Environmental and Resource Issues: Rotokawa Geothermal Power Station

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KEY WORDS

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ABSTRACT

An 18 MW(e) power station is being developed on the Rotokawa geothermal field, situated in the central North Island of NZ, about 10 km from Wairakei. Geothermal developments in New Zealand are controlled by the Resource Management Act 1991 (RMA). The RMA is intended to promote the sustainable management of New Zealand's resources, by balancing the needs of development (which enables people to provide for their well being, health and safety) against misuse of the resource being developed and damage to the environment generally. The resource consents granted for the Rotokawa power station are the first significant geothermal consents granted under the RMA and thus break new ground in geothermal developments in New Zealand. The significant issues of sustainable use of the geothermal resource and discharges to the air have been addressed.

INTRODUCTION

In August 1993, the Tauhara North N°2 Joint Venture (a joint venture between the Tauhara North N° 2 Trust - the land owner, Taupo Electricity Limited - the local electricity supply authority, and WORKS Geothermal Limited - a geothermal engineering company) was granted resource consents from the Waikato Regional Council (WRC) to permit the taking of geothermal fluids sufficient to provide 110 tonnes per hour of steam. These consents include all necessary water permits and discharge permits to enable the taking of the fluid and for its disposal (generally by reinjection into geothermal aquifers); for steamfield well testing and for taking and disposal of water for power station operation. These consents, being the first granted under the innovative Resource Management Act are significant for geothermal development in New Zealand. The Rotokawa development is the first of several 10 to 50 MW(e) geothermal power projects currently under evaluation in New Zealand.

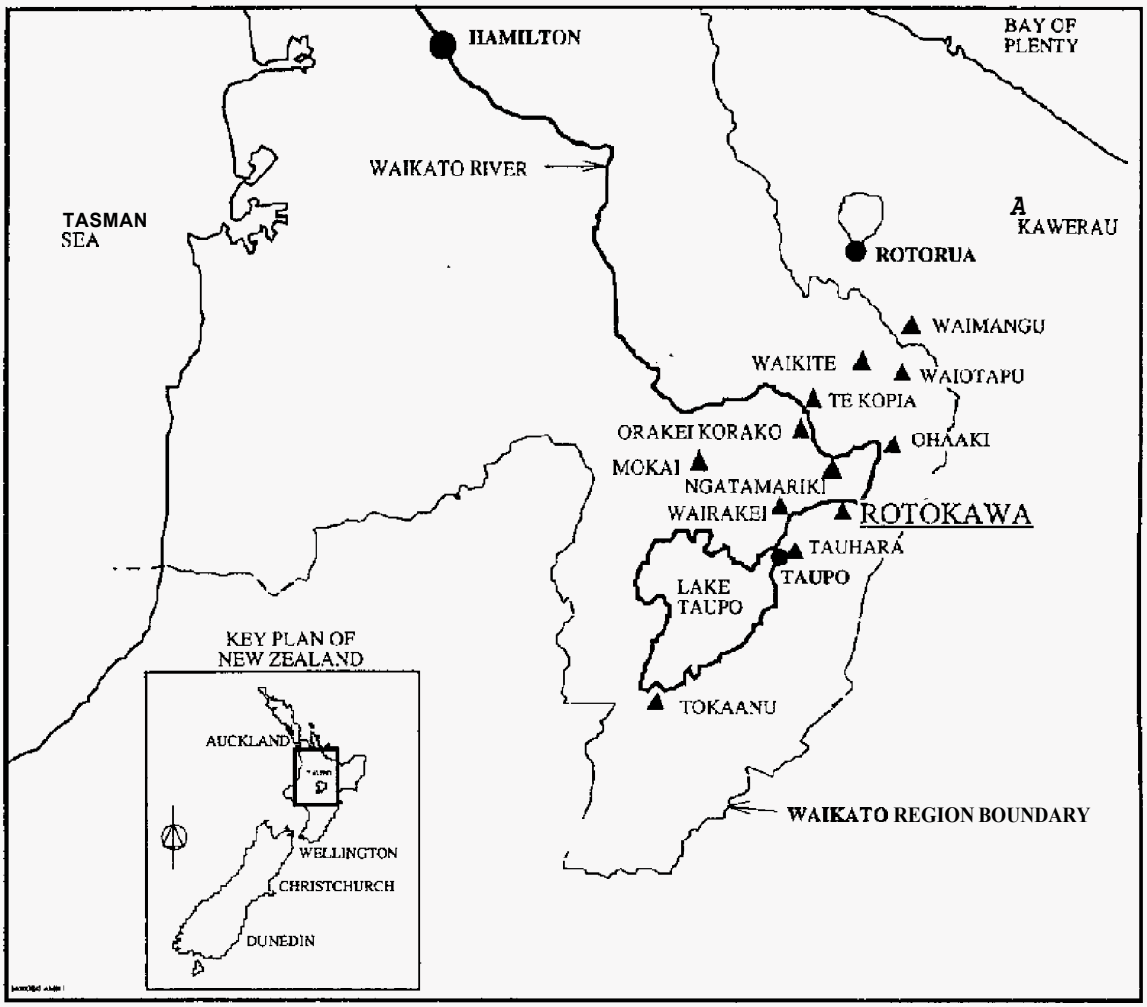


Figure 1 Rotokawa in the Waikato Region

Although each geothermal development has different environmental issues, many of the issues are common. These include sustainability of the resource, protection of unique geothermal features and habitats and contamination of air and water from geothermal discharges.

The two significant resource and environmental issues at Rotokawa are: sustainable use of the geothermal resource and contamination of the environment - particularly the air - from geothermal discharges.

The Joint Venture was also granted development plan approval from the Taupo District Council (the Territorial or District Authority) for the construction and operation of a geothermal power station of up to 20 MW(e) at Rotokawa.

GOVERNING LEGISLATION

The Resource Management Act

Geothermal developments in New Zealand have been controlled by the Resource Management Act 1991 (RMA), since its introduction in October 1991. The purpose of the Resource Management Act is to promote the sustainable management of New Zealand's natural and physical resources. To do this it must balance the needs of development, enabling people to provide for their well being, health and safety, against conservation - the misuse of the resource being developed and damage to the environment. In terms of geothermal development there are two prime requirements: that the resource itself is used in the most efficient manner possible; and that effects on the surface environment are kept within acceptable limits. Knowledge of the resource and the environment are essential to this purpose.

It is important to note that the purpose of the Act is to promote appropriate development, within environmental and sustainability criteria.

In the Act, "sustainable management" means 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 -

- Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and
- Safeguarding the life supporting capacity of air, water, soils, and ecosystems, and
- Avoiding, remedying, or mitigating any adverse effects of activities on the environment

"Environment" is used in the widest sense: ecosystems including people and communities, all natural and physical resources, amenity values, and social, economic, aesthetic and cultural values of the above.

The Act requires that all detrimental effects are avoided, remedied or mitigated.

Other aspects requiring to be addressed include:

- Treaty of Waitangi issues and "kaitiakitanga" (or traditional Maori guardianship of natural resources). (The Treaty of Waitangi was entered into between the Maori people and the Crown, at the formation in 1840 of the then British colony of New Zealand).
- Possible alternative methods of discharge including discharge to other receiving environment.
- Identification of persons interested or affected, consultation undertaken and the response to the views of those consulted..
- Risks to the environment from hazardous substances or installations.
- Nature of discharge and sensitivity of receiving environment
- Description of mitigation measures.
- The monitoring scheme to be put in place.

Matters to be included in an assessment of the effects on the environment are listed in the Fourth Schedule to the Act

Application of the Act

The Act controls the taking of water and geothermal energy, it also controls discharges of water and discharges of contaminants to water and to the air. (A "contaminant" is anything which changes the nature of the receiving environment; it includes heat.) Control is effected by the issue of "consents" to carry out these activities. Issuing of consents is primarily under the jurisdiction of regional councils, at Rotokawa, the Waikato Regional Council.

Management is through the mechanism of a hierarchy of national, regional and district policy statements and plans. (Figure 2) The policy statements give desired objectives and outcomes; the plans are more detailed documents containing rules to ensure that the objectives are achieved.

Activities may be permitted as of right, they may be discretionary - where an application for a consent is examined against the intent of the RMA, or they may be prohibited. Plans are prepared through a consultative process in which any person can make submissions

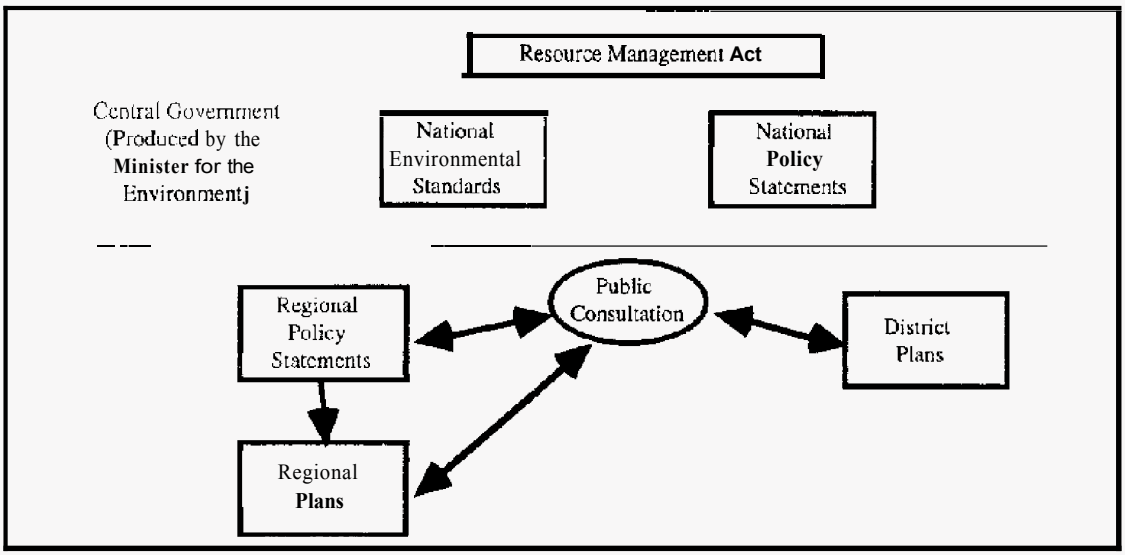


Figure 2: The Planning Framework

SIGNIFICANT RESOUKCE MANAGEMENT AND ENVIRONMENTAL ISSUES AT ROTOKAWA

Effects fall into two categories: equitable and sustainable use of a natural resource - *resource issues,* and effects on the surface environment - environmental issues. These are looked at in more detail

Resource *issues*

The major concern is sustainable management of :he geothermal resource.

Other issues include ensuring that parties with an interest in the resource are not unduly disadvantaged hy the dcvelopment. Thin includes the Maori people, particularly as the geothermal resource is considered a "taonga", or treasure, by Maori, and this interest is protected by the Treaty of Waitangi. Other interested parties included those who own land over the resource arid thus control access to it. (Under current New Zealand law, the resource itself is owned hy the Crown. although Maori are recognised as having "kaitiakitanga", or guardianship right; and responsibilities for the resource,)

Environmental Issues

A major concern at Rotokawa is the effects of hydrogen sulphidc discharge. The Rotokawa resource has a relatively high gas content. a little over 2% by weight of non condensible gas as a proportion of steam. Hydrogen sulphidc is a small percentage of this, amounting to a discharge to the air of some 60 to 70 kg per hour. The method of disposal is to discharge the gas above the cooling lower where the warm moist vapour plume will aid dispersal. Modelling studics (Hadfield and Wratt, 1993) Indicated that the proposed guideline of 70 $\mu g/m^3$ would be cxcccdcd under certain meteorological conditions. But this is mitigated to a certain extent by the low habitation of the area - the nearest houses are some four bin from the power station, and highest levels are *expected* to occur on high ground around the power station - all such areas are uninhabited. being covered in forest. High levels are also expected close to the cooling tower under high wind conditions.

A particular concern of the Maori people was that there be no geothermal discharges to the Waikato River. The River already receives geothermal discharges, both natural and from previous developments, from over half of the geothermal fields in ihe central North Island. This contributes significant mounts of chemicals and heat. The project has been designed to meet this requirement

Other effects considered included: changes to natural thermal features and their ecosysrems, changes to natural hydrslogy, subsidence, hydrothermal eruptions, increases in seismicity, aesthetics. noise and discharge of the green house gas, carbon dioxide.

Rotokawa is a field with relatively few surface features and these are dominated by Lake Rotokawa, a shallow acidic geothermal lake (pH of about 2), in the south of tlie field. Thr remainder of the field shows little evidence of surface geothermal activity. Scenic and recreational values are low, but these will not be affected to any *great* degree at the proposed level of devrlopment. The take area has been mined for sulphur on several occasions over the past 50 years. (Geothermal *stem* has been used in the past both for the Frasch process and to dry the ore.) Owing to past mining operations around Lake Rotokawa the aesthetic values of the geothermal features and ecosystems have been severely impaired. There are no known unusual, fragile nor unique features.

THE STRUCTURE OF THE APPLICATION

Resource consents sought.

The following consents were sought. with a term ot thirty years being requested.

The consents may he separated into three areas: production (the actual use of the resource and the associated long term takes and discharges), drilling. and testing. (figure 3)

Production

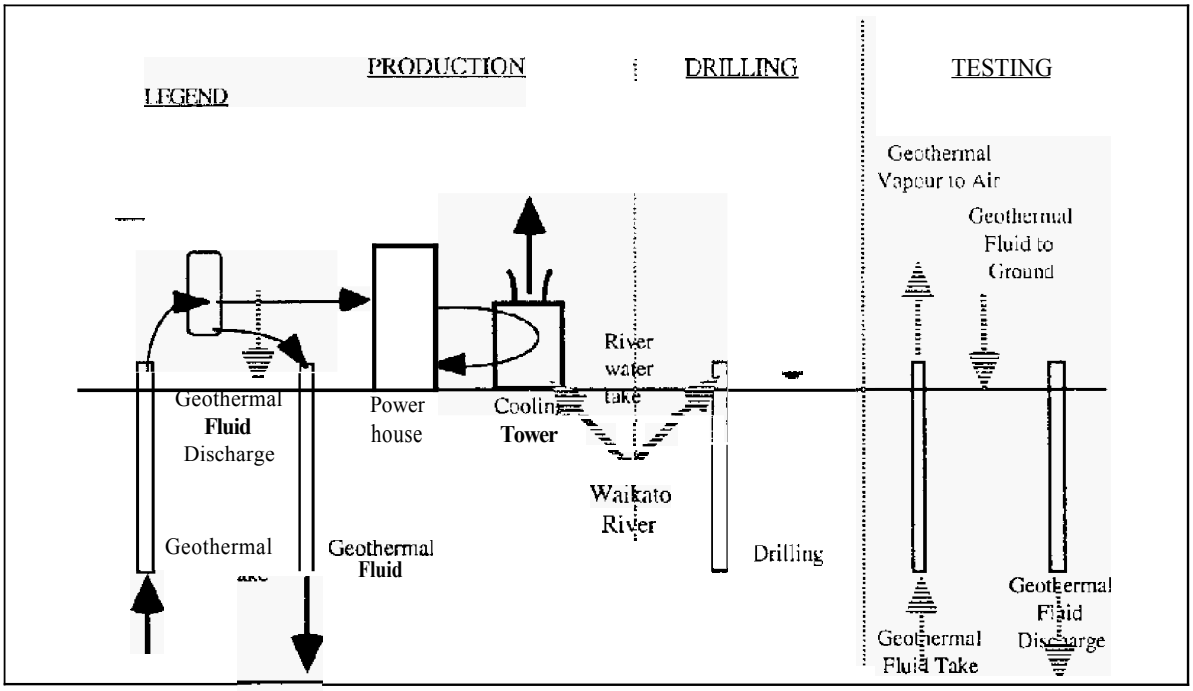
Water permit: to take geothermal fluid and energy.

Discharge permit: to discharge separated geothermal fluid and steam condensate tn geothermal aquifers - separated water and steam condensate reinjection.

Discharge permit: to discharge spent geothermal vapour to the air (both from the cooling tower and from steam vents and silencers).

Discharge permit: to discharge geothermal fluid to the ground, at times of plant start up and shut down and including steam traps.

Water permit: to take water from the Waikato River, for power station use



Drilling

Water permit: tu take water from the Waikato River.

Discharge permit: to discharge natural water and drilling fluid to underground formations during well drilling.

Discharge permit: to discharge natural water and drilling fluid onto land or to the ground during well drilling, via holding ponds. with the water being lost by seepage,

Testing

Water permit: to take geothermal fluid.

Discharge permit: to dischnrge geothermal fluid to geothermal aquifers, if simultaneous production/reinjection testing is undertaken.

Discharge permit: to discharge geothermal vapour into air, the steam component.

Discharge permit: to discharge geothermal fluid onto land or to the ground, the liquid component from a vertical discharge test, oc seepage from a holding pond prior to reinjection as above.

Additional resource consents required

Sewage and stormwater disposal arc covered by 'permitted activities'. That is, they are conventional discharges which are permitted subject to constraints on the systems used.

Land use consents wrre required from the Taupo District Council. Those were straight forward as they fell under the category of permitted activities. or wcrc discretionary activities whcre conventional constraints were applied, such as limits on noisc levels at residential boundaries and provision of roading access.

The application considered both rhe nature of discharges and environments they are to discharge to. in particular; reinjection to the reservoir, watcr into ground water, and vapour to the air

HOW THE RESOURCE AND ENVIRONMENTAL ISSUES HAVE BEEN ADDRESSED

When the consents for Rotokawa were applied tor (December 1992), the Regional Plans had not been prepared, although the Regional Policy Statement (RPS) was in draft form. In consequence the application was considcrcd in detail against the requirements of the RMA which were mirrored in the RP. The Kotokawa consents may Le compared against parameters of the RPS salient to geothermal issues.

Resource issues

The primary objective of the RPS is, "To recognise the wide range of values associated with the region's geothcrmal resource by providing for the protection of intrinsic and amenity features. while allowing for use and development." It further requires, "To ensure the taking or use is carried out in a sustainable manner".

Sustainability of the geothermal resource covers many aspects. Primarily it includes managing the resource as an energy source. but it also includes those features unique to geothermal resources. Waikato Regional Council propose managing sustainability on a region wide basis by categorising geothermal fields either for current development. or for preservation. Fields in the preservation category will not be developed, but the unique geothermal features will bc preserved and where pussible enhanced. Rotokawa is categorised as a developmental field; it is recognised that changes in natural geothermal features are likely to bc occur.. This is considered satisfactory so long as such changes can be remedied or mitigated. Mitigatinn can be pruvide by the benefits of the development. including economic benefits tn the district and tu the region.

As the resource is undeveloped. the precise nature of rhc resource is unknown and significantly more information will be gained once production begins. Following a staged development. when thc first stage applicd for in this application is a fraction of the estimated potential of the resourcc, will ensure that the resource is not unintentionally over exploited. The development of 18 MW(e) compares to estimates of the field potential of 270 to 400 MW(e). A requirement of the RPS is that information on the resource will be continuously obtained, so ensuring well informed decisions are made. The reservoir has been modelled, and this model will be continuously upgraded to cnsure that the development is the most appropriate for long term sustainable use of the resourcc. A comprehensive monitoring programme will ensure that appropriate and accurate information is obtained as the field is developed,

The current proposal returns to the geothermal reservoir all energy not used in the powcr generation cycle The power generation process is among the most efficient currently mailable. (In future it may be pussible to extract further energy from the fluid before reinjection.) Reinjection philosophy is to reinject fluid into aquifers of substantially the same temperature. This is in compliance with the RMX requirement of greatest reduction of "contamination" of the receiving environment, it is also sound reservoir management practice. Chemical composition of the reinjectate will also be similar to the aquifer into which it is being discharged.

A significant problem with geothermal development is the issue of multiple tappers of the onc resource. That is, optimal and thus most efficient use of the resource is fell unlikely to occur wirh independent users, as the preferred developments for each individual user are likely to be in conflict. Ai Rotokawn there are four major land owners, three of whom have an interest in future geothermal developments. In order to meet the desirable goal of having a "single tapper" of the Rotokawa geothermal resourcc. an agrccmcnt has been reached between the major land owners that no subsequent developments will occur until a unified steamfield management organisation (or SMO) has been formed. The final structure of this SMO has yet to be determined, but it will include representation of all stakeholders and the primary objective will be integrated development of the resource within the environmental guidelines of the RMA.

Environmental Issues

The project minimises discharges to the environment and hence minimises effects on the environment. This is achieved by reinjecting virtually all of the used geothermal water. [The only major surface loss is water vapour from the cooling tower.) Reinjection will bc at a relatively high temperature owing io the requirement to keep rhe separated water above the silica saturation temperature. {Glover & Mroczek 1993, Taylor 1995, Stevens 1995). Apart from the vapuur discharge frum the cooling tower - including non-condensible gases - all discharges are intermittent and of short duration. These discharges will occur at plant start up and shut down. which will occur once or twice a year once commissioning is complete. Discharges will also occur during turbine trips and failures of plant for example reinjection control valves. Experience has shown that these occurrences will be infrequent.

Effects inay bc estimated hut they can only be confirmed once production commences, It is necessary to ensure that the development is on a small scale so any undesirable effects are correspondingly small and can thus be addressed when at a low level. Staged dcvclopment is a path by which rhis problem may be overcome. It is thus imperative that a system of monitoring is pur in place to measure actual effects. This will bc structured so that rhe programmed monitoring is targeted at those effects seen as significant, and results so obtained will be compared against those estimated and on which the application has been based. A particular case is that of hydrogen sulphide concentrations. Although the actual discharge can be estimated with some degree of certainty, ground levcl concentralions are significantly harder Io predict. In addition the appropriate maximum level for such concentrations has not been determined. The monitoring conditions imposed on the vapour discharge consent have been structured towards determining these parameters.

An objective of the RPS, not specific to geothermal development, is to achieve a nett reduction in CO_2 emissions. As geothermal developments are rclatively low emitters of CO_2, and as they are high on the "merit order" of thermal electricity generation options, geothermal power developments will bring about a nett reduction in CO_2 emissions from electricity generating plants.

The Waikato Regional Council considered that the environmental effects of the project were likely to be minor and localised, since the probable effects occurred at Rotokawa naturally. As a consequence of thc project the effects were likely to be somewhat more prónounced. Effects wcrc generally of low magnitude or low significance, *except* for the issue of hydrogen sulphide emissions. (This emission had also been a concern of submitters to the application)

Consent Conditions

All of the consents sought were granted by the Regional Council, but the term of cnch consent was 20 years. Conditions were applied to the consents. The majority of the conditions are monitoring requirements - both of the resource and environmental. An important concept of the conditions is that the development is subject to review by an independent panel of geothermal experts - a "peer review panel".

In general the required monitoring has not been detailed, which differs from previous geothermal consents granted under earlier legislation. Instead a "peer review panel" of industry experts has heen formed to review the management of the field. The panel is to review proposed operation and monitoring of the field, to confirm agreement with it, or to recommend changes if it is considered necessary for the sustainable management of the field. (The panel has already been convened to review the proposal to drill make up production and reinjection wells. Their recommendation to WRC, which was accepted. was that the proposals should be permitted.)

Monitoring

Monitoring is required for two purposes:

1. To monitor the operation of the steamfield, reservoir and power plant. and,

2. To munitor effects of the proposal on the environment.

The former is primarily a requirement of the owner, to monitor cfficiency of plant and particularly the behaviour of the geothermal reservoir. The latter is primarily a requirement of the regional council, The requirements of resource consents have been integrated with the general monitoring schedule.

Being the first significant development on the Kotokawa field imposes certain restrictions. There is a requirement to undertake a relatively stringent baseline monitoring programme, so that effects of the developrnent can be accurately determined and compared against natural states

A monitoring schedule has heen derived and the work will be carried out under the steamfield operations and maintenance contract. The schedule includes resource monitoring and production flows as well as environmental monitoring required by the regional council.

The schedule is in two parts:

1. A 'baseline' survey to establish what existing conditions are prior to station start up, and

2. Ongoing monitoring. which may be on a monthly, annual or biennial basis.

Coverage includes:

- Geothermal well temperatures and pressures, casing cnndition
  Production flows. temperatures and chemistry
  Subsidence and gravity surveys
  Ecological (flora and fauna)
  Natural surface heat flow
  Weather/climate
  Ground and surface water
  Noise

Monitoring results will be reported to the regional council, as required by the consents. Results will also be reported to the peer review panel. in particular in conjunction with development proposals. Data should not be gathered for data's sake. Instead, monitoring must be targeted to obtain the information necessary to sustainably manage the resource, and as such will be available to the peer review panel, to the regional councils and to researchers.

Taupo District Council (the Territorial or District Authority) granted development plan approval for the construction and operation of a geothermal pwer station of up to 20 MW(e) at Rotokawa. The District Council also granted right of way approval for the access off the public road. Land use consents were not required as the activity is permitted under the District Plan - the area was zoned for geothermal development, including electricity generation, about eight years previously. Subdivision consents were required however, for the separate leases for the power house and steam ficld installations. Ihese have also been granted by the District Council.

Consent Conditions include the following:

- Road construction minimum standards, including the entrance.
  Restrictions on the route for over weight loads.
  Construction requirements on structures on reserves to minimise visual impact.
- Drilling and testing conditions relating to disposal of wastes, safety and noise.
  Noise restrictions
  Forestry management to maintain visual screening of structures

CONCLUSION

The Rotokawa project will ensure the resource is developed 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 sustaining the potential of the resource to meet the needs of many future generations. It safeguards the life supporting capacity of air, water and soil. Adverse effects are generally avoided, some remedies or mitigation are possible. Mitigation includes the valuable information on the geothermal resource which will be gained by the monitoring programmerun as part of the development.

The development will recognise historical. cultural and spiritual values of the Rotokawa geothermal resource as held by local people. This will he donc through the development being undertaken by the Tauhara North Number 2 'Trust who represent the tangata whenun. or people of the land overlying the resource. The development complies with the Resource Management Act 1991

ACKNOWLEDGMENT

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