Environmental Issues and Geothermal Development in New Zealand

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1. The various physioal and ohemioal properties whioh oommonly oharaoterise geothermal effluents and may oause deleterious effeots to natural environments have been desoribed by Ellis , and there is other reoent literature on speoifio effeots. In the first diploma oourse of the Auckland University Geothermal Institute, leotures were given on airborne and waterborne wastes. This paper will therefore not refer in detail to speoifio geothermal effluents, but rather deal with some environmental implioations of geothermal exploitation and environmental issues in relation to partioular areas of New Zealand.

2. The following are some general features of geothermal exploitation which have environmental implioatione.

2.1 Quantities of potential pollutants in geothermal effluents nay vary greatly from field to field. The oapaoity of natural systems to assimilate pollutants and the risk of damage they may oause ere also very variable. So different sets of environmental problems are likely to arise for each development.

In power generation from coal or nuolear fuels, mining, processing and generation usually occur at separate sites, but in geothermal generation the Fuel oyole is restrloted to the site, in prinoiple reduoing stresses on the environment.

Geothermal power stations have low thermal effioienoies (around 10%) oompared to fossil fuel or nuolear stations, and water dominated fields may present thermal pollution problems. In this regard, disposal of excess oondensate in steam dominated fields is less difficult.

Oeothermal effluent may have direot toxio effeots on plants and animals, and the plant nutrients it oontains may stimulate produotion of algae and rooted plants in water bodies inoreasing risk of nuisanoe growths. Other oonsiderations inolude the inoremental effeot a discharge may have in reduoing the assimilative oapaoity of a partioular environment (e.g. lake or river), and the biologioal availability of pollutants whioh depends on the ohamioal form in whioh they are released or deposited.

Assessment of the produoing potential of a borefield and oharaoterisation of its ohemistry generally require prolonged disoharge. Thus large quantities of stem and water are often produoed at the drilling and testing stage when reinjeotion oapability or other means of organised waste disposal are oommonly not available.

The design of oomponents of geothermal plant oonoerned with waste disposal usually depends to a large extent on the susoeptibility of the site area to pollution. Information on the likely extent of pollution must oome from eoologioal and other investigations.. These take more than a year to oomplete where they oonoern seasonal biologioal or olimatio ohanges, and so must be initiated at an early stage. Early aotion is required also for environmental reports.

Solution of most environmental pollution problems is olosely linked to the development of engineering teohniques. In prinoiple, these problems oould generally be eliminated or much reduoed by the use of known teohnology. But in praotise many promising teohniques for effluent disposal or treatment have yet to be proved on an adequate soale; for example, reinjeotion into a produoing field. The geothermal industry is still at an early stage in the application of many known methods.

Simultaneous use of a geothermal resouroe for different purposes may vary in their environmental oonsequenoes. Confliot of interests may ooour, e.g. withdrawal of fluid for power production has oaused deoay of hot-spring aotivity of value to tourism.

Tourism is a strong contender for first oonsideration where established or in areas of soenio beauty. It may be the industry best able to make good use of geothermal energy[2].

Oeothermal exploitation oan have a direot impaot on people, and either noise, nuisanoe smells or visual effeots may be oonsidered in particular oases to have greater disruptive effeots than effluent pollution.

Nevertheless, publio aooeptanoe of geothermal development is better than for most other energy produoing teohnologies, it being generally regarded as olean. It is not assooiated with oonoern for safety as is nuolear generation.

2.2 In the same context, some partioular features of geothermal fields in New Zealand are:

Most of the exploitable resouroe is looated in the Taupo Voloanio Zone, a relatively small but environmentally sensitive part of the oountry.

Geothermal fields in this zone appear to be water dominated. Ngawha field in Northland is expeoted to be New Zealand's first dry steam field.

3. Main environmental issues oan be ooneidered in relation to partioular areas, as follows.

3.1 The Haikato River.

The majority of possibly exploitable fields in New Zealand appear to be within the Waikato River drainage basin. Almost all geothermal inputs to the river ooaur in the upper 100 km. They profoundly influenoe water ohemistry along the entire river, elevating conc-[3]
entrations of various metals well above levels usual for fresh water and inoreasing the loading of plant nutrients [4]. On the basis of mass flows of ohloride, probably a oonservative oonstituent, first approximation oaloulations indioate a total flow of 6 to 9 m^3/s of geothermal fluid from natural souroes, entering by seepage through the river bed as well as by tributaries draining geothermal fields. In addition, Wairakei power station disoharges about 4000 m^3/h of hot effluent, and river temperature is further raised by direot use for oondensor aooling.

A reoent oomprehensive report on the Waikato River[5], the ohemioal and biologioal ohanges whioh take plaoe in the geothermal reaoh between Taupo and Ohakuri largely determine the biologioal oharaoter of the lower river below Cambridge. Although the lower river reoeives larger inoremento of the nutrients nitrogen and phosphorus, this does not lead to major inoreases in phytoplankton beoause residenoe time of the water thero is only about two days. The report also states that the river "has only a very limited potential for assimilating more wastes without causing nighttime oxygen concentrations to drop below 5 g/m3 in the critical reach from Ngaruawhahia to Tuakau". Concentrations of potentially toxic constituents contributed largely from geothermal sources do not appear at present to reach undesirable levels, with the possible exception of arsenic.

The Waikato is not typical of New Zealand rivers because of its length and extended water residence time. Its represents the most intensively developed hydroelectric resource in the country[3], the catchment is one of the most populous and contributes a large proportion of the total agricultural and industrial production. It is presently under stress, likely to come under further stress, and is in need of careful management[5].

Clearly a central issue from environmental and utilisation viewpoints is to maintain the water quality at least at the present level. Development of industry associated with geothermal fields in the catchment, e.g. sulphur extraction at Rotokaua or pulp/timber processing at Taupo-Tauhara or Atiamuri fields[2], will produce various types of effluent, and development for electric power will of course produce much waste water and condensate. Disposal of those effluents poses a major technical problem. Reinjection would be an excellent solution providing that not much leakage to groundwater occurs.

The generally good water quality of the river and the apparent rarity of events such as mortality among aquatic biota which might indicate short-term increases in potentially toxic constituents, argues that the river system satisfactorily assimilator the geothermal and other wastes. On the other hand, eutrophic conditions in summer and probable sensitivity to additional increments of pollutants indicate that margins for further assimilation are small. Much less is known about river biology than its physical and chemical characteristics[5], and the opportunity provided to determine possible effects on aquatic biota of prolonged exposure to geothermal discharges, including that of a power station, is rare and perhaps unique. There are indications that trout populations are under stress[4], and significant levels of mercury have been measured in trout[6].

In short, the river is strongly influenced throughout its length by geothermal input in its upper reaches. Wairakei power station imposes a distinct chemical character, and geothermal springs contribute much to nutrient loadings. Further geothermal input is definately undesirable.

Near the Waiotapu stream which drains to the river from a hot spring area, cases of sheep and cattle sickness and death are commonly attributed to drinking stream water. Whether or not this assumption is correct, it would be interesting to know whether particular elements tend to accumulate in tissues of stock in geothermal areas and the tolerances of stock to geothermal effluents.

32 Rotorua Lakes area.

Rather different environmental issues are raised by possible geothermal development in the catchment and drainage area of the Rotorua lakes. Conservation of hot spring phenomena and of landscapes are major considerations. The tourist industry centers mainly on the geothermal features and the lakes. The Rotorua geothermal reservoir is intensively exploited, Whakarewarewa geysers bring a partioularly well–known tourirt attraotion,and the shallow reservoir under Rotorua City supplying hot water to many wells, Reoently awareness has inoreased that expanded or even oontinued use of the resouroe for heating will modify hydrothermal aotivity at Whakarewarewa. The existenoe of the geysers is threatened, sinoe small ohanges in aquifer pressure disturb the delioate meoh- anism whioh maintains their aotivity. In a similar way, utilisation of nearby Ruahine Springs field for energy ray be expeoted to pose problems of oonfliot with established tourirt spots. Muoh lerr is known, however, about this reservoir.

Another of the main issues will be tho effeots upon the lakes. Concern about symptoms of eutrophioation in Lake Rotorua has stimulated muoh publio interest in the oonsequenoes of nutrient ea– riohment. Lakes Rotorua and Rotoiti are presently influenoed by ohemioal inputs from geothermal souroes. The importanoe of these inputs is not olear, but some streams flowing into L. Rotorua, e.g. the Ngahewa, are nutrient enriohed espeoially in nitrogen, as are many hot springs entering L. Rotoiti from the Tikitere region and froa the lake bottom. Nitrogen appears to limit phytoplankton in L. Rotorua during summer growth maxima. Heat flow rate through the bot– tom of L. Rotoiti has bean estimated as 150 MW. The lakes will olear- ly bo sensitive to ohanges whioh oould be brought about by geothermal exploitation. In L. Rotorua espeoially, nutrient addition would have deleterious results. Withdrawal of fluid from Ruahine and Taheke res– ervoirs may be expeoted to modify, perhaps lessen, the flux of fluid and heat to both faker.

In thio area, aesthetio oonsiderations will affeot the siting of industrial plant. while Wairakei station attraots many visitors beoause of its teohnioal pioneering history and the speotaole of well–head steam plumes, this will hardly be repeated for new stations. Conoealment of buildings, reduotion of steam esoape, noise and smell are likely to be neoessary.

Confliot between the interests of tourism and of heat util- isation at Rotorua may be solved by management of the resouroe, in other words by oontinually assessing the reservoir and if necessary restrioting withdrawals from it. The Wairakei field has of oourse been managed for some time to sustain power output, but management to satisfy multiple and possibly oonflioting uses, eaoh at some oom- promise level, is a different oonoept. Users who withdraw energy or who wish to maintain surfaoe geothermal aotivity, are in oompetition for a limited resouroe. There are obvious analogies with utilisation of surfaoe water bodies, or perhapr more olosely with resouroes ex– ploited to give a maxima sustainable yield.

The idea of multi-use management ham important environmental implioations. On one hand oonservation and tourism are reoognised am distinot and valid usee of a geothermal field. On the other, simult- aneoua withdrawal of energy is not neoessarily preoluded if oompro- mise conditions are possible.

3.3 Kawerau field on the lower Tarawera River presently provides 180 tonnes per hour of steam for pulp and paper prooessing, and 400 to 500 t/h *of* geothermal effluent is disoharged direot to the river. Further exploitation of this promising field oould rapidly raise the ratio of effluent to river volume to a level representing signifi- oant pollution; e.g. a 100 MW power station would probably inorease present geothermal effluent about six times, But tha lower 22 km of the river is already polluted by pulp mill waste whioh causes dis- solved oxygen concentration to sag drastioally. Efforts are being made to improve pulp waste treatment and water quality.

This diffioult situation poses a ahallenge more perhaps to the prinoiple of environmental conservation than beoause of any reason of utility at present. Users of river water downstream are few, and the only obvious evidence of pollution is its blaok oolour, There are many examples overseas where in similar oiroumstanoes no adequate treatment has been applied, and rivers have in effeot been written off as industrial sewers. Such situations present an issue in whloh eoonomio reasons have to be balanoed against more subjeot-ive ones.

3.4 The Ngawha field in Northland differs markedly in geology and ohemistry from the other fields. When more is known of the likely oharaoter and quantity of effluent, together with possibilities for reiajeotion, its environmental lmpaot may be estimated.

4. Referenoes

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