Spire Renewables
Simplifying Sustainable Heating

These Guidelines have been set out to give an installer a better understanding of the common problems and space requirements of designing a vertical ground array. The responsibility of ensuring this design is correct will always remain in the hands of the Installer.

Spire Renewables accepts no responsibility for the actions of personnel using the information contained in this manual, or any damages or costs arising from such use.

Basic Overview

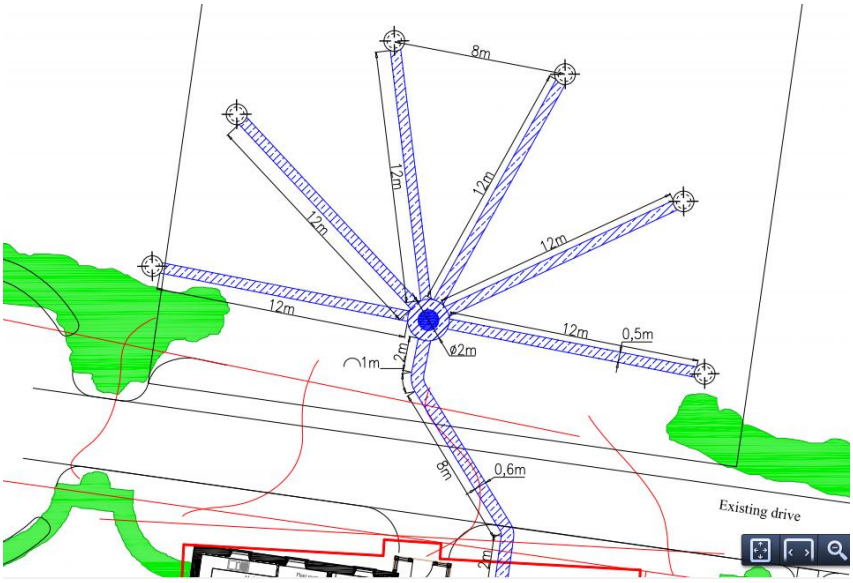
If you do not have the land to install a horizontal array (this document assumes you have read the horizontal guidelines for more information on this), you will need to use boreholes, where the loops are run vertically down, one per borehole into the earth. The drillers will open a 6"-8" hole down the required depth then insert a pair of pipes with a pre-made U bend on the end down to the bottom. The borehole will then be filled with a grout to increase thermal conductivity. Due to slightly higher sustained ground temperatures at depth you can generally get away with less collector pipework than is needed for a horizontal array. As a standard this is normally around 33% less, however it can vary dramatically depending on ground conditions, which we will go into more detail below.

The ground array for a ground source heat pump is essentially its fuel source. Its design is 100% critical to the success of the installation. There must be sufficient pipe buried in the ground, and that pipe must be spread over a large enough area so energy extraction is sustainable. Energy used in the property cannot be extracted from the ground over time in greater quantities than is returned to the ground from solar irradiation or rainfall, otherwise the net ground temperature will drop resulting in the heat pump eventually failing.

A vertical ground array consists of four main components (please see the overleaf diagrams explaining this further):

1. **The Collector Array** – A number of 40mm loops that run in individual boreholes; drilled 6" to 8" wide and at least 150 metres deep. These collect the bulk of the energy from the ground. The boreholes should be set at least 8m apart to avoid thermal intereference
2. **The Header** – an open area (normally 3-4m wide) set at the **centre of the ground array** so that the collector loops can be separated from one another as much as possible on their way back to the manifold. All of the boreholes of the collector array are linked back to the manifold.
3. **The Manifold Pit** – Each of the loops of the borehole array run back to an individual pair of ports on the manifold pit. This is normally sat centrally in the open header. Each port of the manifold has a flow gauge and adjustor to enable flow to be balanced across the array. The manifold pit must sit higher (or at least on a level) than the pipes out to the collector array to allow for air venting (automatic air vents are supplied with the manifold).
4. **The Flow and Return** – The main pair of pipes running from the manifold and pit to the plant room. They are hypothetically the warmest and coldest pipes of the array so should have at

least a minimum of a metre separation and be buried a meter underground either in a single meter wide trench or a pair of 300mm slot trenches. The diameter of these is dictated by the length of run from the plant room to the manifold pit (we can help with these calculations). If these pipes pass over a significant high point between the manifold pit and the plant room (both of which are vented) it may be necessary to install additional vents at this point too.



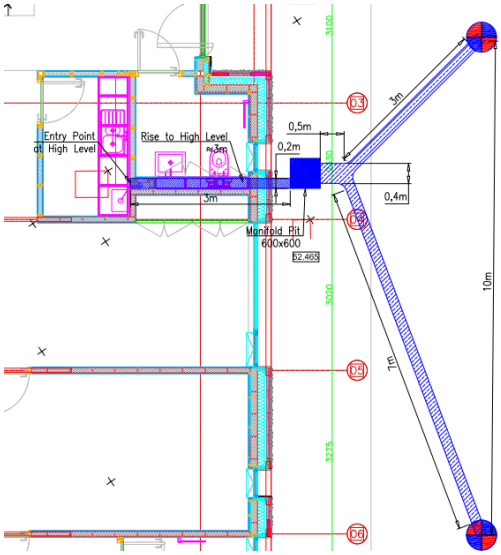
We would recommend that (Please see listed the drill partners we have experience working with below) your chosen drillers seek professional advice for the number and design of the array based on groundwater table and the thermal conductivity of the strata below the site. This should provide an accurate calculation for the depth of borehole required. Tim Baker at BAHS provides an affordable service that can provide these details.

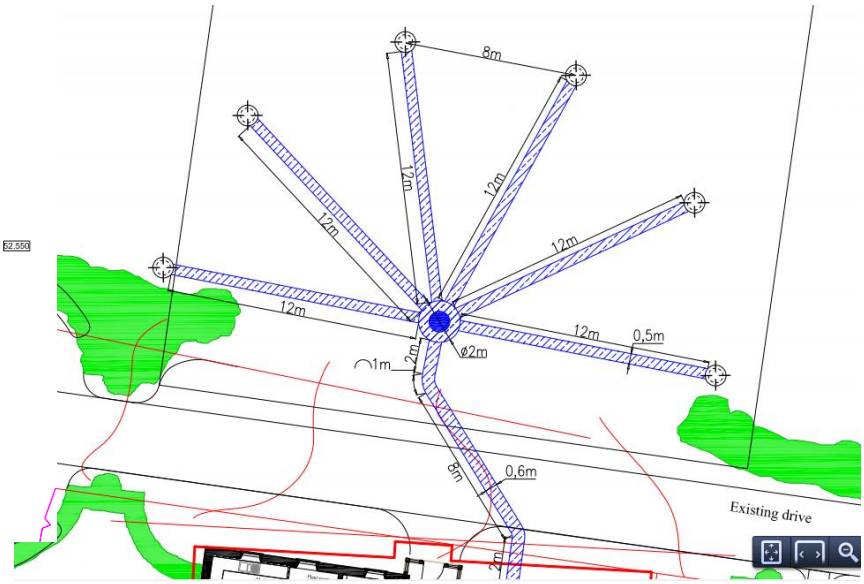
We would recommend that boreholes are drilled in as small a number but as deep as possible, up to a maximum of 150m. The reason for this is as follows. The majority of energy supplied to a horizontal array comes from solar irradiation and energy from the water falling as rain passing over the array. A boreholed array does not have the surface area that a horizontal one does, so the only way to recharge it is through groundwater movement.

It is therefore critical that the array passes into the water table, in order for this energy to be supplied to the borehole. Companies that suggest that only 60m bores are needed or energy piles (coming 15m out of the bottom of the building) are using flawed logic. If the water table is shallow, fine, but otherwise you will not have any energy supplied to the boreholes.

The boreholes come to the surface as a pair of pipes. These then need to be protected (oil barrel over the top for example) until you are ready to conduct the headering works. This is where each of the boreholes are connected back to a central manifold pit much like the horizontal array above.

Below are layout drawings showing example borehole arrays from plan view.





An array should be designed with the direction of groundwater flow in mind, so that a number of boreholes do not shelter each other from the direction of the flow. As groundwater flow is relatively slow, a number of boreholes in a row will extract energy, leaving the downstream bore with cold flow passing over it. The array should be lined up as much as possible perpendicular to the groundwater flow.

The headering process is much the same as the ground loops above, design the header so pipes can be spaced out close to the pit, then a single pair of flow and returns back to the manifold. Drillers can often conduct those works themselves too, and its normally easier for you to let them do that. Some will also fill the array with glycol too.

Realistically the planning of the array should be left to the drillers, but in advance of their arrival there are normally a few things to consider:

1. Drill rigs are large, trailer sized objects that are awkward to lift. Consider access of the plant to the drill area. They are the tracked vehicles the size of a large car trailer, with approximately 3m height, although some can be lowered. They come with two or three other trailers as support that pump mud down the borehole. Space needs to be considered for these.
2. Drill rigs tend to make a lot of noise. Warn your neighbours and consider the implications of having them block up your site.
3. Drill rigs do produce waste. Review the drillers quote and check what they are dealing with and what is your responsibility. Depending in the geology differing amounts of liquid and solid waste are produced. It makes sense to consider dispensing of liquid waste onsite if at all possible as this is expensive to have removed.

We have a list of preferred drillers that we have a significant amount of experience working with. Please contact us for details of these drillers.

Further detailed information over the physical laying of the array will be provided in our installation manual on purchase of our equipment. This document coupled with the radiator assessment guidelines should provide you with sufficient information to start the design process. If you have any queries arising from this document then do not hesitate to contact us.

Part 4: A further list of key points that have to be considered when designing/ excavating a ground array. Please read them!!!!:

1. **Venting:** The manifold pit and the plant room are the only two places air can escape. Automatic Air Vents should be installed on any natural high point of the ground array. Removal of air can be greatly assisted by a well flushed ground array at installation. 90% of heat pump problems are caused by air blockages on either the heating or ground side!!! In order to ensure the manifold is positioned at a natural high point it may well mean a long flow and return run. Our standard kits allow for 50m of flow and return pipework, above this length pipe sizing will need to be re-checked for pressure loss. If you need help sizing the flow and return pipework please contact us.
2. **Venting II:** Please ensure that the Collector array loops are not doubled back on themselves (in order to put fewer, longer loops into a short field) if this involves the pipes heading back uphill.
3. **Be Aware of buried services:** Get the client to locate as many as they can before you start, use a cable locator, metal detector and if you are still concerned over their location use a mini digger or hand dig around tight areas. A mini digger will bounce off services a large machine will tear to pieces.
4. **Wet services** In the depths of winter the fluid in the array can get close, sometimes below freezing point. Wherever a wet service is sharing a trench with the ground array (service entry into the plant room for example) please make sure both the heat pump pipework and the service are insulated as much as possible. We would recommend using Armaflex HT insulation or similar. If you have the option separate wet services and ground array pipework as much as possible to avoid the risk of this.
5. **Flat bottoms:** to the trenches and header are essential to avoid broken ankles and the like. Day-by-day risk assessments taking into account weather conditions and the state of trenches should be considered.
6. **Health and Safety:** Open trenches, generator, hand tools etc are clearly all hazards. Make sure the site is aware of your area of work, schedules and machinery.
7. **Trench Routings:** In an ideal world trenches would run straight (just because its easier to dig the trenches and lay/decoil the pipe) as per the layouts above buts its not vital. Trenches can and should be routed around trees or other large items that will be difficult to excavate through.
8. **Submersible Pumps:** If laying pipes into trenches with a high water table or during winter rain a submersible pump is essential.
9. **Margin:** If you will note in the example trench length calculation above, we have left 1-2m of margin on each end of the loop, leaving your trenches 1-2m shorter to make sure you have some play. There is nothing less fun than having pulled your pipe to the end of the

trench only to have to lift it out and pull it back as there is not enough pipe left on one end!!!

10. **Pegs:** Short metal Pegs (or certain types of tent pegs) are handy to pin the pipes apart in the header and to the sides in the trenches. We can supply these as part of the groundworks kit if required. They are essential in sites with a high water table to pin the pipes close to the bottom once the pump stops.
11. **Manifold Pit Location:** Our standard manifold pits come with a pedestrian rated lid. If the only locations is where a vehicular loading is likely, other options are available, please speak to us for more details.
12. **Backfilling the array:** Please communicate to the digger driver laying the array that the area around the manifold pit should be skimmed with sand or blinded topsoil before backfilling. The points where the pipes connect to the loops is around 150mm from the bottom of the pit, meaning it is a natural weak point when backfilling. Please ensure that the pipework is protected before both backfilling and tracking a machine close to the pit.
13. **Sharps:** Whilst the pipework is fairly thick-walled it can be cut by sharp objects in the surrounding ground. If laying pipework through areas of flint, hardcore or other sharp bedrock we recommend the pipe is laid on top of a 150mm bed of sand, screened topsoil or similar, then a further 150mm is laid on top again. This will act to protect the pipes.
14. **Impermeable layers:** The array relies on energy supplied from the sun and rain. Given that in this country we don't get much winter sun, if situated beneath an inpermeable layer one the vast majority of energy that is supplied to the array during the heating season is taken away. If you are to put an array beneath a car park, please make sure that it has a permeable surface so rainwater is still recovered. Burying a horizontal collector beneath a building is not advisable.