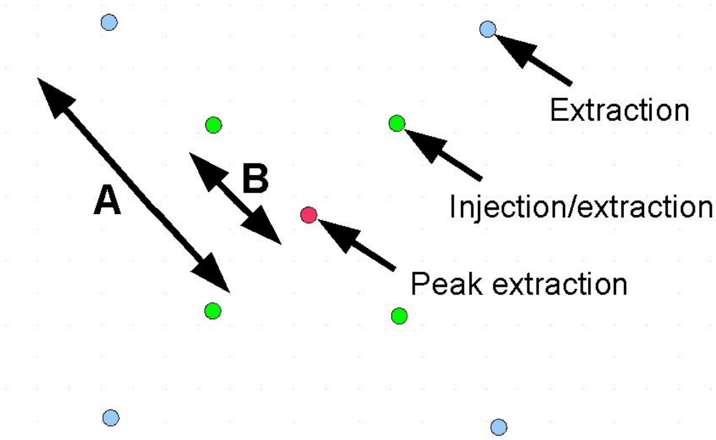
AE borehole layout

The image below shows the layout of a 9-hole AE assembly in which the central heat exchanger (Red) is used to supply heat during the coldest nights of the year, the intermediate (Green) exchangers are used for injecting heat in the summer and for extracting heat in the second half of the winter, and the outer exchangers (Blue) are used for heat extraction only.



The broad objective is to provide a reasonably constant heat storage capacity for a variety of rock types. The size of the storage field (Dimension A plus about 2 metres) is adjusted to meet that requirement. For rock types that have high thermal conductivity the injection holes can be bunched close to the centre, with sufficient spacing to ensure that they do not materially interfere with each other. For rock types that have lower thermal conductivity the injection holes will need to be located closer to the extraction holes

The table below lists the thermal properties of various rock types. **CAUTION:** the values for A and B are initial suggestions only, based primarily on using the diffusivity as a guide to determining the size of the storage field and the distance between the injection and extraction boreholes. It would be appreciated if anyone who builds such systems would report their experiences for various rock types so that the values for A and B can be based on experience with working systems rather than on a theoretical assumption.

Borehole depth The value used for the AE-Street descriptions was 130 metres and the output power capacity calculation was based on a collection of 110 watts per metre of depth (assuming that the top two metres are ineffective). Note that you cannot achieve such a high collection capacity with conventional U-tube heat exchangers. You will need a quad heat exchanger (or equivalent) that minimizes thermal short circuiting and that creates a vertical temperature gradient to improve the heat exchange efficiency with the ground. The thermal conductivity of the grout is particularly important in achieving high power capacity.

High grout conductivity is particularly important for the five central heat exchangers. Such grout is expensive but if possible it should be used at least for these holes, which need to inject and/or extract heat at a high rate for relatively short periods.

While heat is being injected in the summer the temperature profile peaks strongly at the injection points. However, during the fall the profile slumps so that the temperature is uniform throughout the storage field so the design issue is to control the diameter of the “heat pool” to ensure that most of the injected heat can be recovered.

When the heat is being extracted the temperature at the extraction holes will drop well below the ambient ground temperature so that part of the heat is being supplied by the ground's ambient heat. Normally a substantial amount of that ambient heat is borrowed and is subsequently replaced by heat injected in the late winter or spring. That meets the system objective of balancing the annual heat inflows vs. the extraction.

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Rock Type	Diffusivity (m^2/sec)	Density (g/litre)	Specific Heat (cal/g-deg)	Capacity/Volume	A (metres)	B (metres)
Quartzite	0.255	2643	0.170	449	5.5	1.2
Sandstone	0.143	2323	0.190	441	5.5	1.2
Granite	0.086	2961	0.190	563	5	2.5
Limestone	0.091	2611	0.200	522	5	2.5
Basalt	0.059	3011	0.200	602	4.5	2.25
Shale		2675	0.265	696	4.5	2.25