RESOLUTION OF THE ENVIRONMENTAL FACTORS INFLUENCING THE DEVELOPMENT OF OHAAKI POWER PROJECT

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Utilisation of geothermal energy resources posed several environmental problems which were identified during investigations preceding the preparation of an Environmental Impact Report. An audit of the Environmental Impact Report was carried out by the Commission for the Environment and the recommendations of the audit were accepted and taken into account during the planning and design of the station.

Environmental Considerations

Environmental requirements for Ohaaki have necessitated features in the design which were not used at Wairakei. Requirements which considerably increased the capital cost of the station were:-

i) the reinjection of separated geothermal water;
ii) the disposal of much larger quantities of non-condensible gases from the geothermal steam than was the case at Wairakei.

It is the first time that these features have been used in New Zealand and therefore a conservative approach has been taken in the design. The experience gained at Ohaaki will benefit future similar applications.

Because the separated geothermal water contains dissolved minerals which are considered harmful to human and aquatic life if they are allowed to pass into the Waikato River, a requirement of the Water Rights issued by the National Water and Soil Conservation Authority was that all separated water be reinjected into deep wells. The effect that the reinjection will have on the production zone of the geothermal field is not fully known and therefore a conservative approach has been taken in designing a reinjection system using wells remotely located from the production wells.

To operate the turbo-generating plant efficiently and to avoid discharging large quantities of geothermal steam into the atmosphere, it is necessary to condense the steam after it has been through the turbines. This process requires considerable quantities of cooling water. Again the conditions of the Water Rights restrict the amount of cooling that can be provided directly by the Waikato River, making it necessary for a circulating water system incorporating cooling towers to be used. A natural draught cooling tower is considered most suitable for this application.

The geothermal steam from the Broadlands field contains at least fifteen times more non-condensable gases than the Wairakei field. Special measures are necessary to extract these gases from the condensed steam and discharge them in a manner which avoids high ground level concentrations of gases such as hydrogen sulphide. Because the actual gas content varies within the field, design of this extraction equipment has been based on flexible operation up to the highest expected levels.

Description of the Process

Geothermal fluid will be taken from the ground via approximately 25 production wells located in the two connected steamfields on the east and west banks of the Waikato River. The geothermal fluid will be fed to five separation plants where steam and water fractions are separated, with the water being returned to the ground via reinjection wells. The steam will be passed to the power station via a piping system. Some of the steam will condense during this process due to heat loss from, the pipeline and this will be removed from the pipeline by steam traps discharging to drains leading to the river. In the power station, the steam will pass through the turbines, generating electricity, and will be finally condensed (Note: HP steam after passing through the HP turbines is added to the IP steam and passes through the IP turbine for condensing). The condensing process will be achieved by spraying circulating water into the steam. The resultant warm water will be passed through a cooling tower and then be returned to the power station as circulating water. The circulating water system will therefore continuously gain condensed steam. This gain will be balanced by evaporative losses from the tower and by discharge via the condensate reinjection system into the ground. The non-condensible gases, extracted from the condenser by the gas exhausters, mainly carbon dioxide and hydrogen sulphide, are discharged to the natural draught cooling tower to rise with the plume (refer fig. 1).

A factor common to most geothermal power stations is the use of direct contact condensers. As its name implies, steam discharged into this type of condenser comes into direct contact with the cooling water. Steam condensate and some dissolved non-condensible gases will be carried out of the condenser by cooling water.

Generally there are two ways to dissipate heat, either to the atmosphere using a closed cycle cooling system such as a cooling tower or cooling pond; or direct (open cycle) cooling by heating a natural water body.

Normally the method chosen for condenser cooling reflects a balance between availability of cooling water, economic cost and environmental acceptability.

With open cycle river cooling heat is dissipated to the river by raising the temperature of the fraction of river flow which is passed through the condensers. River temperature increases after complete mixing with the condenser discharge and discharges of waste bore water would raise the river temperature above the 7°C maximum river temperature rise stipulated by the water classification applied to this stretch of the Waikato and constraints would be placed on operation of the power station.

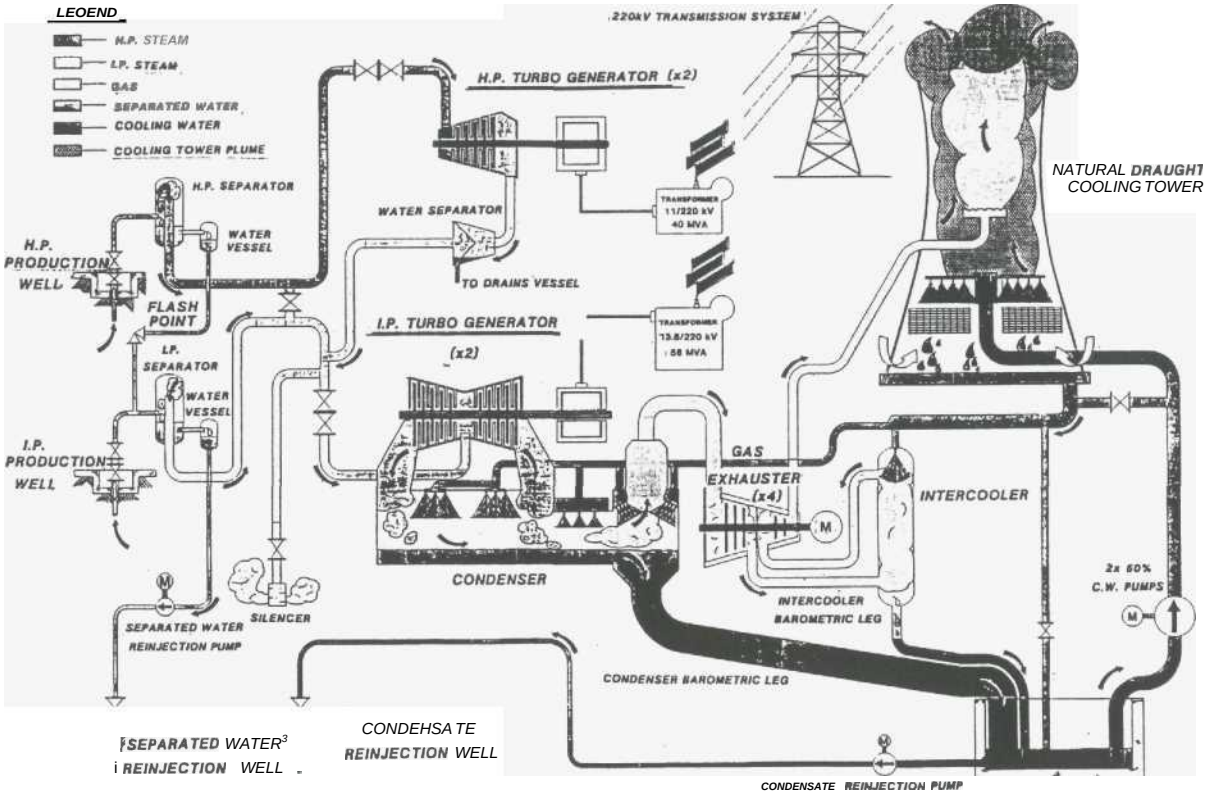

Figure 1 Simplified Flow Diagram

A cooling pond of the size necessary for adequate condenser cooling would need to be located east of the major steam production area and the Waikato River and would cover an area of approximately 350 acres. A major economic disadvantage would accrue from the lengthy circulating water culverts to a station which would be sited west of the river. For this reason cooling ponds were not preferred.

The remaining closed cycle condenser cooling alternative was cooling towers. In a cooling tower heat is removed from the water by allowing it to fall through an induced flow of air. The resulting evaporation of a small fraction of the water provides the necessary cooling. Both natural draft and mechanical draft towers were considered for Ohaaki with the decision being that circulating water will be cooled in a natural draught cooling tower, the tower being of the conventional hyperbolic shape, 105 metres high and 70 metres across at the base (refer fig. 2).

Atmospheric Emissions

Emissions from the cooling tower are the other significant source of chemical substances to the environment surrounding the Ohaaki Power Project.

At full load the discharge from the gas exhausters will be up to 40 tonnefir of geothermal gas. The gas is at 1.05 bar pressure, 130"C, and is discharged to atmosphere through the copling tower.

The composition of the geothermal gas on a percentage weight basis is estimated to be:

Carbon dioxide	97.25
Hydrogen sulphide	1.39
Hydrogen	0.01
Nitrogen	0. 64
Hydrocarbons (mainly methane)	0.71

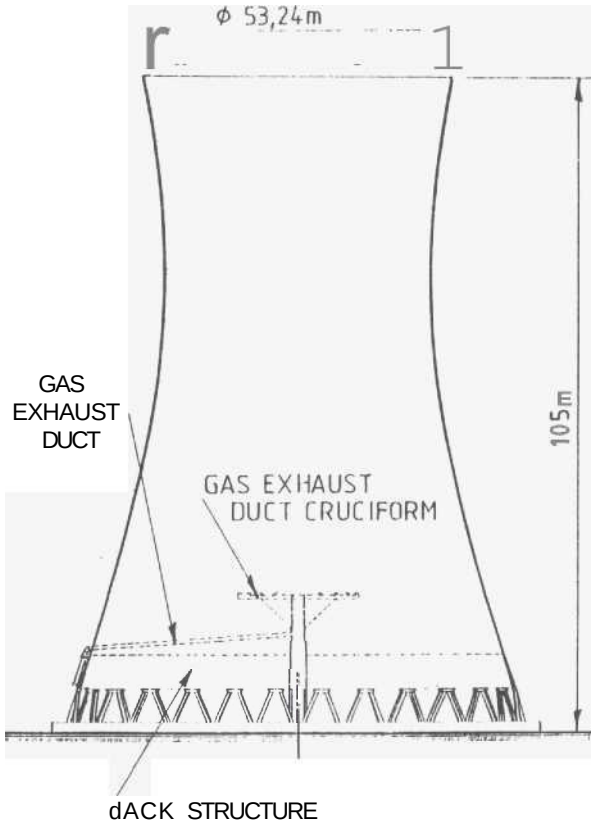

Figure 2 Ohaaki Cooling Tower

Other Discharges

Steam and associated gas will also be discharged to the atmosphere from the followihg sources:

i) Station Vent Valves
ii) Production Wellhead Geothermal Silencers
iii) Reinjection Wellhead Geothermal Silencers
iv) Separation Plant Geothermal Silencers
v) Steamfield Vents

The average gas content of the HP steam is 6.35%
The average gas content of the IP steam is 1.14%
The average gas content of the atmospheric steam is 3.9% (Designpower New Zealand Ltd).

i) Vent Valves:
Four vent valves are located in the vicinity of the 'A' Turbine House. These valves discharge steam to the atmosphere when a turbo-generator either starts up, trips or is required to be shut down in an emergency. The valves are located on the IP line and are capable of discharging a total of up to 710 **tonnes/hour** of steam made up of a mixture of HP steam (either from the HP turbine exhausts or **froin** HP bypass valves) and IP steam.

ii) Production Wellhead Geothermal Silencers:
The silencer located adjacent to each production well will be used to occasionally discharge bore fluid to the atmosphere at times of well maintenance, associated separation plant maintenance and station start up.

iii) Reinjection Wellhead Geothermal Silencers:
The silencer located adjacent to each reinjection well will be used to occasionally discharge separated water and steam to the atmosphere at times of separated reinjection system start up.

iv) Separation Plant Silencers:
The silencer located adjacent to each separation plant will be used to occasionally discharge steam to the atmosphere. Discharges will occur at times of Separation Plant start up, separated water reinjection system start up, separated water reinjection system failure and station start up.

v) Steamfield Vents :
These are manually operated vents used during times of start-up and maintenance for short periods and located on both HP and IP lines. The composition of the gas in the steam will depend on the line being vented.

i) Monitoring

a) Hydrogen Sulphide **(H2S)** -
As a result of extensive discussions beginning in 1978 between officials of the Department of Health and the then Ministry of Energy, Electricity Division, an H2S monitoring system has been installed in the Ohaaki Power Station area. The system has the following components:

4 Monitor LAB H2S Fluorescent Analysers Model 8780
4 Monitor **Enviro/Logger** Dataloggers
1 IBM Portable Computer

The system has been used to provide continuous monitoring of the H2S concentration at four points in the Broadlands Valley at centres of population and areas where maximum ground level concentrations were predicted.

Each monitoring station provides an output of the hourly average ground level concentration.

(b) Wind Speed and Direction -
To assist in identifying the source of any over limit levels of H2S pollution wind speed and direction equipment **has** been installed in the Broadlands Valley.

ii) Design

The power station has been designed on the basis of the hourly average ground level concentration of hydrogen sulphide outside the designated land area not exceeding 0.05 ppm (50 ppb) by volume.

Disposal of Geothermal Fluid

Occasional discharges of geothermal fluid to the Waikato River will occur, the majority of which will emanate from the steamfield areas. Discharges will occur at the production wellheads when the wells are being tested for output (flow measurement) and for short periods during the commissioning and starting up after maintenance of steamfield plant. Discharges will also occur at reinjection wellheads and separation plants for short periods during the commissioning and starting up after maintenance of steamfield plant. Minor discharges will occur from the various drains and vents for short periods during the commissioning and start up of steamfield plant.

The geothermal fluid discharge system incorporates a holding pond on each of the West and East bank of the **Waikao** River. The capacity of th ponds, being 12,000 2 (West Bank) and 16,000 m (East Bank), has been designed to accommodate a **regulated** release to the Waikato River of geothermal water originating from a total failure of the reinjection system (eg. total loss of power to the pumps) and commissioning, starting up and shutting down of plant together with that discharged resultant from flow measurements, maintenance and development work. (Brown and Canvin) .

The use of holding ponds will enable control of the discharge, and enable the loss of heat and volatile pollutants to the atmosphere (CO H_2S, Hg, NH_3) while water is held in the ponds. **(Keppard)** .

It is proposed to make use of the holding ponds to generally restrict major flows to the river under the water right to periods when the river is flowing at a normal to high rate. Electricorps operation of the hydro stations on the Waikato River leads to regular periods of low river flow and it is the intention to minimise flows to the river during those periods.

Statutory Procedures

The development of the Ohaaki Power Project was subject to planning procedures in terms of the Town and Country Planning Act, the Water and Soil Conservation Act and the Clean Air Act.

Town and Country Planning Act

A combined local authority (Taupo County Council for West Steamfield, Rotorua District Council for East Steamfield) public hearing was held on 26 March 1979 to consider the ministerial requirements for the Ohaaki Power Station.

On 29 June 1979, the Minister of Works and Development advised the Taupo County Council of his decision on the designation of land subject to various conditions. The pertinent conditions are reflected within a "Heads of Agreement" between the Crown and the owners (through the Responsible Trustees) on 28 July 1982 for the lease of the designated land on the western side of the Waikato River.

Water and Soil Conservation Act

At its meeting on 5 December 1978, the National Water and Soil Conservation Authority **(NWASCA)** granted the Minister of Energy a number of water rights in connection with the operation and maintenance of the Ohaaki Geothermal Power Station.

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Clean Air Act

A licence authorising operation of the Station in terms of the Clean Air has been granted by the Department of Health and monitoring of Hydrogen Sulphide levels is continuing.

LAND TENURE

The Ohaaki Power Project site covers two distinct areas, each in different ownership.

The area of land on the east bank of the Waikato River (East Steamfield) is Crown land, administered by Land Corporation Ltd (Landcorp) . Electricorp has access to this land for geothermal purposes with farming operations continuing under Landcorp management.

The area of land on the west bank of the Waikato River (West Steamfield) **is** Maori freehold land. A "Heads of Agreement" exists between the Crown and the owners for the lease of the land. Negotiations have continued towards the signing of a **formal** lease agreement. This lease will be between the Crown and the owners with a further agreement between the Crown and Electricorp to ensure that Electricorp has the requisite authority to operate and maintain the power station as well as utilise its output.

The west steamfield land tenure arrangements recognise the owners wish to retain traditional ownership and represents a major departure from normal practice in land acquisition for "public works".

In recognition of the owners traditional use of hot water from the steamfield area Electricorp has provided to the land owners; steam for cooking, hot water for domestic purposes, (ie. heating and bathing), and a supply of energy in the form of heat is to be made available for development purposes once a use has been identified.

SITES OF CULTURAL IMPORTANCE

Electricorp in consultation with the landowners representative prepared a map identifying all known Urupa, archaeological sites and all other sites of historical significance or spiritual or emotional association with the Maori which may be situated in or upon the land.

Should any above described sites, or any further such sites be identified during project development and operation and it was necessary to disturb the site for project development then as soon as a site was discovered or if an identified site (not being a site protected by Section 439 of the Maori Affairs Act, 1953) was required for development, then all work on that site would cease and no work take place to disturb that site until all matters in issue were resolved with the landowners.

Electricorp in consultation with, and without **cost** to the owners has established and will maintain a planted and landscaped area between the Urupa, Te Ohaaki Marae, Ngawha and fertility rock reserve.

PUBLIC **AMENITIES**

Public amenities to satisfy specific social and recreational needs of the local community have been provided in consultation with the local authorities.

These amenities are to recompense the community as a whole for any intangible losses in natural amenities or pleasantries of life which it may have incurred due to the construction or presence of the station. The amenities provided were not intended to compensate individuals or groups of individuals. They included:

i) Broadlands Hall (replacement)
ii) Reporoa Hall (extension)
iii) Reporoa St Johns Hall (extension)
iv) Reporoa Squash Club
v) Waipahihi Hall
vi) Regional Sports Ground Grandstand (Delaney Park)
vii) Taupo Borough Council civil Centre
viii) **Te** Ohaaki Marae - Upgrade of dining hall and ablution block
ix) Te Toke Marae - Upgrade of dining hall

LANDSCAPING

The environment surrounding the Ohaaki Power Project site could be described as extensively man modified, with most land either farmed or utilised for exotic forest and the Waikato River impounded for hydro-electric development.

The basic aim of the landscape development is to integrate the power station with the surrounding landscape. The power station, which includes the associated steamfields must be seen to sit **in** the landscape, not **on the** landscape. In planning to achieve this integration, factors such as the land use and character of the surrounding landscape, Electricorp's policy of landscape maintenance and the life of the power station have been considered.

The various phases of landscape design may be summarised as follows:

a) Landscape assessment.
b) Design philosophy, development and approval.
c) Design proposal development and approval.
d) Preparation of detailed specifications and working drawings.
e) Implementation of design.
f) Production of a maintenance plan.
g) Production of **a** landscape management plan.

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