Proc. 8th NZ Ceotherrnal Workshop 1986

ENVIRONMENTAL MANAGEMENT AND GEOTHERMAL DEVELOPMENT

d'E. C. Darby

KRTA Limited, Auckland, New Zealand

ABSTRACT

All geothermal development projects have actual and potential effects upon the socio-cultural, biological and physical environment of the project, region. Analysis and management of these effects is a fundamental part of KRTA reconnaissance, exploration and development programmes.

The objective of this paper is, ,therefore, to indicate the range of environmental interests which may need to be taken into account in the assessment and development of geothermal resources. The discussion is illustrated with examples from KRTA work over the past 15 years in geothermal fields of Asia, Africa, the Americas, the Caribbean and the Pacific, including New Zealand.

INTRODUCTION

Early assessment of social and cultural values, biological and physical factors, land and water use, archaeological and historic sites and public concerns having regard to the characteristics of the project area, is essential for effective management of a project. The assessments should be sufficiently extensive and advanced in time to be of use in project planning, and in the design of methods to eliminate or reduce the intensity of adverse effects. They should also remain appropriate to other scientific and engineering programmes in case project emphasis shifts to other areas or other development strategies.

THE PHILIPPINES

It is general knowledge that much of our geothermal work has been in the Philippines, but the pace of development and the extent of environmental work in that country is perhaps not so well known. An indication of the effort can be gained from the fact that the first deep well was completed in January 1977, and 112.5MWe power stations were commissioned in Negros and Luzon Islands in June 1983, only six years later. This involved management of up to 10 drilling rigs operating concurrently,drilling both vertical and deviated wells of which 94 ranged from 2000 to 3500m in depth. At the same time, exploration work was carried out in about 20 other promising locations, (Fig 1). An indication of the range and intensity of environmental management work which had to be addresssed in the course of these developments is given below.

TONGONAN, LEYTE ISLAND

The first deep well was completed in January 1977, a 3MWe demonstration power unit was commissioned in June 1977, and the first stage 112.5MWe Leyte I Power Station was commissioned in June 1983. The project is located in a 108 000 ha Watershed Reservation populated by some 450 000 people. land use ranges from tropical rain forest, through intensively horticultured valleys, to logged-out wastelands of fire-stabilised coarse grass and lantana scrub.

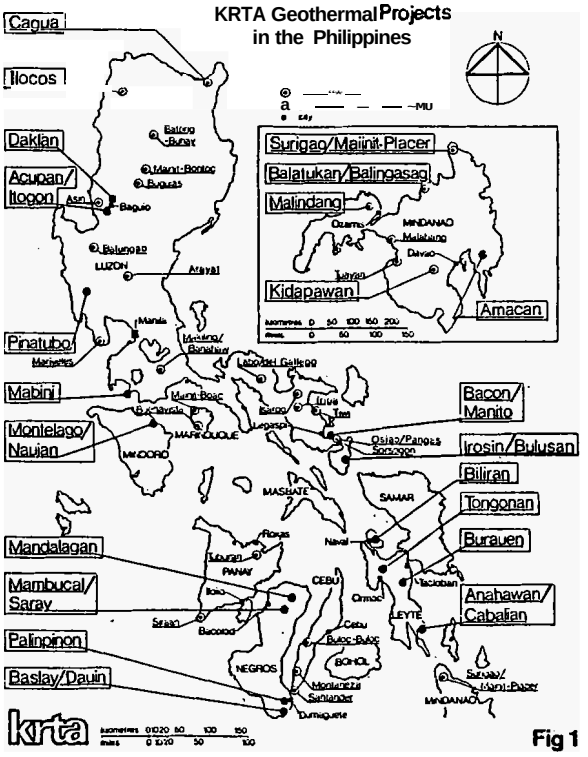
The initial brief, to assist in developing the project in an environmentally acceptable manner and to train Philippine counterpart staff, was carried out by way of a formal Environmental Impact Report which was completed at an early stage of project development. This was the first EIR produced for a geothermal project in the tropics. Information gained in the course of this work opened the way for an extensive range of scientific studies and sociological programmes, which were implemented at a rapidly increasing rate by counterpart staff of the newly-formed Environmental Management Department (EMD). The ability to implement such an innovative range of social agro-forestry and rain forest resource management programmes as part of the geothermal project was made possible through the active support of senior management staff of the Philippine National Oil Co, (PNOC), an attitude which was all the more creditable as it is by no means the norm for large Philippine agencies.

An indication of the range of work carried out as part of the Tongonan project by EMD staff with continuous consultancy input from KRTA field biologists is given below. The increasing workload undertaken by EMD may be judged from the fact that between 1981 and 1983 their scientific and technical staff numbers increased from 17 to 103.

- Environmental Impact Report preparation
- Baseline ecological and sociological studies
- Evaluation of, and compliance with environmental legislation
- Identification of potential environmental constraints on drilling and well-testing programmes
- Determination of maximum acceptable concentrations of chemicals where legislative guidelines were absent
- Formulation and assessment of monitoring programmes
- Design of lichen and bryophyte surveys as a basis for long-term low-level air pollution monitoring
- Forest soil chemistry baseline studies
- Effects on forest of airborne wastewater droplets containing boron and chloride
- Evaluation of critical temperature for river organisms, related to the design of contingency hot wastewater disposal systems

Darby

- Assessment of potential for arsenic accumulation in river fishery resources
- Assessment of effects of H_2S, and design of H_2S management systems
- Rice research; evaluation of irrigation water quality:
  - effects of boron and arsenic at various growth stages
  - effects of arsenic, dissolved H_2S and iron on crop yield
  - screening for boron-resistant rice varieties
  - establishment of demonstration rice-fields
- Liaison between developer and authorities of the adjacent National Park
- Impact assessment of a proposed fish farming project
- Establishment of demonstration hardwood plantations (teak, mahogany), cash-crops (coffee, nuts), fuelwoods (ipil-ipil), fish-farming ponds, Azolla nitrogenous fertiliser ponds
- Rehabilitation of degraded hillsides
- Slope stabilisation using indigenous shrubs and trees
- Soil conservation
- Sociological survey
- Hydrographic study of Ormoc Bay
- Environmental engineering recommendations for project civil work
- River sedimentation control measures
- Design and implementation of drilling waste control measures
- Design of main, standby and emergency systems for the disposal of 1350 tonnes/hour of highly mineralised high temperature fluids
- Disposal of mercury-rich waste sludge from cooling tower basins
- Implementation of forest fire weather index system
- Design and implementation of control measures for logging in critical watersheds
- Assistance in informing hill people and forest dwellers about social forestry and agro-forestry options
- Recommendations for the establishment of Reserves for conservation of forests, wildlife, genetic resources, etc.
- Shifting agriculture:- methods to reduce its effects on forests, demonstration of practicable alternatives, assistance to people wishing to stabilise their agriculture.



PALINPINON, NEGROS ISLAND

Development work on this project commenced about a year later than Tongonan, but its 112.5MWe power station was commissioned at the same time, June 1983. The project is located in a Watershed Reservation which is larger (133.000 ha) and appreciably more mountainous than that of Tongonan and has a smaller human population, (345,000).

Much of the work carried out at Palinpinon was similar in scope to the Tongonan project but additional work was implemented in response to new opportunities provided by the different geothermal characteristics and by the different natural resource base of its Watershed Reservation. Services provided included

- Investigation of the effects of arsenic and boron on river-grown food crops, and evaluation of counter-toxicity methods
- Evaluation of the environmental chemistry of chromium used in drilling mud additives and lost circulation materials
- Preliminary evaluation of sustained yield for non-timber resources of the rain forest, e.g. rattans, palms, orchids, fern-fibre
- Evaluation of river based prawn farm proposal
- Strategic and sociological implications of a proposed cross-island road
- Utilisation of disused drilling sumps and waste ponds for culturing fish and Azolla fern as source material to start village ponds
- Soil conservation on steep, intensively farmed slopes; demonstration areas, appropriate crops and cropping techniques
- Agro-forestry and social forestry; establishment of nurseries and demonstration areas for dipterocarp hardwoods, fuelwoods, cash crops, orchard and vegetable crops

- Design of sediment traps and oil traps for waste management ponds and drainage systems
- Disposal of wastewater by reinjection to depths up to 3500m below surface, and monitoring the subsequent movement of temperature, pressure and chemical fronts associated with the reinjected fluid

BACON MANITO, LUZON ISLAND

This, the third major Philippine geothermal energy undertaken with New Zealand Government assistance, is located in a 25,000 ha Reservation of forested and logged-out hill country populated by about 143,000 people. For several reasons, not least being the rapid decline in the Philippine economy, the project is still under development.

Environmental management services provided for this project were similar to those described above, but there was a significantly greater level of work required in the attempt to bring the effects of civil works to an environmentally acceptable level, largely because of the particularly high rainfall and difficult terrain and soil characteristics. There was also a high level of work on slope stabilisation, erosion control, and land rehabilitation, much of which was linked into a pilot social agro-forestry programme developed in association with the project nurseries, fish ponds and horticultural demonstration areas.

OTHER PHILIPPINE GEOTHERMAL PROJECTS

Environmental work carried out in relation to more than a dozen other exploration and development projects throughout the country included the following:

BILTRAN ISLAND

Preparation of a regional Land Use Plan. with particular emphasis on:

- Conservation of remaining rain forest
- Soil conservation and water resources
- Rehabilitation of degraded land
- Development of multiple-cropping systems for lowlands and hill country

MAMBUCAL, NEGROS ISLAND

- Identification of airborne toxic elements and evaluation of effects on coffee, maize and sugar crops
- Liaison between developer and Canlaon National Park authorities regarding proposed roading and exploration drilling within the Park

DAKLAN, LUZON ISLAND

- Water resource allocation plan to minimise conflict between project and domestic or agricultural water requirements
- Preliminary assessment of effects of effluent on a major freshwater fishery, the Ambuklao Reservoir

ACUPAN, LUZON ISLAND

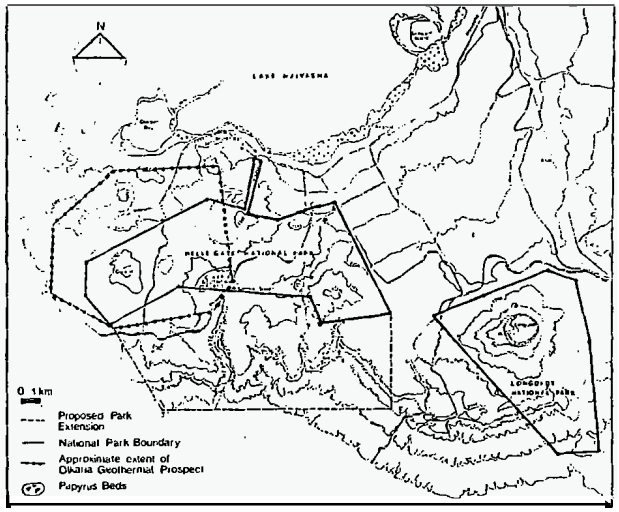
Environmental work here related to the geothermal steam and hot fluids, under considerable pressure, which enter actively mined parts of the Acupan Gold Mine at levels more than 1,000m below the ground surface. Again, opportunities were taken to assist in land rehabilitation.

- Assessment of interaction between mine wastewaters and geothermal wastewaters on aquatic crops
- Relocation of waste disposal outfalls to avoid contamination of irrigation water
- Rehabilitation recommendations for severely deforested and over-exploited hill country
- Initial appraisal of the risk for mine workers of geothermal radon emanation

OLKARIA GEOTHERMAL PROJECT, KENYA

KRTA carried out a detailed field review of project environmental management requirements, and outlined the extent and direction of work required for the Olkaria Geothermal project, (Fig 2). It was found that, while the project had relatively little adverse impact on its environment, the opposite was not equally true. Significant aspects of the project were considered to be at risk from environmental deterioration seen in the project area. Accordingly, proposals were set out to reduce the long-term effects on the project of the rapid degradation of regional water, forest and soil resources and, as a corollary, to improve the resource base for the use of local people. It was proposed that the Kenya Power Company (KPC) should form its own Environmental Management Unit to undertake this work; and an outline of staff requirements and their initial work programmes was prepared.

An interesting and innovative corollary to this work was the request from KPC to prepare for public distribution an extensively illustrated colour document entitled "Olkaria - The Environmental Viewpoint".



Olkaria Geothermal Project Kenya **Fig 2**

Regional and local work carried out in relation to Olkaria project included:

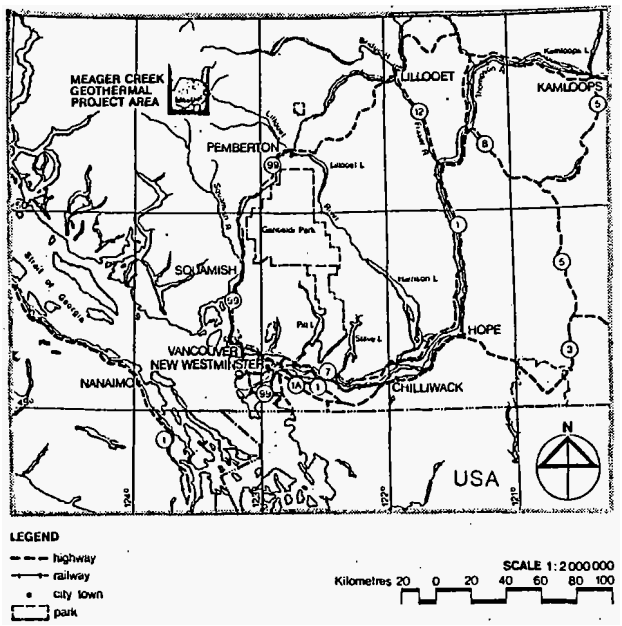
- Ecological significance of the Lake Naivasha basin and its relationship to the five great soda lakes in the Rift Valley in Kenya
- Desertification control; assessment of risk and identification of measures required to prevent the spread of nearby desert conditions into the project region
- Evaluation of the effects of over-grazing by cattle, goats and sheep in promoting change from arid land to desert conditions

- Socio-economic assessment of problems arising from overgrazing by livestock unsuitable for the area, over-exploitation of water resources, forest destruction, and conversion of food-producing land to export-oriented cash crop production
- Rangeland management; outline of recommended policies for sustainable natural resources use in an arid region
- Investigation of ecological relationships between Longonot National Park, Hells Gate National Park, private ranchlands and horticultural areas, and the Olkaria project
- Vegetation of hydrothermally altered ground; initial survey, with emphasis on its scientific and educational values
- Large mammals of the project area; initial survey with emphasis on the financial worth of wildlife as the basis of tourism in Kenya
- Re-vegetation; outline of recommended policies and planning requirements for erosion control, land rehabilitation and social agro-forestry.
- Fluoride in the environment; effects of elevated levels on wildlife, domestic stock and cash crops.
- Waste management and disposal.

MEAGER CREEK GEOTHERMAL PROJECT, CANADA

KRTA involvement in this project was related to deep exploration drilling and data evaluation to an extent sufficient to define the resource, (Fig 3). Environmental work commenced with assistance in the formulation of geothermal development legislation being introduced at that time by the Government of British Columbia. Field work carried out in conjunction with local scientists included the following principal aspects :-

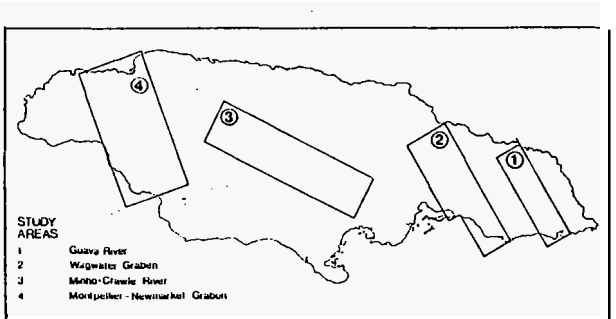
- Detai1ed review of project environmental management, and existing assessment, monitoring and reporting work.
- Baseline studies and monitoring programmes; recommendations related to geothermal development under Canadian conditions.
- Environmental management advice related to discharge of hot mineralised fluids, and their subsequent disposal into surface waterways.
- Dri11ing; environmental recommendations.
- Salmon and trout; assessment of Meager Creek and the Lillooet River fisheries, and the potential effects on them of project development.
- Groundwater studies; establishment of terms of reference for a study of thermal and non-thermal near-surface groundwaters.



krta **Meager Creek Geothermal Project Canada** **Fig 3**

JAMAICA

Work on this project was related to the need for resource assessment and regional planning prior to any detailed investigation of the actual geothermal features upon which possible developments could be based. To this end. energy supply and demand data were related to forestry, fishery, agricultural and industrial applications and tourism, and an assessment was made of the potential electric and non-electric utilisation of geothermal resources.



krta **Jamaica Geothermal Project** **Fig 4**

AHUACHAPAN. EL SALVADOR

One of KRTA's earliest geothermal projects (1971), and also our first encounter with the ramifications of dealing with large quantities of boron-rich wastewater. Studies included assessment of seismic factors and appraisal of alternative strategies for disposal of non-condensable gases and hydrothermal fluids.

MILOS. GREECE

An appraisal was carried out of the environmental implications of operating load-following or non-load-following turbines on this arid island.

NEW ZEALAND

Relatively little geothermal environmental work has been undertaken by KRTA in New Zealand, as virtually all geothermal development in this country up to now has been carried out by Government agencies. Nevertheless, work has been carried out on

- the Ngawha project, in relation to potential non-electric uses of geothermal energy in a proposed industrial estate at Kaikohe,
- the scientific value of rare plant species in three Reserves, and the potential effects on the Waimangu surface thermal features. in relation to a geothermal timber treatment and ethanol production plant and, more recently,
- data review and scoping studies designed to facilitate management and expedite completion of the Environmental Impact Report for the proposed Electricity Division development of the Mokai geothermal field.

SUMMARY

This discussion has outlined a range of geothermal environmental management work, all of which, however, was designed around three basic requirements :

- to provide the basis upon which project development may proceed in an environmentally and socially acceptable manner,
- to provide management information which is appropriate in time and in scale to other aspects of project development,
- to monitor the environmental effects of a project and distinguish them from unrelated effects

In developing countries, there is frequently also the critical requirement to provide for technology transfer and training.

It also became apparent in the course of the work discussed above that the energy authorities in developing countries are often in an excellent position to lead by example in the environmental management of their projects. Their product. energy, depends upon a variable number of natural resources, principally water, but they are not constrained to produce a profit from the harvest of plant or animal crops on the land under their control. As such, they may be able to realise through their scientific and engineering establishments, the potential benefits of natural resource conservation and environmental management, to the advantage of as great a number of local people as possible.

ACKNOWLEDGEMENTS

Much of the Philippine work was carried out as part of the New Zealand Government contribution to the Energy Co-operation Programme for which KRTA is the executing agency. It is a pleasure to acknowledge the Philippine contribution to this Programme since the critical "development years", 1977 - 1984, in particular that of Pablo Malixi (Vice President of PNOC), Dr Mario Berbano (Manager of EMD), and EMD scientific and technical staff. especially Agnes de Jesus, Elizabeth Col1antes, Rowena Garcia, Angel Vil1amarzo and Ray LLena.

In Kenya (a World Bank Project), particular thanks are due to Sebastian Bwire-Ojiambo (Project Superintendent), Meshak Odongo (Senior Scientist) and Mr N Natarajan (Senior Project Engineer) of the Kenya Power Company.