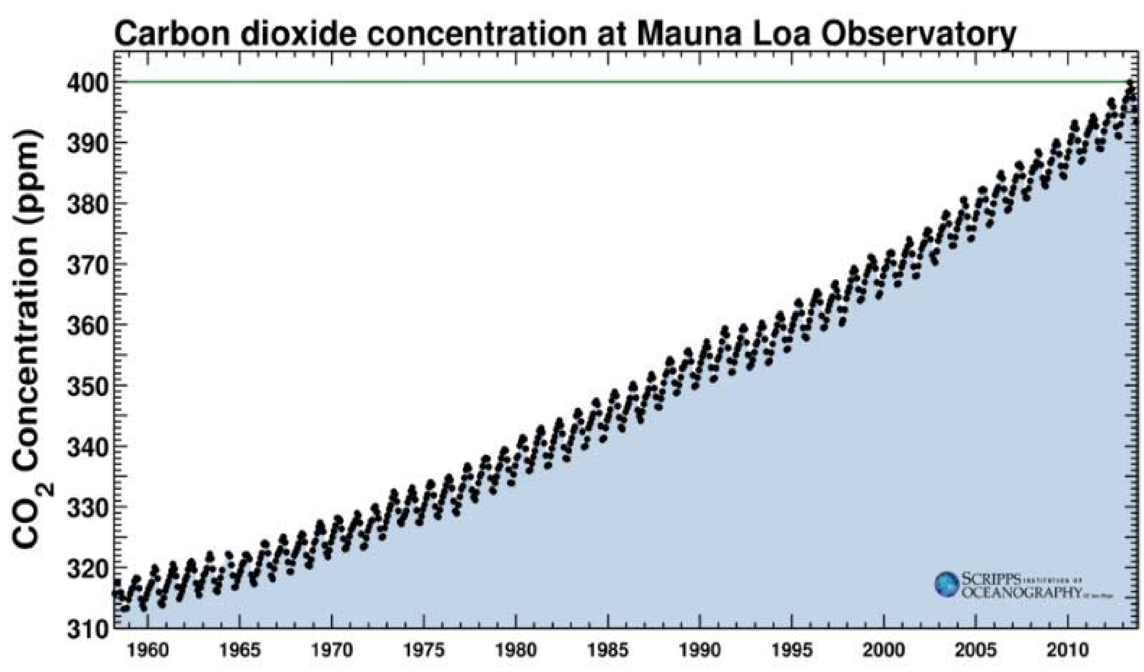
GLD Skill Booster #5:
Climate Change and Loopfield Performance

The GLD Skill Booster Series is a series of documents that guide you through the process of performing a specific task in GLD. This particular Skill Booster focuses on a thought experiment rather than a specific GLD skill. This thought experiment is related to climate change and its influence on geothermal loopfield performance.

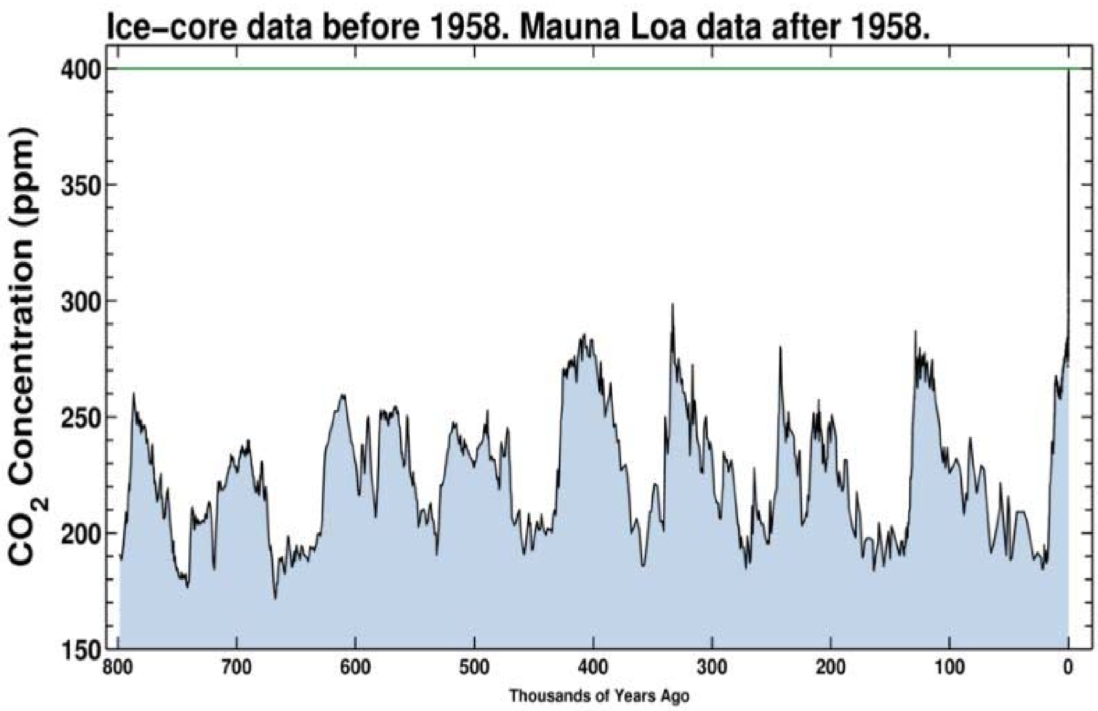
More specifically, the purpose of this Skill Builder is to encourage building energy simulation modelers and geothermal designers to being thinking about what will happen to the heating and primarily cooling requirements of buildings and to the loopfield temperatures as day and night outside air temperatures increase in the future.

The fundamental science of climate change is fairly well understood regarding climate change. While many details remain to be worked out and no doubt, surprises remain on the scientific horizon, the basic concept of human-induced climate is accepted by basically all scientifically literate people across the globe. Predicted temperature increases vary depending on predicted greenhouse gas (primary CO^2) emissions scenarios.

CO^2 emissions trends and total atmospheric CO^2 concentration over the last half century are easily discernible in the famous Keeling Curve:



With a longer longitudinal ice core-based data set, it becomes clear that the last half century of human-induced CO^2 emissions have been quite dramatic on overall CO^2 concentration as can be seen in the next chart.



There is broad agreement among the climate science community that these emissions are driving climate change. In the 2013 IPCC report, the summary states that “it is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century.”

The amount of climate change will be dependent on future emissions. Minimum estimates predict an average global temperature increase of 2˚C. Higher estimates range as high as 6-8˚C, a temperature increase that will likely not be conducive to human civilization as we now know it (which frankly is quite disturbing).

The take home message for geothermal designers is the following: the energy models we create for predicting building heating and cooling loads are based on historical weather data. Historical weather data however are insufficient because future climate and temperature patterns will be different from historical ones. As geothermal designers, we need to assume that the heat rejection needs of our loopfields will be greater than predicted based on our current generation of building energy and loads modeling tools.

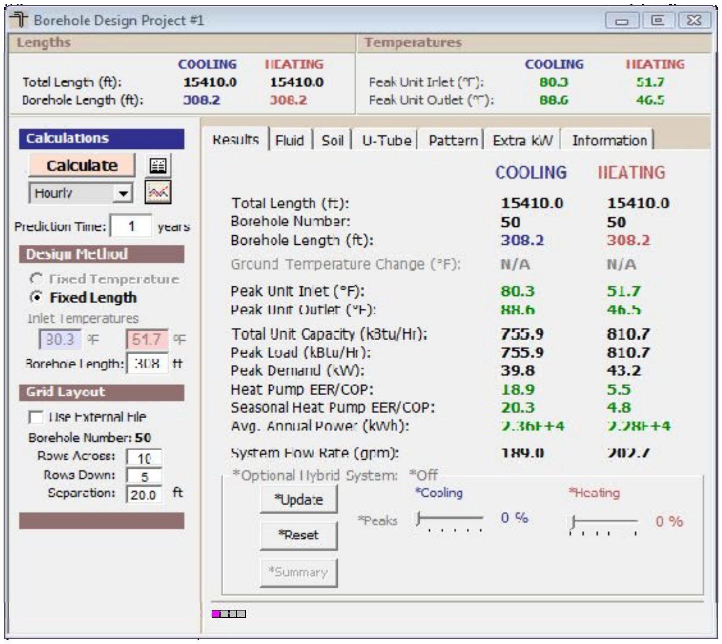
Let’s see what GLD predicts for hourly loopfield temperatures in June/July under several different scenarios. Note that the scenarios should be considered as conceptual demonstrations only for a 40,000 sq ft office building. The three scenarios are described as follows:

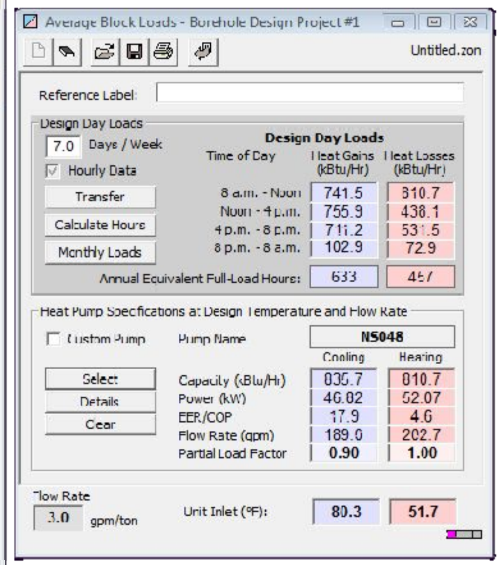
SCENARIO	DESCRIPTION
SCENARIO 1:	Baseline loopfield temperatures in the month of July
SCENARIO 2:	Loopfield temperatures under two week heavy heat wave scenario (similar to a heat wave in summer 2013 in which nighttime temperatures did not drop below 80˚F)
SCENARIO 3:	Loopfield temperatures under climate change temperature-based scenario and two week heat wave. Climate change induced increase is 9.8% overall.

Each of these scenarios is then input to Ground Loop Design for simulation and analyzed for the resulting temperature profiles as shown in the following screenshots:

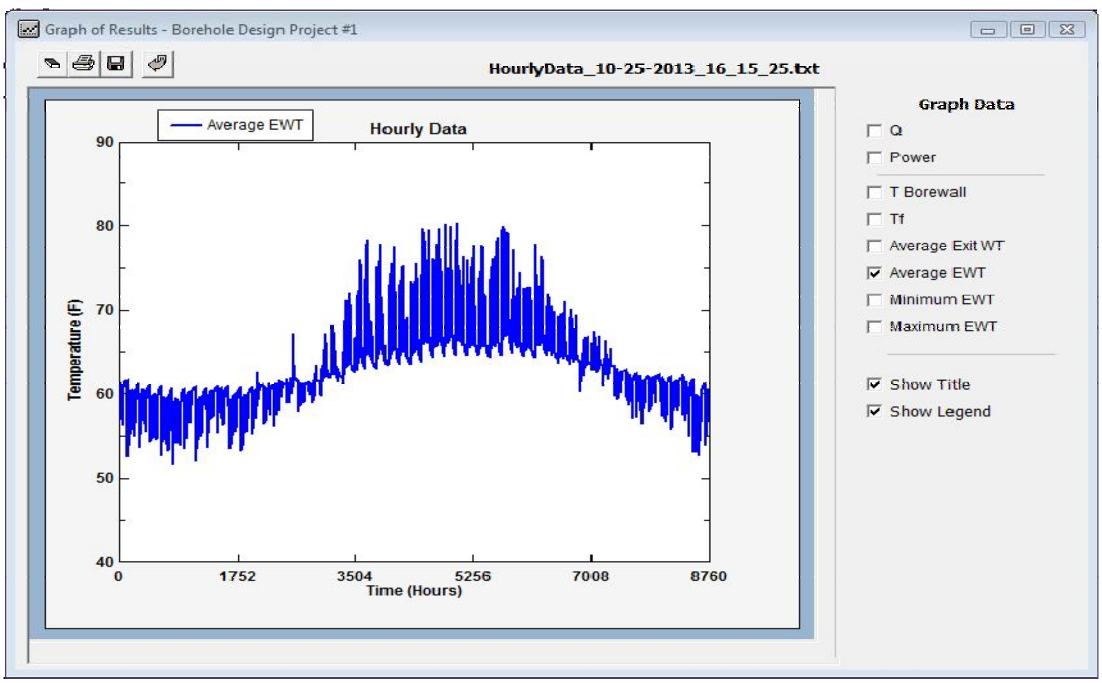
Scenario 1 – Baseline loopfield temperatures in the month of July as Modeled in GLD

Conditions:



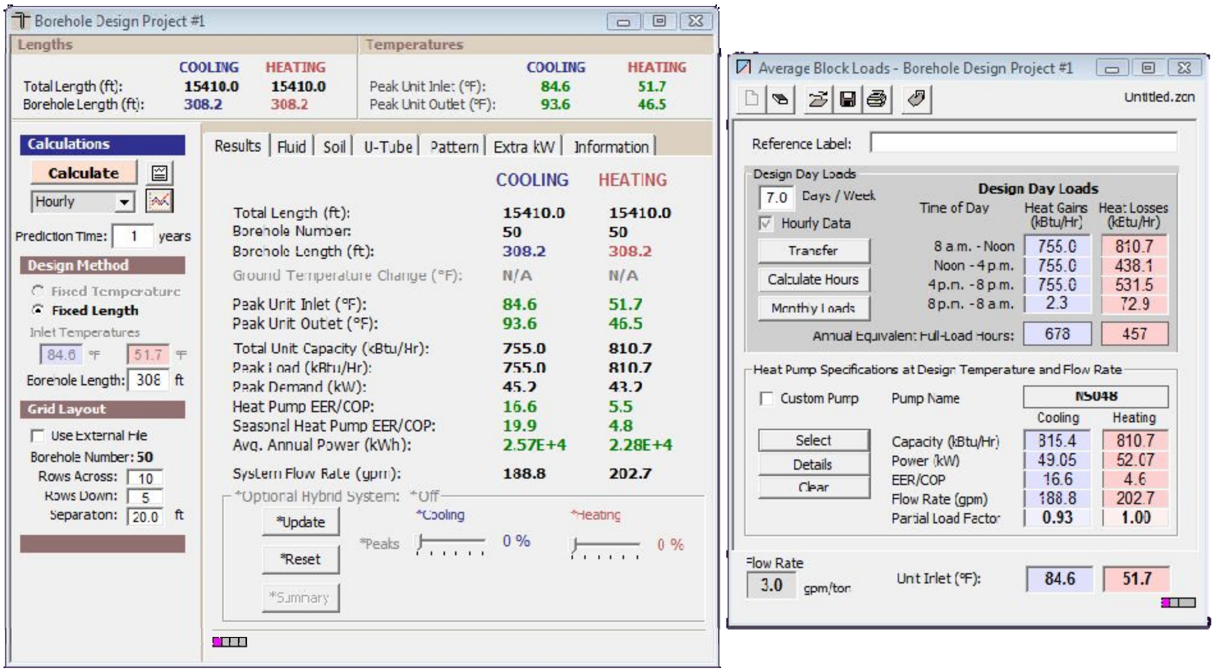


Scenario 1 Results Graph:

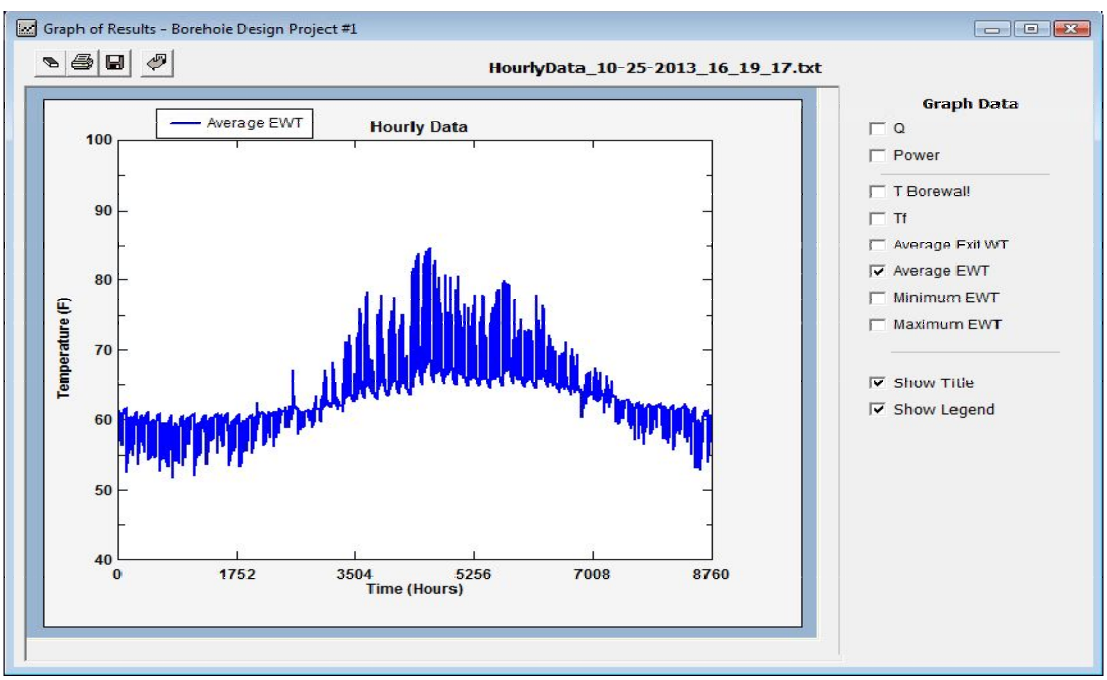


Scenario 2 – Loopfield temperatures under two week heavy heat wave scenario (similar to a heat wave in summer 2013 in which nighttime temperatures did not drop below 80˚F) as Modeled in GLD

Conditions:

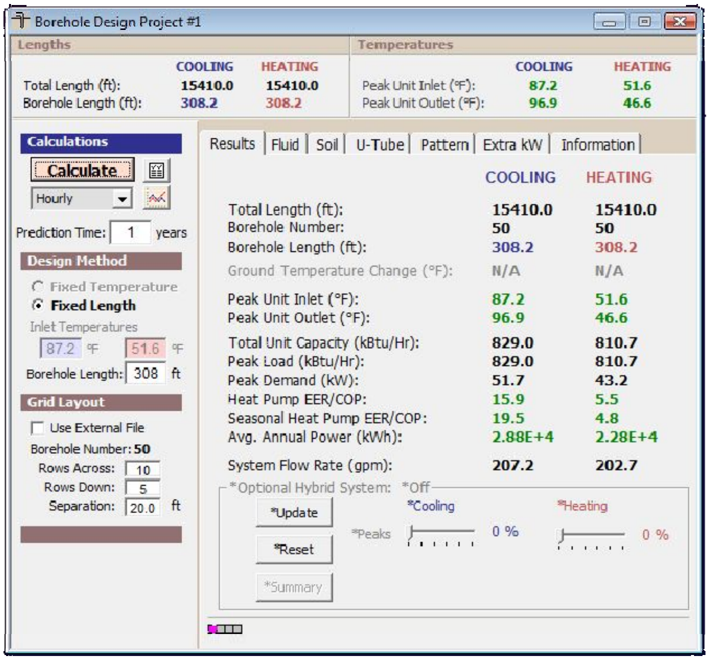


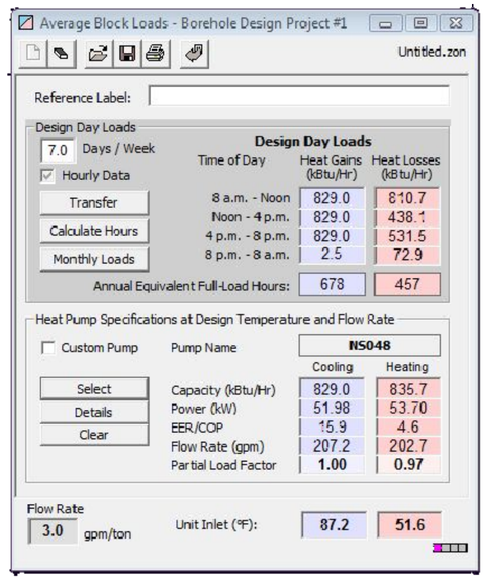
Scenario 2 Results Graph:



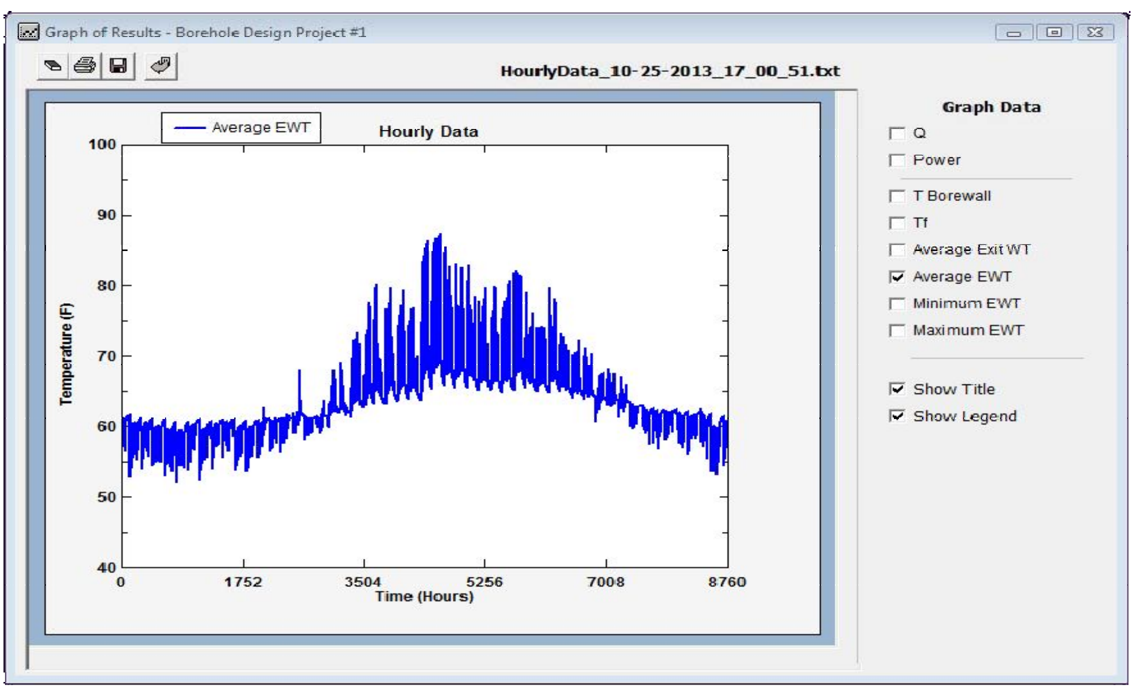
Scenario 3 – Loopfield temperatures under climate change temperature-based scenario and two week heat wave. Climate change induced increase is 9.8% overall as Modeled in GLD

Conditions:

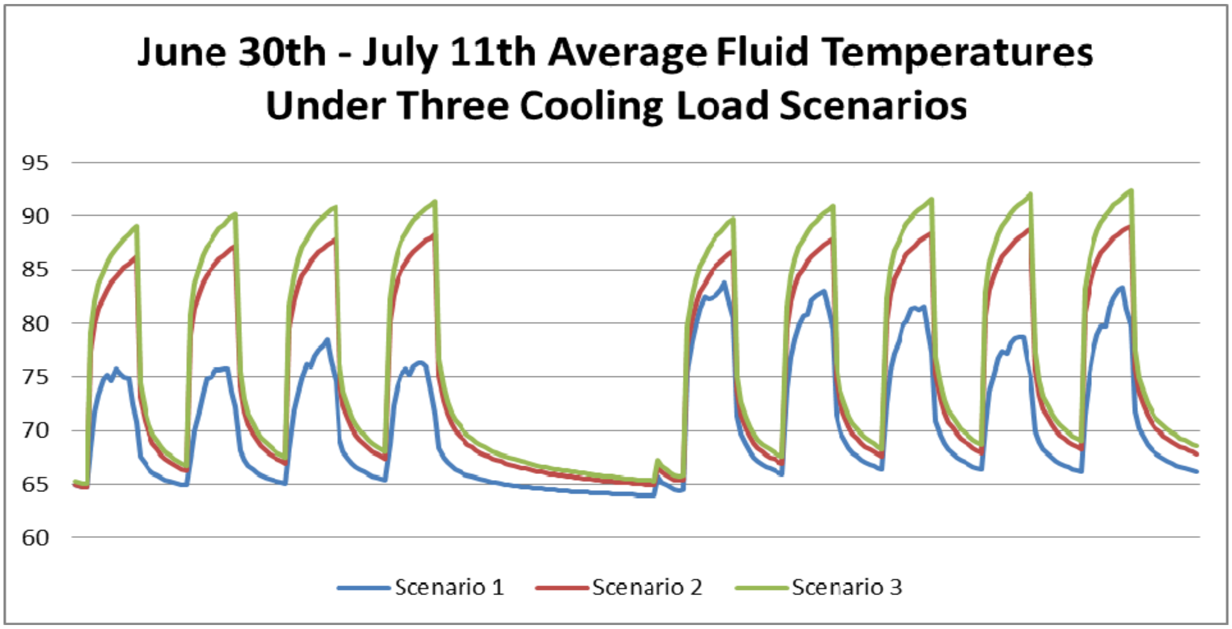




Scenario 3 Results Graph:



The graph below directly compares the average fluid temperatures (average of entering and exiting temperatures) of the three scenarios.



It becomes clear that in scenarios 2 and 3 the average fluid temperatures are 10˚ to 15˚F warmer, respectively, than those in scenario 1. Over the short term with this particular design, the temperature increase results in reduced performance. Over the longer term, one can imagine increased challenges for the loopfield. The take home message is that as the climate warms on average, cooling loads will increase, heating loads will decrease and sustained heat waves will become more common. Designing loopfields for the historical climate rather than the future climate is a risk-fraught endeavor, an endeavor that will negatively impact loopfield performance in many instances.