainage for farming has caused some sinter-depositing springs to cease discharging. Forestry in geothermal areas can lead to geothermal features being damaged by trees falling into them and harvesting machinery destroying delicate sinter terraces. Most of the geysers at Orakeikorako are now underwater as a result of the creation of the hydroelectric Lake Ohakuri when around 70 were flooded. Allowing livestock or vehicles access to geothermal features, or using geothermal features as rubbish dumps can lead to a range of adverse effects including the crushing of fragile sinters, rare native plants, animals and micro-organisms.

In most cases, surface features that are part of a tourism venture are better cared for than those found in land that has other uses such as forestry and farming. Tourism can also increase appreciation of the resource and awareness of its fragility and rarity. However, extensive tourist use can lead to vandalism, wearing away of paths, and contamination of sinter by gravel and rubbish. Draining a feature or diverting its flow to protect paths can also cause destruction of the feature and its ecosystem.

6 ISSUES ADDRESSED

Five management issues have been identified in the Waikato Regional Policy Statement. For each issue there is a corresponding objective to be achieved by the methods in the policy statement and also rules in the Geothermal Module of the Waikato Regional Plan. In some cases rules controlling land use activities are also required in the relevant District Plans.

6.1 ISSUE 1: Sustainability

Take, use and discharge of geothermal energy and fluid can result in depletion of the resource that limits the opportunities for energy use by future generations.

One of the requirements of the RMA is for the management of natural and physical resources to recognise and provide for the reasonably foreseeable needs of future generations.

This translates into the objective of managing the take, use and discharge of geothermal energy and fluid in a way that enables current energy needs, and the reasonably foreseeable energy needs of future generations, to be met.

It is to be achieved through a suite of policies and methods both in the Regional Policy Statement and the regulatory mechanisms of the Waikato Regional Plan.

Geothermal systems are seen as the primary management unit and the systems of the region are divided into five types. Included in a geothermal system are material containing heat or energy surrounding any geothermal water, and all plants, animals and other characteristics dependent on the body of geothermal energy and water.

<u>6.1.1 Identification of Significant Geothermal Surface Features</u>

Geothermal surface features are valued for many reasons, but many are highly vulnerable to geothermal system development or to other uses of land and water. Already most of the region's geothermal surface features have been lost or degraded. Maintenance of the variety of characteristics of the regional geothermal resource requires identification of the significant characteristics. For each of these characteristics of the regional geothermal resource, consideration of the frequency of occurrence, the ability to recover from impacts, and the capacity to adapt to a changing situation need to be identified.

Significant Geothermal Features are described, based on an analysis of their rarity and vulnerability to extractive uses, other uses of land and water, and natural variations in the internal and external environments of the supporting geothermal system (This is the topic of another paper at this congress). These are then used as part of the criteria to place systems into management 'types'.

There are other geothermal features in the Region that have not been included as significant. These include but are not limited to: Fumaroles producing steam of less than 100 °C; Heated or steaming ground; Geothermally altered ground; Collapse pits; Geothermal springs or seeps; and Ancient sinter.

<u>6.1.2 Types of Geothermal Systems</u>

The five systems types are defined as Development, Limited Development, Research, Protected, and Small Geothermal Systems, based on:

1) existing uses,

2) the vulnerability of significant geothermal features to extractive uses of geothermal energy and fluid,

3) the state of knowledge about the system, its surface features, and its possible connection to a Protected Geothermal System, and

4) the potential for development to cause significant adverse effects on the geothermal system and other natural and physical resources.

Management of geothermal systems is determined in a way that ensures that different demands on the regional geothermal resource can be satisfied. Different geothermal systems within the Region are managed to maximise the different characteristics of the regional geothermal resource. Within the Region, the depletion of unique characteristics of the regional geothermal resource will be avoided and recognition will be given to the development potential of the regional geothermal resource. The system types are defined as follows:

DEVELOPMENT Geothermal Systems: are large systems (seven identified) where sustainable development may occur because:

1. the system contains few surface features that are moderately to highly vulnerable; or

2. the existing surface features are significantly impaired by legally established large takes; and

3. there is no evidence of a flow of subsurface geothermal fluid to or from a system described as Limited Development, Research or Protected.

LIMITED DEVELOPMENT Geothermal Systems: are large systems (two identified) where there are significant geothermal features that would be adversely affected by large-scale development but where smaller-scale uses are unlikely to adversely affect those features.

RESEARCH Geothermal Systems: are large geothermal systems (two currently identified) where there is insufficient information to identify them as Development, Limited Development or Protected Geothermal Systems. In such a system, takes may be allowed if it can be demonstrated that they will not threaten significant geothermal features in that system or the natural characteristics of a system described for Protected systems. This includes large geothermal systems yet to be discovered.

PROTECTED Geothermal Systems: are large systems (four identified) where particular care must be taken to ensure that any use of the geothermal resource is sustainable and has no discernible effect on significant natural geothermal characteristics because either:

1. the system supports a substantial number of surface features that are moderately to highly vulnerable to the extraction of fluid; or

2. the system is largely or wholly within a National Park or a World Heritage Area; or

3. there is evidence of a flow of subsurface geothermal fluid to or from an other Protected System.

It is the intention that these systems be protected in perpetuity from large-scale development so as to preserve notable examples of these unique natural phenomena to be enjoyed by many future generations.

SMALL Geothermal Systems: are all other systems and are managed to enable limited takes that do not threaten significant surface features, existing uses, and other natural and physical resources.

6.1.3 Promote Efficient use of Energy

In all systems the efficient use of energy is promoted by permitting activities that:

1. Are efficient in conserving geothermal energy and fluid;

2. Will not adversely affect the stocks and flows of geothermal energy and fluid; and

3. Either individually or in combination (cumulative effects) not affect the viability of Significant Geothermal features.

This is expressed in the policy/plan package by the permitted use of down-hole heat exchangers in Research and Protected systems and the higher permitted threshold for energy from Development and Limited Development systems compared with fluid extraction. A policy preference for community type group heating schemes is also in effect.

6.1.4 Sustainable Management of Large Takes and Discharges in Development Systems

Only the seven Development systems are available for very large scale developments and therefore have the potential for non-sustainable outcomes. In these systems, policies apply that provide for a wide range of development and use by means of controlled depletion of energy, and staged development that maximises productive efficiency and applies an appropriate social discount rate.

6.1.5 Use of a Social Discount Rate

Extracting the geothermal resource today has a trade-off for future generations. Economic (dynamic) efficiency requires that all the future consequences flowing from a current decision be accounted for. Applying a social discount rate promotes sustainable use by allowing comparisons between today and in the future. Efficient policy attempts to maximise the value of the resource over the life of the resource.

It is expected that at some time in the future the generation of electricity will no longer require geothermal resources due to advances in other renewable energy sources that make them more cost effective options. This gives rise to the idea of controlled depletion of the geothermal resource in Development Systems. Applying a positive social discount rate allows for extraction of the resource into the future, but favours present extraction over future extraction. MacDonald (2003) notes that there appears to be a growing consensus that the social discount rate should be between 1.5 and 3%. Rules in the Regional Plan require developers to justify any discount rate above 2%.

The cost of lost opportunity to prospective resource developers and the people on whose land they want to build their plant could be substantial if the sustainability criteria are inconsistent with their plans for depletion of that system within a shorter period, such as 30 years. In that case, there may be fewer geothermal power stations built than if sustainability were not required. This may cause electricity prices to increase slightly for consumers, as the next most expensive electricity generating method will be used instead. However, the policy may allow long-term electricity prices to remain lower than otherwise, by ensuring that geothermal energy is available for a longer timeframe.

6.1.6 Injection of Taken Fluid

Sustainable management is promoted through a strong policy preference in the Regional Policy Statement supported by a hierarchy of rules in the Regional Plan for injection of taken fluid back into the same system. This recognises the benefits of:

1. conserving the stocks and flows of geothermal energy and fluid within the geothermal system;

2. preventing the contamination of fresh water;

3. minimising adverse effects on other natural and physical resources (the built environment) by reducing the likelihood or severity of land subsidence, hydrothermal eruptions, and land instability; and

4. minimising adverse effects on surface features by ensuring that reservoir pressures and surface flows of energy and fluid are not unnecessarily altered.

The Waikato Regional Plan uses a hierarchy of rules to give effect to the policies and methods in the Regional Policy

Statement, particularly with a preference for fluid and energy efficient technologies such as heat exchangers and for reinjection of taken fluid.

Figure 2 summarises the relationships between rules that apply in the seven Development Geothermal Systems.

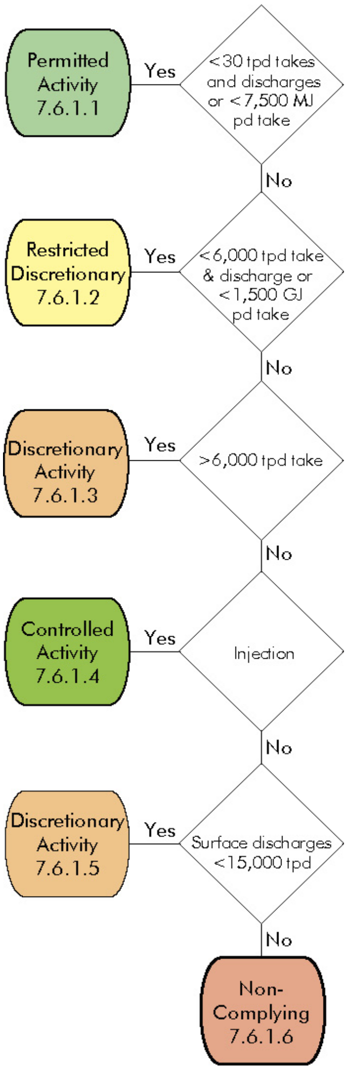

Figure 2 Rules for Takes and Discharges in Development Systems

6.1.7 System-wide Management with Single Operator, Management Plans and Peer Review.

Sustainable management requires integrated system management which is to be achieved by limiting large extraction and discharges to a single operator (a legal entity that may include joint ventures or partnerships) and requiring the preparation of a system management plan that:

1. demonstrates how integrated management of the system is to be achieved;
2. identifies, within the geothermal system, future sources of high enthalpy fluid and how these may be accessed;
3. identifies, within the geothermal system, suitable sites for targeted return of as much energy and fluid as is practicable; and
4. identifies how adverse effects on the characteristics of the geothermal system, overlying structures (the built environment), and other natural and physical resources will be managed to ensure that the burden of adverse effects falls on those who cause them.

Waikato Regional Council will establish an independent peer-review panel for each system that will undertake, but not limit itself to:

1. overseeing the implementation of the system management plan and use and development of the system;
2. reporting with findings being publicly available; and
3. making recommendations on changes to resource consents within that system.

System management by a single operator enables long-term system-wide planning, reduces interference effects within each system, clarifies accountability for adverse effects and facilitates productive efficiency and optimum use of the resource.

6.2 ISSUE 2: Effects on Surface Features

Take use and discharge of geothermal energy and fluid can affect surface features and their characteristics.

This translates into two complementary objectives, one for activities in Development systems and another for all other systems. In Development Systems, adverse effects on Significant Geothermal Features arising from the take of geothermal energy and fluid are to be avoided where practicable and otherwise remedied or mitigated by enhancement of the regional geothermal resource. In all other systems, significant adverse effects on Significant Geothermal Features arising from the take of geothermal energy and fluid are to be avoided.

The take, use, and discharge of geothermal fluid can have a significant adverse effect on Significant Geothermal Features. Distinctly different management approaches are required for those geothermal systems that are subject to development and those that are to be protected.

Where extractive uses in Development Systems cause significant adverse effects to Significant Geothermal Features that are unable to be remedied, these effects should be mitigated by enhancing to the same extent the natural characteristics of similar types of surface features in other geothermal systems. Enhancement of a natural characteristic involves improving the natural character through measures such as removal of plant pests, exclusion of stock and contaminants, and reduction of adverse effects of land and water use. Enhancement does not involve artificially altering the area of a surface feature or the flow of energy, fluid or minerals to it.

Destruction of features of one type will not necessarily be mitigated by the enhancement of characteristics of a feature of a different type. For example, the destruction of geysers is not mitigated by the enhancement of steaming land. Steam features are relatively common to exploited geothermal systems, whereas geysers and associated hot chloride springs are more rare, and are normally the first features affected. Hence, geysers, chloride springs, and their ecosystems are becoming increasingly rare. Remediation of some surface characteristics affected by heat and fluid extraction may occur to an extent once the extraction stops. Ecosystems may be revitalised over the course of years or decades if fluid flows to them are re-established. However, it is unlikely that complete remediation will occur, even if the 'natural state' is known, because of the irreversibility of some effects.

To assist implementation, maps of all Significant Geothermal Features in Development and Limited Development Systems are included in the Regional Plan as these systems are the only ones where moderate to large scale extractions will be considered and therefore the only system types where the potential for degradation of Significant Geothermal features through extractive uses exists.

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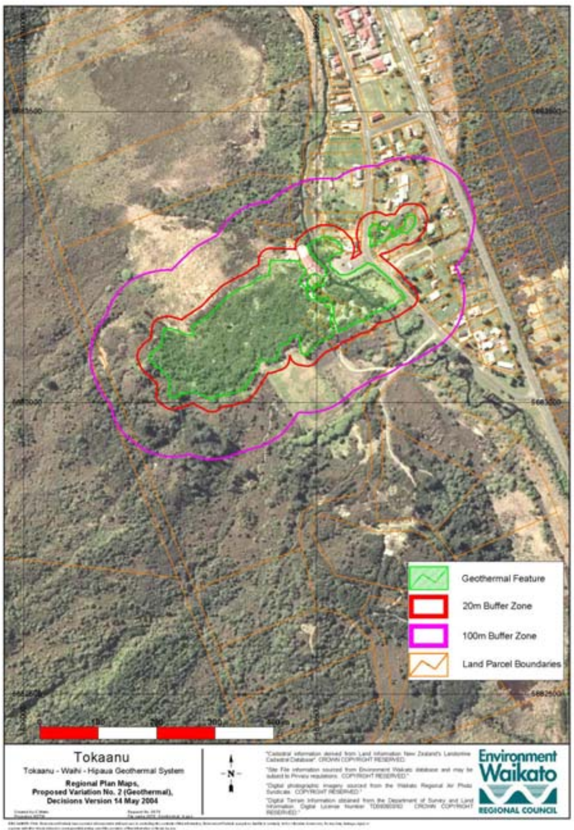

Figure 3 Mapped Significant Geothermal Features in Tokaanu–Waihi–Hipaua Limited Development System. Includes 20m and 100m buffer zones for land use activities and drilling respectively.

In order to maintain the extent and variety of the valued regional geothermal characteristics, it is appropriate to protect Significant Geothermal Features in Limited Development, Protected, and Small Geothermal Systems from adverse effects arising from the extraction of energy and fluid from these systems. In Research Systems, a precautionary approach must be applied to protect known and unknown features within each system and within any Protected System that may later prove to be hydrologically connected to it.

6.3 ISSUE 3: Land use Effects on Surface Features

Other uses of land and water can adversely affect geothermal surface features and their characteristics

This translates into the objective of avoiding significant adverse effects on Significant Geothermal Features arising from land use activities and the take, use and discharge of non-geothermal water. This objective applies to all geothermal systems irrespective of use.

Unlike the potential effects on Significant Geothermal Features from using the resource, which may not be able to be avoided, land use activities and use of non-geothermal water do not need to occur in close proximity to sensitive features. Activities can be re-located or re-designed to avoid any adverse effects.

Land use is one of the responsibilities of Territorial councils and is covered in District Plans. The Regional Policy Statement contains policies and methods that require relevant Territorial Councils to include methods and apply conditions to land-use consents that protect Significant Geothermal features.

The Regional Plan backs this up with rules requiring resource consents for vegetation clearance or use of natural water within 20 metres of a Significant Geothermal Feature.

6.4 ISSUE 4: Effects on Other Resources

Take, use and discharge of Geothermal energy and fluid can adversely affect other natural and physical resources including overlying structures (the built environment).

The management objective recognises the existing situation and applies a precautionary approach to management in the future. It also requires the internalisation of costs, requiring developers to avoid, remedy or mitigate the adverse effects on other natural and physical resources including overlying structures and the built environment.

This objective is supported by policies and methods including rules in the Regional Plan which actively favour injection of taken fluid (reinjection) back to the parent system and also make it easy to discharge other waters into a development geothermal system to offset the effects of extraction. See Figure 2.

6.5 ISSUE 5: Lack of knowledge

Lack of information and knowledge about the geothermal resource creates uncertainty for management of the resource.

The objective aims for increased knowledge about the regional geothermal resource, and better understanding of the effects of using the resource and effects of other activities on the resource. It achieves this with an integrated package of policies and methods that:

- Recognises the value of taking a precautionary approach to new developments;
- Requires a staged approach to developments in Development systems. This links well with the requirement to use a social discount rate of up to 2% for such developments;
- Provides for the use of peer review teams for any aspect of geothermal management and the formal establishment of system-wide peer review panels for large developments;
- Defines a 'Research System' category for those systems where there is insufficient knowledge to identify them for development, limited development or protection. All new large systems will by default fall into the Research System category. Use of geothermal resources in Protected and Research Systems is restricted in comparison with Development Systems, but exceptions are provided for to allow short term

research investigations as a discretionary activity in both cases; and

- Contains methods to actively seek release and publication of information collected using public funds maintained in confidence by the government.

CONCLUSION

Through a restructuring of local government in the late 1980s and comprehensive legislative changes in the early 1990s, one local government agency, Environment Waikato, a regional council, has been devolved the task of managing 80% of New Zealand's known geothermal resources. The planning instruments available under the Resource Management Act 1991 have been used to their potential to incorporate the competing objectives of sustainably using the energy potential of the resource whilst at the same time ensuring the extent and variety of spectacular surface features and their associated ecosystems endure into the future.

This has been achieved by recognising the discrete nature of geothermal systems and using that as the primary management unit. Individual geothermal systems are managed for particular uses depending on characteristics of each system.

The process for developing Regional Policy Statements and Plans is very transparent example of the Sustainable Development principle of subsidiarity. It has allowed the consideration and incorporation of matters of:

1. The national interest;
2. The concerns of indigenous people;
3. The local effects of large scale extractive use of energy and fluid in an urban environment;
4. The maintenance of the extent and variety of spectacular surface features.
5. The need to ensure choices are preserved for future generations of New Zealanders.

The devolved local government and resource management structure, combined with the characteristics of the geothermal resource itself and its concentration within a single region have allowed a rational, robust and coherent management framework to be developed.

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