THE UNIVERSITY OF AUCKLAND

NEW ZEALAND GEOTHERMAL WORKSHOP

REINJECTION FROM 4 USERS POINT OF VIEW

OHAKI POWER STATION

NEW ZEALAND

INTRODUCTION

Setting the design parameters for the 80 - 100 MW Ohaki Power Station is proving to be a fascinating task because of the large number of imponderables sseociated with estimating the field output characteristics during exploitation end the effects that reinjection might have on the field performance if recharging the producing aquifer is attempted.

Reinjection will have to be used for the Ohaki Power Station, situated in the Broadlands Geothermal Field, to avoid contamination of the surface water and Waikato river. The ponding and chemical treatment of the water before discharging it into the river has been considered, but rejected on the grounds of cost and likely operating problems.

This paper tends to highlight some of the problems connected with reinjeotion, and unfortunately does not answer them because our preliminary tests axe incomplete and our operating experience is limited to one small reinjection well.

There are two fluids we have to reinject:

1) Waste geothermal water separated at ground level

2) Surplus condensate from the closed cooling system. (A closed cooling system is necessary as we cannot inorease the heat burden on the Waikato river.)

At this stage we do not know whether we can mix the two fluids for reinjection or whether we have to have separate systems.

OBJECTIVES OF REINJECTION

There are two main objectives:

1) To dispose of chemical laden waste geothermal water such that it does not contaminate the ground water, and adversely affect the producing wells if reinjected within the geothermal field.

2) To recharge the geothermal system, if possible.

The Broadlands field is a gas/water/steam system with oold water perohed above the system and free to find its way into the producing levela through breaks in the intervening mudstones. It appears important to reinject the water to reduce tho pressure drawdown in the system by minimising the rete at which aold water will flow into the bot structures.

REINJECTION WELLS

We suggest that from an operators point of view (keeping in mind fields such as Broadlands, whioh is a gas/steam/water system) the ideal reinjection well should have tho following characteristics:

1) Be reasonably olore to the separator station

2) Be capable of swallowing between 150 and 400 t/h of geothermal water, with a minimal wellhead preasure

3) Have good permeability in high temperature (250°Cplus) struotures, at depth. greater than the producing levela

4) Be oapable of swallowing the selected rate of geothermal water continuously, and if possible, to assist with recharging of the field.

5) Should not downgrade the performance of produotion wella.

It is fully appreciated that the above defines some of the ideal characteristics of a reinjeotion well and that reasonable compromises will have to be accepted.

WORLD REINJECTION EXPERIENCE

Reinjeotion experience round the world ranges from good to bad for the follow—— reasons:

Japan

The separated water, whioh is exposed to oxygen before reinjection, bar blocked a number of wells through the deposition of silica. However, whilst the well. aooept the water, reinjection appears to have been benefioial in maintaining output.

Ahuachapen

Reinjeotion has proved benefioial and few problems have been experienced, because the water is reinjected at 150°C, whioh is above the silica saturation temperature.

Larderello

Reinjection of surplus condensate has worked satisfactorily; apart from one area where local seismic shocks were produced, and reinjection had to be stopped.

Note Other reinjeotion teste have been oarried out, bot there is insufficient time to oover them all,

TESTS CARRIED OUT AT BROADLANDS

The follow teste have been oarried out at Broadlands,

(1) Reinjeotion of water above and at produotion depth in the oentre of the Weet Bank produoing area - whioh had been exposed to the atmosphere resulted in deposits in the well, and reoirculation in nearby wella. The average reinjeotion rate for the three month period was 170 t/h. (Br 33, see Drg No. 8/1427/00/1844).

(2) Reinjeotion on the eastern *edge* of the East Bank with water between 105° to 150°C into a well whioh has a number of loss zones above and below the produoing levela, bas resulted in an improved performanoe over a three year period. The average flow into the well has been around 25 t/h, with a well-head pressure of between 7 and 14 bar g. (Br, 7)

(3) Reinjeotion into a well outside the produoing field on the Ueet Bank with a *good* lore zone at 750 m and a water temperature of 60°C *using* reinjeotion water at a temperature of 95°C, required a relatively high well-head pressure for a maximum flow of 215 t/h. *Over* a period of one month the well-head preasure rose to 12 bar g whilst the water flow dropped to 160 t/h. The test was stopped becaause of a pump failure just ae it appeared that the pressures and flows were stabilising, It vas oonoluded that the teat was unsatisfaotory becauee silica was depositing in tho rook immediately surrounding the well. (Br 34).

(4) Three short term tests (duration 1 week) in three different wella on the Ueet Bank which range from marginal to *good* produoers towards the edge of the produotion zones. The reinjeoted water, whioh did not oome into contact with air, was reinjected into welle having temperatures around 270°C at their loss zones. Wellhead pressures ranged from 0 to 6 bar abs. The pressures were falling in the two wella with positive back pressures at the end of the teetr, for water flows of about 200 t/h. The tests were stopped after a week to avoid permanent damage to *the* wells through deposition of silica. The tests were certainly enoouraging. (Br 13, 23 and 31).

TESTS BEING PREPARED

Two further tests are being prepared one on either bank:

East Bank

Water from BR 35 will be separated at 150°C and injected into BR 27 which is a relatively high enthalpy well (1600 J/g) having a high gas content (approximately 11% by weight in steam) and a down-hole temperature of some 240°C. The reinjected water has a silica saturation temperature around 150°C. We believe we should experience few problems in disposing of 150 t/h (plus) of water at a reasonable well-head pressure (up to 5 bar abs) for the selected period of six months. Some reservations have been expressed about the wisdom of using this well, because we will be reinjecting into a two phase zone in a good producing area at the main prodwtion level.

Weet Bank

After much thought it has been decided to take the separated water from BE 19, which has a silica saturation temperature of 175°C, and inject it into BR 13 whioh is well away from the main producing zone. Initially the water will be separated at 175°C and gradually lowered to the point at which problems with deposition are experienced. The initial target temperature is 150°C, but hopefully the reinjection temperature can be dropped to 115°C which would allow low pressure steam to be used.

Comment

A silica deposition test rig, comprising a long length of small bore pipe, is helping to identify the critical water temperatures and hold-up times for silica laden water. The testa will include acid dosing of the water to establish whether the water temperatures can be lowered to the target figures. Silica depositing in the surface pipework could be almost as embarrassing as depositions in the rock.

CONDENSATE REINJECTION

We would like to reinject this with the waste geothermal fluids, but because of the large quantities (200 to 400 t/h) and lower temperature (50°C) it might promote silica deposition became of the lower temperature of the *mixture*. A series of tests will be carried out on the test rig to assess the problem.

POINTS TO CONFIRM

At this stage there are more opinions on reinjection than facts, hence we have still to determine:

1) *Where* waste geothermal water should be reinjeoted, i.e. either into a few bores in the centre of the field or a larger number on the outer edge of the producing zone.

2) Whether the water must be reinjeoted at or below produotion level, or whether it can be reinjected above the produoing levels without hastening field rundown rates.

3) Whether reinjecting into a high enthalpy well will be detrimental to the field output.

4) What are the minimum praotical reinjection temperatures of the waste geothermal water, and the struoture accepting the water.

5) Whether the condensate can be reinjeoted with the waste geothermal fluids.

6) Whether acid dosing to depress the silica saturation temperature of the water is practical.

7) What reinjection well-head pressures will have to be considered acceptable.

NEW ZEALAND ELECTRICITY - THOUGHTS ON REINJECTION

Ourrently we believe *that* reinjection should be:

1) At or below produation level.

2) Spread amongst a large number of wells situated towards the edge of the produoing field.

3) Into permeable structures with temperaturea above 240°C.

4) At temperatures not exceeding 150°C (to enable us to use steam at' 4.5 bar abs at the turbine stop valve)

5) Without acid dosing, unless it ia proved that a 150°C reinjeotion temperature cannot be achieved without it.

NOTE: We believe that *many* of the marginal wells towards the edge of the produoing zone could be used for reinjeotion.

WHAT'S AT STAKE

If we construot an *80* to 100 MW station and then find that reinjeotion problems reduoe power output, stops production or requires an unrealistio number of replaoement reinjeotion wells, then it will put a large question mark against further large scale use of *geothermal* anergy in New Zealand.

J.P.P. Robinson
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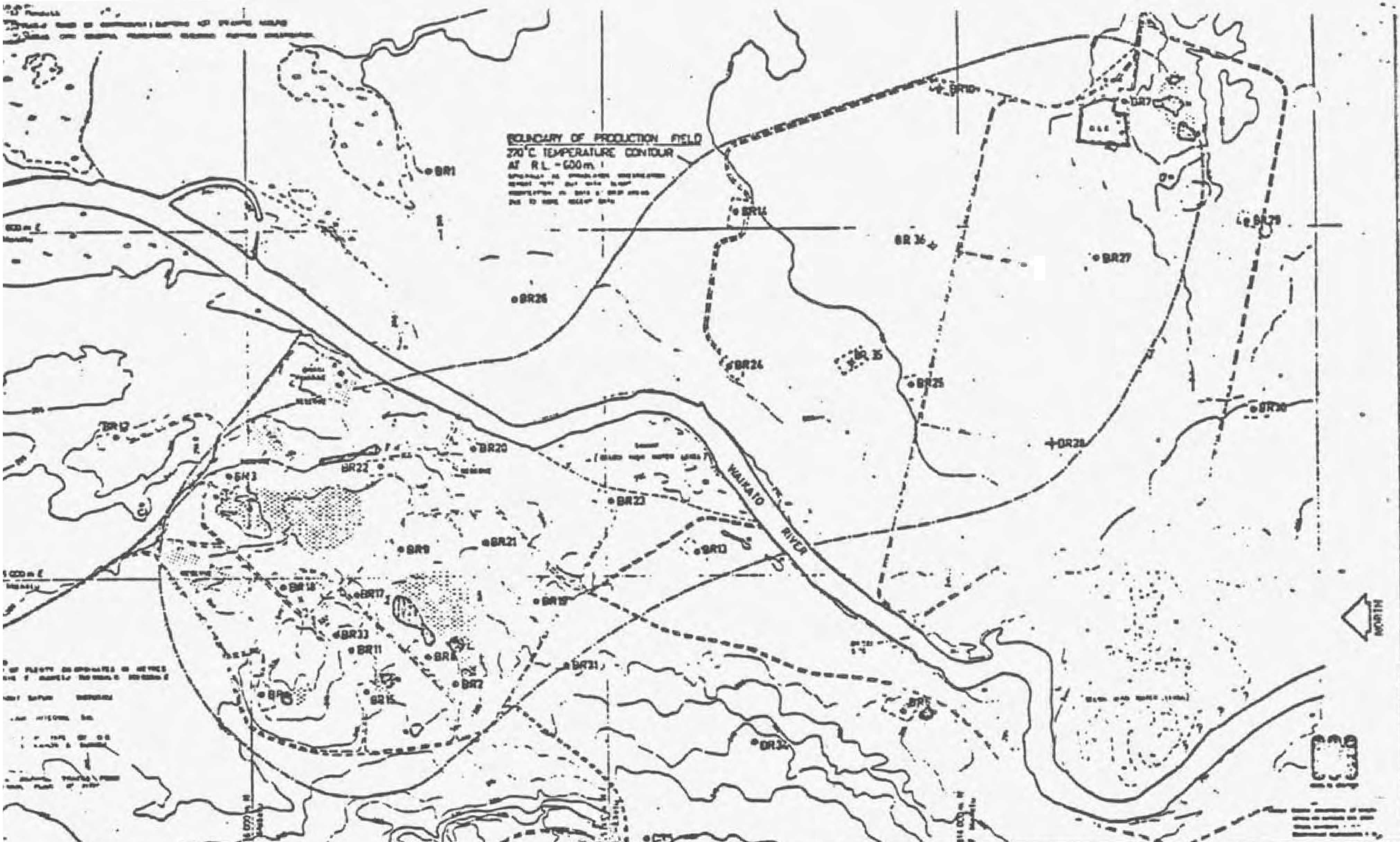

BROADLANDS GEOTHERMAL AREA

AREA LAYOUT

TOPOGRAPHY

1 : 5000

8/1427/CQ/1844

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