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Heat flow modelling of selected wells in SEL26/2005, Tasmania

Prepared for KUTh Energy Ltd (KEN)

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Executive summary

Four (4) shallow wells in SEL26/2005 (Tasmania) were measured by Hot Dry Rocks Pty Ltd (HDRPL) for equilibrated downhole temperature. Core from the same wells was sampled and measured for rock thermal conductivity. Temperature and conductivity data have been combined using HDRPLs 1D Heat Flow Modelling Software to determine vertical heat flow within each well.

The resulting surface heat flows for each well are summarised in the table below:-

Well	Beaconsfield	Lisle	Rocherlea	Weymouth
Modelled Heat Flow (mW/m^2)	86 ± 0.4	65 ± 0.5	48 ± 0.4 *	75 ± 1.3
Relative confidence	High	High	Low	High

Two of the four wells have elevated surface heat flow, ie >75 mW/m^2. The Rocherlea well displays an anomalously low heat flow of 48 mW/m^2. The Lisle well approximates the Australian Median average for surface heat flow.

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1.0 Introduction

Hot Dry Rocks Pty Ltd (HDRPL) was commissioned by KUTh Energy Ltd (KEN) to undertake heat flow modelling of selected wells in their tenement (SEL26/2005).

SEL26/2005 is located in eastern Tasmania and extends from George Town in the north of the state to Hobart in the south. As part of its work program, KEN has undertaken a shallow drilling program to define heat flow variation within its tenement. This report provides modelled heat flow values for the following shallow wells:-

- Beaconsfield 1
- Lisle 1
- Rocherlea 1
- Weymouth 1

Heat flow models described in this report incorporate rock thermal conductivity measurements and calibrated precision temperature logs recently undertaken by HDRPL for the same wells.

2.0 Introduction to heat flow

Heat flow is a power unit expressed at surface (mW/m^2) and is a function of heat generated within the crust plus heat conducted from the mantle.

The principle aim of geothermal exploration is to locate anomalously high temperatures within a productive reservoir at an economically and technically viable drilling depth. The thermal state of a region is usually expressed at the surface in the form of heat flow units (mW/m^2) and it is generally assumed that heat is transported to the surface by conductive means.

In a conductive heat regime the temperature **T**, at depth **z** is equal to the surface temperature $\mathbf{T_0}$ plus the product of heat flow **Q** and thermal resistance **R**, such that:

$\mathbf{T=T_0+QR}$, where **R**=**z**/(average thermal conductivity between the surface and **z**).

Consequently the most highly prospective regions for geothermal exploration are those that have geological units of sufficiently low conductivity (high thermal resistance) in the cover sequence combined with high heat flow.

Heat flow is a product of temperature gradient and rock thermal conductivity and is therefore not directly measured. The measurement of heat flow is a precision skill that requires a detailed understanding of physical conditions in the bore and the physical properties of the rocks; including potential advective processes that may influence bore temperature (such as ground water flow) and the temperature dependence of conductivity.

HDRPL utilises its own 1D Heat Flow Modelling Software to determine heat flow from measured values. Forward modelled temperature distribution with depth, incorporating advective influences and temperature dependence of thermal conductivity, is compared against the observed temperature profile within a bore. The precise vertical heat flow value is determined that best fits the observed profile. The results of 1D heat flow modelling should be treated with caution when extrapolating over lateral distances, because heat refraction can lead to significant variation in vertical heat flow over relatively short lateral distances. Detailed 2D or 3D modelling is recommended if such effects are suspected.

3.0 Results of heat flow models

3.1 Summary of modelled surface heat flows

A summary of modelled surface heat flow results is shown in Table 1. Sections below describe each model in detail.

Table 1. Summary of modelled surface heat flows for shallow wells in SEL26/2005 in this study

Well	Beaconsfield	Lisle	Rocherlea	Weymouth
Modelled Heat Flow (mW/m^2)	86 ± 0.4	65 ± 0.5	48 ± 0.4 *	75 ± 1.3
Relative confidence	High	High	Low	High

* The anomalously low surface heat flow may be a result of advection below the drilling base of the shallow well.

3.2 Beaconsfield 1

The heat flow model for Beaconsfield 1 (Fig. 1) illustrates a good fit between the observed and predicted temperature profiles. The well intersected Jurassic Dolerite in the upper approximately 200 m and finished in a sandstone member of the Parmeener Supergroup, with thermal conductivities ranging from 2.28 – 2.82 W/mK The conductive surface **heat flow** is **86.0 ± 0.4 mW/m²** over the conductivity-constrained interval (approximately 90 m – 249 m).

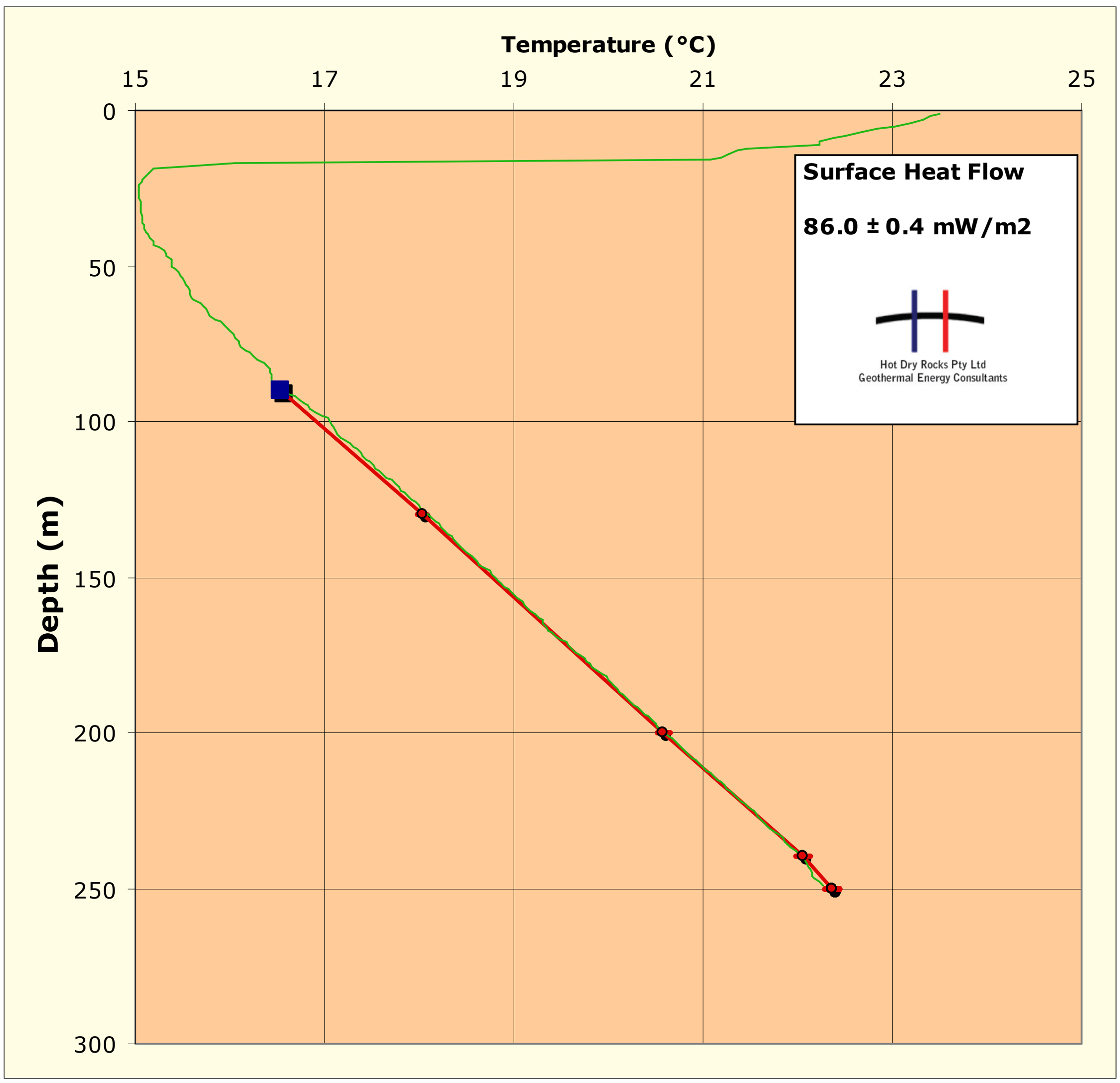

Figure 1. Beaconsfield 1 – Red line is the modelled temperature profile for the stated heat flow and measured rock thermal conductivity data. Green line is the measured precision temperature log.

3.3 Lisle 1

The heat flow model for Lisle 1 (Fig.2) illustrates a good fit between the observed and predicted temperature profiles. The well only intersected Mathinna Beds in the cored section. Thermal conductivities range from 3.18 – 4.80 W/mK. The modelled surface heat flow is **65.0 ± 0.5 mW/m²** calculated from the conductivity-constrained interval (approximately 100 m – 250 m).

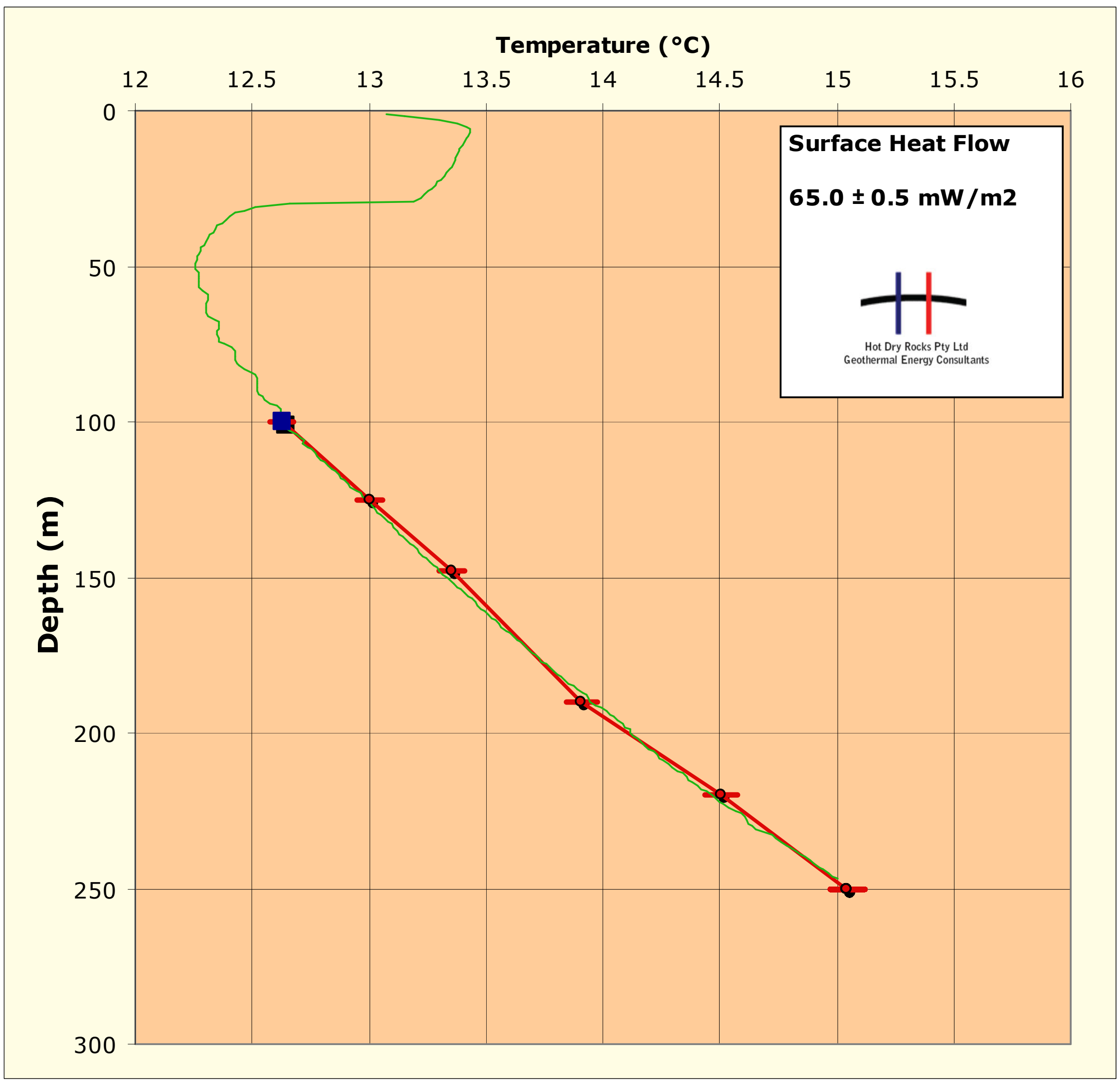

Figure 2. Lisle 1 – Red line is the modelled temperature profile for the stated heat flow and measured rock thermal conductivity data. Green line is the measured precision temperature log.

3.4 Rocherlea 1

The heat flow model for Rocherlea 1 (Fig. 3) illustrates a good fit between the observed and predicted temperature profiles, but an anomalously low heat flow. This result is most probably demonstrating the influence of advection below the base of the hole, removing some of the vertical heat component. The well only intersected Jurassic Dolerite with thermal conductivities ranging from 1.97 – 2.25 W/mK. The conductive surface **heat flow** is **48.0 ± 0.4 mW/m²** over the conductivity-constrained interval (approximately 120 m – 250 m).

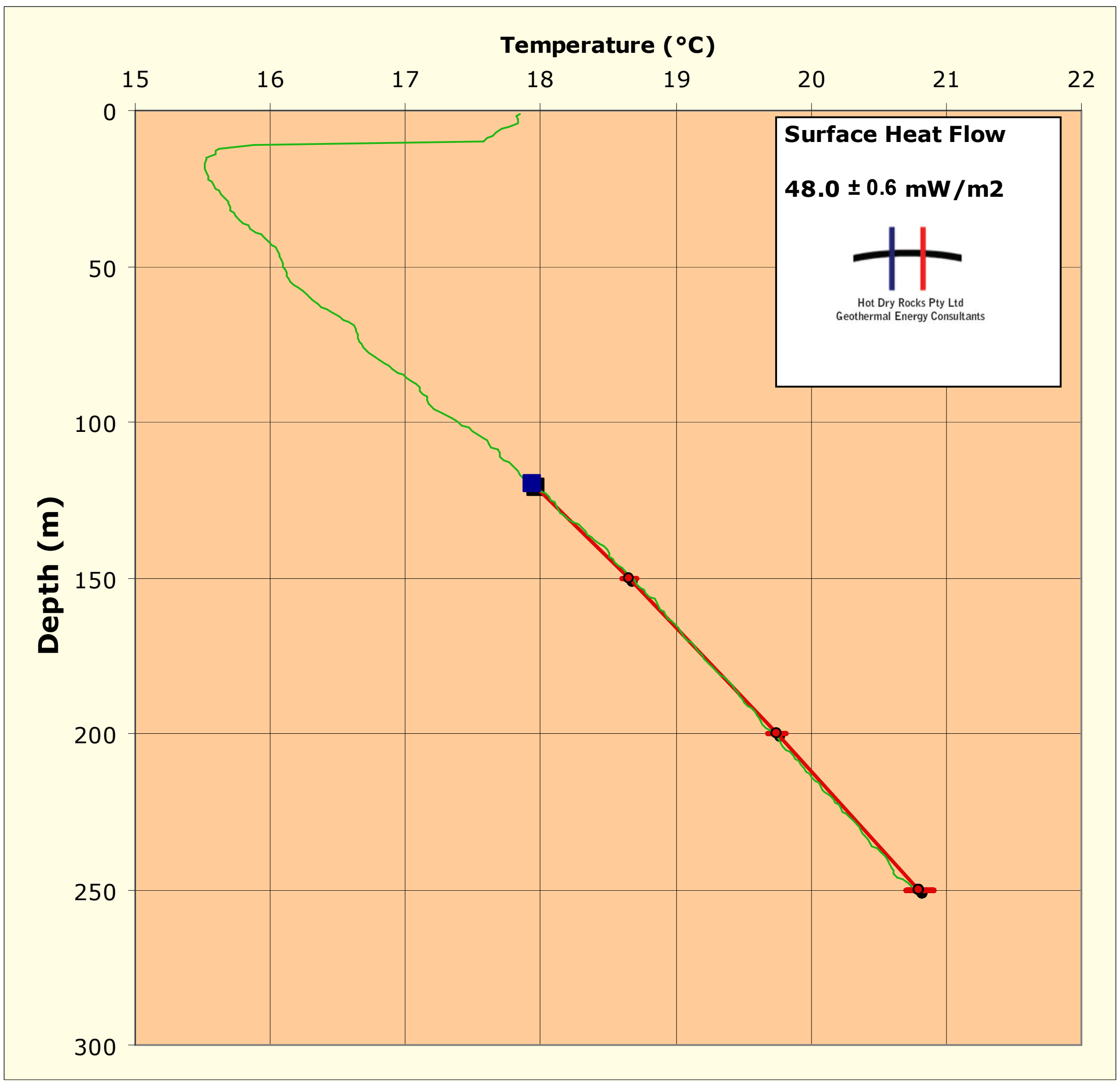

Figure 3. Rocherlea 1 – Red line is the modelled temperature profile for the stated heat flow and measured rock thermal conductivity data. Green line is the measured precision temperature log.

3.5 Weymouth 1

The heat flow model for Weymouth 1 (Fig.4) illustrates a good fit between the observed and predicted temperature profiles. The well only intersected Mathinna Beds in the cored section. Thermal conductivities range from 2.95 – 4.02 W/mK. The modelled surface heat flow is **75.0 ± 1.3 mW/m²** calculated from the conductivity-constrained interval (approximately 90 m – 250 m).

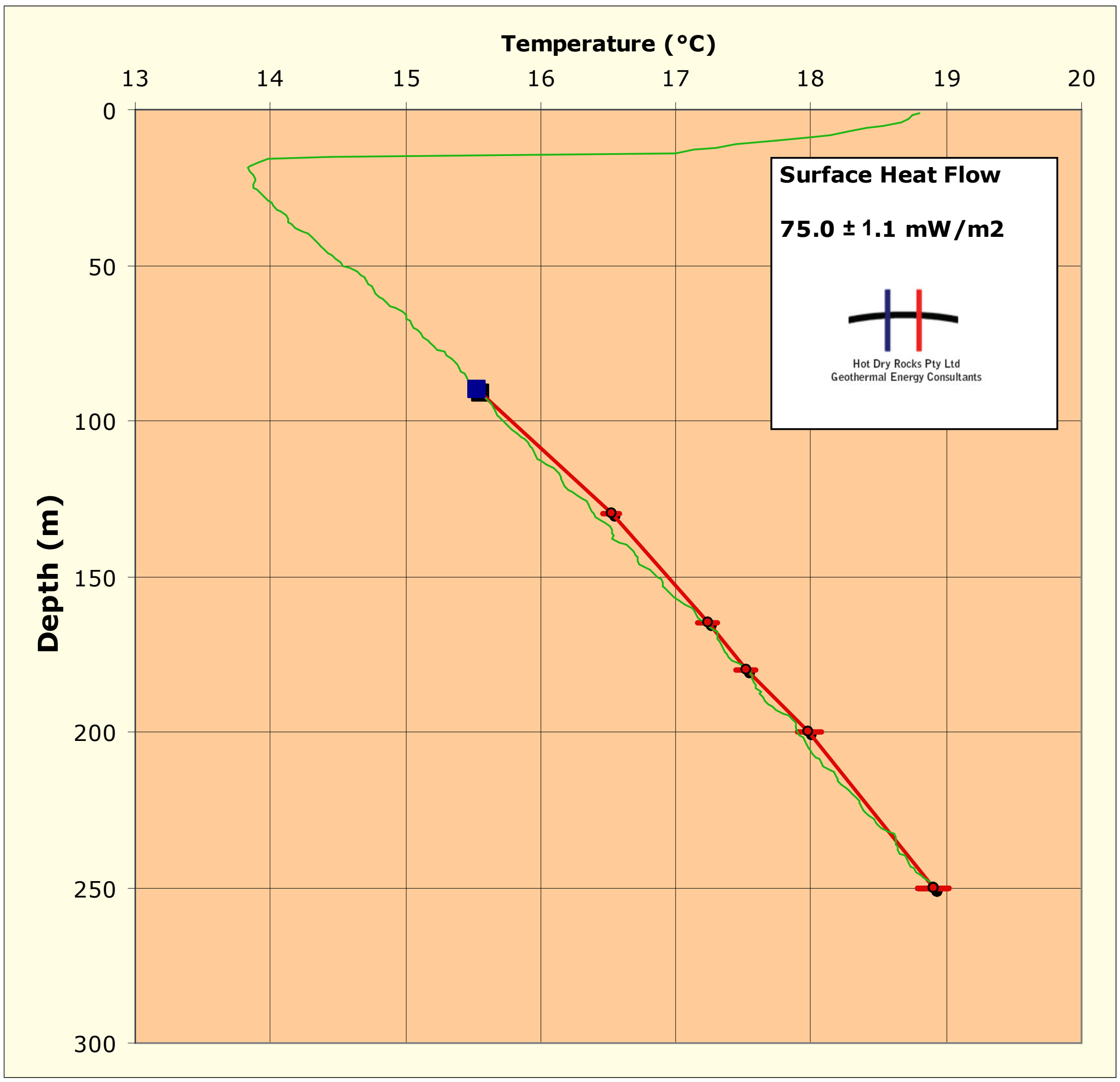

Figure 4. Weymouth 1 – Red line is the modelled temperature profile for the stated heat flow and measured rock thermal conductivity data. Green line is the measured precision temperature log.

4.0 Comparative interpretation of heat flow data

Modelled surface heat flow values for the four selected wells in SEL26/2005 range from 48 to 86 mW/m^2. Figure 5 illustrates the distribution of heat flow data modelled in this report with respect to those values presently available for all of Australia within the *Global Heat Flow Database*. Two of the wells modelled in this report have surface heat flow values that are within the top 40% of heat flow values for Australia in the *Global Heat Flow Database,* one approximates the Australian median and the other displays an anomalously low value that is most probably attributable to lateral advective heat transport via permeable lithologies or fractures below the base of the shallow well.

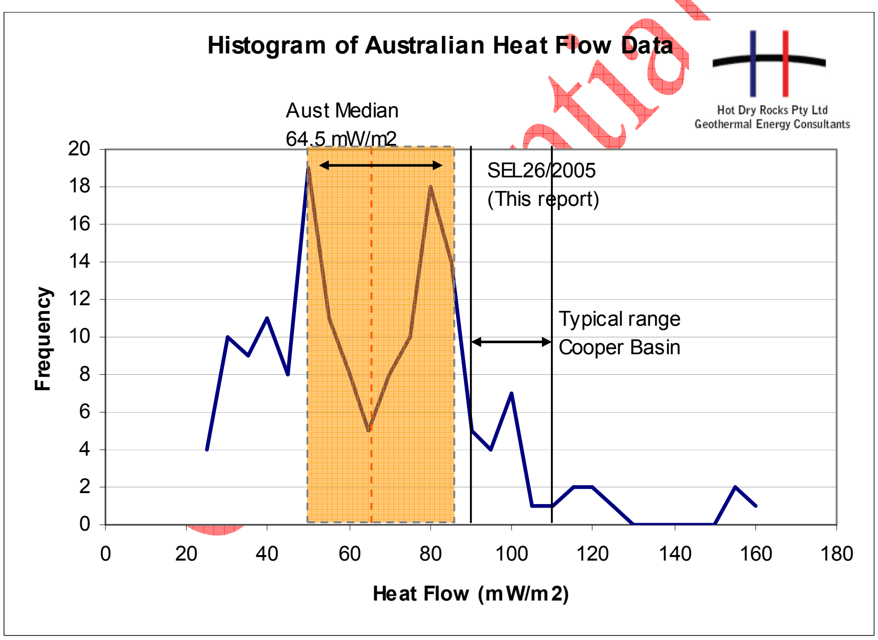

Figure 5. Distribution of Australian heat flow data from the Global Heat Flow Database showing relative position of values commonly reported for the Cooper Basin (South Australia) and values modelled for the four wells of this study.

5.0 Conclusions and recommendations

Modelled conductive surface heat flow values for the five selected shallow wells in SEL26/2005 in this report range between 48 and 86 mW/m^2. Overall the results are regionally consistent with previous heat flow data calculated for the tenement, although Beaconsfield does display a heat flow above that of the wells to the east of this location.

The following recommendations are presented for KEN's consideration:-

- Undertake a review of all heat flow data received to date and determine the benefit that could be gained from infill drilling to increase the spatial density of available quality heat flow data within the main target area to further define surface heat flow patterns.
- Drill wells that display anomalously low heat flows (ie Rocherlea) to greater depths to determine the depth and nature of the probable advective influence below the current final depth of the well.
- Model deep 1D heat flow projections of selected areas based on data presented in this and earlier reports and using stratigraphy derived from regional reflection seismic data and/or geological cross-sections and maps. This modelling should also consider thermal resistance risks associated with anisotropy. This process would provide preliminary projections of temperature at depth.
- Consideration be given to the likely temperature of the target reservoir based on the above modelling work as well as the hydromechanical properties of that reservoir with respect to reservoir stimulation under in-situ stress.
- Undertake 3D heat flow modelling to better model any possible refractive influences and thereby better constrain the lateral variations in heat flow observed from the 1D modelling undertaken to date.