Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 125 (2017) 571–579

Energy Procedia

www.elsevier.com/locate/procedia

European Geosciences Union General Assembly 2017, EGU Division Energy, Resources & Environment, ERE

Multivariate regression model from water level and production rate time series for the geothermal reservoir Waiwera (New Zealand)

Michael Kühn[a,b,*] and Tim Schöne[b,c]

[a]*GFZ German Research Centre for Geosciences, Fluid Systems Modelling, Potsdam, Germany*
[b]*University of Potsdam, Earth and Environmental Science, Potsdam, Germany*
[c]*Free University Berlin, Department of Earth Sciences, Berlin, Germany*

Abstract

Water management tools are necessary to guarantee the preservation of natural resources while ensuring optimum utilization. Linear regression models are a simple and quick solution for creating prognostic capabilities. Multivariate models show higher precision than univariate models. In the case of Waiwera, implementation of individual production rates is more accurate than applying just the total production rate. A maximum of approximately 1,075 m^3/day can be pumped to ensure a water level of at least 0.5 m a.s.l. in the monitoring well. The model should be renewed annually to implement new data and current water level trends to keep the quality.

Peer-review under responsibility of the scientific committee of the European Geosciences Union (EGU) General Assembly 2017 – Division Energy, Resources and the Environment (ERE).

Keywords: geothermal reservoir; water management; data based model; multivariate regression; coefficient of determination; scenario analysis

1. Introduction

The geothermal water reservoir below the village of Waiwera is located about 40 kilometres north of Auckland on the Northern Island of New Zealand (Fig. 1A). Increased water temperatures are observed in an area of approximately 1 km^2 (Fig. 1B). Since 1863, commercial and private use supplies hotels and spas with water of

* Corresponding author. Tel.: +49 331 288-1594; fax: +49 331 288-1529.
E-mail address: michael.kuehn@gfz-potsdam.de

1876-6102
Peer-review under responsibility of the scientific committee of the European Geosciences Union (EGU) General Assembly 2017 – Division Energy, Resources and the Environment (ERE).
10.1016/j.egypro.2017.08.196

50 °C. Until the end of the 1960s, the warm water flow was artesian from all wells drilled. Due to overproduction, water needs to be pumped up nowadays and the hot springs on the beach ceased [1]. Consequently, in the early 1980s, the "Auckland Regional Water Board" (today Auckland Council) deployed a water allocation and management plan to enable a sustainable utilization of the resource [2]. Beside others, the management plan demands that the water level in the official and appropriate observation well of the council (no. 74 in Fig. 1C) is 0.5 m above sea level throughout the year in average. This guideline aims to preserve the resource, preventing intrusion of cold ground- and seawater into the reservoir.

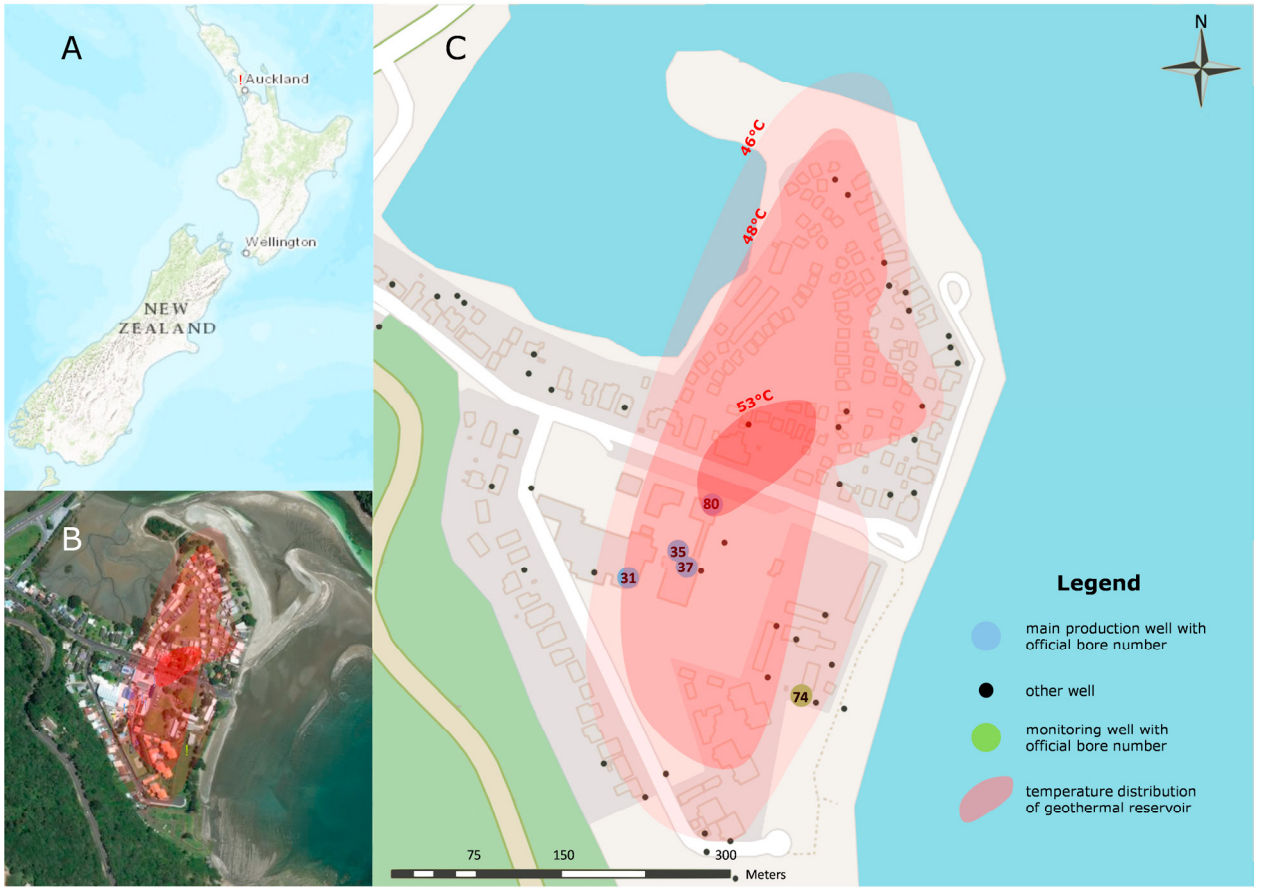

Fig. 1. Location of Waiwera around 40 km north of Auckland on the Northern Island of New Zealand (A). The satellite image shows the village on the south bank of the estuary of the Waiwera river on a flat peninsula (B). The street map indicates locations of the main production wells (blue dots), smaller wells of mainly private users (black dots), the monitoring well (green dot) and the approximate temperature distribution (C).

Water management tools are essential to ensure the conservation of natural resources. They are based on simple mathematical equations [2] or complex, computer based simulation models [1] and are used to determine water quantity and quality or to give insides about underlying processes governing the system. In order to use model outputs for regulation, they need to be scientifically accurate and robust [3]. For a sustainable water management, it is necessary to be able to forecast the water level as a function of the production rates in the production wells. A previous study showed that the best predictions for Waiwera were provided by a multivariate regression model of the water level and production rate time series taking into account the production rates of individual wells [4].

The work presented here is based on data sets of almost three decades (since 1986) of metred water production rates from the Waiwera geothermal reservoir and resulting water levels in the official observation well 74 [5,6]. We