Modeling of Stockton University Geothermal System Using COMSOL Multiphysics® and the Subsurface Flow Module

G. Villaluna[1], S. Pal[1], M. Sharobeam[1]

1. Stockton University, School of Natural Sciences and Mathematics, Galloway, NJ, USA

Introduction: Stockton University has one of the largest closed loop geothermal system in North America. It provides heating and cooling for about 410,000 square feet of academic facilities. The well field of the geothermal system comprises of a grid of four hundred wells bored to a depth of 130 m over an area of about 11,000 m^2. The well field is buried under one of the university's main parking lots. The ground for the well field is composed of three aquifers of saturated sand sandwiched between confining beds and transition layers of sand and clay. Underground water flows in the aquifers at a speed of 3 to 4 in/day. See figure 1 for the details of the well field. Because of the regional climate, the amount of heat delivered to the ground during the hot season is higher than the amount of heat extracted from the ground during the cold season. This can cause the warming up of the ground and may result in long term thermal and biological impacts on the ground and the aquifers.

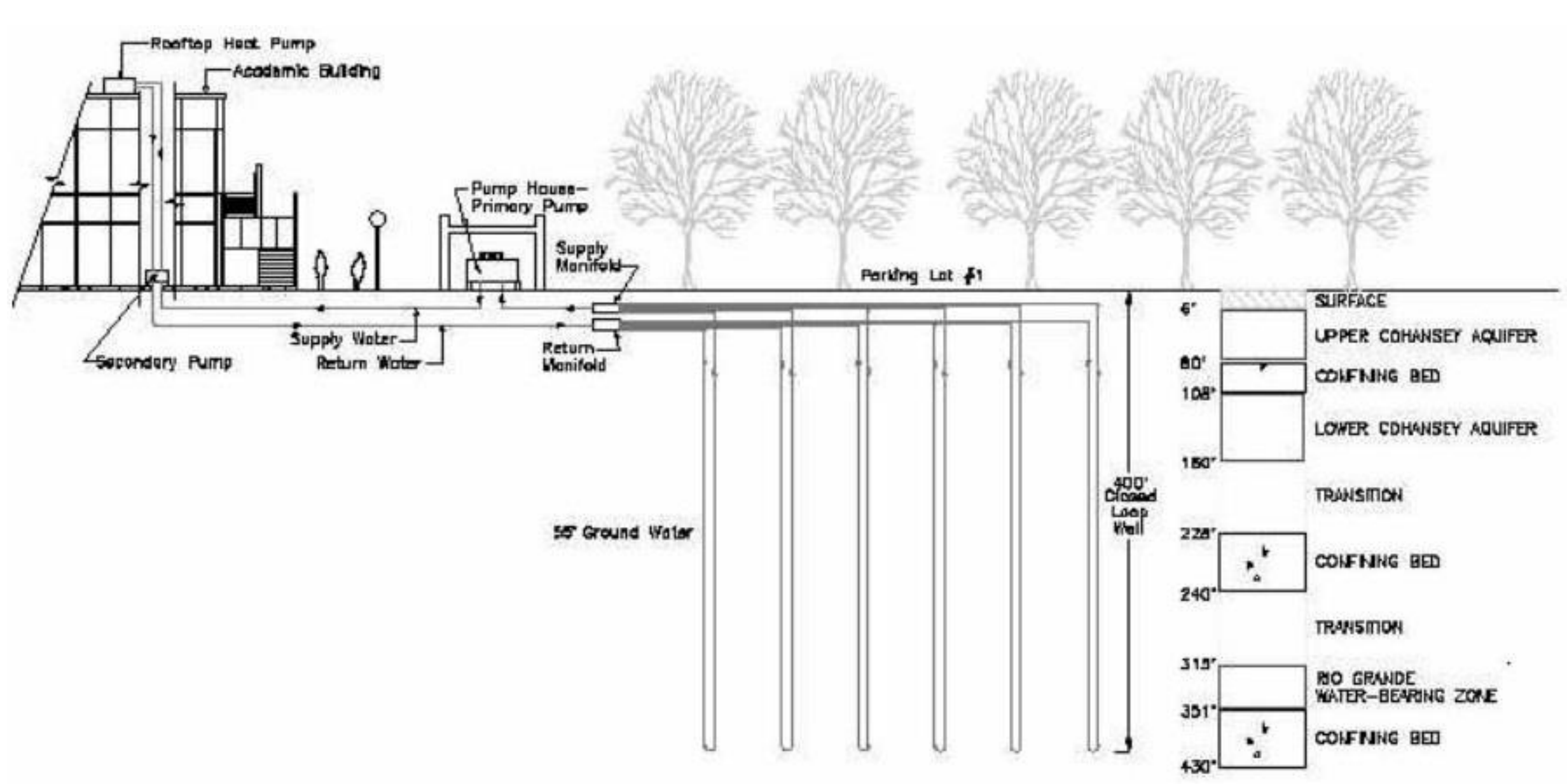

Figure 1. Stockton University's Geothermal System

Computational Methods: Two models (I & II) are developed for this study. Both models use COMSOL subsurface module to model the heat transfer in the porous media with Darcy's law to model the underground water flow in the aquifers. Model I assumes a ground surface with constant temperature while model II includes, instead, a layer of moving air on the top of the ground surface. The later uses also the laminar flow module to model the air layer. Figure 2 shows the geometry for both models.

To capture the heat variation due the underground water flow, the model is stretched in the direction of the underground water flow (y-axis) and includes all ground layers as defined by the hydrogeological analysis of the well field ground. The small rectangular box in the image is the well field.

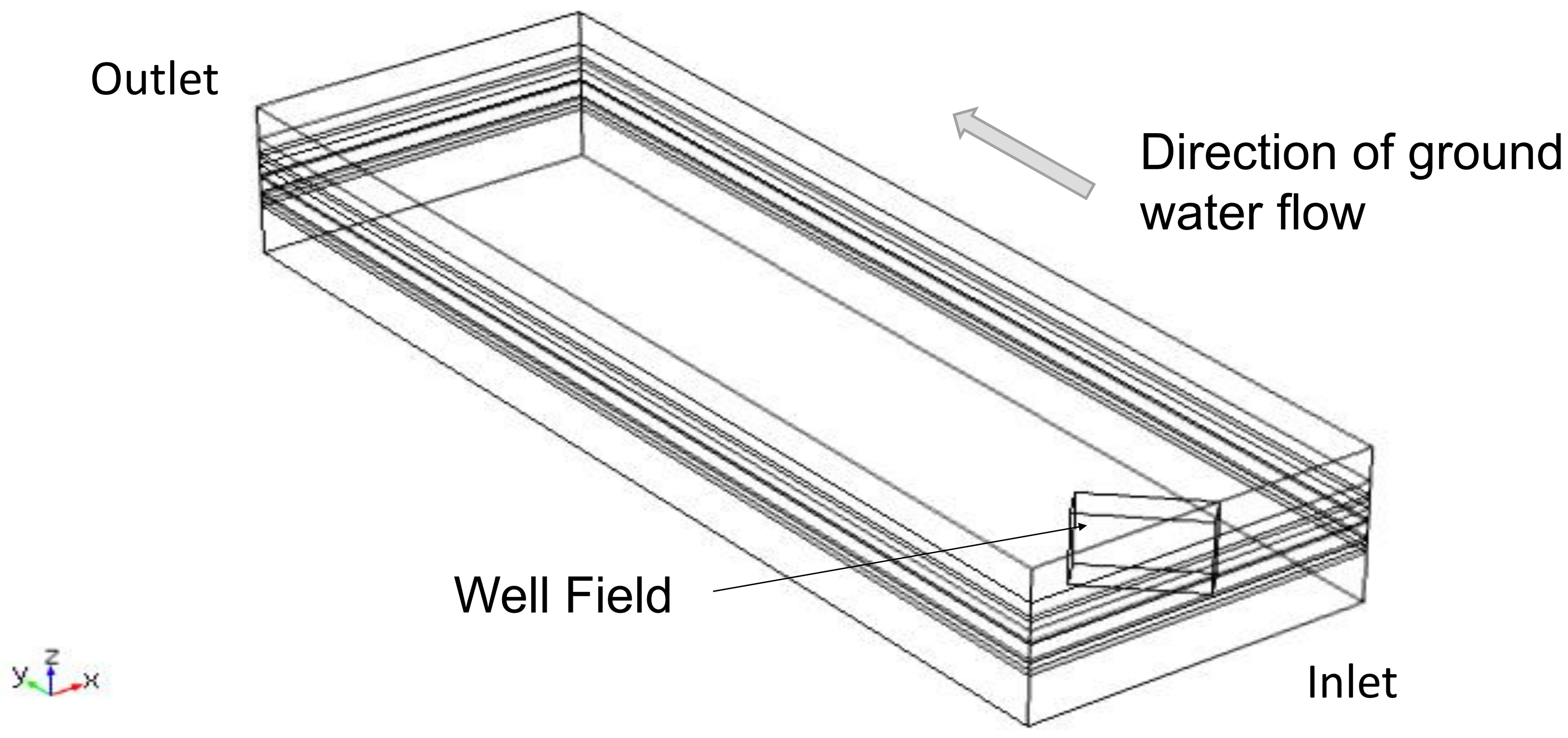

Figure 2. Stockton University's Geothermal Model

Results: Figures 3 and 4 shows the temperature variation on the mid plane for the two models. Figures 5 and 6 show the temperature distributions on multiple planes perpendicular to the direction of the ground water flow for both models. Figures 7 and 8 show line graphs for the temperature variation with depth (z-axis) at different distances from the well field starting from its edge.

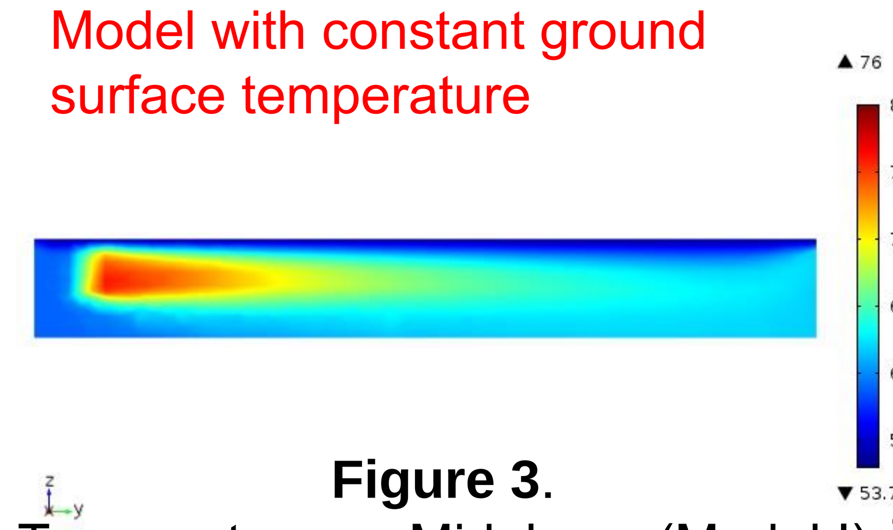

Figure 3.
Temperature on Midplane (Model I)

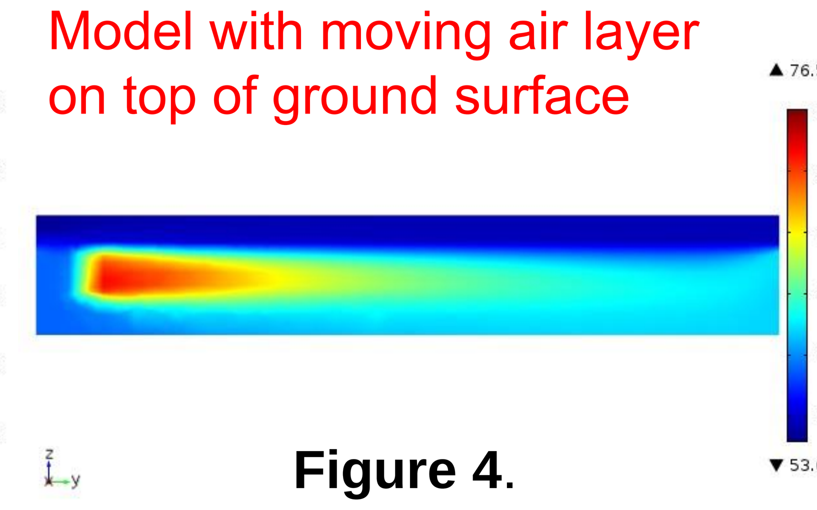

Figure 4.
Temperature on Midplane (Model II)

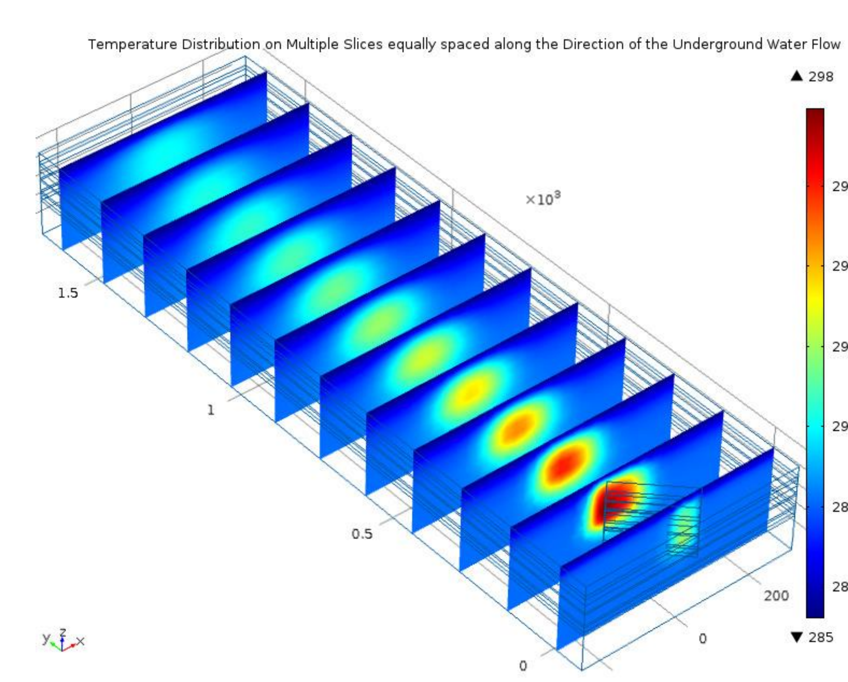

Figure 5.
Temperature on Multislice (Model I)

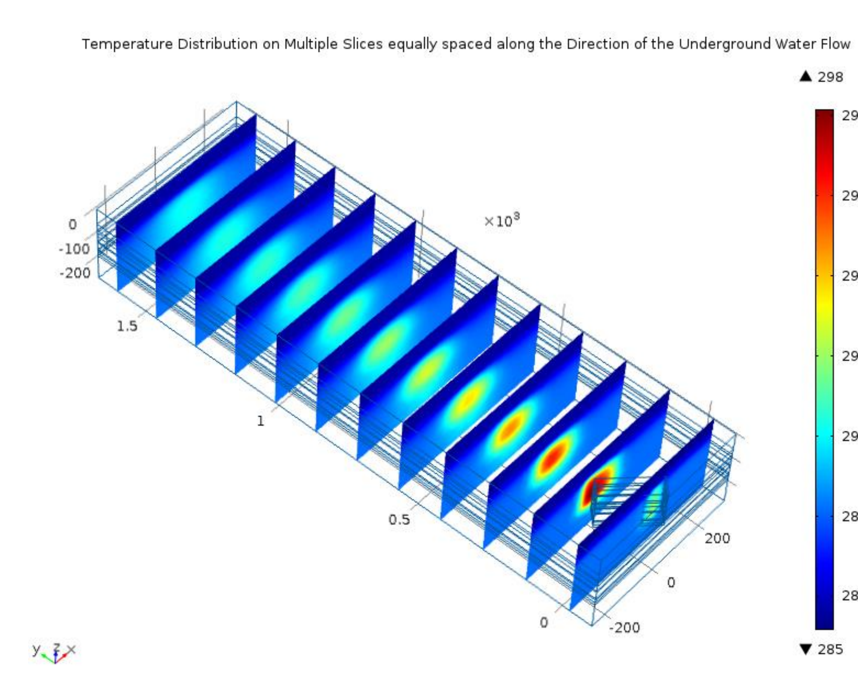

Figure 6.
Temperature on Multislice (Model II)

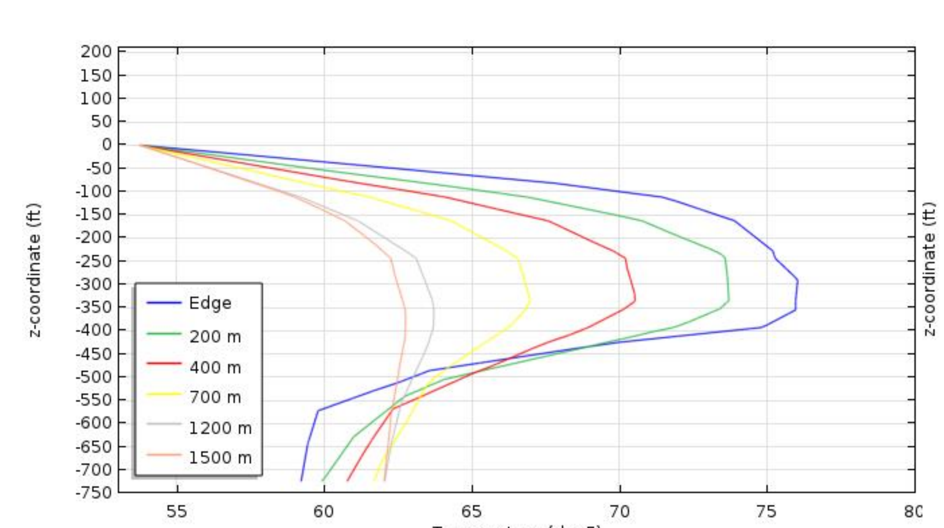

Figure 7.
Temperature Line Graph (Model I)

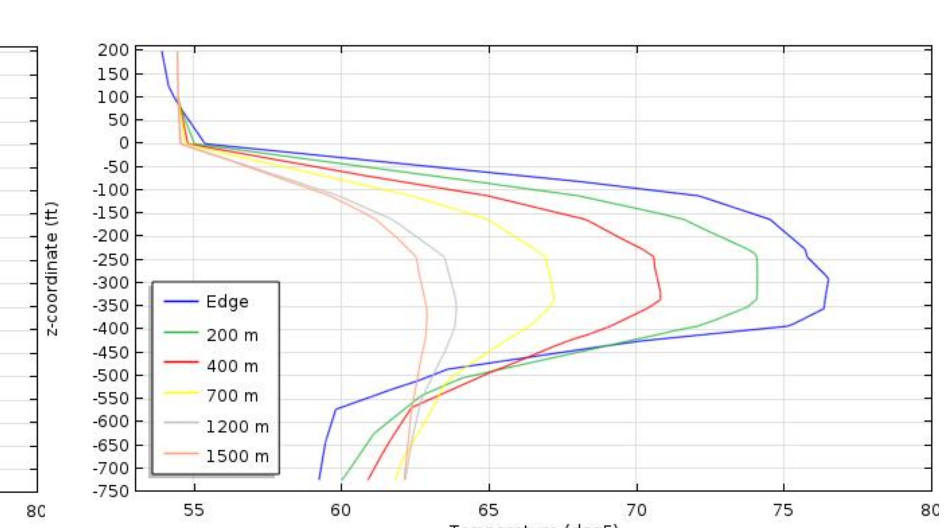

Figure 8.
Temperature Line Graph (Model II)

Conclusions: The study presented a computational approach to analyze large size closed loop geothermal system. The two models in the study provided similar results which makes the one with constant surface temperature more practical to use in modeling similar systems. We expect to expand the study to transient behavior of the field where the surface temperature is represented by a time varying function and the heat source/sink is modeled with a seasonal depended function.

References:

1. Pal, S.,L. Stiles, C. Mowbray, Simulation of Stockton well field using Lund model, *The Second Stockton International Geothermal Conference Proceedings*, 226-75. (1998)
2. Eskilson, P., *Super Position Bore Hole Model*, Department of Mathematical Physics, University of Lund, Sweden. (1986)