**Final Technical Report for Resource Confirmation Testing at the Raft River
Geothermal Project, Cassia County, Idaho**

DOE Award Number: DE-FC36-02AL68229

Recipient: US Geothermal Inc.

Project Title: Resource Confirmation Testing & Demo of Generating Capacity,
Raft River Project

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Executive Summary

A Department of Energy “Financial Assistance Award” allowed U.S. Geothermal Inc. to sufficiently define the reservoir parameters at the Raft River geothermal project in Cassia County, Idaho to complete the first; privately owned, commercial, geothermal power plant in the State.

The Raft River geothermal project was originally developed by the Department of Energy as a demonstration of the viability of the geothermal resource and of binary cycle power plant technology. Five production wells and two injection wells were drilled which were used to operate a 5 MW power plant. In 2002 the property was acquired by U.S. Geothermal Inc. for commercial geothermal development. Late that year U.S. Geothermal Inc. was granted a “Financial Assistance Award” from the DOE to test the existing geothermal wells in order to assess and define the geothermal resource.

In compliance with the statement of objectives of the “Financial Assistance Award”, flow and pressure build-up tests were conducted and analyzed on five existing geothermal wells at Raft River. Based on the results of those tests U.S. Geothermal initiated a six well drilling program in 2006 in an effort to obtain enough injection and production capacity to operate a 13 MW power plant. Two wells (RRGI-6 and RRGI-7) were deepened, two wells (RRGI-3 and RRGI-4) had new legs drilled to increase productivity, and two wells (RRGI-9 and RRGI-11) were drilled as new grass roots wells.

Analysis of additional flow, pressure build-up, and interference testing performed on some of the new and modified wells showed that there was sufficient capacity to complete the construction of a 13 MW, binary cycle power plant. U.S. Geothermal’s Raft River Unit One power plant construction was completed in the fall of 2007, followed by initial startup and testing. The power plant went into commercial operation in January 2008 demonstrating the commercial feasibility of deeper, lower temperature geothermal resources in the western United States.

Objectives, Accomplishments, Activities

When U.S. Geothermal acquired the Raft River Geothermal project in 2002, five production wells and two injection wells had been drilled and extensively tested by DOE in the late 1970's and early 1980's. However, the wells had been shut-in since that time; the condition and capacities of the wells after such a long period of inactivity was unknown.

The production zones from the Raft River wells were known to be deep (greater than 5000 ft.) and relatively low temperature (less than 300 degrees F). It was uncertain whether deep, low temperature geothermal wells could be economically developed for electrical power generation. Therefore the objectives stated in the application for the "Financial Assistance Award" were:

- 1) To test and assess the existing wells in order to define the geothermal resource.
- 2) To demonstrate that even deep, low temperature fields can be developed commercially in the western United States.

A testing and assessment program for the existing production wells was implemented in 2004. Flow and pressure build-up tests were conducted on all five existing production wells. The interpretation of the results of those tests was done by GeothermEx, Inc. and their detailed findings can be found in the section of this report entitled "Results from the Short-Term Well Testing Program at the Raft River Geothermal Field, Cassia Count, Idaho." The first objective was met upon completion of this report. However, to meet the second objective an investment decision needed to be made. It was decided that the results of the testing program were encouraging enough to justify the investment of millions of dollars in a drilling program to expand the resource sufficiently for commercial development.

The expansion drilling program was initiated in August 2006 and completed in May 2007. During the program well RRG-7 was deepened and converted from an injection well to a production well. Well RRG-6 was deepened and retained as an injection well. The original leg of production well RRG-4 was plugged off and a side track drilled. Well RRG-3 was converted from a production well to an injection well by deepening the original leg and then drilling a second leg.

Wells RRG-9 and 11 were drilled as grassroots wells. Well RRG-11 was drilled with two legs and completed as an injection well. Well RRG-9 was drilled with one leg and completed as a spare injection well.

An interference testing program was conducted in March 2007 which confirmed that sufficient production and injection capacity was available to supply a 13 MW binary power plant. The detailed results of the interference test were performed by SAIC, Inc. and can be found in the section of this report entitled "RRG-4 Flow and Pressure Build-up Test."

Concurrently with the drilling program, construction of a 13 MW binary power plant was started and construction was completed in the fall of 2007. Initial startup and testing followed completion and the power plant went into commercial operation in January 2008. Commercial operation of the power plant met the second objective of the “Financial Assistance Award.”

In summary, both objectives of the “Financial Assistance Award” were met in the manner and using the techniques and activities originally envisioned. Although no new products or technologies were developed with this award, the major goal of demonstrating the commercial feasibility of power generation from deep, low temperature geothermal resources in the western United States was accomplished.

**RESULTS FROM THE SHORT-TERM WELL TESTING PROGRAM AT
THE RAFT RIVER GEOTHERMAL FIELD, CASSIA COUNTY, IDAHO**

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1. DATA COLLECTION AND PROCESSING

Preparation for and execution of the production tests, and collection of test data, were carried out by U.S. Geothermal. GeothermEx personnel were on site during the entire test of well RRG-4 only, and assisted in the direction and data collection. GeothermEx personnel were on site during the entire flow portion of the tests conducted for RRG-3 and RRG-5, but were not present when the downhole tool was run or retrieved.

The production-testing set-up included:

- a flow tee installed on the wellhead above the master valve;
- a lubricator (to allow downhole tools to be run) on the wellhead;
- a flow line, consisting of flanged line pipe and a control valve, with ports for chemical sampling and measurement of temperature and pressure installed upstream and downstream of the valve;
- a separator/silencer (of low-emission atmospheric metering separator, or LEAMS, design);
- a weirbox, with a 90° V-notch weir.

Fluid produced during each test was piped from the weirbox to the existing drilling sump adjacent to the well pad.

The test procedure for each of the 5 wells tested (RRG-1, RRG-2, RRG-3, RRG-4 and RRG-5) was as follows:

- With the well shut in, logging tools were run in the hole to bottom, making stops to measure the static temperature profile. The logging tools included two combination pressure/temperature sensors to provide redundant measurements, with on-board data

loggers which recorded at intervals of 30 seconds (except in the case of RRG-1, where the interval was 5 seconds).

- The logging tools were pulled up and hung just above the flapper valve (except in RRG-4, which has no flapper valve and therefore the tools were hung near bottom, at 4,820 feet depth).
- The control valve was opened and the well was allowed to produce for a period ranging from 25 hours (in the cases of RRG-3 and RRG-4) to 60 hours (RRG-1).
- During the late part of the flow period, the tool was lowered below the flapper valve (throttling the well back briefly to minimize the risk of parting the wireline) and hung near the bottom of the well, measuring pressure and temperature at this depth for the remainder of the test.
- The well was shut in, and the tools left in the well to monitor pressure buildup for a period ranging from 24 hours (RRG-3) to 89 hours (RRG-4).

Measurements made during each test included:

- Wellhead temperature and pressure (measured on the flowline upstream of the control valve), typically recorded at intervals of 1 minute in the early part of the test and then increasing to 30 minutes.
- Water height above the weir, was recorded at the same intervals of the wellhead pressures. Several methods of measuring water height were implemented; the most reliable proved to be measurement of the length from the top of the weirbox to the water surface, upstream of the weir (and calculating the water height by subtracting the length to the water height when the box was full to the weir with no flow).
- Downhole pressure and temperature, monitored continuously throughout the test (at intervals of 30 seconds or less, as described above).

Observations with respect to well behavior and test conditions were made and recorded as appropriate. Fluid samples for chemical analysis were collected at least once during the test of each well.

With the exception of RRG-4, each well was allowed to flow with its control valve fully open throughout the production period (except when throttling to move the tool through the flapper valve). RRG-4 quickly developed an intermittent, cyclical flow (with a period of about 40 minutes), which caused downhole pressures to fluctuate. In order to obtain stable conditions for pressure transient analysis, the well was throttle for approximately the last 2.5 hours of the production period to obtain a stable flow rate.

The flow rate of separated water passing through the weirbox was calculated using the standard equation for a V-notch weir. The rate of steam discharged from the separator (as a percentage of total flow) was calculated by assuming flashing to local atmospheric pressure of single-phase water originally at the flowing downhole temperature measured during the test. The total production rate was determined by adjusting the water flow rate based on the calculated lost steam fraction. Some water leakage from the LEAMS separator was observed during production; however, this leakage was estimated to be, at most, a few gpm, which is not significant compared with the overall uncertainty in the measurement of production rate.

The downhole tools were configured with two sensors to provide redundant information. However, one sensor failed during the program and duplicate data (Sensor A and B) was only collected for wells RRG-2, RRG-3 and RRG-5. Figure 1.1 shows the flow rate and downhole pressure histories of RRG-1 during the test. Similarly, Figure 1.2 shows the flow rate and downhole temperature histories of RRG-1 during the same test. Figures 1.3 and 1.4, Figures 1.5 and 1.6, Figures 1.7 and 1.8, and Figures 1.9 and 1.10 show similar test data from RRG-2, RRG-3, RRG-4, and RRG-5, respectively.

Figures 1.11 through 1.15 show the downhole pressure and temperature profiles recorded in wells RRG-1, RRG-2, RRG-3, RRG-4 and RRG-5, respectively, prior to pressure build-up testing. Figure 1.16 is a plot of the measured static pressure at the top of the production interval versus the depth to the top of the production interval for each of the 5 wells. Extrapolating the linear trend of the pressure data points in Figure 1.16 to the surface indicates the existence of an artesian head of 140 psi at the Raft River field. This significant artesian head allowed production of the wells for the flow test program at adequate rates without the need for pumping.

2. DATA ANALYSIS METHODOLOGY

This section presents the quantitative methodology used to interpret the results of the flow and pressure build-up test program and make forecasts of well performance. Section 4 describes the fluid sampling and analysis conducted in conjunction with the flow test and interpretation of the resulting fluid chemistry database.

2.1 Power Available from the Fluid

It is possible to estimate the fluid requirement per kilowatt generation capacity, or kilowatt capacity available from a given fluid supply rate, from:

$$\text{Electrical energy per lb of fluid} = e \cdot W_{\max}, \quad (2.1)$$

where e = utilization efficiency of the power plant, and

$W_{\max}$ = maximum thermodynamically available work per lb of fluid.

W in equation (2.1) is derived from the First and Second Laws of Thermodynamics:

$$dq = c_p dt \quad (2.2)$$

$$dW_{\max} = dq(1 - T_o/T) \quad (2.3)$$

where c_p = specific heat of water,

T = resource temperature, and

T_o = rejection temperature.

For calculation of power capacity, T_o was assumed to be 60°F (average ambient temperature at Raft River) and T was measured for each well during the flow test (Figures 1.2, 1.4, 1.6, 1.8 and 1.10). For power generation from a resource at this temperature range, the binary-cycle

technology must be used; for modern binary power plants, a value of 0.45 can be assumed for utilization efficiency. If the plant is water-cooled, with a cooling water temperature of 60°F, the calculated capacities are reasonable. If the plant is air-cooled, T_o will be higher than 60°F in the summer and lower than 60°F in the winter; however, the average ambient temperature should still not be far from 60°F.

From the above equations the fluid requirement per MW (gross) generation, not counting the parasitic load of production and injection pumps and power plant auxiliaries, was estimated; Figure 2.1 presents the calculated fluid requirement in gpm per MW (gross) versus resource temperature. Therefore, the next step in this analysis was to estimate the fluid production capacity of the wells, from which the parasitic power needed for pumping and the net power capacity at the wellhead could then be calculated.

2.2 Initial Well Productivity

The productive capacity of a geothermal well can be quantified by the parameter Productivity Index (PI), which is defined as the total mass flow rate (w) per unit pressure drawdown (Δp), that is,

$$PI = w / \Delta p . \quad (2.4)$$

In the above definition Δp can be defined as:

$$\Delta p = p_i - p , \quad (2.5)$$

where p_i is the initial static pressure in the reservoir and p is the flowing bottom hole pressure at the well, which will decline with time if the well is produced at a constant rate w . Therefore, p , and consequently PI, of a well flowing at a constant rate declines with time. This decline trend in PI is a function of the hydraulic properties and boundary conditions of the reservoir, and interference effect between wells (if more than one well is active). For such estimation it is

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customary to utilize the so-called Line-Source Solution of the partial differential equation describing transient pressure behavior in a porous medium filled with a single-phase fluid. This solution gives the production rate from a single well in an infinite system as:

$$w = \frac{2\pi(kh)\rho(\Delta p)}{\mu p_D} \quad (2.6)$$

where k = reservoir permeability,

h = net reservoir thickness,

kh = reservoir flow capacity,

ρ = fluid density,

μ = fluid viscosity, and

p_D = a dimensionless variable that is a function of time.

In equation (2.6), p_D is given by:

$$p_D = -\frac{1}{2} \text{Ei} \left(\frac{-r_D^2}{4t_D} \right) \quad (2.7)$$

where t_D = dimensionless time

$$= \frac{(kh)t}{(\phi c_t h) \mu r_w^2}$$

$\phi c_t h$ = reservoir storage capacity,

c_t = total compressibility of rock and fluid,

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ϕ = reservoir porosity,

r_D = dimensionless radius,

r = distance between the line source and the point at which the pressure is being considered (equal to wellbore radius if flowing wellbore pressure is being considered),

r_w = wellbore radius, and

t = time.

In equation (2.7), Ei represents the Exponential Integral, defined by

$$Ei(-x) = -\int_x^{\infty} \frac{e^{-u}}{u} du \quad (2.8)$$

Equation (2.6) is true if the wellbore skin factor is zero, that is, the wellbore flow efficiency is 100%, the well being neither damaged nor stimulated. If the skin factor is positive (that is, the wellbore is damaged), for the same flow rate w , there will be an additional pressure drop given by:

$$\Delta p_{skin} = \frac{w\mu}{2\pi(kh)\rho} \cdot S \quad (2.9)$$

Productive geothermal wells usually display a negative skin factor, which implies a “stimulated” well (that is, the wellbore flow efficiency is greater than 100%), because such wells intersect open fractures.

2.3 Decline in Well Productivity with Time and due to Well Interference

From equations (2.4) through (2.9) it is seen that the PI of a well flowing by itself as defined here is independent of the production rate, and can be calculated as a function of time. The PI of a well declines with time, but the decline rate lessens continuously, and after a few months of flow the PI levels off substantially. If more than one well produce from the same reservoir, there will be interference between the wells, reducing the PIs of all wells. From equations (2.4) through (2.9) it is possible to calculate the pressure drawdown at a well, and therefore its PI, in response to both its own production plus the interference effect of simultaneous production from other wells in the field; this is accomplished by the mathematical process of "superposition in space" of the Line-Source Solution, as described below.

If n wells produce simultaneously, the PI of a well will decline with time according to:

$$PI = \frac{2\pi(kh)\rho_w}{\mu \left[\sum_{i=1}^n w_i p_{Di}(t, r_i) + wS \right]} \quad (2.10)$$

and, from (2.7),

$$p_{Di}(t, r_i) = -\frac{1}{2} Ei \left(\frac{-(\phi c_t h) \mu r_i^2}{4(kh)t} \right), \quad (2.11)$$

where w_i and S_i are the flow rate and skin factor, respectively, of well I, and r_i is the distance between the subject well and well i ($i=1, \dots, n$).

Equations (2.10) and (2.11) show that if all wells flow at the same rate, PI becomes independent of flow rate:

$$PI = \frac{2\pi(kh)\rho}{\mu \left[\sum_{i=1}^n p_{Di}(t, r_i) + S \right]} \quad (2.12)$$

Similarly, the mathematical process of “super position in time” of the Line-Source Solution can be used to calculate the pressure drawdown and PI when the flow rate is assumed to change with time.

In addition to flow-rate, skin factor, and diameter of the production well whose PI is being considered, the calculation requires the distance to and flow rate from (or injection into) each neighboring active well and estimates of several reservoir parameters. These input parameters are: viscosity and specific volume of the reservoir fluid, reservoir flow capacity (transmissivity), reservoir storage capacity (storativity) and initial reservoir pressure. While reservoir flow capacity and wellbore skin factor values can be estimated from short-term well tests, reservoir storage capacity cannot be estimated without the benefit of an interference test program. However, an average reservoir storage capacity value can be assumed for the calculations discussed below without introducing significant errors. Storage capacity values in the range of 0.001 to 0.1 ft/psi were reported from the interference tests conducted in the late 1970s and early 1980s at Raft River; a mid-range value of 0.01 ft/psi was assumed for analysis in this report. The specific volume and viscosity of pure water can be used for calculation since the reservoir water at Raft River has a low salinity and low gas concentration. The next section describes the analysis methodology used to arrive at the values of reservoir transmissivity and wellbore skin factor from the flow and pressure build-up tests conducted.

2.4 Analysis of Flow Test and Pressure-Build-up Data

The initial productivity index of each well can be approximated as follows:

$$PI = \frac{w}{p_s - p_f}, \quad (2.13)$$

where w = stabilized flow rate prior to shut-in,

p_f = flowing wellbore pressure just prior to shut-in, and

p_s = final build-up pressure.

However, forecast of the decline in PI with time and due to interference between wells requires the use of equations (2.10) and (2.11); this, in turn, requires the estimation of reservoir flow capacity and skin factor.

The approach used here to estimate flow capacity and skin factor of a well was to match, by trial and error, the observed pressure build-up behavior of the well to that calculated according to the following mathematical model for wellbore pressure build-up versus time, taking into account the intertwined effects of skin factor and wellbore storage effects:

Pressure build-up:

$$p_{ws} = p_i - \frac{w\mu}{2\pi(kh)\rho} \left\{ p_D(t_p + \Delta t) - p_D(\Delta t_D) \right\} \quad (2.14)$$

where p_{ws} = well pressure at a build-up time Δt ,

t_p = duration of production prior to shut-in,

w = average production rate prior to shut-in, and

p_D is as described by (2.7).

Skin Factor:

Defined by equation (2.9)

Wellbore Storage:

$$w_{bh} = w \left[1 - C_D \frac{d}{dt_D} p_D(t_D, C_D) \right], \quad (2.15)$$

where w_{bh} = flow rate from the reservoir to the bottom of the well even after the well has been shut-in at the wellhead,

C_D = dimensionless wellbore storage

$$= \frac{C}{2\pi(\phi c_t h) r_w^2}, \text{ and}$$

C = wellbore storage coefficient (volume stored in the well per unit pressure increase).

Reservoir flow capacity, skin factor and wellbore storage estimates (in reservoir barrels per psi) were varied by trial and error until convergence was obtained between the measured and calculated pressure build-up behavior within an acceptable tolerance level.

One needs to estimate the maximum available pressure drawdown (Δp) at a well before its maximum production rate can be calculated. Since the wells at Raft River will be pumped, the next step in the analysis was to estimate the maximum available drawdown for pumping of these wells and the parasitic load of this pumping. The next section therefore considers the intertwined issues related to well pumping and parasitic load.

2.5 Well Pumping Issues

In a pumped well, the water level must lie above the pump intake; otherwise the pump will cavitate. For any given pump setting depth, the maximum available pressure drawdown (Δp) in a pumped well without the risk of cavitation can be estimated from:

$$\Delta p = p_i - (h - h_p)G - p_{sat} - p_{gas} - p_{suc} - p_{fr} - p_{sm}, \quad (2.16)$$

where p_i = initial static reservoir pressure,

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h = depth to production zone,

h_p = pump setting depth,

G = hydrostatic gradient at production temperature,

p_{sat} = fluid saturation pressure at production temperature,

p_{gas} = gas partial pressure,

p_{suc} = net positive suction head required by pump,

p_{fr} = pressure loss due to friction in well between h and h_p , and

p_{sm} = additional safety margin to ensure cavitation does not occur at pump intake.

The pressure loss due to friction (p_{fr}) in equation (2.16) can be calculated as follows:

$$p_{fr} = \frac{f \rho v^2}{2 g_c d} (h - h_p), \quad (2.17)$$

where f = moody friction factor,

v = fluid velocity in well,

ρ = fluid density,

d = internal diameter of the wellbore, and

g_c = gravitational unit conversion factor.

The value of f in (2.17) can be calculated from:

$$f = \left[1.14 - 2 \log(\epsilon / d + 9.35(f^{-1/2}) / N_{Re}) \right]^2, \quad (2.18)$$

where ϵ is relative roughness of the pipe.

In (2.18), N_{Re} is Reynold's Number, given by:

$$N_{Re} = \rho v d / \mu, \quad (2.19)$$

where μ is fluid viscosity.

The maximum available pressure drawdown can be derived from equations (2.16) through (2.19).

The pump can be set as deep as 1,500 feet if a line shaft pump is used, but if an electric submersible pump is used it can be set considerably deeper. U.S. Geothermal proposes to utilize submersible pumps. Some of the above-mentioned parameters were specified by U.S. Geothermal based on their discussion with the pump manufacturers (Kevin Kitz, personal communication, October 1-4, 2004); these are described later. The remaining parameters in equation (2.16) were either known or measured, or estimated from the fluid characteristics. From the calculated value of the PI of a well and maximum allowable pressure drawdown, one can calculate, as a function of time, the maximum available production rate (w) given by:

$$w = (PI) \cdot (\Delta p), \quad (2.20)$$

The power required for pumping must be subtracted from the gross power available from the pumped well. The power required by a pump operating at the maximum allowable drawdown condition is given by:

$$\text{Pumping power} = (w.H/E_p + h_p.L)/E_m, \quad (2.21)$$

where H = total delivered head,

L = shaft horsepower loss per unit length,

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E_p = pump efficiency, and

E_m = motor efficiency.

In equation (2.21), H is given by:

$$H = (p_d - p_{\text{sat}} - p_{\text{gas}} - p_{\text{sm}})/G + h_p, \quad (2.22)$$

where p_d = pump discharge pressure.

The following parameters were specified by U.S. Geothermal, and have been used as such in this analysis:

- Casing ID = 8.75 inches (9-5/8 inch OD)
- $p_{\text{gas}} + p_{\text{suc}} + p_{\text{sm}} = 200$ feet of head (p_{gas} was determined as indicated in Section 4.3 and in footnotes to Tables 3.1 through 3.4)
- $L = 0$
- $E_p = 0.76$
- $E_m = 0.88$
- $p_d = 80$ psia for wells RRG-1, RRG-2 and RRG-5; 120 psia for RRG-3
- $h_p =$ no limit for RRG-1 and RRG-2; 1,165 feet for RRG-3; and 1,226 feet for RRG-5
- horsepower limit = 1,000 for submersible pumps and 1,500 for line-shaft pumps.

3. RESULTS OF FLOW AND PRESSURE BUILD-UP TESTS

This section presents the results of flow and pressure build-up tests conducted for each well; the results of fluid sampling and analysis are described in Section 4.

3.1 Initial Well Productivity

Based on the stabilized flow rate measured just prior to shut-in and the total pressure build-up following shut-in, the initial productivity index for each well was calculated using equation (2.13). The flow rate and pressure build-up data have been presented in Figures 1.1, 1.3, 1.5, 1.7 and 1.9 for RRG-1, RRG-2, RRG-3, RRG-4 and RRG-5, respectively. The estimates of initial PI were as follows:

<u>Well</u>	<u>Productivity Index (gpm/psi)</u>
RRG-1	3.2
RRG-2	2.6
RRG-3	3.3
RRG-4	0.3
RRG-5	2.9

The above table indicates that well RRG-4 has too low a PI to be considered commercial. The remaining 4 wells show eminently commercial and remarkably similar PI values. This observation implies that:

- (a) the Raft River field has commercially attractive flow capacity; and

- (b) there is little influence of any specific faults or local geologic control on well productivity, implying a relatively low risk in well siting.

3.2 Initial Power Capacity

Table 3.1 presents the values of the parameters used (on the first page) and estimated flow rate (gallons per minute), gross power capacity (MW) and net power capacity (MW) versus pump setting depth (feet), on the second page, for well RRG-1 at the initial condition. The calculation follows the methodology presented in Sections 2.1 and 2.5. Figure 3.1 shows the initial gross capacity and initial net capacity (after deducting the parasitic load for pumping) as a function of pump setting depth for well RRG-1. Similar tabular information for wells RRG-2, RRG-3 and RRG-5 are shown in Tables 3.2, 3.3 and 3.4, respectively. Figures 3.2, 3.3 and 3.4 present graphically the gross and net initial power capacities versus pump setting depth for wells RRG-2, RRG-3 and RRG-5, respectively. These calculations were not conducted for RRG-4 as this well was considered non-commercial.

The changes in well productivity with time and due to well interference can be calculated using the methodology presented in Sections 2.2 and 2.3; however, for this calculation one needs to estimate the reservoir flow capacity and skin factor for each well. This has been done from the analysis of the build-up test results (Figures 1.1 through 1.10) using the methodology presented in Section 2.4.

3.3 Analysis of Pressure Build-up Data

For each well the observed pressure build-up behavior was matched, by trial and error, to that calculated from equations (2.14), (2.9) and (2.15). The parameters varied in the trial-and-error matching process were: reservoir flow capacity, skin factor and wellbore storage. The goodness of the match was assessed from the ability to reach convergence and the calculated confidence intervals for the parameters.

Figures 3.5 shows the match between the measured and calculated pressure build-up behavior for RRG-1; this match was obtained for a reservoir flow capacity of 34,000 md-ft and a skin factor value of 2.2. Figure 3.6 shows the same match for RRG-1 but on a log-log plot; the quality of the match is better discerned on a log-log plot. Similarly, Figures 3.7 and 3.8, Figures 3.9 and 3.10, Figures 3.11 and 3.12, and Figures 3.13 and 3.14 show the pressure build-up data matches for wells RRG-2, RRG-3, RRG-4 and RRG-5, respectively.

Table 3.5 summarizes the relevant results obtained from the analysis of pressure build-up data for all wells. Table 3.5 also indicates the match quality, based on, the confidence interval achieved for the estimated parameters. Data from RRG-1 and RRG-4 allowed good matches and data from RRG-2 and RRG-3 allowed matches that are questionable, while the data from RRG-5 proved uninterpretable. However, it should be noted that for the wells with questionable or uninterpretable build-up behavior, one can still use the calculated initial PI values and normalize the information against those from wells RRG-1 and RRG-4, for which good matches were possible, to allow reasonable forecast of productivity decline with time and due to well interference. This exercise is present below.

3.4 Forecast of Power Capacity Decline

In estimating the effect of well interference on PI one has to estimate an effective reservoir-wide flow capacity, which is invariably higher than can be measured from short-term tests of single wells. Even if long-term interference testing involving multiple wells is conducted, the choice of a reservoir-wide flow capacity to be used for interference calculation can be rather subjective. For this analysis, we considered the flow capacity of RRG-1, which has the highest value among the 5 wells, to be a reasonable, if not conservative, estimate of the reservoir-wide flow capacity. In interference tests conducted at Raft River in the late 1970s and early 1980s, reservoir flow capacity values as high as 200,000 md-ft were reported; however, reliability of those old results cannot be assessed with any confidence. For any well other than RRG-1, a “pseudo” skin factor value was calculated assuming a reservoir flow capacity of 34,000 md-ft. The pseudo skin factor

was calculated such that the initial PI of the well (for a reservoir flow capacity of 34,000 md-ft) is the same as estimated in Section 3.1. These pseudo skin factor values are listed in Table 3.5.

Using an effective reservoir-wide flow capacity of 34,000 md-ft, a reservoir storage capacity of 0.01 ft/psi (as assumed in Section 2.3) and the pseudo skin factor values listed in Table 3.5, the decline in PI of each well with time, taking into account the interference between the wells, was calculated using the methodology presented in Section 2.3. Then using the methodology presented in Section 2.5 and the assumptions listed in Tables 3.1 through 3.4, the decline in net power capacity of each well as a function of pump setting depth and time could be calculated with due recognition to the interference effect between the wells.

Figure 3.15 presents the forecast of decline in the net power capacity of well RRG-1 as a function of both pump setting depth and time. Figures 3.16, 3.17 and 3.18 present the same type of forecast for wells RRG-2, RRG-3 and RRG-5, respectively.

3.5 Sustainable Plant Capacity

Given the specified horsepower limits (1,000 for electric submersible and 1,500 for line-shaft pumps) we calculate the following range of pump setting depths using the methodology of section 2.5:

<u>Well</u>	<u>Deepest Practical Setting Depth for Electric Submersible Pump (Ft)</u>	<u>Deepest Practical Setting Depth for Line-shaft Pump (Ft)</u>
RRG-1	1,570	1,500
RRG-2	1,650	1,500
RRG-3	1,165	1,165
RRG-5	1,226	1,226

For electrical submersible pumps the depth limit from the above table would be between 1,165 to 1,650 feet. For line-shaft pumps, for which US Geothermal has specified a maximum pump setting depth of 1,500 feet, the maximum practical pump setting depth would vary from 1,165 to 1,500 feet.

The above discussion shows that irrespective of pump technology to be used, pump setting depth for all practical purposes would range from 1,165 to 1,650 feet. Furthermore, electric submersible pumps would allow the deepest overall pump setting depths in the existing wells. Assuming the use of electrical submersible pumps, we estimate the initial MW capacity (after subtracting pump parasitic) as follows:

<u>Well</u>	<u>Pump Setting Depth (Ft)</u>	<u>Initial MW Capacity</u>
RRG-1	1,570	4.05
RRG-2	1,650	3.59
RRG-3	1,165	3.50
RRG-5	1,226	<u>2.63</u>

Total: 13.77

Therefore, an initial capacity of 13.77 MW (net) will be available at the plant inlet from the existing wells. Figure 3.23 shows the approximate calculated decline in this initial capacity with time over 20 years. Even assuming the need for as much as 20% of the capacity for plant auxiliaries and injection parasitic, the initial capacity should be sufficient to start a 10 MW (net) plant. Figure 3.23 indicates that a make-up well will be needed one to two years after plant start-up to maintain a 10 MW (net) capacity at the busbar.

It is estimated that 3 or 4 good injection wells will be required for a 10 MW (net) plant. The non-commercial producer RRG-4 was originally drilled as an injection well but was found to short-circuit fluids to RRG-1; therefore, this well cannot be used as is. It is likely that this well

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can be reworked as an injector or producer. The two shallow existing wells RRG-6 and RRG-7 can be deepened or “forked” and used as injectors. Therefore, at least one new injection well will have to be drilled for a 10 MW (net) project. The 3 existing potential injectors (RRG-4, RRG-6 and RRG-7) with appropriate reworking would be able to support about half of the 10 MW (net) capacity.

4. RESULTS OF FLUID SAMPLING AND ANALYSIS

4.1 Sample Collection, Analyses and Reporting

During each well test, water and steam samples were obtained from the flow line near the wellhead by use of a portable steam-water sampling separator provided by GeothermEx. The first well test was sampled by GeothermEx, with training provided to U.S. Geothermal staff. Subsequent tests were sampled by U.S. Geothermal. Sample containers and chemical analyses were provided by Thermochem, Inc., of Santa Rosa, CA. Each well was sampled twice, except for RRG-4, which was sampled once. Samples of water and gases were also collected for government-funded isotope analyses at Lawrence Berkeley Laboratory: the analyses of these are not yet complete (as of October 18, 2004).

Water samples were collected from the portable separator and split into three portions: (a) unfiltered and untreated (for anions and pH); (b) filtered (0.45 micron) and acidified (nitric acid) (for cations); and (c) filtered-diluted in 0.1 nitric acid (for silica). Steam samples were collected into evacuated containers that contained sodium hydroxide-cadmium chloride solution, which captures and preserves acidic gas components (CO_2 , H_2S) for wet chemical analysis and concentrates the non-reactive gas components for gas chromatographic analysis.

The steam fraction at steam-water sample separation conditions was calculated from the temperature in the portable separator and the enthalpy of total discharge at the wellhead, which was estimated from temperature logged downhole below the level of boiling (discounted by 1°C for wellbore cooling).

Results of the analyses have been reported by Thermochem and these data have been integrated into GeothermEx's database of Raft River fluids chemistry previously reported in a technical report on the resource to U.S. Cobalt in August 2002. The new water analyses are reproduced herein as table 4.1 parts 1 to 3, and aqueous geothermometer temperatures calculated from these

are reproduced as table 4.2. The new gas/steam data are reproduced as table 4.3, which also contains the small amount of previously available gas data.

4.2 Water Chemistry

The 2004 test water samples are in good agreement with chemical data obtained in the 1970s, confirming the presence in the reservoir of a sodium-chloride (Na-Cl) water which has lower salinity at wells along the range-front (Cl 650 – 875 mg/kg), and higher salinity at wells in the basin (Cl 2600 mg/kg at RRGE-3). At all wells, there is good agreement between measured downhole temperature and the silica (chalcedony) temperature, whereas higher cation (Na-K-Ca) temperatures suggest somewhat hotter conditions at greater depth.

The hottest well in terms of both measured downhole temperature and chemical geothermometry is the basin well RRGE-3: measured 144°C and Na-K-Ca 180-185°C. The range-front wells are only slightly cooler in spite of a lower salinity: measured 139-141°C and Na-K-Ca 174-180°C. By comparison, the version of the Na-K-Ca geothermometer being used herein has an uncertainty of about + or -20°C, although greater errors are possible.

4.3 Gas Chemistry

Gas data had not been obtained from well RRGE-3 prior to this flow test, and the better of the two samples collected shows gases in steam at 750 ppmw, and gases in total flow at 41 ppmw (gases in the other sample were slightly diluted by brine carry-over in the portable separator). Hydrogen sulfide was 4.4 ppmw in steam, and so less than 1 ppm in total flow. The gas composition is 44-51 vol.% nitrogen (N₂), and 48-52 vol.% carbon dioxide (CO₂), which is about as expected from a reservoir of this temperature and composition.

None of the steam samples from the other wells, at the range-front, contained gases above reported detection limits of 30 ppmw at wells RRGE-1, RRGE-2 and RRGP-5, and 107 ppmw at RRGP-4 (a high limit most-likely due to small sample size and air contamination). These

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detection limits are somewhat uncertain, because the samples generally contained some air contamination and additionally were probably contaminated by very roughly 10% to 25% brine-carryover from the portable separator (allowed by connection of the separator to a horizontal sampling port instead of a vertical one; a vertical port was used at RRGE-3). Carryover is estimated very approximately from the conductivity of the steam condensate measured before or after sample collection (details are in table 4.3).

Although brine contamination would dilute a steam sample and cause gases to be under-reported, it is improbable that the amount of brine contamination in any of the range-front steam samples was enough to mask a gas concentration anywhere close to the level measured at RRGE-3. The three steam samples obtained in the 1970s (one each from the BLM well, RRGE-1 and RRGE-2) showed gas/steam at 16 - 42 ppmw, so it is concluded that the range front wells have extremely low gas contents, probably about 30 - 40 ppmw in steam at about 5% steam fraction, or less than 2 ppmw in total flow, and perhaps as high as about 60 ppmw in steam.

4.4 Comments

The cause of the difference in chemistry between range front wells and basin wells remains incompletely understood, except that the range front wells may be producing fluids derived mostly on in part from basement rocks and/or diluted by recharge through mountains to the west, whereas the basin wells show the effects of fluids concentration within basin sediments.

Drilling and testing of wells in the one mile gap between RRGP-4 (range front chemistry) and RRGE-3 (basin chemistry) may provide data which will help explain the difference. It may be noted that samples obtained from RRGP-4 in the 1970s showed a range of Cl of 1370 to 2575 mg/kg, characteristic of the basin water type, or a mixture, whereas RRGP-4 has now produced Cl at 879 mg/kg (range front or slightly mixed water type). The RRGP-4 samples from the 1970s are not well-documented, and some may have been collected before the well was re-worked and casing deepened in November 1979. Others may have been affected by prior injection into the well (although an undated sample with 1630 mg/kg Cl was "assumed to be

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representative of aquifer water.”). In any case, the current chemistry of the well is consistent with the fact that only the very bottom 400 feet are open, and most or all of this interval is in basement rock.

5. CONCLUSIONS

1. Four of the five existing wells are usable as commercial production wells without the need for any major rework.
2. The non-commercial well, RRG-4, should be studied for re-drilling a directional leg toward a more productive zone, which would provide capital savings over drilling a new production well from surface.
3. The wells exhibit an artesian head of 140 psi, and produce a very low salinity water, and with a very low dissolved gas content, at temperatures of 272° to 300° F.
4. The four commercially productive wells have attractive productivity index values (in the range of 2.6 to 3.3 gpm/psi initially); well RRG-4 is non-commercial.
5. The similarity of the productivity index values of all four productive wells indicates the absence of any major control of faults or local geological conditions on well productivity; this reduces well siting risk.
6. The effective reservoir flow capacity is on the order of 34,000 millidarcy-feet and the effective skin factor values of the wells range from 1.9 to 4.7.
7. After one year of production, the net power capacity from the 4 wells (after subtracting the parasitic load of pumping) will be about 13 MW for a pump setting depth of 1,500 feet to 20 MW for a pump setting depth of 3,000 feet.
8. After 20 years of operation with fixed pump setting depths and without drilling make-up wells, net power capacity from the 4 wells (after subtracting the parasitic load for pumping) will vary from about 9.5 MW for a 1,500 feet pump setting depth to 14.5 MW for a 3,000 feet pump setting depth.

9. For existing wells RRG-1, RRG-2, RRG-3 and RRG-5, the maximum available setting depths for electric submersible pumps are 1,570 feet, 1,650 feet, 1,165 feet and 1,226 feet, respectively. With these pump setting depths, the initial MW capacity (after subtracting the pump parasitic) will amount to 13.8 MW. Assuming a 20% reduction in net capacity at the busbar (for plant auxiliaries and injection parasitic), a 10 MW (net) plant can be initially supported by the existing wells. However, a make-up production well will be required after one to two years of plant operation.
10. It is estimated that 3 or 4 good injection wells will be required for a 10 MW (net) plant. The non-commercial producer RRG-4 and two shallow existing wells RRG-6 and RRG-7 can be reworked, deepened and "forked" and used as injectors. Therefore, at least one new injection well will have to be drilled for a 10 MW (net) project. The 3 existing potential injectors (RRG-4, RRG-6 and RRG-7) would be able to support about half of the 10 MW (net) capacity.

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TABLES

Table 3.1. Pump Calculation for Well RRG-1

Input Parameters

Productivity index:	3.2	gpm/psi
Static pressure at production level:	1,650	psia
Depth to production level:	3,630	feet
Density of produced water:	57.77	lb/ft ³
Vapor pressure at temperature of produced water:	53.26	psia
Gas partial pressure*:	1.95	psi
Pump suction pressure:	68	psi
Pressure safety margin:	10	psi
Relative roughness:	0.0006	feet
Casing ID:	8.75	inches
Viscosity of produced water:	0.2	cp
Pump discharge pressure:	80	psia
Pump efficiency:	0.76	
Motor efficiency:	0.88	
Power loss per unit length of pump shaft:	0	hp/ft
Parasitic load factor:	0	
Temperature of produced water:	285	°F
Rejection temperature:	60	°F
Average specific heat of water between T and T0:	1	BTU/lb/°F
Utilization factor:	0.45	
Number of wells:	1	
Surface pipeline length:	0	feet
Surface pipeline ID:	0	inches
Increase in net elevation in pipeline run:	0	feet

*Maximum likely value, based on CO₂/stm = 10 mg/kg, N₂/stm = 35 mg/kg
 (actual gases in 2004 were "<DL of 30 ppm", but data from 1970s
 imply possibly 30-40 ppm, to maybe 60 ppm)

Table 3.1. Pump Calculation for Well RRG-1 (continued)

Results							
Depth (feet)	Drawdown (feet)	Flow Rate		Head (feet)	MW used	Gross MW	Net MW
(gpm)	(lb/hr)						
3,630	1,516.8	4,853.9	2,249,199	3,497.4	4.431	11.281	6.850
3,530	1,466.6	4,693.3	2,174,816	3,397.4	4.162	10.908	6.746
3,430	1,417.8	4,537.1	2,102,407	3,297.4	3.905	10.545	6.640
3,330	1,370.1	4,384.5	2,031,689	3,197.4	3.660	10.190	6.531
3,230	1,323.6	4,235.5	1,962,654	3,097.4	3.425	9.844	6.419
3,130	1,278.0	4,089.7	1,895,115	2,997.4	3.200	9.505	6.305
3,030	1,233.4	3,946.9	1,828,949	2,897.4	2.985	9.173	6.188
2,930	1,189.6	3,806.9	1,764,041	2,797.4	2.780	8.848	6.068
2,830	1,146.6	3,669.3	1,700,291	2,697.4	2.584	8.528	5.944
2,730	1,104.3	3,534.0	1,637,602	2,597.4	2.396	8.214	5.817
2,630	1,062.7	3,400.8	1,575,887	2,497.4	2.217	7.904	5.687
2,530	1,021.7	3,269.6	1,515,064	2,397.4	2.046	7.599	5.553
2,430	981.2	3,140.1	1,455,057	2,297.4	1.883	7.298	5.415
2,330	941.3	3,012.2	1,395,794	2,197.4	1.728	7.001	5.273
2,230	901.8	2,885.7	1,337,208	2,097.4	1.580	6.707	5.127
2,130	862.7	2,760.6	1,279,234	1,997.4	1.439	6.416	4.977
2,030	824.0	2,636.7	1,221,812	1,897.4	1.306	6.128	4.822
1,930	785.6	2,513.9	1,164,883	1,797.4	1.179	5.843	4.663
1,830	747.5	2,392.0	1,108,390	1,697.4	1.060	5.559	4.499
1,730	709.6	2,270.9	1,052,279	1,597.4	0.947	5.278	4.331
1,630	672.1	2,150.8	996,625	1,497.4	0.841	4.999	4.158
1,530	634.7	2,031.0	941,116	1,397.4	0.741	4.720	3.979
1,430	597.4	1,911.7	885,832	1,297.4	0.647	4.443	3.796
1,330	560.2	1,792.7	830,722	1,197.4	0.560	4.167	3.606
1,230	523.1	1,674.1	775,735	1,097.4	0.480	3.891	3.411
1,130	486.1	1,555.6	720,821	997.4	0.405	3.615	3.210
1,030	449.1	1,437.1	665,931	897.4	0.337	3.340	3.003
930	412.0	1,318.6	611,013	797.4	0.274	3.065	2.790
830	375.0	1,199.9	556,014	697.4	0.218	2.789	2.570
730	337.8	1,080.9	500,882	597.4	0.169	2.512	2.344
630	300.5	961.5	445,560	497.4	0.125	2.235	2.110
530	263.0	841.6	389,964	397.4	0.087	1.956	1.869
430	225.3	721.0	334,099	297.4	0.056	1.676	1.620
330	187.4	599.6	277,862	197.4	0.031	1.394	1.363
230	149.2	477.3	221,187	97.4	0.012	1.109	1.097
130	110.6	353.9	164,001	-2.6	0.000	0.823	0.823
30	71.6	229.2	106,229	-102.6	-0.006	0.533	0.539

Table 3.2. Pump Calculation for Well RRG-2

Input Parameters

Productivity index:	2.6	gpm/psi
Static pressure at production level:	1,900	psia
Depth to production level:	4,220	feet
Density of produced water:	57.67	lb/ft ³
Vapor pressure at temperature of produced water:	55.8	psia
Gas partial pressure*:	1.95	psi
Pump suction pressure:	68	psi
Pressure safety margin:	10	psi
Relative roughness:	0.0006	feet
Casing ID:	8.75	inches
Viscosity of produced water:	0.2	cp
Pump discharge pressure:	80	psia
Pump efficiency:	0.76	
Motor efficiency:	0.88	
Power loss per unit length of pump shaft:	0	hp/ft
Parasitic load factor:	0	
Temperature of produced water:	288	°F
Rejection temperature:	60	°F
Average specific heat of water between T and T0:	1	BTU/lb/°F
Utilization factor:	0.45	
Number of wells:	1	
Surface pipeline length:	0	feet
Surface pipeline ID:	0	inches
Increase in net elevation in pipeline run:	0	feet

*Maximum likely value, based on CO₂/stm = 10 mg/kg, N₂/stm = 35 mg/kg
 (actual gases in 2004 were "<DL of 30 ppm", but data from 1970s
 imply possibly 30-40 ppm, to maybe 60 ppm)

Table 3.2. Pump Calculation for Well RRG-2 (continued)

Results							
Depth (feet)	Drawdown (feet)	Flow Rate		Head (feet)	MW used	Gross MW	Net MW
		(gpm)	(lb/hr)				
4,220	1,764.3	4,587.2	2,121,942	4,080.8	4.878	10.898	6.019
4,120	1,715.1	4,459.5	2,062,882	3,980.8	4.626	10.594	5.968
4,020	1,667.1	4,334.5	2,005,036	3,880.8	4.383	10.297	5.914
3,920	1,619.9	4,211.8	1,948,319	3,780.8	4.150	10.006	5.856
3,820	1,573.5	4,091.3	1,892,562	3,680.8	3.924	9.720	5.795
3,720	1,528.0	3,973.0	1,837,827	3,580.8	3.707	9.438	5.731
3,620	1,483.3	3,856.6	1,783,995	3,480.8	3.498	9.162	5.664
3,520	1,439.2	3,742.1	1,731,003	3,380.8	3.297	8.890	5.593
3,420	1,395.8	3,629.2	1,678,796	3,280.8	3.103	8.622	5.519
3,320	1,353.0	3,517.9	1,627,319	3,180.8	2.916	8.357	5.441
3,220	1,310.8	3,408.1	1,576,522	3,080.8	2.736	8.097	5.360
3,120	1,269.1	3,299.7	1,526,358	2,980.8	2.563	7.839	5.276
3,020	1,227.8	3,192.5	1,476,784	2,880.8	2.397	7.584	5.188
2,920	1,187.1	3,086.5	1,427,756	2,780.8	2.237	7.332	5.096
2,820	1,146.7	2,981.6	1,379,236	2,680.8	2.083	7.083	5.000
2,720	1,106.8	2,877.7	1,331,184	2,580.8	1.935	6.837	4.901
2,620	1,067.2	2,774.8	1,283,566	2,480.8	1.794	6.592	4.798
2,520	1,027.9	2,672.7	1,236,346	2,380.8	1.658	6.349	4.691
2,420	989.0	2,571.4	1,189,490	2,280.8	1.528	6.109	4.580
2,320	950.3	2,470.8	1,142,968	2,180.8	1.404	5.870	4.466
2,220	911.9	2,370.9	1,096,746	2,080.8	1.286	5.633	4.347
2,120	873.7	2,271.6	1,050,796	1,980.8	1.173	5.397	4.224
2,020	835.7	2,172.8	1,005,088	1,880.8	1.065	5.162	4.097
1,920	797.8	2,074.4	959,592	1,780.8	0.963	4.928	3.965
1,820	760.2	1,976.5	914,281	1,680.8	0.866	4.695	3.830
1,720	722.6	1,878.9	869,125	1,580.8	0.774	4.464	3.690
1,620	685.2	1,781.5	824,099	1,480.8	0.687	4.232	3.545
1,520	647.8	1,684.4	779,173	1,380.8	0.606	4.002	3.395
1,420	610.5	1,587.4	734,320	1,280.8	0.530	3.771	3.241
1,320	573.3	1,490.6	689,514	1,180.8	0.459	3.541	3.082
1,220	536.0	1,393.8	644,725	1,080.8	0.393	3.311	2.919
1,120	498.8	1,296.9	599,926	980.8	0.331	3.081	2.750
1,020	461.5	1,200.0	555,089	880.8	0.275	2.851	2.575
920	424.2	1,102.9	510,185	780.8	0.224	2.620	2.396
820	386.8	1,005.6	465,184	680.8	0.178	2.389	2.211
720	349.2	908.1	420,056	580.8	0.137	2.157	2.020
620	311.6	810.2	374,769	480.8	0.102	1.925	1.823
520	273.8	711.9	329,291	380.8	0.071	1.691	1.620
420	235.8	613.1	283,588	280.8	0.045	1.456	1.412
320	197.6	513.7	237,626	180.8	0.024	1.220	1.196
220	159.1	413.7	191,365	80.8	0.009	0.983	0.974
120	120.4	313.0	144,770	-19.2	-0.002	0.743	0.745
20	81.3	211.4	97,797	-119.2	-0.007	0.502	0.509

Table 3.3. Pump Calculation for Well RRG-3

Input Parameters		
Productivity index:	3.3	gpm/psi
Static pressure at production level:	1,860	psia
Depth to production level:	4,230	feet
Density of produced water:	57.31	lb/ft ³
Vapor pressure at temperature of produced water:	67.01	psia
Gas partial pressure*:	14.65	psi
Pump suction pressure:	55	psi
Pressure safety margin:	10	psi
Relative roughness:	0.0006	feet
Casing ID:	8.75	inches
Viscosity of produced water:	0.2	cp
Pump discharge pressure:	120	psia
Pump efficiency:	0.76	
Motor efficiency:	0.88	
Power loss per unit length of pump shaft:	0	hp/ft
Parasitic load factor:	0	
Temperature of produced water:	300	°F
Rejection temperature:	60	°F
Average specific heat of water between T and T0:	1	BTU/lb/°F
Utilization factor:	0.45	
Number of wells:	1	
Surface pipeline length:	0	feet
Surface pipeline ID:	0	inches
Increase in net elevation in pipeline run:	0	feet

*Based on sample of 19 May 2004: 752 ppm gas/stm @ steam fraction 0.055

Table 3.3. Pump Calculation for Well RRG-3 (continued)

Results							
Depth (feet)	Drawdown (feet)	Flow Rate		Head (feet)	MW used	Gross MW	Net MW
(gpm)	(lb/hr)						
4,230	1,713.3	5,654.2	2,599,190	4,163.0	6.096	14.625	8.529
4,130	1,660.0	5,478.1	2,518,232	4,063.0	5.764	14.170	8.406
4,030	1,608.2	5,307.3	2,439,752	3,963.0	5.447	13.728	8.281
3,930	1,558.0	5,141.7	2,363,591	3,863.0	5.144	13.299	8.156
3,830	1,509.2	4,980.5	2,289,526	3,763.0	4.854	12.883	8.029
3,730	1,461.7	4,823.6	2,217,380	3,663.0	4.576	12.477	7.901
3,630	1,415.3	4,670.5	2,146,991	3,563.0	4.309	12.081	7.771
3,530	1,369.9	4,520.9	2,078,217	3,463.0	4.054	11.694	7.639
3,430	1,325.6	4,374.5	2,010,926	3,363.0	3.810	11.315	7.505
3,330	1,282.1	4,231.1	1,945,001	3,263.0	3.575	10.944	7.369
3,230	1,239.5	4,090.4	1,880,333	3,163.0	3.351	10.580	7.230
3,130	1,197.6	3,952.2	1,816,822	3,063.0	3.135	10.223	7.088
3,030	1,156.5	3,816.4	1,754,377	2,963.0	2.928	9.872	6.943
2,930	1,115.9	3,682.7	1,692,913	2,863.0	2.730	9.526	6.795
2,830	1,076.0	3,550.9	1,632,349	2,763.0	2.541	9.185	6.644
2,730	1,036.8	3,421.5	1,572,863	2,663.0	2.360	8.850	6.491
2,630	997.9	3,293.3	1,513,901	2,563.0	2.186	8.518	6.333
2,530	959.5	3,166.5	1,455,626	2,463.0	2.020	8.191	6.171
2,430	921.5	3,041.1	1,397,977	2,363.0	1.861	7.866	6.005
2,330	883.9	2,916.9	1,340,893	2,263.0	1.709	7.545	5.835
2,230	846.6	2,793.9	1,284,317	2,163.0	1.565	7.227	5.662
2,130	809.6	2,671.8	1,228,193	2,063.0	1.427	6.911	5.483
2,030	772.9	2,550.5	1,172,469	1,963.0	1.297	6.597	5.301
1,930	736.4	2,430.1	1,117,091	1,863.0	1.172	6.286	5.113
1,830	700.1	2,310.3	1,062,011	1,763.0	1.055	5.976	4.921
1,730	663.9	2,191.0	1,007,179	1,663.0	0.944	5.667	4.724
1,630	627.9	2,072.1	952,544	1,563.0	0.839	5.360	4.521
1,530	592.0	1,953.6	898,059	1,463.0	0.740	5.053	4.313
1,430	556.1	1,835.3	843,675	1,363.0	0.648	4.747	4.099
1,330	520.3	1,717.1	789,342	1,263.0	0.562	4.441	3.880
1,230	484.5	1,598.9	735,013	1,163.0	0.482	4.136	3.654
1,130	448.7	1,480.6	680,635	1,063.0	0.408	3.830	3.422
1,030	412.8	1,362.1	626,158	963.0	0.340	3.523	3.184
930	376.7	1,243.3	571,529	863.0	0.278	3.216	2.938
830	340.6	1,124.0	516,692	763.0	0.222	2.907	2.685
730	304.3	1,004.1	461,590	663.0	0.172	2.597	2.425
630	267.7	883.5	406,162	563.0	0.129	2.285	2.157
530	230.9	762.1	350,344	463.0	0.091	1.971	1.880
430	193.8	639.7	294,069	363.0	0.060	1.655	1.595
330	156.4	516.1	237,263	263.0	0.035	1.335	1.300
230	118.5	391.2	179,838	163.0	0.017	1.012	0.995
130	80.2	264.8	121,731	63.0	0.004	0.685	0.681
30	41.4	136.7	62,831	-37.0	-0.001	0.354	0.355

Table 3.4. Pump Calculation for Well RRG-5

Input Parameters		
Productivity index:	2.9	gpm/psi
Static pressure at production level:	1,560	psia
Depth to production level:	3,490	feet
Density of produced water:	58.16	lb/ft ³
Vapor pressure at temperature of produced water:	43.25	psia
Gas partial pressure*:	2.18	psi
Pump suction pressure:	67	psi
Pressure safety margin:	10	psi
Relative roughness:	0.0006	feet
Casing ID:	8.75	inches
Viscosity of produced water:	0.2	cp
Pump discharge pressure:	80	psia
Pump efficiency:	0.76	
Motor efficiency:	0.88	
Power loss per unit length of pump shaft:	0	hp/ft
Parasitic load factor:	0	
Temperature of produced water:	272	°F
Rejection temperature:	60	°F
Average specific heat of water between T and T0:	1	BTU/lb/°F
Utilization factor:	0.45	
Number of wells:	1	
Surface pipeline length:	0	feet
Surface pipeline ID:	0	inches
Increase in net elevation in pipeline run:	0	feet

*Maximum likely value, based on CO₂/stm = 10 mg/kg, N₂/stm = 35 mg/kg
 (actual gases in 2004 were "<DL of 30 ppm", but data from 1970s
 imply possibly 30-40 ppm, to maybe 60 ppm)

Table 3.4. Pump Calculation for Well RRG-5 (continued)

Results

Depth (feet)	Drawdown (feet)	Flow Rate		Head (feet)	MW used	Gross MW	Net MW
		(gpm)	(lb/hr)				
3,490	1,437.6	4,169.1	1,944,919	3,384.9	3.709	8.768	5.060
3,390	1,389.7	4,030.3	1,880,182	3,284.9	3.479	8.477	4.997
3,290	1,342.9	3,894.4	1,816,796	3,184.9	3.260	8.191	4.931
3,190	1,296.9	3,761.1	1,754,592	3,084.9	3.049	7.910	4.861
3,090	1,251.8	3,630.2	1,693,551	2,984.9	2.848	7.635	4.787
2,990	1,207.4	3,501.6	1,633,555	2,884.9	2.655	7.365	4.710
2,890	1,163.8	3,375.1	1,574,523	2,784.9	2.470	7.099	4.628
2,790	1,120.8	3,250.5	1,516,379	2,684.9	2.294	6.836	4.543
2,690	1,078.4	3,127.6	1,459,052	2,584.9	2.125	6.578	4.453
2,590	1,036.6	3,006.3	1,402,476	2,484.9	1.963	6.323	4.360
2,490	995.3	2,886.5	1,346,588	2,384.9	1.809	6.071	4.262
2,390	954.5	2,768.1	1,291,331	2,284.9	1.662	5.822	4.160
2,290	914.1	2,650.8	1,236,649	2,184.9	1.522	5.575	4.053
2,190	874.0	2,534.7	1,182,490	2,084.9	1.389	5.331	3.942
2,090	834.3	2,419.7	1,128,803	1,984.9	1.262	5.089	3.827
1,990	795.0	2,305.5	1,075,540	1,884.9	1.142	4.849	3.707
1,890	755.9	2,192.1	1,022,654	1,784.9	1.028	4.611	3.582
1,790	717.0	2,079.5	970,101	1,684.9	0.921	4.374	3.453
1,690	678.4	1,967.4	917,837	1,584.9	0.820	4.138	3.318
1,590	640.0	1,855.9	865,819	1,484.9	0.724	3.903	3.179
1,490	601.7	1,744.9	814,004	1,384.9	0.635	3.670	3.035
1,390	563.5	1,634.2	762,352	1,284.9	0.552	3.437	2.885
1,290	525.4	1,523.7	710,820	1,184.9	0.474	3.205	2.730
1,190	487.4	1,413.4	659,369	1,084.9	0.403	2.973	2.570
1,090	449.4	1,303.2	607,956	984.9	0.337	2.741	2.404
990	411.4	1,193.0	556,540	884.9	0.277	2.509	2.232
890	373.3	1,082.7	505,079	784.9	0.223	2.277	2.054
790	335.2	972.2	453,529	684.9	0.175	2.045	1.870
690	297.0	861.4	401,847	584.9	0.132	1.812	1.679
590	258.7	750.2	349,986	484.9	0.096	1.578	1.482
490	220.2	638.6	297,902	384.9	0.065	1.343	1.278
390	181.5	526.3	245,543	284.9	0.039	1.107	1.068
290	142.5	413.4	192,858	184.9	0.020	0.869	0.849
190	103.3	299.7	139,795	84.9	0.007	0.630	0.624
90	63.8	185.0	86,295	-15.1	-0.001	0.389	0.390

Table 3.5. Results of Pressure Build-up Data Analysis

<u>Well</u>	<u>Reservoir Flow Capacity (md-ft)</u>	<u>Skin Factor</u>	<u>Match Quality</u>	<u>Pseudo Skin Factor*</u>
RRG-1	34,000	2.2	Good	2.2
RRG-2	11,500	-5.1	Questionable	4.7
RRG-3	4,000	-7.3	Questionable	1.9
RRG-4	3,200	-3.5	Good	-
RRG-5	Uninterpretable			3.3

* Assuming a flow capacity of 34,000 md-ft.

Table 4.1. Chemical Analyses of Water Samples from Raft River Well Tests 2004 - part 1

mg/L-----(1)																			
ID. Name	Date	T°C	Flow gpm	pH	Ca	Mg	Na	K	TALK (HCO3)	SO4	Cl	F	SiO2	Li	Sum+ (meq)	Sum- (meq)	Sum+- (meq)	%Dif +-	Data Source (2)
264 RRGE-1	03-Jun-04	114			48.5	0.064	489.0	35.8	45.9	59.3	797.0	7.37	163.0	1.710	24.859	24.859	49.718	0.00	USGeo (2004a); Tchem 10951-7
265 RRGE-1	04-Jun-04	115			49.9	0.060	493.0	34.8	43.6	59.7	798.0	7.31	161.0	1.700	25.075	24.855	49.930	0.44	USGeo (2004a); Tchem 10951-8
262 RRGE-2	27-May-04	114			33.7	0.064	373.0	31.3	52.2	49.9	639.0	9.98	168.0	1.100	18.871	20.447	39.318	-4.01	USGeo (2004a); Tchem 10951-5
263 RRGE-2	28-May-04	114			36.5	0.052	429.0	33.2	47.1	51.1	674.0	9.61	171.0	1.150	21.502	21.356	42.858	0.34	USGeo (2004a); Tchem 10951-6
258 RRGE-3	18-May-04	119			224.0	0.345	1310.0	107.0	34.4	58.4	2560.0	4.74	178.0	3.260	71.397	74.247	145.644	-1.96	USGeo (2004a); Tchem 10951-2
259 RRGE-3	19-May-04	114			232.0	0.362	1380.0	102.0	30.5	67.8	2600.0	4.68	172.0	3.250	74.839	75.505	150.344	-0.44	USGeo (2004a); Tchem 10951-1
266 RRGP-4	18-Jun-04	104			63.7	0.661	522.0	40.4	46.5	80.1	879.0	6.94	161.0	1.830	27.237	27.593	54.829	-0.65	USGeo (2004a); Tchem 10951-9
260 RRGP-5	21-May-04	106			42.7	0.157	424.0	31.6	49.3	59.2	714.0	7.70	141.0	1.520	21.615	22.588	44.203	-2.20	USGeo (2004a); Tchem 10951-3
261 RRGP-5	22-May-04	105			40.3	0.146	444.0	31.9	47.8	68.6	721.0	7.62	148.0	1.580	22.405	22.953	45.358	-1.21	USGeo (2004a); Tchem 10951-4

Notes:

1) A negative sign on an mg/L value indicates less than (i.e. less than detection limit).

2) Citations in this part of table may be truncated. See complete citations and list of references in part 3.

Table 4.1. Chemical Analyses of Water Samples from Raft River Well Tests 2004 - part 2

ID. Name	Date	T°C	Map location	mg/L------(1)					Ec micro-S	Stable Isotopes ‰ (SMOW)		Data Source (2)
				Cl	Fe	B	As	Sr		dD	d18O	
264 RRGE-1	03-Jun-04	114		797		0.21						USGeo (2004a); Tchem 10951-7(Aug 9/04); Tchem 10960-5 (Aug 9/04)
265 RRGE-1	04-Jun-04	115		798		0.29						USGeo (2004a); Tchem 10951-8(Aug 9/04); Tchem 10960-6 (Aug 9/04)
262 RRGE-2	27-May-04	114		639		0.18						USGeo (2004a); Tchem 10951-5(Aug 9/04); Tchem 10960-3 (Aug 9/04)
263 RRGE-2	28-May-04	114		674		0.22						USGeo (2004a); Tchem 10951-6(Aug 9/04); Tchem 10960-4 (Aug 9/04)
258 RRGE-3	18-May-04	119	15S-26E-25bda1	2560		0.52						USGeo (2004a); Tchem 10951-2(Aug 9/04); Tchem 10960-1 (Aug 9/04)
259 RRGE-3	19-May-04	114	15S-26E-25bda1	2600	-0.31	0.49	0.01	5.47				USGeo (2004a); Tchem 10951-1(Aug 9/04); Tchem 10952-1 (Aug 9/04)
266 RRGP-4	18-Jun-04	104		879		0.33						USGeo (2004a); Tchem 10951-9(Aug 9/04); Tchem 10960-7 (Aug 9/04)
260 RRGP-5	21-May-04	106		714		0.20						USGeo (2004a); Tchem 10951-3(Aug 9/04); Tchem 10960-2 (Aug 9/04)
261 RRGP-5	22-May-04	105		721	-0.31	0.20	0.00	1.06				USGeo (2004a); Tchem 10951-4(Aug 9/04); Tchem 10952-2(Aug 9/04)

Notes:

- 1) A negative sign on an mg/L value indicates less than (i.e. less than detection limit).
- 2) Citations in this part of table may be truncated. See complete citations and list of references in part 3.

Table 4.1. Chemical Analyses of Water Samples from Raft River Well Tests 2004 - part 3

ID. Name	Date	T°C		Well Depths (ft)			Comments on Collection Conditions or Data	Comments on Methods or Data	Data Source - see References at end of table	Source I.D.#
		Down-hole	Stm Fr. ⁽¹⁾	Cl	Wtr	Open				
		Smpl	hole	(mg/L)	Lvl	Interval	Total			
264 RRG-1	03-Jun-04	114	138.5	0.044		797	ReT = flowing DHT at sample time (see production test data) Ht = f(ReT - 1°C)	MS @ horizontal (side) port on line 5'4" up from FCV, 3' 1" down from WH, at 1245 hrs; 236.2°F/113.4°C in ms. 500 ml Ru; 500 ml Fa(HNO3); 500 ml Fd (0.1N HNO3)	USGeo (2004a); Tchem 10951-7(Aug 9/04); Tchem 10960-3 (Aug 9/04)	
265 RRG-1	04-Jun-04	115	139.4	0.046		798	ReT = flowing DHT at sample time (see production test data) Ht = f(ReT - 1°C)	MS @ horizontal (side) port on line 5'4" up from FCV, 3' 1" down from WH, at 1300 hrs; 238.2°F/114.6°C in ms. 500 ml Ru; 500 ml Fa(HNO3); 500 ml Fd (0.1N HNO3)	USGeo (2004a); Tchem 10951-8(Aug 9/04); Tchem 10960-6 (Aug 9/04)	
262 RRG-2	27-May-04	114	139.7	0.047		639	WHP surging 11-15 (0-60 ga) ReT = flowing DHT at sample time (see production test data) Ht = f(ReT - 1°C)	MS @ horizontal (side) port on line 5'4" up from FCV, 3' 1" down from WH, at 1524 hrs; 236.6°F/113.7°C in ms. 500 ml Ru; 500 ml Fa(HNO3); 500 ml Fd (0.1N HNO3)	USGeo (2004a); Tchem 10951-5(Aug 9/04); Tchem 10960-3 (Aug 9/04)	
263 RRG-2	28-May-04	114	139.6	0.048		674	"Some very high pressure surges up to 18 psi (GEEx at WH or ms?). Flow dropping 1/4" every couple of hours." ReT = flowing DHT at sample time (see production test data) Ht = f(ReT - 1°C)	MS @ horizontal (side) port on line 5'4" up from FCV, 3' 1" down from WH, at 1550 hrs; 236.6°F/113.7°C in ms. 500 ml Ru; 500 ml Fa(HNO3); 500 ml Fd (0.1N HNO3)	USGeo (2004a); Tchem 10951-6(Aug 9/04); Tchem 10960-4 (Aug 9/04)	
258 RRG-3	18-May-04	119	144.3	0.048		2560	WHP surging 16-24 psig (0-60 gauge); WHPg is best estimate of average. ReT = flowing DHT at sample time (see production test data) Ht = f(ReT - 1°C)	Brine sample from ms on horizontal (side) port--1.5 m upst of FCV, --4 m from WH @ 1845 hrs; 245.9°F/118.8°C in ms. 500 ml Ru; 500 ml Fa(HNO3); 500 ml Fd (0.1N HNO3)	USGeo (2004a); Tchem 10951-2(Aug 9/04); Tchem 10960-1 (Aug 9/04)	

Table 4.1: Chemical analyses of water samples from Raft River well tests 2004 - part 3

ID. Name	Date	T°C-----			Well Depths (ft)-----			Comments on Collection Conditions or Data	Comments on Methods or Data	Data Source - see References at end of table	Source I.D.#
		Down- Smpl	Stm hole	Fr. ⁽¹⁾	Cl Wtr (mg/L)	Open Lvl	Interval Total				
259 RRGE-3	19-May-04	114	143.8	0.055	2600			WHP surging 9-12 psig at start of sample collection and 8-15 psig at end (0-60 gauge); WHPg is best estimate of average. "Temperature difference in ms at top and side ports (5°F) is not explained (ports/valves/ms inlet well-insulated)." Smplt is average at the two port locations. RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C)	Brine sample from ms on horizontal(side) port--1.5 m upstr of FCV, -4 m from WH @1130 hrs; 235°F/112.8°C in ms. 500 ml Ru; 500 ml Fa(HNO3); 500 ml Fd (0.1N HNO3)	USGeo (2004a); Tchem 10951-1(Aug 9/04); Tchem 10952-1 (Aug 9/04)	
266 RRGP-4	18-Jun-04	104	140.8	0.069	879			This well had to be restricted down to 5 five turns on FCV to get a constant flow for sampling. Only able to sample once on this well because of geyser effect. Lab report lists water sample date 20 June but R.Nye field report lists 18 June. RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C)	MS @ middle port on line 3' 2" from FCV, 9' 10" from well head, at 1435 hrs; 218.6°F/103.7°C in ms. 500 ml Ru; 500 ml Fa(HNO3); 500 ml Fd (0.1N HNO3)	USGeo (2004a); Tchem 10951-9(Aug 9/04); Tchem 10960-7 (Aug 9/04)	
260 RRGP-5	21-May-04	106	130.4	0.045	714			WHP surging 6.5-8.5 (0-60ga) RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C)	MS @ horizontal (side) port on line 5'4" up from FCV, 3' 1" down from WH, at 1200 hrs; 221.7°F/105.4°C in ms. 500 ml Ru; 500 ml Fa(HNO3); 500 ml Fd (0.1N HNO3)	USGeo (2004a); Tchem 10951-3(Aug 9/04); Tchem 10960-2 (Aug 9/04)	
261 RRGP-5	22-May-04	105	131.2	0.048	721			WHP surging 8-10 (0-60ga) RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C)	MS @ horizontal (side) port on line 5'4" up from FCV, 3' 1" down from WH, at 1600 hrs; 220.8°F/104.9°C in ms. 500 ml Ru; 500 ml Fa(HNO3); 500 ml Fd (0.1N HNO3)	USGeo (2004a); Tchem 10951-4(Aug 9/04); Tchem 10952-2(Aug 9/04)	

Table 4.1: Chemical analyses of water samples from Raft River well tests 2004 - part 3

ID. Name	Date	T°C-----		Well Depths (ft)-----				Comments on Collection Conditions or Data	Comments on Methods or Data	Data Source - see References at end of table	Source I.D.#
		Down- Smpl	Stm hole	Fr. ⁽¹⁾	Cl Wtr (mg/L)	Open Lvl	Interval	Total			

(1) Steam fraction at Sample temperature, calculated using total flow enthalpy

References (to entire Raft River chemistry database)

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Table 4.1: Chemical analyses of water samples from Raft River well tests 2004 - part 3

ID. Name	Date	T°C-----		Well Depths (ft)-----				Comments on Collection Conditions or Data	Comments on Methods or Data	Data Source - see References at end of table	Source I.D.#
		Down- Smpl	Stm hole	Fr. ⁽¹⁾ (mg/L)	CI Wtr Lvl	Open Interval	Total				
Parlman & Young (1992)		Parlman, D.J. and H.W. Young, 1992. Compilation of selected data for thermal-water wells and springs in Idaho, 1921 through 1991. U.S. Geological Survey Open-File Report 92-175. Boise, Idaho									
Ross (1970)		Ross, S.H., 1970. Geothermal Potential of Idaho. Idaho Bureau of Mines and Geology, Open-File Report, January 1970.									
Spencer & Callan (1980)		Spencer, S.G. and D.M. Callan, 1980. An analysis of the response of the Raft River monitor wells to the 1979 injection tests. EG&G Idaho, Idaho Falls. Report number EGG-2057, prepared for the U.S. Department of Energy, September 1980. 27 pages.									
Status Report (ND)		Status Report, ND. Status report, data compilation of chemical analysis of the Raft River geothermal monitor, culinary and irrigation wells. Photocopy of report. No author. No date. 9 pages including tables.									
Tchem #		Chemical analysis by Thermochem, Inc. of Santa Rosa, CA, with lab ID number and date.									
USGeo (2004a)		U.S.Geothermal, Inc. field sampling data and information (Randy Nye) as transcribed into Excel spreadsheets RRG-*.xls, dated 6/22 and 6/23/04.									
Young & Mitchell (1973)		Young, H.W. and J.C. Mitchell, 1973. Geothermal Investigations in Idaho, Part I, Geochemistry and Geologic Setting of Selected Thermal Waters. Idaho Department of Water Administration, Water Information Bulletin No.30. May 1973. 43 pages plus figures.									

Table 4.2. Aqueous Geothermometry of Samples from Raft River - Tests of 2004

ID. Name	Date	Flow gpm	T°C-----		Cl mg/l	Geothermometers, °C ⁽¹⁾										Na-K-Ca-Mg 4° - 340°		Na/K (F) >150°	K-Mg (Fg) 30° - 350°	Comments
			Down- hole	Smpl		Quartz 0° - 330°		Chalcedony 0° - 250°		Amor 0° - 250°	Na - K - Ca 4° - 340°			R- factor	Final Temp					
						Con.	Ad.	Con.	Ad.		SQ- CaNa	B= 4/3	B= 1/3			Final Temp				
264 RRGE-1	03-Jun-04		114	139	797	167	159	143	137	44	1.64	150	175	175	0	175	192	175	RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C)	
265 RRGE-1	04-Jun-04		115	139	798	166	158	142	136	43	1.65	148	173	173	0	173	189	175	RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C)	
262 RRGE-2	27-May-04		114	140	639	169	161	146	138	45	1.79	151	180	180	0	180	202	170	WHP surging 11-15 (0-60ga) RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C)	
263 RRGE-2	28-May-04		114	140	674	170	162	147	140	46	1.62	153	178	178	0	178	196	176	"Some very high pressure surges up to 18 psi (GEX: at WH or ms?). Flow dropping 1/4" every couple of hours." RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C)	
258 RRGE-3	18-May-04		119	144	2560	173	164	150	142	49	1.31	170	185	185	0	185	200	185	WHP surging 16-24 psig (0-60 gauge); WHPg is best estimate of average. RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C)	
259 RRGE-3	19-May-04		114	144	2600	170	162	147	140	47	1.27	167	180	180	0	180	192	182	WHP surging 9-12 psig at start of sample collection and 8-15 psig at end (0-60 gauge); WHPg is best estimate of average. "Temperature difference in ms at top and side ports (5°F) is not explained (ports/valves/ms inlet well-insulated)." Smpl is average at the two port locations. RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C)	
266 RRGP-4	18-Jun-04		104	141	879	166	158	142	136	43	1.76	148	176	176	1	176	196	139	This well had to be restricted down to 5 five turns on FCV to get a constant flow for sampling. Only able to sample once on this well because of geyser effect. Lab report lists water sample date 20 June but R.Nye field report lists 18 June. RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C)	
260 RRGP-5	21-May-04		106	130	714	158	151	133	128	35	1.77	146	174	174	0	174	193	155	WHP surging 6.5-8.5 (0-60ga) RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C)	
261 RRGP-5	22-May-04		105	131	721	161	154	136	131	38	1.64	149	174	174	0	174	190	156	WHP surging 8-10 (0-60ga) RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C)	

(1) See references at end of table

Table 4.2 : Aqueous geothermometry of samples from Raft River - tests of 2004

GeothermEx, Inc. - Pg. 1 of 2

Table 4.2 : Aqueous geothermometry of samples from Raft River - tests of 2004

ID. Name	Date	Geothermometers, °C ⁽¹⁾																	Comments	
		T°C-----		Flow gpm	Down- hole	Cl mg/l	Quartz 0° - 330°		Chalcedony 0° - 250°		Amor 0° - 250°	Na - K - Ca 4° - 340°				Na-K-Ca-Mg 4° - 340°		Na/K (F) >150°		K-Mg (Fg) 30° - 350°
		Con.	Ad.				Con.	Ad.	SQ- CaNa	B= 4/3		B= 1/3	Final Temp	R- factor	Final Temp					

References:

1) Henley, R.W., Truesdell, A.H., Barton, P.B.Jr., 1984, Fluid-Mineral Equilibria in Hydrothermal Systems. Reviews in Economic Geology, Vol.1. Society of Economic Geologists. The Economic Geology Publishing Company, El Paso Texas USA.

Quartz: quartz geothermometer of Fournier and Potter
Con. = conductive
Ad. = adiabatic, for waters boiling at 100°C

Chalcedony: chalcedony geothermometer of Fournier
Con. = conductive
Ad. = adiabatic, for waters boiling at 100°C

Amor (amorphous silica): amorphous silica geothermometer of Fournier

Na-K-Ca: Na-K-Ca geothermometer of Fournier and Truesdell
SQ-CaNa = factor square root(Ca)/Na
B13 = temperature for factor B = 4/3
B43 = temperature for factor B = 1/3
Final Temperature = B43 or B13, according to rules for B and SQ-CaNa

Na-K-Ca-Mg: Na-K-Ca-Mg geothermometer of Fournier and Truesdell
Factor R (Mg, K, Ca) = relative concentration of Mg, the applicable range is 5 - 50.
Final Temperature = final result, according to rules for application of Factor R.

Na-K (F): Na/K geothermometer of Fournier

2) Fournier, R.O., 1990, The interpretation of Na-K-Mg relations in geothermal waters. Geothermal Resources Council Transactions, vol.14, part II, pp. 1421 - 1425. August 1990.

K-Mg (Fg): K-Mg geothermometer of Fournier (equations corrected by GeothermEx)

(1) See references at end of table

Table 4.3. Raft River - Analyses of Gases in Steam ⁽¹⁾⁽²⁾

Name	Date Time	WHP psig	Smpl T°C	Ht J/gm Stm Fr	Gas/steam m/1000m ppmw	Smpl % air	H2S ppmw	Dry Gas vol. %									Data Source(s)	Well status	Sampling methods				
								CO2	H2S	NH3	Ar	N2	CH4	H2	O2	Sum	Comments on data						
BLM					0.010 16	1.9		1.187				1.250	96.692		0.871	0.000	100.0	Allen (1977)-Appendix; depth from Overton et al (1979), Campbell et al (1981)			No date; hot well; Allen (1977) describes depth as less than 500 ft; Overton et al (1979) lists same chemistry as Allen (1977) and shows a map with depth 1500 m (4922 ft). Cambell et al (1981) shows a map with well depth 4924 ft but no chemistry.	air-correction by GeothermEx	gases converted from standard cc/L (conversion factor 1/(22.414*55.56))
RRGE-1					0.027 42	1.9		5.852				1.484	92.266		0.306	0.000	100.0	Allen (1977)-Tbl 4 and Appendix; Status Report (ND)Kunze & Turner (1979)(completion and T data)			Averaged data; csd to 3625 ft.; completed March 1975; 296°F/146.7°C at 4632 ft.	air-correction by GeothermEx	gases converted from standard cc/L (conversion factor 1/(22.414*55.56))
RRGE-1	03-Jun-04 13:00	18	114.4°	578 0.044	-30													USGeo (2004a); Tchem 10951-7(Aug 9/04); Tchem 10960-5 (Aug 9/04)			RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C) MS @ horizontal (side) port on line 5'4" up from FCV, 3' 1" down from WH, at 1330 hrs; 239.6°F/115.3°C in ms. Condensate Ec 450 micromho, brine contamination probable. Lab report: 391 gm of condensate in sample, 0.87 STP ml of air, headspace at <0.50 psiaSTP.		
RRGE-1	04-Jun-04 13:45	18	114.7°	582 0.046	-29													USGeo (2004a); Tchem 10951-8(Aug 9/04); Tchem 10960-6 (Aug 9/04)			RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C) MS @ horizontal (side) port on line 5'4" up from FCV, 3' 1" down from WH, at 1350 hrs; 238.4°F/114.7°C in ms.		

Table 4.3: Raft River - analyses of gases in steam ⁽¹⁾⁽²⁾

Name	Date	WHP psig	Smpl T°C	Ht J/gm Stm Fr	Gas/steam m/1000m ppmw	H2S % air ppmw	Dry Gas vol. %										Data Source(s)	Well status	Sampling methods
							CO2	H2S	NH3	Ar	N2	CH4	H2	O2	Sum	Comments on data			
RRGE-2					0.028 25	6.1	5.095				1.708	89.767		3.380	0.000	100.0	Condensate Ec 600 micromho, brine contamination probable. Lab report: 451 gm of condensate in sample, 0.94 STP ml of air, headspace at <0.50 psiaSTP.		
																	Allen (1977)-Tbl 4 and Appendix; Status Report (ND); Kunze and Turner (1979)(completion & T data)		
																	Averaged data; completed 1975, bulk of production appears to be from above 5200 ft (Kunze & Turner), "major production" 290°F/143.3°C from 4227-c4800ft, "minor production" c5000-5200 ft.; 298°F/147.8°C at TD		
																	air-correction by GeothermEx		
																	gases converted from standard cc/L (conversion factor 1/(22.414*55.56)); apparent error in tabulation - reported total NCGmkm is >> sum of components		
RRGE-2dpm	27-May-04	13	114.2°	584													USGeo (2004a); Tchem 10951-5(Aug 9/04); Tchem 10960-3 (Aug 9/04)		
	15:45			0.047	-30												WHP surging 11-15 (0-60ga) RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C)		
																	MS @ horizontal (side) port on line 5'4" up from FCV, 3' 1" down from WH, at 1600 hrs; 238.4°F/114.7°C in ms.		
																	Condensate Ec 450 micromho, brine contamination probable. Lab report: 418 gm of condensate in sample, 0.53 STP ml of air, headspace at <0.50 psiaSTP.		
RRGE-2dpm	28-May-04	11	113.7°	583													USGeo (2004a); Tchem 10951-6(Aug 9/04); Tchem 10960-4 (Aug 9/04)		
	16:15			0.048	-30												"Some very high pressure surges up to 18 psi (GEx: at WH or ms?). Flow dropping 1/4" every couple of hours." RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C)		
																	MS @ horizontal (side) port on line 5'4" up from FCV, 3' 1" down from WH, at 1630 hrs; 236.6°F/113.7°C in ms.		
																	Condensate Ec 300 micromho, brine contamination probable. Lab report: 375 gm of condensate in sample, 0.47		

Table 4.3: Raft River - analyses of gases in steam ⁽¹⁾⁽²⁾

Name	Date	WHP psig	Smpl T°C	Ht J/gm Stm Fr	Gas/steam m/1000m ppmw	H2S % air ppmw	Dry Gas vol. %									Sum	Data Source(s)
							CO2	H2S	NH3	Ar	N2	CH4	H2	O2	Well status		
															Sampling methods		
	Time																Comments on data
																	STP ml of air, headspace at <0.50 psiaSTP.
RRGE-3rw	18-May-04	20	118.5°	603	0.298	2.7	4.13	47.800	0.733	-1.600	1.090	50.800	0.229	0.870	0.000	101.5	USGeo (2004a); Tchem 10951-2(Aug 9/04); Tchem 10960-1 (Aug 9/04)
	19:00			0.048	590												WHP surging 16-24 psig (0-60 gauge); WHPg is best estimate of average. RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C) Steam sample from ms on vertical (top) port -1.5 m upstr of FCV, -4 m from WH @1930hrs; 244.7°F/118.2°C Could not avoid surges of brine into steam (condensate Ec >600 micromho). Brine contamination probable. Lab report: 384 gm condensate in sample, headspace at 6.53 psiaSTP
RRGE-3rw	19-May-04	12	114.1°	601	0.376	20.5	4.43	51.500	0.623	1.380	1.020	44.300	0.221	0.940	0.000	100.0	USGeo (2004a); Tchem 10951-1(Aug 9/04); Tchem 10952-1 (Aug 9/04)
	11:00			0.055	751												WHP surging 9-12 psig at start of sample collection and 8-15 psig at end (0-60 gauge); WHPg is best estimate of average. "Temperature difference in ms at top and side ports (5°F) is not explained (ports/valves/ms inlet well-insulated)." Smplt is average at the two port locations. RefT = flowing DHT at sample time (see production test data) Ht = f(RefT - 1°C) Steam sample from ms on vertical (top) port -1.5 m upstr of FCV, -4 m from WH @1040hrs; 240°F/115.5°C Condensate Ec 30 micromho (no brine contamination indicated) "Sample is more yellow then yesterday. Closed flask when no longer being sucked in. About 60 to 70% full with liquid." Lab reports 337 gm condensate in sample, headspace at 7.64 psiaSTP.
RRGP-4rw	18-Jun-04	4	103.6°	588													USGeo (2004a); Tchem 10951-9(Aug 9/04); Tchem 10960-7 (Aug 9/04)
	14:40			0.069	-107												

Table 4.3: Raft River - analyses of gases in steam ⁽¹⁾⁽²⁾

Name	Date	WHP psig	Smpl T°C	Ht J/gm Stm Fr	Gas/steam m/1000m ppmw	Smpl % air	H2S ppmw	Dry Gas vol.%								Sum	Data Source(s)	Well status	Sampling methods	Comments on data																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
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RRGP-5rw	21-May-04 12:30	8	105.6°	544 0.045	-30																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						</

Table 4.3: Raft River - analyses of gases in steam ⁽¹⁾⁽²⁾

Name	Date	WHP	Smpl	Ht		Gas/steam		Dry Gas vol. %										Data Source(s)
				J/gm		m/1000m												Well status
				Stm	Fr	ppmw	Smpl	H2S	CO2	H2S	NH3	Ar	N2	CH4	H2	O2	Sum	Sampling methods
	Time	psig	T°C				% air	ppmw										Comments on data
																		probable. Lab report: 413 gm of condensate in sample, 0.67 STP ml of air, headspace at <0.50 psiaSTP

(1) After calculated removal of air contamination on the basis of measured oxygen concentration

(2) Negative numbers indicate values less than (e.g. -30 indicates <30)

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FIGURES

Figure 1.1 Production Rate and Pressure Data - Well RRG-1

Figure 1.2 Production Rate and Temperature Data - Well RRG-1

Figure 1.3 Production Rate and Pressure Data - Well RRG-2

Figure 1.4 Production Rate and Temperature Data - Well RRG-2

Figure 1.5 Production Rate and Pressure Data - Well RRG-3

Figure 1.6 Production Rate and Temperature Data - Well RRG-3

Figure 1.7 Production Rate and Pressure Data - Well RRG-4

Figure 1.8 Production Rate and Temperature Data - Well RRG-4

Figure 1.9 Production Rate and Pressure Data - Well RRG-5

Figure 1.10 Production Rate and Temperature Data - Well RRG-5

Figure 1.11: Downhole Summary Plot - Raft River Well RRG-1

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10-19-2004 T750202.PLT

Figure 1.11A: Explanation for Downhole Summary Plots

Figure 1.12: Downhole Summary Plot - Raft River Well RRG-2

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10-19-2004 F.T750512.PLT

Figure 1.13: Downhole Summary Plot - Raft River Well RRG-3

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10-19-2004 T760522.PLT

Figure 1.14: Downhole Summary Plot - Raft River Well RRG-4

GeothermEx, Inc.

10-19-2004 T781113A.PLT

Figure 1.15: Downhole Summary Plot - Raft River Well RRG-5

GeothermEx, Inc.

10-19-2004 T780914.PLT

Figure 1.16 Static Pressure vs. Depth of Production Level of Wells

Figure 2.1 Calculated Fluid Requirement vs Resource Temperature

Figure 3.1: Well RRG-1 - Power Capacity vs. Pump Setting Depth

Figure 3.2: Well RRG-2 - Power Capacity vs. Pump Setting Depth

Figure 3.3: Well RRG-3 - Power Capacity vs. Pump Setting Depth

Figure 3.4. Well RRG-5 - Power Capacity vs. Pump Setting Depth

Figure 3.5: Pressure Build-up Data Match (Cartesian coordinates)
Well RRG-1

Figure 3.6: Pressure Build-up Data Match (Log-log plot)
Well RRG-1

Figure 3.7: Pressure Build-up Data Match (Cartesian coordinates)
Well RRG-2

Figure 3.8: Pressure Build-up Data Match (Log-log plot)
Well RRG-2

Figure 3.9: Pressure Build-up Data Match (Cartesian coordinates)
Well RRG-3

Figure 3.10: Pressure Build-up Data Match (Log-log plot)
Well RRG-3

Figure 3.11: Pressure Build-up Data Match (Cartesian coordinates)
Well RRG-4

Figure 3.12: Pressure Build-up Data Match (Log-log plot)
Well RRG-4

Figure 3.13: Pressure Build-up Data Match (Cartesian coordinates)
Well RRG-5

Figure 3.14: Pressure Build-up Data Match (Log-log plot)
Well RRG-5

Figure 3.15: Well RRG-1 - Flow Rate vs. Pump Setting Depth

Figure 3.16: Well RRG-1 - Net Power Capacity vs. Pump Setting Depth

Figure 3.17: Well RRG-2 - Flow Rate vs. Pump Setting Depth

Figure 3.18: Well RRG-2 - Net Power Capacity vs. Pump Setting Depth

Figure 3.19: Well RRG-3 - Flow Rate vs. Pump Setting Depth

Figure 3.20: Well RRG-3 - Net Power Capacity vs. Pump Setting Depth

Figure 3.21: Well RRG-5 - Flow Rate vs. Pump Setting Depth

Figure 3.22: Well RRG-5 - Net Power Capacity vs. Pump Setting Depth

Figure 3.23 Capacity Available from Existing Wells vs Time

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**RESULTS FROM THE SHORT-TERM WELL TESTING
PROGRAM AT THE RAFT RIVER GEOTHERMAL
FIELD, CASSIA COUNTY, IDAHO**

for

**US Geothermal, Inc.
Boise, Idaho**

by

**GeothermEx, Inc.
Richmond, California**

OCTOBER 2004

RRG-4 FLOW AND PRESSURE BUILD-UP TEST

RRG-4 Flow and Pressure Buildup Test

Introduction and Summary

A 75.5 hour flow test of RRG-4 followed by a 138-hour pressure buildup was conducted March 14 to 23, 2006. Wells RRG-1, RRG-2, RRG-5, and RRG-11 were instrumented for pressure interference measurement during the flow test. The memo presents the pressure transient results of the flow test and the four pressure observation wells.

Flow Test Results

The rate history is presented below in Figure 1. The well flow rate was restricted to 1800 gpm due to surface equipment limitations. The flow duration was 75.75 hours with an average flowrate of 1,681 gpm and a cumulative production of 7,614,400 gallons.

Figure 1 – RRG-4 flow rate history, March 14 to 17, 2007.

Pressure Drawdown

The pressure/temperature tool was set at 4,500 ft MD for the first part of the test and then reset at 2,850 ft MD for the duration of the flow test. The pressure data was adjusted for a datum at 4,500 ft from the change in tool setting depth for the transient analysis. A flowing traverse of the well was made using the pressure/temperature tool to measure the flowing well temperatures for determination of the stagnation enthalpy for flow rate and flash calculations. The flowing temperature was from 278.2°F to 279.6°F.

The pressure drawdown and buildup response was analyzed using a homogenous radial flow model and a finite conductivity fracture in a dual porosity system. The pressure buildup data clearly shows the presence of a constant pressure boundary with the pressure derivative declining after about four hours into the test. The results are summarized below and the Saphir program output is in Appendix A.

Homogeneous flow model

$kh = 77,000$ mD-ft
 $skin = -3.53$
 $C = 0.00299$ bbl/psi
 $L = 15,000$ ft to constant pressure fault

The homogeneous flow model analysis was conducted to determine if infinite acting radial flow behavior was present. The pressure transient response is poorly characterized by this flow model so another flow model was used.

Finite conductivity, dual porosity flow model

$kh = 63,950$ mD-ft
 $\Omega = 1E-4$
 $\Lambda = 2.96E-7$
 $C = 2.9E-4$ bbl/psi
 $X_f = 50$ ft
 $F_c = 13,950$ md-ft
 $L = 2,200$ ft to a constant pressure fault

The finite conductivity, dual porosity flow model is consistent with the general geologic model and is considered to be the preferred analysis.

Pressure Buildup

As in the pressure drawdown test, the pressure/temperature tool was set at 2,850 ft MD. The pressure buildup response was again analyzed using a homogenous radial flow model and a finite conductivity fracture and a dual porosity system. The pressure data clearly shows the presence of a constant pressure boundary distant from the well with the pressure derivative declining after about four hours into the pressure buildup.

Homogeneous flow model

$kh = 92,850$ mD-ft
 $skin = -5.78$
 $C = 2.13E-4$ bbl/psi
 $L = 3,690$ ft to constant pressure fault

Finite conductivity, dual porosity flow model

$kh = 95,550$ mD-ft
 $\Omega = 0.00265$
 $\Lambda = 1.7E-5$
 $C = 3.35E-5$ bbl/psi
 $X_f = 5$ ft
 $F_c = 1,390$ md-ft
 $L = 1,130$ ft to a constant pressure fault

Discussion

The finite conductivity dual porosity flow regime is preferred from geologic considerations. Leg C is targeted into the Bridge fault zone and intersected zones of lost circulation during drilling. A

comparison of the pressure drawdown and pressure buildup pressure transient results using the finite conductivity, dual porosity model are in very good agreement and indicate a reservoir kh of about 95,000 mD-ft from the pressure buildup test. RRG-4, leg C is completed into a fracture system with a fracture permeability of 1,390 mD-ft and a very short apparent fracture half-length of about 5 ft. A constant pressure feature is noted about 1130 ft away from the well. The productivity index from the pressure buildup is estimated at 12.38 gpm/psi. A comparison of the finite conductivity model results with the measured data is presented in Figure 2.

Figure 2 – Comparison of measured and finite conductivity analytic model results from buildup.

RRG-4 Temperature Surveys

Two temperature surveys were taken during the test program, the March 13th survey before the start of the flow and the second survey on March 21 at the completion of the pressure buildup test. These two surveys are presented below in Figure 2.

Figure 2 – Temperature surveys in RRG-4.

The initial survey shows some character in profile and is generally correlative with the Salt Lake formation. The static surveys before and after the test with temperature converge at approximately 4700 feet, probably the primary feed in the Bridge fault zone. During the production test, the stabilized measured temperature was $\sim 278.0^{\circ}\text{F}$, set at 2,850 ft MD.

Pressure Interference Results

Pressure interference was measured in RRG-1, RRG-2, RRG-5, and RRG-11 in response to RRG-4, the active well. The estimate of interwell distances from the active well, RRG-4, is somewhat problematic due to the multiple legs in each well, the active portion of the reservoir exposed in the wellbore, and such. However, for this exercise, the interwell distances are estimated from a map view and the approximate centroid of the well legs. The observation pressures were measured for approximately 210 hours, Figure 3, with three wells clear showing pressure response to both the start and termination of production in RRG-4. In general, RRG-1, RRG-2, and RRG-5 showed clear and rapid response to the start and termination of production in RRG-4. This is consistent with all three wells completion in the Bridge fault zone, a high permeability and low storage structural feature. Pressure tool response in RRG-11 exhibited fairly rapid pressure response to the start of the flow test, but no response to the shut-in of RRG-4, raising questions as to tool reliability during the testing program. The pressure fall-off analysis is presented for completeness, however, the results are suspect.

The interference data was analyzed using a homogeneous or line source solution for flow in a radial system and a line source in a finite conductivity fractured media. Both solutions provide information on the interwell reservoir properties between the flowing well and the observation

wells. The interference test results are consistent with RRG-4 sharing the same high permeability (structural) feature as RRG-1, RRG-2, and RRG-5 in the presence of a constant pressure boundary located several thousand of feet away. RRG-1, the closest well to RRG-4 exhibited clear and rapid response to rate changes in RRG-4 and had achieved almost full pressure recovery at the end of the 135 hour pressure buildup period suggesting closer proximity to a fault upflow zone than the other two wells.

Figure 3 – Interference pressures in RRG-1, RRG-2, RRG-5, and RRG-11 due to RRG-4.

Table 1. Observation well interference pressure response to active well RRG-4.

	Estimated distance to RRG-4, ft	Datum, ft, MD	Pressure at datum, psi	First interference time, hours	Maximum pressure change, psi	Comments
RRG-1	1,570	3,450	1,567.442	0.0639	-44.92	
RRG-2	6,000	5,000	2,185.220	1.652	-10.64	
RRG-5	2,360	4,780	2,034.861	0.4000	-17.50	
RRG-11	6,000	0	51.675	0.3000	-7.54	No response to RRG-4 shut-in

Table 2. Interference pressure transient results.

	RRG-1	RRG-2	RRG-5	RRG-11
Homogeneous Flow Model	Pressure drawdown flow period			
p_i , psi	1567.51	2185.28	2034.86	51.675
kh, mD-ft	133,960	202,190	201,680	102,700
ϕh , ft	2.82	21.7	25.1	51.4
L , ft	3.75E+5	28,400	502,000	25,000
Boundary condition	Constant pressure	Constant pressure	Constant pressure	Constant pressure
Two Porosity Slab Model	Pressure drawdown flow period			
kh	120,600	136,070	183,990	98,060

ϕh , ft	10.8	29.4	29.1	221
Lambda	0.00217	2.55E-8	1.84E-4	1.33E-14
Omega	0.00447	0.0477	0.689	0.196
L, ft	995,000	94,700	281,000	35,200
Homogeneous Flow Model				
	Pressure buildup flow period			
p_i , psi	1563.9	2184.12	2031.2	n/a
kh, mD-ft	296,760	373,240	140,510	n/a
ϕh , ft	3.79	28.4	31.8	n/a
L, ft	183	5000	3650	n/a
Boundary condition	Constant pressure	No flow	Constant pressure	Constant pressure
Two Porosity Slab Model				
	Pressure buildup flow period			
kh	64,550	136,070	161,640	n/a
ϕh , ft	5.74	31.3	31.6	n/a
Lambda	3.68E-5	2.55E-8	5.4E-5	n/a
Omega	0.00171	0.0477	0.0392	n/a
L, ft	3,750	94,700	4,540	n/a

The Saphir plots and analysis are attached in Appendix A.

Discussion of Test Results

The interference results for RRG-11 are presented for completeness, though there is concern the pressure tool had drift and was not responding to the pressure transient. The interference results will address only wells RRG-1, RRG-2, and RRG-5. These three wells are completed in the Bridge fault zone show fault conductivities of ranging from 64,000 to 184,000 md-ft. The interference storage indicates fault porosity of 1 to 3% consistent with fault porosities. RRG-1, RRG-2, and RRG-5 all used a constant pressure boundary from 3700 to 4500 ft distant with the finite conductivity analysis.

Temperature Surveys of Observation Wells

Figure 4 – RRG-1 temperature surveys.

Figure 5 – RRG-2 temperature surveys.

Figure 6 – RRG-5 temperature surveys.

Discussion of Observation Well Temperature Surveys

The temperature survey of RRG-1 is rather blocky, as the tool had some temperature lag. The tool stops during surveying the well are very noticeable. The surveys exhibit very poor repeatability. The temperature survey of RRG-2 has much better tool response but some temperature drift during the March 13th survey. Below 4,000 ft MD there is very good agreement between the three temperature surveys. RRG-5 temperature surveys are in very good agreement with the March 16 survey going into the well exhibiting some anomalous behavior from about 1,200 to 2,000 ft MD.

D.D. Faulder, P.E.
SAIC
April 11, 2007

Appendix A – Saphir

RRG-4 pressure transient results

Interference results for:

RRG-1

RRG-2

RRG-5

RRG-11

History plot

DD homogeneous

Company US Geothermal
Well Observation well RRG-1Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure production #1

Rate 59310 STB/D
Rate change 59310 STB/D
P@dt=0 1567.44 psia
PI 1567.51 psia
Smoothing 0.5
Prod. Index 38.9252 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters

TMatch 3.75 [hr]⁻¹
PMatch 0.074 [psia]⁻¹
Phi 0.00282
Phi.h 2.82 ft
k.h, total 1.3396E+5 md.ft
k, average 133.96 md
PI 1567.51 psia
Well distance 1570 ft

Model Parameters

Reservoir & Boundary parameters
PI 1567.51 psia
k.h 1.3396E+5 md.ft
k 133.96 md
Phi 0.00282
Phi.h 2.82 ft
L - Constant P. 3.75E+5 ft

Derived & Secondary Parameters

Log-Log plot

DD homogeneous

Company US Geothermal
Well Observation well RRG-1Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure production #1
Rate 59310 STB/D
Rate change 59310 STB/D
P@dt=0 1567.44 psia
Pi 1567.51 psia
Smoothing 0.5
Prod. Index 38.9252 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters
TMatch 3.75 [hr]⁻¹
PMatch 0.074 [psia]⁻¹
Phi 0.00282
Phi.h 2.82 ft
k.h, total 1.3396E+5 md.ft
k, average 133.96 md
Pi 1567.51 psia
Well distance 1570 ft

Model Parameters
Reservoir & Boundary parameters
Pi 1567.51 psia
k.h 1.3396E+5 md.ft
k 133.96 md
Phi 0.00282
Phi.h 2.82 ft
L - Constant P. 3.75E+5 ft

Derived & Secondary Parameters
Semilog Line (Pressure production #1)
From 8.27778 hr
To 44.9778 hr
Slope 17.4477 psi
P@1hr -9.0673 psia
PMatch 0.066 [psia]⁻¹
k.h 1.1947E+5 md.ft
k 119.47 md
Phi 0.00427

Main Results

DD homogeneous

Company US Geothermal
Well Observation well RRG-1Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007 Test date / time
Formation interval
Perforated interval
Gauge type / #
Gauge depth

TEST TYPE Interference

Well distance 1570 ft
Well Radius rw 0.3 ft
Pay Zone h 1000 ftWater Salt (ppm) 10000
Form. compr. 3E-6 psi-1
Reservoir T 290 °F
Reservoir P 2500 psia

FLUID TYPE Water

Volume Factor B 1.07018 B/STB
Viscosity 0.202066 cp
Total Compr. ct 6.71002E-6 psi-1

Selected Model

Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters

TMatch 3.75 [hr]-1
PMatch 0.074 [psia]-1
Phi 0.00282
Phi.h 2.82 ft
k.h, total 1.3396E+5 md.ft
k, average 133.96 md
Pi 1567.51 psia
Well distance 1570 ft

Model Parameters

Reservoir & Boundary parameters

Pi 1567.51 psia
k.h 1.3396E+5 md.ft
k 133.96 md
Phi 0.00282
Phi.h 2.82 ft
L - Constant P. 3.75E+5 ft

Derived & Secondary Parameters

Semi-Log plot

DD homogeneous

Company US Geothermal
Well Observation well RRG-1Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure production #1
Rate 59310 STB/D
Rate change 59310 STB/D
P@dt=0 1567.44 psia
Pi 1567.51 psia
Smoothing 0.5
Prod. Index 38.9252 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters
TMatch 3.75 [hr]⁻¹
PMatch 0.074 [psia]⁻¹
Phi 0.00282
Phi.h 2.82 ft
k.h, total 1.3396E+5 md.ft
k, average 133.96 md
Pi 1567.51 psia
Well distance 1570 ft

Model Parameters
Reservoir & Boundary parameters
Pi 1567.51 psia
k.h 1.3396E+5 md.ft
k 133.96 md
Phi 0.00282
Phi.h 2.82 ft
L - Constant P. 3.75E+5 ft

Derived & Secondary Parameters
Semilog Line (Pressure production #1)
From 8.27778 hr
To 44.9778 hr
Slope 17.4477 psi
P@1hr -9.0673 psia
PMatch 0.066 [psia]⁻¹
k.h 1.1947E+5 md.ft
k 119.47 md
Phi 0.00427

History plot

BU homogeneous

Company US Geothermal
Well Observation well RRG-1

Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure build-up #1

Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 1523.33 psia
Pi 1563.9 psia
Smoothing 0.5
Prod. Index 1461.85 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters

TMatch 6.17 [hr]⁻¹
PMatch 0.164 [psia]⁻¹
Phi 0.00379
Phi.h 3.79 ft
k.h, total 2.9676E+5 md.ft
k, average 296.76 md
Pi 1563.9 psia
Well distance 1570 ft

Model Parameters

Reservoir & Boundary parameters
Pi 1563.9 psia
k.h 2.9676E+5 md.ft
k 296.76 md
Phi 0.00379
Phi.h 3.79 ft
L - No flow 183 ft

Derived & Secondary Parameters

Log-Log plot

BU homogeneous

Company US Geothermal
Well Observation well RRG-1Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure build-up #1

Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 1523.33 psia
Pi 1563.9 psia
Smoothing 0.5
Prod. Index 1461.85 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters

TMatch 6.17 [hr]⁻¹
PMatch 0.164 [psia]⁻¹
Phi 0.00379
Phi.h 3.79 ft
k.h, total 2.9676E+5 md.ft
k, average 296.76 md
Pi 1563.9 psia
Well distance 1570 ft

Model Parameters

Reservoir & Boundary parameters

Pi 1563.9 psia
k.h 2.9676E+5 md.ft
k 296.76 md
Phi 0.00379
Phi.h 3.79 ft
L - No flow 183 ft

Derived & Secondary Parameters

Semilog Line (Pressure build-up #1)

From 83.5264 hr
To 144.682 hr
Slope 13.1064 psi
Intercept 1570.24 psia
P@1hr 1546.14 psia
PMatch 0.0878 [psia]⁻¹
k.h 1.5905E+5 md.ft
k 159.05 md
p* 1570.24 psia
Phi 5.18E-4

Main Results

BU homogeneous

Company US Geothermal
Well Observation well RRG-1Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007 Test date / time
Formation interval
Perforated interval
Gauge type / #
Gauge depth

TEST TYPE Interference

Well distance 1570 ft
Well Radius rw 0.3 ft
Pay Zone h 1000 ftWater Salt (ppm) 10000
Form. compr. 3E-6 psi-1
Reservoir T 290 °F
Reservoir P 2500 psia

FLUID TYPE Water

Volume Factor B 1.07018 B/STB
Viscosity 0.202066 cp
Total Compr. ct 6.71002E-6 psi-1

Selected Model

Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters

TMatch 6.17 [hr]-1
PMatch 0.164 [psia]-1
Phi 0.00379
Phi.h 3.79 ft
k.h, total 2.9676E+5 md.ft
k, average 296.76 md
Pi 1563.9 psia
Well distance 1570 ft

Model Parameters

Reservoir & Boundary parameters

Pi 1563.9 psia
k.h 2.9676E+5 md.ft
k 296.76 md
Phi 0.00379
Phi.h 3.79 ft
L - No flow 183 ft

Derived & Secondary Parameters

Semi-Log plot

BU homogeneous

Company US Geothermal
Well Observation well RRG-1Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure build-up #1
Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 1523.33 psia
Pi 1563.9 psia
Smoothing 0.5
Prod. Index 1461.85 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters
TMatch 6.17 [hr]⁻¹
PMatch 0.164 [psia]⁻¹
Phi 0.00379
Phi.h 3.79 ft
k.h, total 2.9676E+5 md.ft
k, average 296.76 md
Pi 1563.9 psia
Well distance 1570 ft

Model Parameters
Reservoir & Boundary parameters
Pi 1563.9 psia
k.h 2.9676E+5 md.ft
k 296.76 md
Phi 0.00379
Phi.h 3.79 ft
L - No flow 183 ft

Derived & Secondary Parameters
Semilog Line (Pressure build-up #1)
From 83.5264 hr
To 144.682 hr
Slope 13.1064 psi
Intercept 1570.24 psia
P@1hr 1546.14 psia
PMatch 0.0878 [psia]⁻¹
k.h 1.5905E+5 md.ft
k 159.05 md
p* 1570.24 psia
Phi 5.18E-4

History plot

DD dual porosity

Company US Geothermal
Well Observation well RRG-1Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure production #1
Rate 59310 STB/D
Rate change 59310 STB/D
P@dt=0 1567.44 psia
Pi 1560.8 psia
Smoothing 0.5
Prod. Index 38.9252 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters
TMatch 0.882 [hr]⁻¹
PMatch 0.0666 [psia]⁻¹
Phi 0.0108
Phi.h 10.8 ft
k.h, total 1.206E+5 md.ft
k, average 120.6 md
Pi 1560.8 psia
Well distance 1570 ft

Model Parameters
Reservoir & Boundary parameters
Pi 1560.8 psia
k.h 1.206E+5 md.ft
k 120.6 md
Phi 0.0108
Phi.h 10.8 ft
Omega 0.00447
Lambda 0.00217
L - Constant P. 9.95E+5 ft

Derived & Secondary Parameters

Log-Log plot

DD dual porosity

Company US Geothermal
Well Observation well RRG-1Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure production #1
Rate 59310 STB/D
Rate change 59310 STB/D
P@dt=0 1567.44 psia
Pi 1560.8 psia
Smoothing 0.5
Prod. Index 38.9252 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters
TMatch 0.882 [hr]⁻¹
PMatch 0.0666 [psia]⁻¹
Phi 0.0108
Phi.h 10.8 ft
k.h, total 1.206E+5 md.ft
k, average 120.6 md
Pi 1560.8 psia
Well distance 1570 ft

Model Parameters
Reservoir & Boundary parameters
Pi 1560.8 psia
k.h 1.206E+5 md.ft
k 120.6 md
Phi 0.0108
Phi.h 10.8 ft
Omega 0.00447
Lambda 0.00217
L - Constant P. 9.95E+5 ft

Derived & Secondary Parameters
Semilog Line (Pressure production #1)
From 3.44722 hr
To 68.9736 hr
Slope 16.2402 psi
P@1hr -12.6465 psia
PMatch 0.0709 [psia]⁻¹
k.h 1.2836E+5 md.ft
k 128.36 md
Phi 0.00832

Main Results

DD dual porosity

Company US Geothermal
Well Observation well RRG-1Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007 Test date / time
Formation interval
Perforated interval
Gauge type / #
Gauge depth

TEST TYPE Interference

Well distance 1570 ft
Well Radius rw 0.3 ft
Pay Zone h 1000 ftWater Salt (ppm) 10000
Form. compr. 3E-6 psi-1
Reservoir T 290 °F
Reservoir P 2500 psia

FLUID TYPE Water

Volume Factor B 1.07018 B/STB
Viscosity 0.202066 cp
Total Compr. ct 6.71002E-6 psi-1

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.882 [hr]-1
PMatch 0.0666 [psia]-1
Phi 0.0108
Phi.h 10.8 ft
k.h, total 1.206E+5 md.ft
k, average 120.6 md
Pi 1560.8 psia
Well distance 1570 ft

Model Parameters

Reservoir & Boundary parameters

Pi 1560.8 psia
k.h 1.206E+5 md.ft
k 120.6 md
Phi 0.0108
Phi.h 10.8 ft
Omega 0.00447
Lambda 0.00217
L - Constant P. 9.95E+5 ft

Derived & Secondary Parameters

Semi-Log plot

DD dual porosity

Company US Geothermal
Well Observation well RRG-1Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure production #1
Rate 59310 STB/D
Rate change 59310 STB/D
 $P@dt=0$ 1567.44 psia
 P_i 1560.8 psia
Smoothing 0.5
Prod. Index 38.9252 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters
TMatch 0.882 [hr]⁻¹
PMatch 0.0666 [psia]⁻¹
 Φ 0.0108
 $\Phi \cdot h$ 10.8 ft
 $k \cdot h$, total 1.206E+5 md.ft
 k , average 120.6 md
 P_i 1560.8 psia
Well distance 1570 ft

Model Parameters
Reservoir & Boundary parameters
 P_i 1560.8 psia
 $k \cdot h$ 1.206E+5 md.ft
 k 120.6 md
 Φ 0.0108
 $\Phi \cdot h$ 10.8 ft
 Ω 0.00447
 Λ 0.00217
L - Constant P. 9.95E+5 ft

Derived & Secondary Parameters
Semilog Line (Pressure production #1)
From 3.44722 hr
To 68.9736 hr
Slope 16.2402 psi
 $P@1hr$ -12.6465 psia
PMatch 0.0709 [psia]⁻¹
 $k \cdot h$ 1.2836E+5 md.ft
 k 128.36 md
 Φ 0.00832

History plot

BU dual porosity

Company US Geothermal
Well Observation well RRG-1Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure build-up #1

Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 1523.33 psia
Pi 1565.94 psia
Smoothing 0.5
Prod. Index 1391.98 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.887 [hr]⁻¹
PMatch 0.0356 [psia]⁻¹
Phi 0.00574
Phi.h 5.74 ft
k.h, total 64546 md.ft
k, average 64.546 md
Pi 1565.94 psia
Well distance 1570 ft

Model Parameters

Reservoir & Boundary parameters

Pi 1565.94 psia
k.h 64546 md.ft
k 64.546 md
Phi 0.00574
Phi.h 5.74 ft
Omega 0.00171
Lambda 3.68E-5
L - Constant P. 3730 ft

Derived & Secondary Parameters

Log-Log plot

BU dual porosity

Company US Geothermal
Well Observation well RRG-1Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure build-up #1
Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 1523.33 psia
Pi 1565.94 psia
Smoothing 0.5
Prod. Index 1391.98 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters
TMatch 0.887 [hr]⁻¹
PMatch 0.0356 [psia]⁻¹
Phi 0.00574
Phi.h 5.74 ft
k.h, total 64546 md.ft
k, average 64.546 md
Pi 1565.94 psia
Well distance 1570 ft

Model Parameters
Reservoir & Boundary parameters
Pi 1565.94 psia
k.h 64546 md.ft
k 64.546 md
Phi 0.00574
Phi.h 5.74 ft
Omega 0.00171
Lambda 3.68E-5
L - Constant P. 3730 ft

Derived & Secondary Parameters

Semilog Line (Pressure build-up #1)
From 99.6792 hr
To 144.682 hr
Slope 12.3358 psi
Intercept 1569.89 psia
P@1hr 1547.2 psia
PMatch 0.0933 [psia]⁻¹
k.h 1.6898E+5 md.ft
k 168.98 md
p* 1569.89 psia
Phi 3.51E-4

Main Results

BU dual porosity

Company US Geothermal
Well Observation well RRG-1

Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Test date / time
Formation interval
Perforated interval
Gauge type / #
Gauge depth

TEST TYPE Interference

Well distance 1570 ft
Well Radius rw 0.3 ft
Pay Zone h 1000 ft

Water Salt (ppm) 10000
Form. compr. 3E-6 psi-1
Reservoir T 290 °F
Reservoir P 2500 psia

FLUID TYPE Water

Volume Factor B 1.07018 B/STB
Viscosity 0.202066 cp
Total Compr. ct 6.71002E-6 psi-1

Selected Model
Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters
TMatch 0.887 [hr]-1
PMatch 0.0356 [psia]-1
Phi 0.00574
Phi.h 5.74 ft
k.h, total 64546 md.ft
k, average 64.546 md
Pi 1565.94 psia
Well distance 1570 ft

Model Parameters
Reservoir & Boundary parameters
Pi 1565.94 psia
k.h 64546 md.ft
k 64.546 md
Phi 0.00574
Phi.h 5.74 ft
Omega 0.00171
Lambda 3.68E-5
L - Constant P. 3730 ft

Derived & Secondary Parameters

Semi-Log plot

BU dual porosity

Company US Geothermal
Well Observation well RRG-1Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure build-up #1
Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 1523.33 psia
Pi 1565.94 psia
Smoothing 0.5
Prod. Index 1391.98 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters
TMatch 0.887 [hr]⁻¹
PMatch 0.0356 [psia]⁻¹
Phi 0.00574
Phi.h 5.74 ft
k.h, total 64546 md.ft
k, average 64,546 md
Pi 1565.94 psia
Well distance 1570 ft

Model Parameters
Reservoir & Boundary parameters
Pi 1565.94 psia
k.h 64546 md.ft
k 64,546 md
Phi 0.00574
Phi.h 5.74 ft
Omega 0.00171
Lambda 3.68E-5
L - Constant P. 3730 ft

Derived & Secondary Parameters
Semilog Line (Pressure build-up #1)
From 99.6792 hr
To 144.682 hr
Slope 12.3358 psi
Intercept 1569.89 psia
P@1hr 1547.2 psia
PMatch 0.0933 [psia]⁻¹
k.h 1.6898E+5 md.ft
k 168.98 md
p* 1569.89 psia
Phi 3.51E-4

History plot

DD homogeneous

Company US Geothermal
Well Observation well RRG-2Field Raft River
Test Name / # RRG-4 flow test

Pressure production #1

Rate 59310 STB/D
Rate change 59310 STB/D
P@dt=0 2185.28 psia
Pi 2185.28 psia
Smoothing 1
Prod. Index 27.2636 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters

TMatch 0.0502 [hr]⁻¹
PMatch 0.112 [psia]⁻¹
Phi 0.0217
Phi.h 21.7 ft
k.h, total 2.0219E+5 md.ft
k, average 202.19 md
Pi 2185.28 psia
Well distance 6000 ft

Model Parameters

Reservoir & Boundary parameters
Pi 2185.28 psia
k.h 2.0219E+5 md.ft
k 202.19 md
Phi 0.0217
Phi.h 21.7 ft
L - Constant P. 28400 ft

Derived & Secondary Parameters

Log-Log plot

DD homogeneous

Company US Geothermal
Well Observation well RRG-2Field Raft River
Test Name / # RRG-4 flow test

Pressure production #1
Rate 59310 STB/D
Rate change 59310 STB/D
P@dt=0 2185.28 psia
Pi 2185.28 psia
Smoothing 1
Prod. Index 27.2636 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters
TMatch 0.0502 [hr]-1
PMatch 0.112 [psia]-1
Phi 0.0217
Phi.h 21.7 ft
k.h, total 2.0219E+5 md.ft
k, average 202.19 md
Pi 2185.28 psia
Well distance 6000 ft

Model Parameters
Reservoir & Boundary parameters
Pi 2185.28 psia
k.h 2.0219E+5 md.ft
k 202.19 md
Phi 0.0217
Phi.h 21.7 ft
L - Constant P. 28400 ft

Derived & Secondary Parameters
Semilog Line (Pressure production #1)
From 10.4111 hr
To 74.3222 hr
Slope 8.47124 psi
P@1hr -16.8222 psia
PMatch 0.136 [psia]-1
k.h 2.4607E+5 md.ft
k 246.07 md
Phi 0.0176

Main Results

DD homogeneous

Company US Geothermal
Well Observation well RRG-2Field Raft River
Test Name / # RRG-4 flow test Test date / time March 13-21, 2007
Formation interval
Perforated interval
Gauge type / #
Gauge depth

TEST TYPE Interference

Well distance 6000 ft
Well Radius rw 0.3 ft
Pay Zone h 1000 ftWater Salt (ppm) 10000
Form. compr. 3E-6 psi-1
Reservoir T 290 °F
Reservoir P 2500 psia

FLUID TYPE Water

Volume Factor B 1.07018 B/STB
Viscosity 0.202066 cp
Total Compr. ct 6.71002E-6 psi-1

Selected Model

Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters

TMatch 0.0502 [hr]⁻¹
PMatch 0.112 [psia]⁻¹
Phi 0.0217
Phi.h 21.7 ft
k.h, total 2.0219E+5 md.ft
k, average 202.19 md
Pi 2185.28 psia
Well distance 6000 ft

Model Parameters

Reservoir & Boundary parameters
Pi 2185.28 psia
k.h 2.0219E+5 md.ft
k 202.19 md
Phi 0.0217
Phi.h 21.7 ft
L - Constant P. 28400 ft

Derived & Secondary Parameters

Semi-Log plot

DD homogeneous

Company US Geothermal
Well Observation well RRG-2Field Raft River
Test Name / # RRG-4 flow test

Pressure production #1
Rate 59310 STB/D
Rate change 59310 STB/D
P@dt=0 2185.28 psia
Pi 2185.28 psia
Smoothing 1
Prod. Index 27.2636 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters
TMatch 0.0502 [hr]⁻¹
PMatch 0.112 [psia]⁻¹
Phi 0.0217
Phi.h 21.7 ft
k.h, total 2.0219E+5 md.ft
k, average 202.19 md
Pi 2185.28 psia
Well distance 6000 ft

Model Parameters
Reservoir & Boundary parameters
Pi 2185.28 psia
k.h 2.0219E+5 md.ft
k 202.19 md
Phi 0.0217
Phi.h 21.7 ft
L - Constant P. 28400 ft

Derived & Secondary Parameters
Semilog Line (Pressure production #1)
From 10.4111 hr
To 74.3222 hr
Slope 8.47124 psi
P@1hr -16.8222 psia
PMatch 0.136 [psia]⁻¹
k.h 2.4607E+5 md.ft
k 246.07 md
Phi 0.0176

History plot

DD dual porosity

Company US Geothermal
Well Observation well RRG-2Field Raft River
Test Name / # RRG-4 flow test

Pressure production #1

Rate 59310 STB/D
Rate change 59310 STB/D
P@dt=0 2185.28 psia
Pi 2185.28 psia
Smoothing 1
Prod. Index 27.2636 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.025 [hr]⁻¹
PMatch 0.0751 [psia]⁻¹
Phi 0.0294
Phi.h 29.4 ft
k.h, total 1.3607E+5 md.ft
k, average 136.07 md
Pi 2185.28 psia
Well distance 6000 ft

Model Parameters

Reservoir & Boundary parameters
Pi 2185.28 psia
k.h 1.3607E+5 md.ft
k 136.07 md
Phi 0.0294
Phi.h 29.4 ft
Omega 0.0477
Lambda 2.55E-8
L - Constant P. 94700 ft

Derived & Secondary Parameters

Log-Log plot

DD dual porosity

Company US Geothermal
Well Observation well RRG-2Field Raft River
Test Name / # RRG-4 flow test

Pressure production #1

Rate 59310 STB/D
Rate change 59310 STB/D
P@dt=0 2185.28 psia
Pi 2185.28 psia
Smoothing 1
Prod. Index 27.2636 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.025 [hr]⁻¹
PMatch 0.0751 [psia]⁻¹
Phi 0.0294
Phi.h 29.4 ft
k.h, total 1.3607E+5 md.ft
k, average 136.07 md
Pi 2185.28 psia
Well distance 6000 ft

Model Parameters

Reservoir & Boundary parameters
Pi 2185.28 psia
k.h 1.3607E+5 md.ft
k 136.07 md
Phi 0.0294
Phi.h 29.4 ft
Omega 0.0477
Lambda 2.55E-8
L - Constant P. 94700 ft

Derived & Secondary Parameters

Semilog Line (Pressure production #1)

From 10.4111 hr
To 74.3222 hr
Slope 8.47124 psi
P@1hr -16.8222 psia
PMatch 0.136 [psia]⁻¹
k.h 2.4607E+5 md.ft
k 246.07 md
Phi 0.0176

Main Results

DD dual porosity

Company US Geothermal
Well Observation well RRG-2Field Raft River
Test Name / # RRG-4 flow test Test date / time March 13-21, 2007
Formation interval
Perforated interval
Gauge type / #
Gauge depth

TEST TYPE Interference

Well distance 6000 ft
Well Radius rw 0.3 ft
Pay Zone h 1000 ftWater Salt (ppm) 10000
Form. compr. 3E-6 psi-1
Reservoir T 290 °F
Reservoir P 2500 psia

FLUID TYPE Water

Volume Factor B 1.07018 B/STB
Viscosity 0.202066 cp
Total Compr. ct 6.71002E-6 psi-1

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.025 [hr]-1
PMatch 0.0751 [psia]-1
Phi 0.0294
Phi.h 29.4 ft
k.h, total 1.3607E+5 md.ft
k, average 136.07 md
Pi 2185.28 psia
Well distance 6000 ft

Model Parameters

Reservoir & Boundary parameters
Pi 2185.28 psia
k.h 1.3607E+5 md.ft
k 136.07 md
Phi 0.0294
Phi.h 29.4 ft
Omega 0.0477
Lambda 2.55E-8
L - Constant P. 94700 ft

Derived & Secondary Parameters

Semi-Log plot

DD dual porosity

Company US Geothermal
Well Observation well RRG-2Field Raft River
Test Name / # RRG-4 flow test

Pressure production #1
Rate 59310 STB/D
Rate change 59310 STB/D
P@dt=0 2185.28 psia
Pi 2185.28 psia
Smoothing 1
Prod. Index 27.2636 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters
TMatch 0.025 [hr]⁻¹
PMatch 0.0751 [psia]⁻¹
Phi 0.0294
Phi.h 29.4 ft
k.h, total 1.3607E+5 md.ft
k, average 136.07 md
Pi 2185.28 psia
Well distance 6000 ft

Model Parameters
Reservoir & Boundary parameters
Pi 2185.28 psia
k.h 1.3607E+5 md.ft
k 136.07 md
Phi 0.0294
Phi.h 29.4 ft
Omega 0.0477
Lambda 2.55E-8
L - Constant P. 94700 ft

Derived & Secondary Parameters
Semilog Line (Pressure production #1)
From 10.4111 hr
To 74.3222 hr
Slope 8.47124 psi
P@1hr -16.8222 psia
PMatch 0.136 [psia]⁻¹
k.h 2.4607E+5 md.ft
k 246.07 md
Phi 0.0176

History plot

BU homogeneous

Company US Geothermal
Well Observation well RRG-2Field Raft River
Test Name / # RRG-4 flow test

Pressure build-up #1

Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 2175.07 psia
Pi 2184.12 psia
Smoothing 1
Prod. Index 6554.11 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters

TMatch 0.0711 [hr]⁻¹
PMatch 0.206 [psia]⁻¹
Phi 0.0284
Phi.h 28.4 ft
k.h, total 3.7324E+5 md.ft
k, average 373.24 md
Pi 2184.12 psia
Well distance 6000 ft

Model Parameters

Reservoir & Boundary parameters
Pi 2184.12 psia
k.h 3.7324E+5 md.ft
k 373.24 md
Phi 0.0284
Phi.h 28.4 ft
L - No flow 5000 ft

Derived & Secondary Parameters

Log-Log plot

BU homogeneous

Company US Geothermal
Well Observation well RRG-2Field Raft River
Test Name / # RRG-4 flow test

Pressure build-up #1

Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 2175.07 psia
Pi 2184.12 psia
Smoothing 1
Prod. Index 6554.11 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters

TMatch 0.0711 [hr]⁻¹
PMatch 0.206 [psia]⁻¹
Phi 0.0284
Phi.h 28.4 ft
k.h, total 3.7324E+5 md.ft
k, average 373.24 md
Pi 2184.12 psia
Well distance 6000 ft

Model Parameters

Reservoir & Boundary parameters
Pi 2184.12 psia
k.h 3.7324E+5 md.ft
k 373.24 md
Phi 0.0284
Phi.h 28.4 ft
L - No flow 5000 ft

Derived & Secondary Parameters

Semilog Line (Pressure build-up #1)

From 83.3722 hr
To 97.6222 hr
Slope 4.74285 psi
Intercept 2180.98 psia
P@1hr 2172.26 psia
PMatch 0.243 [psia]⁻¹
k.h 4.3951E+5 md.ft
k 439.51 md
p* 2180.98 psia
Phi 0.021

Main Results

BU homogeneous

Company US Geothermal
Well Observation well RRG-2Field Raft River
Test Name / # RRG-4 flow test Test date / time March 13-21, 2007
Formation interval
Perforated interval
Gauge type / #
Gauge depth

TEST TYPE Interference

Well distance 6000 ft
Well Radius rw 0.3 ft
Pay Zone h 1000 ftWater Salt (ppm) 10000
Form. compr. 3E-6 psi-1
Reservoir T 290 °F
Reservoir P 2500 psia

FLUID TYPE Water

Volume Factor B 1.07018 B/STB
Viscosity 0.202066 cp
Total Compr. ct 6.71002E-6 psi-1

Selected Model

Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters

TMatch 0.0711 [hr]-1
PMatch 0.206 [psia]-1
Phi 0.0284
Phi.h 28.4 ft
k.h, total 3.7324E+5 md.ft
k, average 373.24 md
Pi 2184.12 psia
Well distance 6000 ft

Model Parameters

Reservoir & Boundary parameters
Pi 2184.12 psia
k.h 3.7324E+5 md.ft
k 373.24 md
Phi 0.0284
Phi.h 28.4 ft
L - No flow 5000 ft

Derived & Secondary Parameters

Semi-Log plot

BU homogeneous

Company US Geothermal
Well Observation well RRG-2Field Raft River
Test Name / # RRG-4 flow test

Pressure build-up #1

Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 2175.07 psia
Pi 2184.12 psia
Smoothing 1
Prod. Index 6554.11 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters

TMatch 0.0711 [hr]⁻¹
PMatch 0.206 [psia]⁻¹
Phi 0.0284
Phi.h 28.4 ft
k.h, total 3.7324E+5 md.ft
k, average 373.24 md
Pi 2184.12 psia
Well distance 6000 ft

Model Parameters

Reservoir & Boundary parameters
Pi 2184.12 psia
k.h 3.7324E+5 md.ft
k 373.24 md
Phi 0.0284
Phi.h 28.4 ft
L - No flow 5000 ft

Derived & Secondary Parameters

Semilog Line (Pressure build-up #1)

From 83.3722 hr
To 97.6222 hr
Slope 4.74285 psi
Intercept 2180.98 psia
P@1hr 2172.26 psia
PMatch 0.243 [psia]⁻¹
k.h 4.3951E+5 md.ft
k 439.51 md
p* 2180.98 psia
Phi 0.021

History plot

BU dual porosity

Company US Geothermal
Well Observation well RRG-2Field Raft River
Test Name / # RRG-4 flow test

Pressure build-up #1

Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 2175.07 psia
Pi 2184.91 psia
Smoothing 1
Prod. Index 6029.89 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.0235 [hr]⁻¹
PMatch 0.0751 [psia]⁻¹
Phi 0.0313
Phi.h 31.3 ft
k.h, total 1.3607E+5 md.ft
k, average 136.07 md
Pi 2184.91 psia
Well distance 6000 ft

Model Parameters

Reservoir & Boundary parameters
Pi 2184.91 psia
k.h 1.3607E+5 md.ft
k 136.07 md
Phi 0.0313
Phi.h 31.3 ft
Omega 0.0477
Lambda 2.55E-8
L - Constant P. 94700 ft

Derived & Secondary Parameters

Log-Log plot

BU dual porosity

Company US Geothermal
Well Observation well RRG-2Field Raft River
Test Name / # RRG-4 flow test

Pressure build-up #1

Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 2175.07 psia
Pi 2184.91 psia
Smoothing 1
Prod. Index 6029.89 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.0235 [hr]⁻¹
PMatch 0.0751 [psia]⁻¹
Phi 0.0313
Phi.h 31.3 ft
k.h, total 1.3607E+5 md.ft
k, average 136.07 md
Pi 2184.91 psia
Well distance 6000 ft

Model Parameters

Reservoir & Boundary parameters
Pi 2184.91 psia
k.h 1.3607E+5 md.ft
k 136.07 md
Phi 0.0313
Phi.h 31.3 ft
Omega 0.0477
Lambda 2.55E-8
L - Constant P. 94700 ft

Derived & Secondary Parameters

Semilog Line (Pressure build-up #1)

From 83.7444 hr
To 106.675 hr
Slope 5.2933 psi
Intercept 2181.44 psia
P@1hr 2171.7 psia
PMatch 0.217 [psia]⁻¹
k.h 3.938E+5 md.ft
k 393.8 md
p* 2181.44 psia
Phi 0.0209

Main Results

BU dual porosity

Company US Geothermal
Well Observation well RRG-2Field Raft River
Test Name / # RRG-4 flow test Test date / time March 13-21, 2007
Formation interval
Perforated interval
Gauge type / #
Gauge depth

TEST TYPE Interference

Well distance 6000 ft
Well Radius rw 0.3 ft
Pay Zone h 1000 ftWater Salt (ppm) 10000
Form. compr. 3E-6 psi-1
Reservoir T 290 °F
Reservoir P 2500 psia

FLUID TYPE Water

Volume Factor B 1.07018 B/STB
Viscosity 0.202066 cp
Total Compr. ct 6.71002E-6 psi-1

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.0235 [hr]-1
PMatch 0.0751 [psia]-1
Phi 0.0313
Phi.h 31.3 ft
k.h, total 1.3607E+5 md.ft
k, average 136.07 md
Pi 2184.91 psia
Well distance 6000 ft

Model Parameters

Reservoir & Boundary parameters

Pi 2184.91 psia
k.h 1.3607E+5 md.ft
k 136.07 md
Phi 0.0313
Phi.h 31.3 ft
Omega 0.0477
Lambda 2.55E-8
L - Constant P. 94700 ft

Derived & Secondary Parameters

Semi-Log plot

BU dual porosity

Company US Geothermal
Well Observation well RRG-2Field Raft River
Test Name / # RRG-4 flow test

Pressure build-up #1

Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 2175.07 psia
Pi 2184.91 psia
Smoothing 1
Prod. Index 6029.89 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.0235 [hr]⁻¹
PMatch 0.0751 [psia]⁻¹
Phi 0.0313
Phi.h 31.3 ft
k.h, total 1.3607E+5 md.ft
k, average 136.07 md
Pi 2184.91 psia
Well distance 6000 ft

Model Parameters

Reservoir & Boundary parameters

Pi 2184.91 psia
k.h 1.3607E+5 md.ft
k 136.07 md
Phi 0.0313
Phi.h 31.3 ft
Omega 0.0477
Lambda 2.55E-8
L - Constant P. 94700 ft

Derived & Secondary Parameters

Semilog Line (Pressure build-up #1)

From 83.7444 hr
To 106.675 hr
Slope 5.2933 psi
Intercept 2181.44 psia
P@1hr 2171.7 psia
PMatch 0.217 [psia]⁻¹
k.h 3.938E+5 md.ft
k 393.8 md
p* 2181.44 psia
Phi 0.0209

History plot

DD homogeneous

Company US Geothermal
Well Observation well RRG-5Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure production #1
Rate 59310 STB/D
Rate change 59310 STB/D
P@dt=0 2034.86 psia
Pi 2034.86 psia
Smoothing 0.5
Prod. Index 29.3947 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters
TMatch 0.28 [hr]⁻¹
PMatch 0.111 [psia]⁻¹
Phi 0.0251
Phi.h 25.1 ft
k.h, total 2.0168E+5 md.ft
k, average 201.68 md
Pi 2034.86 psia
Well distance 2360 ft

Model Parameters
Reservoir & Boundary parameters
Pi 2034.86 psia
k.h 2.0168E+5 md.ft
k 201.68 md
Phi 0.0251
Phi.h 25.1 ft
L - Constant P. 5.02E+5 ft

Derived & Secondary Parameters

Log-Log plot

DD homogeneous

Company US Geothermal
Well Observation well RRG-5Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure production #1
Rate 59310 STB/D
Rate change 59310 STB/D
P@dt=0 2034.86 psia
Pi 2034.86 psia
Smoothing 0.5
Prod. Index 29.3947 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters
TMatch 0.28 [hr]-1
PMatch 0.111 [psia]-1
Phi 0.0251
Phi.h 25.1 ft
k.h, total 2.0168E+5 md.ft
k, average 201.68 md
Pi 2034.86 psia
Well distance 2360 ft

Model Parameters
Reservoir & Boundary parameters
Pi 2034.86 psia
k.h 2.0168E+5 md.ft
k 201.68 md
Phi 0.0251
Phi.h 25.1 ft
L - Constant P. 5.02E+5 ft

Derived & Secondary Parameters
Semilog Line (Pressure production #1)
From 5.34722 hr
To 44.9778 hr
Slope 9.52048 psi
P@1hr -12.5774 psia
PMatch 0.121 [psia]-1
k.h 2.1895E+5 md.ft
k 218.95 md
Phi 0.0219

Main Results

DD homogeneous

Company US Geothermal
Well Observation well RRG-5Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007 Test date / time
Formation interval
Perforated interval
Gauge type / #
Gauge depth

TEST TYPE Interference

Well distance 2360 ft
Well Radius rw 0.3 ft
Pay Zone h 1000 ftWater Salt (ppm) 10000
Form. compr. 3E-6 psi-1
Reservoir T 290 °F
Reservoir P 2500 psia

FLUID TYPE Water

Volume Factor B 1.07018 B/STB
Viscosity 0.202066 cp
Total Compr. ct 6.71002E-6 psi-1

Selected Model

Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters

TMatch 0.28 [hr]-1
PMatch 0.111 [psia]-1
Phi 0.0251
Phi.h 25.1 ft
k.h, total 2.0168E+5 md.ft
k, average 201.68 md
Pi 2034.86 psia
Well distance 2360 ft

Model Parameters

Reservoir & Boundary parameters

Pi 2034.86 psia
k.h 2.0168E+5 md.ft
k 201.68 md
Phi 0.0251
Phi.h 25.1 ft
L - Constant P. 5.02E+5 ft

Derived & Secondary Parameters

Semi-Log plot

DD homogeneous

Company US Geothermal
Well Observation well RRG-5Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure production #1
Rate 59310 STB/D
Rate change 59310 STB/D
P@dt=0 2034.86 psia
Pi 2034.86 psia
Smoothing 0.5
Prod. Index 29.3947 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters
TMatch 0.28 [hr]-1
PMatch 0.111 [psia]-1
Phi 0.0251
Phi.h 25.1 ft
k.h, total 2.0168E+5 md.ft
k, average 201.68 md
Pi 2034.86 psia
Well distance 2360 ft

Model Parameters
Reservoir & Boundary parameters
Pi 2034.86 psia
k.h 2.0168E+5 md.ft
k 201.68 md
Phi 0.0251
Phi.h 25.1 ft
L - Constant P, 5.02E+5 ft

Derived & Secondary Parameters
Semilog Line (Pressure production #1)
From 5.34722 hr
To 44.9778 hr
Slope 9.52048 psi
P@1hr -12.5774 psia
PMatch 0.121 [psia]-1
k.h 2.1895E+5 md.ft
k 218.95 md
Phi 0.0219

History plot

DD dual porosity

Company US Geothermal
Well Observation well RRG-5Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure build-up #1

Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 2017.7 psia
Pi 2034.86 psia
Smoothing 0.5
Prod. Index 3457.3 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.221 [hr]⁻¹
PMatch 0.102 [psia]⁻¹
Phi 0.0291
Phi.h 29.1 ft
k.h, total 1.8399E+5 md.ft
k, average 183.99 md
Pi 2034.86 psia
Well distance 2360 ft

Model Parameters

Reservoir & Boundary parameters
Pi 2034.86 psia
k.h 1.8399E+5 md.ft
k 183.99 md
Phi 0.0291
Phi.h 29.1 ft
Omega 0.689
Lambda 1.84E-4
L - Constant P. 2.81E+5 ft

Derived & Secondary Parameters

Log-Log plot

DD dual porosity

Company US Geothermal
Well Observation well RRG-5Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure build-up #1

Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 2017.7 psia
Pi 2034.86 psia
Smoothing 0.5
Prod. Index 3457.3 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.221 [hr]⁻¹
PMatch 0.102 [psia]⁻¹
Phi 0.0291
Phi.h 29.1 ft
k.h, total 1.8399E+5 md.ft
k, average 183.99 md
Pi 2034.86 psia
Well distance 2360 ft

Model Parameters

Reservoir & Boundary parameters
Pi 2034.86 psia
k.h 1.8399E+5 md.ft
k 183.99 md
Phi 0.0291
Phi.h 29.1 ft
Omega 0.689
Lambda 1.84E-4
L - Constant P. 2.81E+5 ft

Derived & Secondary Parameters

Semilog Line (Pressure build-up #1)

From 77.3389 hr
To 90.5722 hr
Slope 9.45836 psi
Intercept 2034.3 psia
P@1hr 2016.98 psia
PMatch 0.122 [psia]⁻¹
k.h 2.2039E+5 md.ft
k 220.39 md
p* 2034.3 psia
Phi 0.0202

Main Results

DD dual porosity

Company US Geothermal
Well Observation well RRG-5Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007 Test date / time
Formation interval
Perforated interval
Gauge type / #
Gauge depth

TEST TYPE Interference

Well distance 2360 ft
Well Radius rw 0.3 ft
Pay Zone h 1000 ftWater Salt (ppm) 10000
Form. compr. 3E-6 psi-1
Reservoir T 290 °F
Reservoir P 2500 psia

FLUID TYPE Water

Volume Factor B 1.07018 B/STB
Viscosity 0.202066 cp
Total Compr. ct 6.71002E-6 psi-1

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.221 [hr]-1
PMatch 0.102 [psia]-1
Phi 0.0291
Phi.h 29.1 ft
k.h, total 1.8399E+5 md.ft
k, average 183.99 md
Pi 2034.86 psia
Well distance 2360 ft

Model Parameters

Reservoir & Boundary parameters

Pi 2034.86 psia
k.h 1.8399E+5 md.ft
k 183.99 md
Phi 0.0291
Phi.h 29.1 ft
Omega 0.689
Lambda 1.84E-4
L - Constant P. 2.81E+5 ft

Derived & Secondary Parameters

Semi-Log plot

DD dual porosity

Company US Geothermal
Well Observation well RRG-5Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure build-up #1

Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 2017.7 psia
Pi 2034.86 psia
Smoothing 0.5
Prod. Index 3457.3 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.221 [hr]⁻¹
PMatch 0.102 [psia]⁻¹
Phi 0.0291
Phi.h 29.1 ft
k.h, total 1.8399E+5 md.ft
k, average 183.99 md
Pi 2034.86 psia
Well distance 2360 ft

Model Parameters

Reservoir & Boundary parameters
Pi 2034.86 psia
k.h 1.8399E+5 md.ft
k 183.99 md
Phi 0.0291
Phi.h 29.1 ft
Omega 0.689
Lambda 1.84E-4
L - Constant P. 2.81E+5 ft

Derived & Secondary Parameters

Semilog Line (Pressure build-up #1)

From 77.3389 hr
To 90.5722 hr
Slope 9.45836 psi
Intercept 2034.3 psia
P@1hr 2016.98 psia
PMatch 0.122 [psia]⁻¹
k.h 2.2039E+5 md.ft
k 220.39 md
p* 2034.3 psia
Phi 0.0202

History plot

BU homogeneous

Company US Geothermal
Well Observation well RRG-5

Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure build-up #1
Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 2017.7 psia
Pi 2031.2 psia
Smoothing 0.5
Prod. Index 4395.54 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters
TMatch 0.154 [hr]⁻¹
PMatch 0.0776 [psia]⁻¹
Phi 0.0318
Phi.h 31.8 ft
k.h, total 1.4051E+5 md.ft
k, average 140.51 md
Pi 2031.2 psia
Well distance 2360 ft

Model Parameters
Reservoir & Boundary parameters
Pi 2031.2 psia
k.h 1.4051E+5 md.ft
k 140.51 md
Phi 0.0318
Phi.h 31.8 ft
L - Constant P. 3650 ft

Derived & Secondary Parameters

Log-Log plot

BU homogeneous

Company US Geothermal
Well Observation well RRG-5Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure build-up #1
Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 2017.7 psia
Pi 2031.2 psia
Smoothing 0.5
Prod. Index 4395.54 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters
TMatch 0.154 [hr]⁻¹
PMatch 0.0776 [psia]⁻¹
Phi 0.0318
Phi.h 31.8 ft
k.h, total 1.4051E+5 md.ft
k, average 140.51 md
Pi 2031.2 psia
Well distance 2360 ft

Model Parameters
Reservoir & Boundary parameters
Pi 2031.2 psia
k.h 1.4051E+5 md.ft
k 140.51 md
Phi 0.0318
Phi.h 31.8 ft
L - Constant P. 3650 ft

Derived & Secondary Parameters
Semilog Line (Pressure build-up #1)
From 78.0667 hr
To 92.0778 hr
Slope 9.41803 psi
Intercept 2034.27 psia
P@1hr 2017.02 psia
PMatch 0.122 [psia]⁻¹
k.h 2.2133E+5 md.ft
k 221.33 md
p* 2034.27 psia
Phi 0.0201

Main Results

BU homogeneous

Company US Geothermal
Well Observation well RRG-5

Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Test date / time
Formation interval
Perforated interval
Gauge type / #
Gauge depth

TEST TYPE Interference

Well distance 2360 ft
Well Radius rw 0.3 ft
Pay Zone h 1000 ft

Water Salt (ppm) 10000
Form. compr. 3E-6 psi-1
Reservoir T 290 °F
Reservoir P 2500 psia

FLUID TYPE Water

Volume Factor B 1.07018 B/STB
Viscosity 0.202066 cp
Total Compr. ct 6.71002E-6 psi-1

Selected Model

Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters

TMatch 0.154 [hr]-1
PMatch 0.0776 [psia]-1
Phi 0.0318
Phi.h 31.8 ft
k.h, total 1.4051E+5 md.ft
k, average 140.51 md
Pi 2031.2 psia
Well distance 2360 ft

Model Parameters

Reservoir & Boundary parameters

Pi 2031.2 psia
k.h 1.4051E+5 md.ft
k 140.51 md
Phi 0.0318
Phi.h 31.8 ft
L - Constant P. 3650 ft

Derived & Secondary Parameters

Semi-Log plot

BU homogeneous

Company US Geothermal
Well Observation well RRG-5Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure build-up #1
Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 2017.7 psia
Pi 2031.2 psia
Smoothing 0.5
Prod. Index 4395.54 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters
TMatch 0.154 [hr]-1
PMatch 0.0776 [psia]-1
Phi 0.0318
Phi.h 31.8 ft
k.h, total 1.4051E+5 md.ft
k, average 140.51 md
Pi 2031.2 psia
Well distance 2360 ft

Model Parameters
Reservoir & Boundary parameters
Pi 2031.2 psia
k.h 1.4051E+5 md.ft
k 140.51 md
Phi 0.0318
Phi.h 31.8 ft
L - Constant P. 3650 ft

Derived & Secondary Parameters
Semilog Line (Pressure build-up #1)
From 78.0667 hr
To 92.0778 hr
Slope 9.41803 psi
Intercept 2034.27 psia
P@1hr 2017.02 psia
PMatch 0.122 [psia]-1
k.h 2.2133E+5 md.ft
k 221.33 md
p* 2034.27 psia
Phi 0.0201

History plot

BU dual porosity

Company US Geothermal
Well Observation well RRG-5Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure build-up #1
Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 2017.7 psia
Pi 2031.28 psia
Smoothing 0.5
Prod. Index 4369.39 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters
TMatch 0.178 [hr]-1
PMatch 0.0892 [psia]-1
Phi 0.0316
Phi.h 31.6 ft
k.h, total 1.6164E+5 md.ft
k, average 161.64 md
Pi 2031.28 psia
Well distance 2360 ft

Model Parameters
Reservoir & Boundary parameters
Pi 2031.28 psia
k.h 1.6164E+5 md.ft
k 161.64 md
Phi 0.0316
Phi.h 31.6 ft
Omega 0.0392
Lambda 5.4E-5
L - Constant P. 4540 ft

Derived & Secondary Parameters

Log-Log plot

BU dual porosity

Company US Geothermal
Well Observation well RRG-5Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure build-up #1

Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 2017.7 psia
Pi 2031.28 psia
Smoothing 0.5
Prod. Index 4369.39 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.178 [hr]⁻¹
PMatch 0.0892 [psia]⁻¹
Phi 0.0316
Phi.h 31.6 ft
k.h, total 1.6164E+5 md.ft
k, average 161.64 md
Pi 2031.28 psia
Well distance 2360 ft

Model Parameters

Reservoir & Boundary parameters
Pi 2031.28 psia
k.h 1.6164E+5 md.ft
k 161.64 md
Phi 0.0316
Phi.h 31.6 ft
Omega 0.0392
Lambda 5.4E-5
L - Constant P. 4540 ft

Derived & Secondary Parameters

Semilog Line (Pressure build-up #1)

From 77.7139 hr
To 93.3028 hr
Slope 9.45073 psi
Intercept 2034.31 psia
P@1hr 2017 psia
PMatch 0.122 [psia]⁻¹
k.h 2.2057E+5 md.ft
k 220.57 md
p* 2034.31 psia
Phi 0.0201

Main Results

BU dual porosity

Company US Geothermal
Well Observation well RRG-5Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007 Test date / time
Formation interval
Perforated interval
Gauge type / #
Gauge depth

TEST TYPE Interference

Well distance 2360 ft
Well Radius rw 0.3 ft
Pay Zone h 1000 ftWater Salt (ppm) 10000
Form. compr. 3E-6 psi-1
Reservoir T 290 °F
Reservoir P 2500 psia

FLUID TYPE Water

Volume Factor B 1.07018 B/STB
Viscosity 0.202066 cp
Total Compr. ct 6.71002E-6 psi-1

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.178 [hr]-1
PMatch 0.0892 [psia]-1
Phi 0.0316
Phi.h 31.6 ft
k.h, total 1.6164E+5 md.ft
k, average 161.64 md
Pi 2031.28 psia
Well distance 2360 ft

Model Parameters

Reservoir & Boundary parameters

Pi 2031.28 psia
k.h 1.6164E+5 md.ft
k 161.64 md
Phi 0.0316
Phi.h 31.6 ft
Omega 0.0392
Lambda 5.4E-5
L - Constant P. 4540 ft

Derived & Secondary Parameters

Semi-Log plot

BU dual porosity

Company US Geothermal
Well Observation well RRG-5Field Raft River
Test Name / # RRG-4 flow test March 13-21, 2007

Pressure build-up #1

Rate 0 STB/D
Rate change 59310 STB/D
P@dt=0 2017.7 psia
Pi 2031.28 psia
Smoothing 0.5
Prod. Index 4369.39 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.178 [hr]⁻¹
PMatch 0.0892 [psia]⁻¹
Phi 0.0316
Phi.h 31.6 ft
k.h, total 1.6164E+5 md.ft
k, average 161.64 md
Pi 2031.28 psia
Well distance 2360 ft

Model Parameters

Reservoir & Boundary parameters
Pi 2031.28 psia
k.h 1.6164E+5 md.ft
k 161.64 md
Phi 0.0316
Phi.h 31.6 ft
Omega 0.0392
Lambda 5.4E-5
L - Constant P. 4540 ft

Derived & Secondary Parameters

Semilog Line (Pressure build-up #1)

From 77.7139 hr
To 93.3028 hr
Slope 9.45073 psi
Intercept 2034.31 psia
P@1hr 2017 psia
PMatch 0.122 [psia]⁻¹
k.h 2.2057E+5 md.ft
k 220.57 md
p* 2034.31 psia
Phi 0.0201

History plot

DD homogeneous

Company US Geothermal
Well Observation well RRG-11Field Raft River
Test Name / # RRG-4 flow test

Pressure #2 production #1
Rate 1 STB/D
Rate change 1 STB/D
P@dt=0 51.675 psia
Pi 51 psia
Smoothing 1
Prod. Index 0.0225887 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters
TMatch 0.0108 [hr]-1
PMatch 3360 [psia]-1
Phi 0.0514
Phi.h 51.4 ft
k.h, total 1.027E+5 md.ft
k, average 102.7 md
Pi 51 psia
Well distance 6000 ft

Model Parameters
Reservoir & Boundary parameters
Pi 51 psia
k.h 1.027E+5 md.ft
k 102.7 md
Phi 0.0514
Phi.h 51.4 ft
L - Constant P. 25000 ft

Derived & Secondary Parameters

Log-Log plot

DD homogeneous

Company US Geothermal
Well Observation well RRG-11Field Raft River
Test Name / # RRG-4 flow test

Pressure #2 production #1
Rate 1 STB/D
Rate change 1 STB/D
P@dt=0 51.675 psia
Pi 51 psia
Smoothing 1
Prod. Index 0.0225887 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters
TMatch 0.0108 [hr]-1
PMatch 3360 [psia]-1
Phi 0.0514
Phi.h 51.4 ft
k.h, total 1.027E+5 md.ft
k, average 102.7 md
Pi 51 psia
Well distance 6000 ft

Model Parameters
Reservoir & Boundary parameters
Pi 51 psia
k.h 1.027E+5 md.ft
k 102.7 md
Phi 0.0514
Phi.h 51.4 ft
L - Constant P. 25000 ft

Derived & Secondary Parameters

Main Results

DD homogeneous

Company US Geothermal
Well Observation well RRG-11Field Raft River
Test Name / # RRG-4 flow test Test date / time March 13-21, 2007
Formation interval
Perforated interval
Gauge type / #
Gauge depth

TEST TYPE Interference

Well distance 6000 ft
Well Radius rw 0.3 ft
Pay Zone h 1000 ftWater Salt (ppm) 10000
Form. compr. 3E-6 psi-1
Reservoir T 290 °F
Reservoir P 2500 psia

FLUID TYPE Water

Volume Factor B 1.07018 B/STB
Viscosity 0.202066 cp
Total Compr. ct 6.71002E-6 psi-1

Selected Model

Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters

TMatch 0.0108 [hr]-1
PMatch 3360 [psia]-1
Phi 0.0514
Phi.h 51.4 ft
k.h, total 1.027E+5 md.ft
k, average 102.7 md
Pi 51 psia
Well distance 6000 ft

Model Parameters

Reservoir & Boundary parameters
Pi 51 psia
k.h 1.027E+5 md.ft
k 102.7 md
Phi 0.0514
Phi.h 51.4 ft
L - Constant P. 25000 ft

Derived & Secondary Parameters

Semi-Log plot

DD homogeneous

Company US Geothermal
Well Observation well RRG-11Field Raft River
Test Name / # RRG-4 flow test

Pressure #2 production #1
Rate 1 STB/D
Rate change 1 STB/D
P@dt=0 51.675 psia
Pi 51 psia
Smoothing 1
Prod. Index 0.0225887 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Homogeneous
Boundary One fault

Main Model Parameters
TMatch 0.0108 [hr]-1
PMatch 3360 [psia]-1
Phi 0.0514
Phi.h 51.4 ft
k.h, total 1.027E+5 md.ft
k, average 102.7 md
Pi 51 psia
Well distance 6000 ft

Model Parameters
Reservoir & Boundary parameters
Pi 51 psia
k.h 1.027E+5 md.ft
k 102.7 md
Phi 0.0514
Phi.h 51.4 ft
L - Constant P. 25000 ft

Derived & Secondary Parameters

History plot

DD dual porosity

Company US Geothermal
Well Observation well RRG-11Field Raft River
Test Name / # RRG-4 flow test

Pressure #2 production #1

Rate 1 STB/D
Rate change 1 STB/D
P@dt=0 51.675 psia
PI 51.675 psia
Smoothing 1
Prod. Index 0.0225887 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.0024 [hr]-1
PMatch 3210 [psia]-1
Phi 0.221
Phi.h 221 ft
k.h, total 98064 md.ft
k, average 98.064 md
PI 51.675 psia
Well distance 6000 ft

Model Parameters

Reservoir & Boundary parameters

Pi 51.675 psia
k.h 98064 md.ft
k 98.064 md
Phi 0.221
Phi.h 221 ft
Omega 0.196
Lambda 1.33E-14
L - Constant P. 35200 ft

Derived & Secondary Parameters

Log-Log plot

DD dual porosity

Company US Geothermal
Well Observation well RRG-11Field Raft River
Test Name / # RRG-4 flow test

Pressure #2 production #1

Rate 1 STB/D
Rate change 1 STB/D
P@dt=0 51.675 psia
Pi 51.675 psia
Smoothing 1
Prod. Index 0.0225887 [STB/D]/psia

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.0024 [hr]⁻¹
PMatch 3210 [psia]⁻¹
Phi 0.221
Phi.h 221 ft
k.h, total 98064 md.ft
k, average 98.064 md
Pi 51.675 psia
Well distance 6000 ft

Model Parameters

Reservoir & Boundary parameters

Pi 51.675 psia
k.h 98064 md.ft
k 98.064 md
Phi 0.221
Phi.h 221 ft
Omega 0.196
Lambda 1.33E-14
L - Constant P. 35200 ft

Derived & Secondary Parameters

Main Results

DD dual porosity

Company US Geothermal
Well Observation well RRG-11Field Raft River
Test Name / # RRG-4 flow test Test date / time March 13-21, 2007
Formation interval
Perforated interval
Gauge type / #
Gauge depth

TEST TYPE Interference

Well distance 6000 ft
Well Radius r_w 0.3 ft
Pay Zone h 1000 ftWater Salt (ppm) 10000
Form. compr. $3E-6$ psi-1
Reservoir T 290 °F
Reservoir P 2500 psia

FLUID TYPE Water

Volume Factor B 1.07018 B/STB
Viscosity 0.202066 cp
Total Compr. ct $6.71002E-6$ psi-1

Selected Model

Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters

TMatch 0.0024 [hr]-1
PMatch 3210 [psia]-1
Phi 0.221
Phi.h 221 ft
k.h, total 98064 md.ft
k, average 98.064 md
Pi 51.675 psia
Well distance 6000 ft

Model Parameters

Reservoir & Boundary parameters

Pi 51.675 psia
k.h 98064 md.ft
k 98.064 md
Phi 0.221
Phi.h 221 ft
Omega 0.196
Lambda $1.33E-14$
L - Constant P. 35200 ft

Derived & Secondary Parameters

Semi-Log plot

DD dual porosity

Company US Geothermal
Well Observation well RRG-11Field Raft River
Test Name / # RRG-4 flow test

Pressure #2 production #1
Rate 1 STB/D
Rate change 1 STB/D
P@dt=0 51.675 psia
Pi 51.675 psia
Smoothing 1
Prod. Index 0.0225887 [STB/D]/psia

Selected Model
Model Option Standard Model
Well Line source
Reservoir Two porosity PSS
Boundary One fault

Main Model Parameters
TMatch 0.0024 [hr]⁻¹
PMatch 3210 [psia]⁻¹
Phi 0.221
Phi.h 221 ft
k.h, total 98064 md.ft
k, average 98.064 md
Pi 51.675 psia
Well distance 6000 ft

Model Parameters
Reservoir & Boundary parameters
Pi 51.675 psia
k.h 98064 md.ft
k 98.064 md
Phi 0.221
Phi.h 221 ft
Omega 0.196
Lambda 1.33E-14
L - Constant P. 35200 ft

Derived & Secondary Parameters