Environmental good practice guide for ground source heating and cooling

GEHO0311BTPA-E-E

We are The Environment Agency. It's our job to look after your environment and make it **a better place** – for you, and for future generations.

Your environment is the air you breathe, the water you drink and the ground you walk on. Working with business, Government and society as a whole, we are making your environment cleaner and healthier.

The Environment Agency. Out there, making your environment a better place.

To contact us:

Call: 08708 506 506 (Mon-Fri 8-6)

Email: enquiries@environment-agency.gov.uk

Website: www.environment-agency.gov.uk

Published by:

Environment Agency
Horizon House, Deanery Road
Bristol BS1 5AH
Tel: 0117 934 4000
Email: enquiries@environment-agency.gov.uk
www.environment-agency.gov.uk

Further copies of this report are available from our publications catalogue: http://publications.environment-agency.gov.uk or our National Customer Contact Centre: T: 08708 506506

E: enquiries@environment-agency.gov.uk.

Contents

1	**Introduction**	**1**
1.1	Using this guide	1
1.2	Types of scheme	1
1.3	Environmental risks of GSHC schemes and your role	4
2	**General requirements for GSHC schemes**	**5**
2.1	Assessment of environmental impacts	5
2.2	Environmental risks related to scheme location	5
2.3	General good practice for excavations and drilling	8
2.4	Good practice for borehole completion	11
2.5	Decommissioning	12
3	**Good practice guidance – closed loop schemes**	**13**
3.1	Our approach to closed loop schemes	13
3.2	Liability for pollution from closed loop schemes	13
3.3	Horizontal closed loop schemes	14
3.4	Good practice for pollution prevention	14
3.5	Loop construction and pressure testing of indirect closed loop schemes	16
3.6	Thermal transfer fluid	17
3.7	Direct circulation (DX) closed loop installations	18
3.8	Post installation care and maintenance	18
4	**Open loop schemes**	**19**
4.1	Introduction	19
4.2	General well construction and operation principles	20
4.3	Groundwater investigation consent and abstraction licence	21
4.4	Discharge of water from your scheme	23
4.5	Open loop schemes and contaminated water	25
4.6	Recharge well hydraulic impacts	26
4.7	Pumping of particulate matter	26
5	**Further information**	**27**
6	**References**	**28**
7	**Abbreviations**	**30**
8	**Glossary**	**31**
Appendix A1 – best practice checklist		**33**

Table 1.1	Summary of current permit requirements for different types of water source heating and cooling schemes - closed loop	3
Table 1.2	Summary of current permit requirements for different types of water source heating and cooling schemes - open loop	3
Table 2.1	Site checklist	5
Table 2.2	Geological checklist	9
Table 4.1	Detailed approach to permitting of discharges	24

Figure 1.1	Schematic of open loop GSHC scheme where groundwater is used for heating	2
Figure 1.2	Schematic of horizontal closed loop and vertical closed loop GSHC scheme	2
Figure 2.1	The risk associated with drilling in contaminated ground or groundwater shown in a closed loop system installed in an aquifer (in this case a sandstone), but the same concerns would apply to an open loop system	8
Figure 2.2	The risks associated with drilling in a multiple aquifer situation. A closed loop system installed through several aquitards (such as clay) and aquifer (such as limestone, sandstone or sand/gravel) horizons	11
Figure 4.1	Current regulatory pathway for open loop GSHC systems (modified after Fry, 2009), showing the separate permitting systems required for different stages	

1 Introduction

Ground source heating and cooling (GSHC) systems use energy stored in the ground to heat or cool buildings. They can also provide hot water. Electricity, and sometimes other sources such as gas, is used to power the heat pumps and they can typically provide three to four times the amount of energy used to drive the system, depending on their design.

1.1 Using this guide

This environmental good practice guide (EGPG) is for designers, developers, installers, drillers and owners of GSHC schemes. It sets out what needs to be done to comply with environmental legislation and manage environmental risks.

Following the guide will help you to meet your legal requirements and reduce the risk that your scheme causes environmental harm. It is in your interest to avoid environmental harm as it can lead to legal action, including by third parties claiming damages. It could also damage your reputation and that of the industry.

This EGPG is not intended to provide guidance on health and safety or designing thermally efficient or cost-effective systems as such guidance can be sought elsewhere (see section 5 for links to sources of further information).

We expect operators of GSHC schemes to install, manage and decommission all GSHC schemes carefully following this EGPG and to adhere to the conditions we set. This section sets out the types of GSHC scheme and highlights possible environmental impacts and legislation for all types of GSHC scheme. Section 2 details good practice and legislative requirements for both open and closed loop systems in terms of location, excavation and drilling. For those planning to install a closed loop GSHC scheme, section 3 details good practice for pollution prevention and installation of your scheme. For those planning to install an open loop scheme, section 4 details the good practice and the statutory requirements for the environment for this type of scheme. Appendix A1 contains a summary of what to consider ensuring protection of the environment.

1.2 Types of scheme

This guide deals with the two main types of GSHC system: closed loop and open loop. In open loop systems, water is abstracted from the ground and pumped through a heat exchanger and then it is normally pumped back into the ground (see figure 1.1). Where the same volume of water is returned to the same aquifer the scheme is classed as non-consumptive and does not affect the water resource. Some schemes which use the water for other purposes or discharge into a sewer or surface water are classed as consumptive.

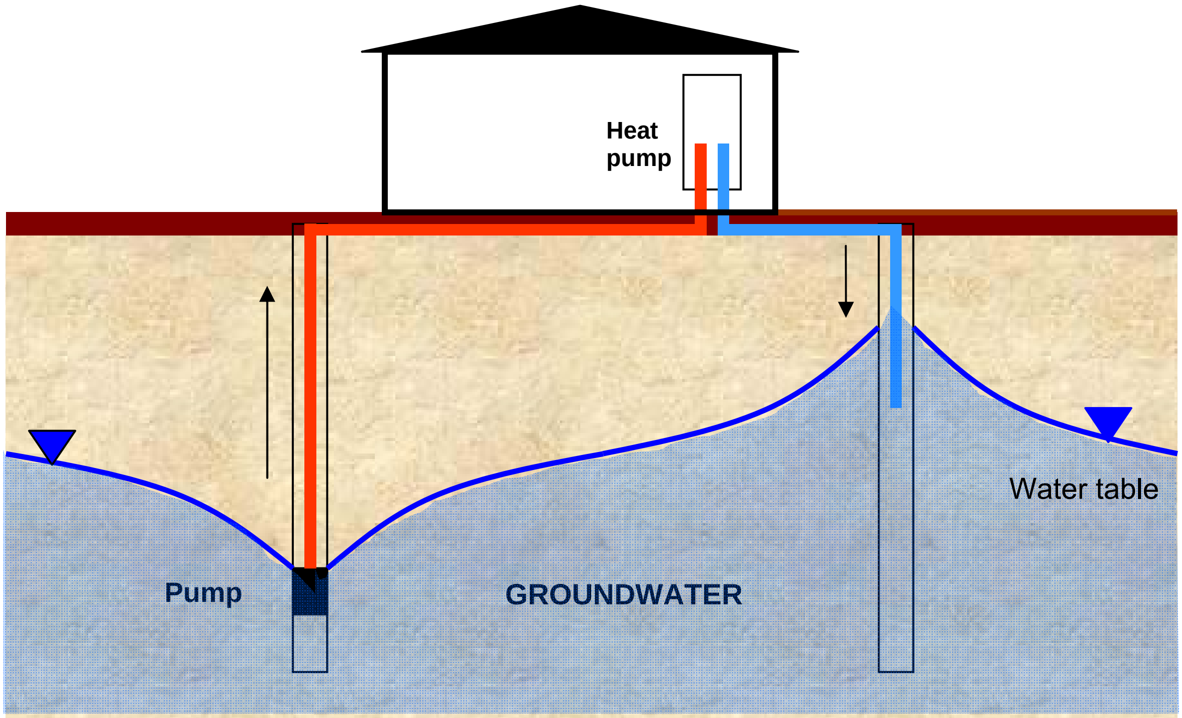

Figure 1.1 Schematic of open loop GSHC scheme where groundwater is used for heating.

Closed loop systems consist of a closed pipe system buried in the ground and filled with thermal transfer fluid (which comprises anti-freeze, biocide, corrosion and scale inhibitors). When the liquid travels around the pipe loops, it absorbs heat from, or gives heat out to the ground (see figure 1.2).

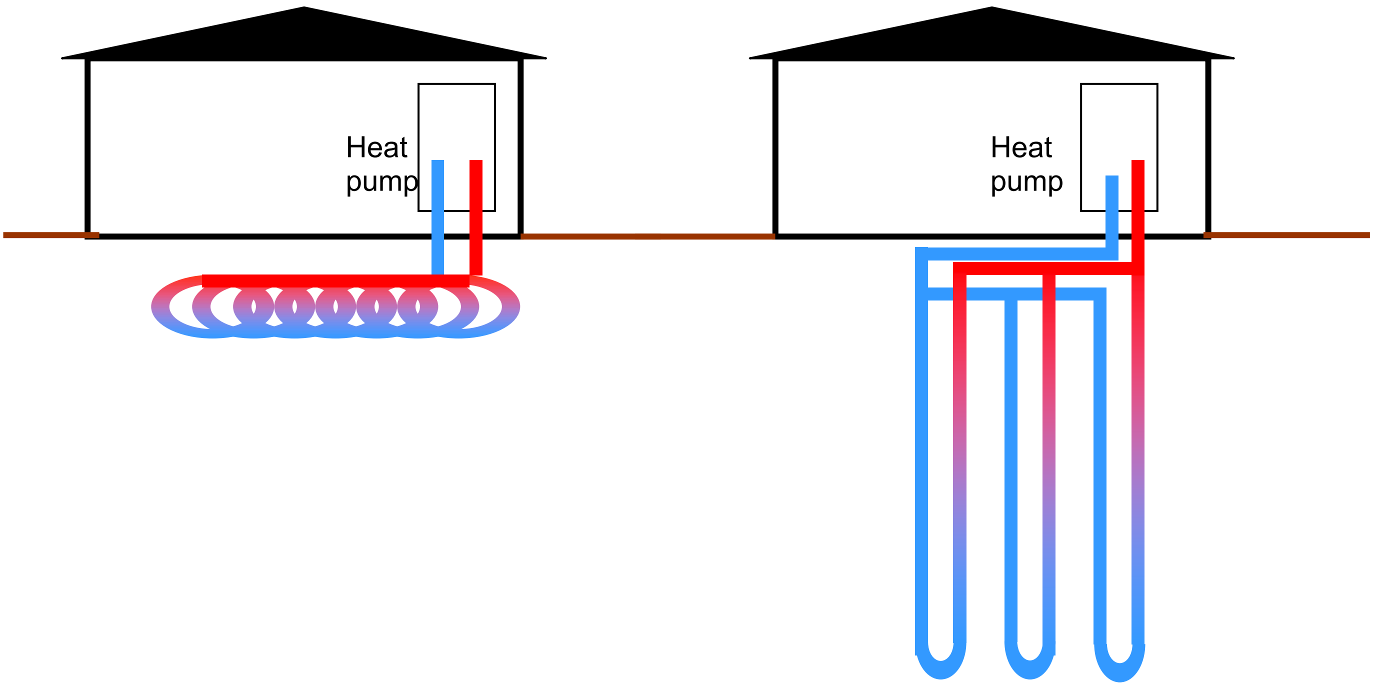

Figure 1.2 Schematic of horizontal closed loop and vertical closed loop GSHC scheme

In addition to ground source schemes, there are also water source heating and cooling schemes. These may be closed loop in rivers, lakes and ponds or may be open loop and abstract water directly from (and discharge water to), rivers, lakes, ponds or even the sea. Some schemes may be a hybrid of these types where water may be abstracted from the groundwater and returned, for example, to rivers. This guide covers both the groundwater abstraction and discharge. It does not cover surface water abstraction and discharge. For more information and detail on regulation of surface water abstraction and discharge, see table 1.2 and the web links in the table.

GSHC schemes should be distinguished from deeper geothermal schemes (several kilometres deep) which use the earth's internal heat, which increases with depth. In contrast GSHC schemes use the stable temperatures of the ground and groundwater, at much shallower depths. This document solely considers GSHC schemes and not deep geothermal schemes.

A summary of environmental permissions for different types of schemes are detailed in the table 1.1 and 1.2. More details can be found in section 4.

Tables 1.1 and 1.2 Summary of current permit requirement for different types of water source heating and cooling schemes

Closed loop	Installation in	
	Ground	**Surface water**
	No permit needed	Flood defence consent may be needed in rivers. Contact us for more information[1]

	Abstraction from		Discharge to	
	Groundwater	Surface water	Groundwater	Surface water
Open loop	See section 4 for details. Consent to investigate groundwater, and an abstraction licence required for abstractions over 20 cubic metres per day	Abstraction licence required for abstractions over 20 cubic metres per day, apply as any other abstraction licence, see our website	See section 4. Bespoke environmental permit required	See section 4 for details. Deregulated, standard or bespoke environmental permit depending on risk. Further details can be found on our website. In addition, any works in or near a river may require a flood defence consent[1]

[1] A flood defence consent is likely to be needed if you plan to put any pipework near or in a river, or you are changing a river bank (for example putting in an outfall). These fall into the following categories:
- Works within Main River and flood defence byelaw distance. These distances will vary around the country and so please contact us for more information. Main Rivers are watercourses designated as such on Main River maps (held by the us) and are generally the larger arterial watercourses.
- Works to an ordinary watercourse such as culverting (a pipe through which a watercourse flows) or obstructing the flow (e.g. weirs or dams). These are all watercourses not designated as a Main River.

1.3 Environmental risks of GSHC schemes and your role

The main environmental risks associated with GSHC schemes are listed below.

- All GSHC systems can result in undesirable temperature changes in the ground and the water environment with impacts on water quality or aquatic ecology.
- Both open loop systems and closed systems installed at depth can result in the interconnection of different aquifers units during drilling - affecting water quality or flow.
- Closed loop systems may contain thermal transfer fluids which are toxic and can pollute groundwater if they leak.

Open loop systems present the following additional environmental risks:

- Localised increase in groundwater levels which could affect adjacent structures.
- The potential impact of groundwater abstraction on the environment or other users of groundwater or surface water.

Developers of open loop systems should contact the Environment Agency at an early stage to discuss the intended location, proposed design, and operation of their system. Developers of closed loop schemes where there may be environmental risks such as within a groundwater source protection zone should also contact us at an early stage.

Significant consideration must be given to the design of both open and closed loop schemes in order to ensure their longevity and efficient performance. Such design considerations do not fall within our remit. Organisations such as the Ground Source Heat Pump Association and International Ground Source Heat Pump Association have useful publications to help with these considerations.

2 General requirements for GSHC schemes

The guidance provided in this section is relevant to all types of schemes. In addition, there are regulatory requirements for open loop schemes to assess the environmental impacts of both the abstraction and discharge as part of the application process, detailed in section 4. There is no formal need to obtain consent from us for a closed loop scheme. Other permissions may be needed, for example planning permission which may have associated conditions. The boxed text in bold highlights your statutory environmental obligations. A checklist of the items you need to consider when planning a new scheme, both closed and open loop, is included as Appendix A1. This contains references to the relevant sections of this guide to help you.

2.1 Assessment of environmental impacts

A competent person (for example a trained geological or hydrogeological professional) should carry out an assessment of the environmental impact of your scheme and document the results. The assessment should take into account the risks listed in section 1.3, as well as sections 2.2 – 2.5 below.

The majority of these (except Note 6) relate specifically to vertical borehole schemes and not necessarily horizontal closed loop schemes which generally present a lower risk to the environment. This tick box should be used however if horizontal schemes are installed below the water table.

2.2 Environmental risks related to scheme location

As part of your environmental impact assessment you should use the checklist below to find out if your proposed GSHC scheme is in a sensitive location. We recommend that you avoid such locations if possible but if you cannot do this, the notes below explain what you should do.

Table 2.1 Site checklist

Tick box		**Check whether the proposed site is in these locations**	**Note number**
Yes	No		
		Within a defined groundwater source protection zone 1 or within 50m from a well, spring or borehole used for potable supply?	1
		On land affected by contamination?	2
		Close[2] to a designated wetland site?	3
		Within 10m of a watercourse?	4
		Close1 to other GSHC schemes?	5
		Adjacent to a septic tank or cesspit	6

[2] This will depend on the size of the scheme: for open loop schemes it will be based on pumping rate and whether the heat demand is for both heating and cooling and will need to be considered by the applicant. For closed loop, it will depend on the size of the thermal input into the ground but a simple guide for closed loop schemes could be: 20m for single domestic scheme (assuming this is at 45kW as defined by MCS), 50m for a few houses/single community building to at least 250 m for factory/ large office space.

Note 1: Find out if your proposed site is in a groundwater source protection zone 1 (SPZ1), by checking the maps in our What's in your backyard (WIYBY) pages on our website (for mapped zones of large potable abstractions) or whether your proposed site is within 50 m of a smaller potable abstraction (this is the default SPZ1 for small abstractions). The location details for small abstractions may be obtained from your local authority and/or by local enquiries with neighbours. If you cannot avoid locating your scheme within a SPZ1 we recommend you contact us at an early stage of design for advice concerning the drilling, installation and operational procedures and materials to protect the quality of the drinking water. For all schemes the main risks occur during the drilling and installation process. Once operational, you will need to ensure there are no impacts on the abstraction from the temperature change in the groundwater. For closed loop schemes the choice of low toxicity thermal transfer fluid used in the ground loop is important within a SPZ1 (see section 3.6).

The main additional implications you need to consider for open loop schemes in a SPZ1 are the hydraulic impacts your abstraction may have on existing water supply abstractions. These will require assessment as part of the process to obtain an abstraction licence and an environmental permit to discharge, as detailed in section 4.

If we consider a proposed closed loop GSHC scheme could pose an unacceptable risk of pollution (for example the use and potential leakage of toxic anti-freeze in a SPZ1) we can serve a prohibition notice. This notice prohibits you from carrying out that activity under the Environmental Permitting Regulations.

Note 2: If the site is contaminated, there is a risk that drilling or excavation could lead to pollution of groundwater or migration of contaminants for which you or your contractors may be liable. Your understanding of the contamination risk should be based on knowledge of the site's history, previous works on the site and any clean-up of contaminated soil or groundwater as detailed in NHBC and EA, 2008 R&D 66.

If the proposed site is contaminated you should carry out a risk assessment[3] and seek advice from the local authority and ourselves. This risk assessment could form part of a wider risk assessment during remediation and development of the site or may need to be standalone if a GSHC system was not considered at this stage. You must establish a drilling and working plan to ensure materials are handled responsibly and to prevent migration of contaminants (see figure 2.1). You will need to design and construct boreholes to avoid groundwater becoming polluted and obtain our approval to proceed with borehole or pile construction. Several guidance documents are available, providing further details of good practice when drilling or excavating contaminated land. See section 6 for references: EA, 2002; EA, 2001; BDA, 2008; HSE, 1991; Thomas Telford, 1993.

An activity that disturbs contaminated land to the extent that it results in additional inputs of pollutants to groundwater may be considered to be a groundwater activity under the Environmental Permitting Regulations and may require a permit.

---

[3] This risk assessment should be appropriate: this means that you have obtained enough information to develop a clear conceptual understanding of the relationship between the activity and all relevant receptors. You have checked the surrounding area and know what the receptors are within a relevant distance - which may mean you need to carry out a survey of water features and contact adjacent land owners. You understand the nature and content of the materials you are using and have sufficient information about the geological and hydrogeological conditions (both natural and man-made) to understand how pollutants may be transmitted and what impact they may have. Further information on risk assessments can be found at EA, 2010.

If there is any suspicion that the ground or groundwater at the site may be contaminated you will need to test arisings from the excavation or drilling process. If the arisings are contaminated, treat them as hazardous waste and dispose of them accordingly.

Note 3 and 4: There is a small risk that GSHC schemes will adversely affect the ecology of rivers or wetlands by changing the temperature of groundwater which feeds them. You should identify the risks[4] of a closed loop system freezing the ground if very close to a wetland site or river. Both types of schemes can influence temperatures at these sites. We consider a temperature change of less than 2°C (considering upstream dilution of the temperature change) in a river to be acceptable. Locations of designated wetlands in England can be found at www.natureonthemap.org.uk. For sites in Wales contact the Countryside Council for Wales. For open loop schemes, you will need to assess the impacts of temperature on the environment as part of the environmental permitting process (section 4.4)

Note 5: It is good practice not to place a scheme too close to an existing one to ensure efficient operation of both or all schemes in close proximity to one another. You also need to bear in mind that other GSHC schemes could be installed close to yours in the future, reducing the overall thermal efficiency of your scheme. We hold information on schemes that we regulate which you will need to understand the possible impact of your scheme on other schemes nearby.

Note 6: To avoid pollution risks you should avoid installing GSHC systems adjacent to a cesspit or a septic tank and in the case of the latter through the associated infiltration drains (which may be extensive). A search of the services should be undertaken prior to installation for all types of scheme, including horizontal closed loop schemes.

[4] See footnote on page 6

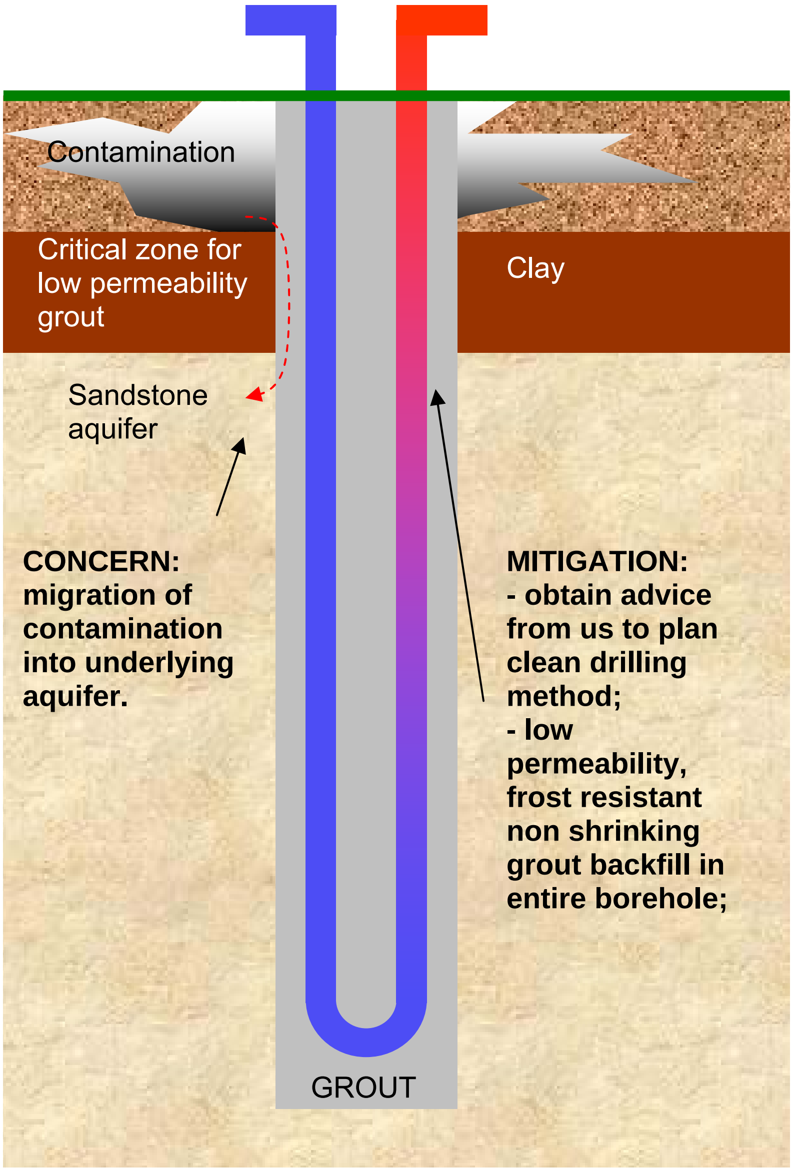

Figure 2.1. The risks associated with drilling in contaminated ground or groundwater shown in a closed loop system installed in an aquifer (in this case, a sandstone), but the same concerns would apply to an open loop system.

2.3 General good practice for excavations and drilling

There are two main types of excavation that can be used for closed loop GSHC schemes: shallow trenches and deeper boreholes. In practice, shallow trenches pose little risk to the groundwater environment, but we recommend you follow the good practice in section 3 to prevent pollution of soil and shallow groundwater.

Before you start drilling a borehole (for both closed and open loop schemes) you should seek the advice of a qualified hydrogeologist to understand the geology and hydrogeology you will be drilling into in order to anticipate and mitigate any problems. When drilling a closed loop borehole there is no obligation to consult us, but it is good practice to identify the risks in advance. For open loop schemes, you require a groundwater investigation consent from us to drill and test the borehole. Further details can be found in section 4.

For water wells drilled deeper than 15m you are legally required to notify the British Geological Survey, however it is good practice to notify them for any borehole. On completion of drilling, a brief report and drilling log should be submitted to the British Geological Survey, using the form found on their website.

The geological checklist below is a guide to what you need to consider for vertical schemes (horizontal schemes that do not go into an aquifer or intersect the water table are deemed to be low risk and therefore this assessment is not needed). The use and interpretation of geological data is likely to require the involvement of a specialist consultant or advisor. There are a number of documents detailing best practice for borehole construction including our Water Supply Borehole Construction and Headworks: Guide to Good Practice (EA2000).

As part of your assessment of risks you should use the checklist in table 2.2 to find out if there may be problems encountered during drilling that you should consider. Where your answer is yes to any of these questions, please refer to the relevant notes

As well as the geological risks of borehole construction dealt with here, you should also consider health and safety, driller competence, liability, ground conditions, stability and impact on other structures (refer to the information sources in section 5).

Table 2.2 Geological checklist

Tick box		**A geological checklist**	**Note Number**
Yes	No		
		Is the proposed scheme in a principal aquifer?	1
		Is the proposed scheme likely to penetrate multiple aquifer horizons?	2
		Is the proposed scheme likely to go through contaminated soil, rock or water?	3
		Is the proposed scheme in an area with likely artesian conditions?	4
		Is the proposed scheme in a coal mining or unworked coal area?	5
		Is the proposed scheme in an area of significant evaporites or karstic conditions?	6

Note 1: You can use the WIYBY pages on our website to check aquifer designations but please note that these are the designations mapped at the surface. For installation of boreholes it is likely you may encounter several aquifer types, so you need to assess the likely sub-surface geology. Principal aquifer designations identify our aquifers with the highest resource potential, so you may need to take extra measures to prevent pollution for closed loop schemes (see section 3). An assessment of the type and resource potential of the aquifer will form part of the assessment for open loop schemes (section 4).

Note 2: If you plan to drill through multiple aquifer horizons you should obtain information from geological maps and literature and seek advice from a qualified hydrogeologist so that the geological conditions can be anticipated. Drilling through multiple aquifer horizons presents risks of interconnecting aquifers of different quality, or significantly altering flow patterns. You will need to agree a drilling and grouting plan with us to ensure that the aquifers remain hydraulically separate during and after borehole completion (figure 2.2). The low permeability (aquitard) section separating the aquifer horizons should be backfilled with a non-shrinking grout of known low hydraulic conductivity (10^{-9} m/s or less) or grouted the entire length for a closed loop system.

Note 3: See note 3 in previous section 2.2.

Note 4: You also need to understand the aquifer conditions prior to excavation. If there is a risk of artesian groundwater conditions being encountered during drilling, we recommend you find an alternative location for closed loop schemes due to the risk of causing uncontrolled artesian overflow. Be aware that it can be very difficult (and costly) to control artesian groundwater pressures if appropriate precautions are not taken at the design and construction stages. Where this is not possible you will need to:

- identify the risks of artesian overflow
- seek advice from competent professionals such as hydrogeologists and drilling experts
- contact us to discuss a drilling and grouting plan to control the artesian pressure during construction and on completion.

If you have assessed the risks prior to drilling this should minimise the chance to encountering unexpected artesian flows. However if small artesian flows are inadvertently encountered, the completed borehole must be securely sealed, typically by backfilling with a non-shrinking grout mixture of low enough hydraulic conductivity (10^{-9} m/s or less) that any future leakage of artesian groundwater is prevented.

If you allow uncontrolled artesian overflow you will be in contravention of water resources legislation, which could lead to regulatory action by us.

For open loop schemes, the method of drilling and a contingency plan should be agreed with us to ensure that artesian heads can be safely controlled during and after drilling. Where the artesian pressures are too great for the abstracted water to be returned to the aquifer when also taking into account the additional pressure of re-injection, such schemes would likely be classed as consumptive. It is possible that we would not be able to issue an abstraction licence in these circumstances because of the potential impact on other users and the water resource. For more information see section 4.

Note 5: If drilling in an area that is currently being used or has been used for coal mining, a mining assessment of coal workings beneath is required using information held by the Coal Authority. The Coal Authority will be able to advise on risks related to mine gas and contaminated water in mine workings. In addition, if you are proposing to drill through coal-bearing strata or through abandoned or operational coal mine workings (this applies to all boreholes, for both open and closed loop schemes), there is a requirement to seek consent from the Coal Authority under the Coal Industry Act 1994. Current guidance on the application for permission can be obtained from the Coal Authority.

Note 6: If you intend to drill boreholes through karstic rock or significant thicknesses of evaporite minerals (for example, anhydrite, gypsum or halite such as that found in the Cheshire Basin), we recommend you consult a qualified hydrogeologist in order to assess the risks and plan actions to avoid subsidence. In the German town of Staufen, significant structural damage is alleged to have occurred after closed loop boreholes allowed confined groundwater to come into contact with anhydrite layers in the German equivalent of the Mercia Mudstone. The anhydrite reacted with the water to form gypsum, causing ground swelling and heave.

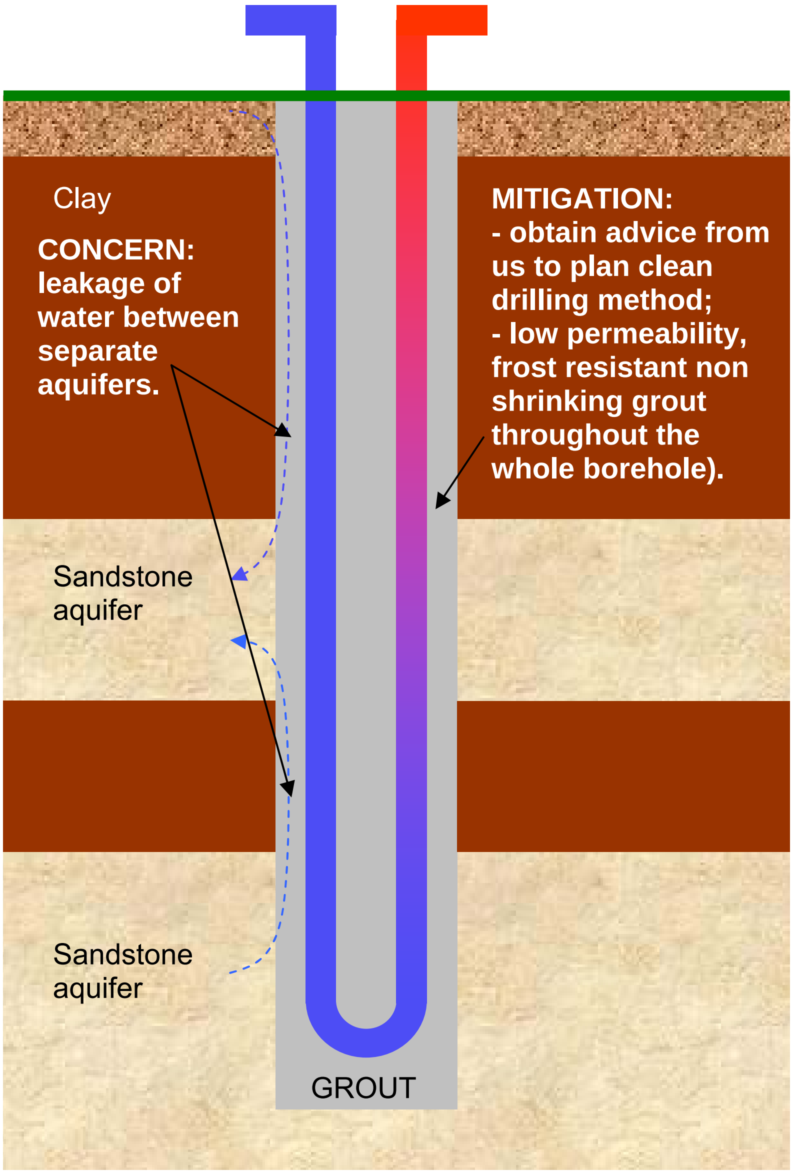

Figure 2.2 The risks associated with drilling in a multiple aquifer situation. A closed loop system installed through several aquitards (such as clay) and aquifer (such as limestone, sandstone or sand/gravel) horizons.

2.4 Good practice for borehole completion

In order to protect groundwater from contamination from surface water ingress, backfill the top 5m of all boreholes with a low-permeability, frost-resistant, non-shrinking grout (bentonite or cement-based grout of documented hydraulic conductivity 10^{-9} m/s or less) on top of any other annular fill (such as granular material for open loop systems) to prevent run-in of surface water (EA, 2000). For closed loop systems, this low permeability grout should normally be used throughout the entire length of the borehole. Further details on installation and completion of closed loop schemes can be found in section 3, and open loop in section 4.

2.5 Decommissioning

When a ground source heating scheme has reached the end of its life, it is important that these deep-drilled structures are not left open in the ground as they may provide potential pathways for surface contaminants to enter groundwater. All boreholes and wells should be responsibly decommissioned.

To decommission boreholes constructed as open wells:

- if the borehole is no longer needed, remove all pumps, pipework and cables and heat exchange loops and backfill according to the principles set out in Decommissioning Redundant Boreholes and Wells (EA, 1999).

Failure to decommission a system effectively could result in pollution of the environment and enforcement action by us

To decommission closed loop borehole heat exchangers installed in grouted (or otherwise backfilled) boreholes:

- remove any thermal transfer fluid from any subsurface heat exchange element and dispose of it appropriately (see section 3.6);

- backfill the ground loop itself by injection under pressure of a non-shrinking, low-viscosity grout mix, which results in a hydraulic conductivity of $<10^{-9}$ m/s.

3 Good practice guidance – closed loop schemes

3.1 Our approach to closed loop schemes

Closed loop **ground** source heating and cooling systems do not currently require any form of permission from us. However, poor installation practices can lead to water pollution. If a closed loop scheme was put into or adjacent to a watercourse, this may require a flood defence consent from us, see table 1.2.

Some proposed GSHC schemes may form part of planning applications, on which we may be consulted. We will not normally seek to impose specific restrictions or conditions on GSHC schemes in planning consents, other than to require that the GSHC scheme is designed, installed and operated in accordance with this environmental good practice guide.

We may raise concerns at the planning stage (if appropriate), or serve a prohibition notice which prohibits you from carrying out a specific activity under the Environmental Permitting Regulations 2010 to prevent pollution from a scheme if:

- the installed infrastructure may pass through a potentially contaminated area or an area of known contamination and the approach has not been discussed and agreed with us; or

- the proposed scheme is in the immediate vicinity of a sensitive site (for example, within an SPZ1).

The owner or operator of a closed loop GSHC scheme that forms part of a planning application should also anticipate that third parties may object to the installation of the scheme. For example, a large closed loop scheme in the source protection zone of a major public water supply groundwater abstraction may draw concerns from the water company.

3.2 Liability for pollution from closed loop schemes

While the majority of closed loop schemes are installed and operated with no detrimental effect on the environment, owners and installers of such schemes should bear in mind that they remain liable for any adverse effects that closed loop schemes may cause:

- if the drilling, installation or operation of a GSHC scheme leads to the discharge of a polluting substance to controlled waters (including groundwater), the drilling contractor, the installer, the owner or the operator of the scheme may be liable to prosecution: leakages of thermal transfer fluid from closed loop systems will fall under this category;

- if the discharge or removal of heat by a GSHC scheme interferes with a neighbouring GSHC installation, water supply (or other installation) or environmental feature, an action under Common Law Nuisance could be brought against the operator or owner of the scheme.

- if the scheme impacts on a third party, for example thought flooding of properties through uncontrolled artesian overflow, causes subsidence, or impacts on an existing water supply through interconnecting aquifer units, the owner or operator may also be subject to civil action.

3.3 Horizontal closed loop schemes

In horizontal closed loop systems, the heat exchange pipe is laid in a trench. The good practice guidance for these types of systems is contained in sections 3.4.1 3.5, 3.6 and 3.7 below.

3.4 Good practice for pollution prevention

3.4.1 General requirements

The following general points should be adhered when installing subsurface heat exchangers and associated pipework, with a view to minimising their pollution potential:

- only install pipe materials of a quality appropriate to the pressure and ground conditions under which they will be operated to ensure longevity of the scheme operation and to prevent leaks;
- pressure test pipe circuits to appropriate standards (GSHPA, 2011) following installation to check the integrity of the system and prevent leaks;
- install downhole tubes which have been prefabricated from appropriate materials under quality controlled conditions and delivered as a complete installation to site. Avoid or minimise pipe joints in the subsurface heat exchanger as these are weak points where leaks may occur. Prefabricate any subsurface joints by socket, butt or electrofusion welding or field-fabricated by electrofusion welding under quality-controlled conditions. No mechanical joints should be used below ground, again to reduce the risk of leakage;
- provision should be made to enable any damaged or leaking element of the array or ground loops to be shut off or isolated in an emergency;
- fit systems with an automatic shut-down mechanism in the event of critical drops in fluid temperature or pressure which would indicate a leak of thermal transfer fluid;
- overlay buried ground loops and header pipes with marker tape, to clearly warn workers who conduct future excavation or drilling activities of the presence of GSHC pipes below at depth, with suitable printed warning tape.

3.4.2 Borehole completion

The way in which boreholes are completed is important to ensure pollution is prevented. Our recommendation for the completion of a closed loop borehole is by backfilling with a low-permeability, non-shrinking, frost-resistant, thermally-enhanced grout from bottom to top of the borehole (Figure 2.1).

Thermally-enhanced grout means a low-permeability backfill with a hydraulic conductivity of less than 10^{-9} m/s and with a thermal conductivity of 1.3 W/m/K or more[5].

If any grouting materials contain blast furnace cement or fly ash they must meet the waste quality protocols as detailed on our website.

For boreholes backfilled with thermally enhanced grout, it is good practice that:

- the diameter of the borehole is sufficient to permit the installation of the ground-loop and a tremie pipe to aid careful placement of the grout;

- the grout should be added from the base of the borehole upwards by pumping through a tremie pipe (or removable injection pipe integrated with the ground loop) to ensure an efficient thermal and hydraulic seal without trapped pockets or voids of air;

- the grout mix, once set, should be chemically inert and not leach potential contaminants;

- the grout should not shrink away from the heat exchange pipe or borehole walls on setting and should not be susceptible to freeze damage or dehydration damage at the temperatures of operation of the ground loop. This would result in a poor seal and may produce a pathway for the thermal transfer fluid and other contaminants to escape;

- the grout mix should have a hydraulic conductivity of less than 10^{-9}m/s. Ready-formulated grouts are preferred. Note that, in the case of grouts comprising two or more parts that must be combined on site, the hydraulic conductivity will depend on the mix ratio, moisture content and quality of installation on site.

3.4.3 Borehole completion as water well

In lithified rock (solid rock) with a shallow water table it can be an economically viable solution to drill an open-hole, self-supporting water well. The closed loop tube is simply suspended in the column of natural groundwater. Only apply this method of completion on the advice of a qualified and experienced hydrogeologist or groundwater engineer in suitable hydrogeological locations. Note that this approach can present greater risks to groundwater as there is no low permeability grout seal through the entire length of the borehole which would prevent leakage of the thermal transfer fluid into the groundwater. Only use this method of completion in single, non-artesian aquifer units and never attempt in multiple aquifer or artesian situations or near land affected by contamination.

---

[5] According to the definitions offered by the International Ground Source Heat Pump Association (2007)

3.4.4 Heat exchangers installed by cone/push penetrometer techniques

It is possible to place a heat exchanger into soft sediments by penetrometer (and other similar) drilling techniques. In this case, a heat exchanger is introduced into the formation via a narrow diameter borehole and the sides of the borehole are allowed to collapse back onto the heat exchanger, forming a thermal contact.

For operational and environmental reasons, never attempt this approach in lithified or consolidated formations (such as chalk, mudstones or shales). There is a significant risk that collapse will not take place: this would result in an open annulus that is a potential pathway for contaminated surface water to enter the groundwater. It is also likely to have a poor thermal contact and so the system would be inefficient. The technique is only applicable in unconsolidated sands, silts and soft clays at shallow depths. Do not attempt this type of installation where artesian or multiple aquifer horizons will be penetrated or at any site where there is suspected or known ground or shallow groundwater contamination.

The heat exchanger should be of simple, regular geometry (for example, a circular co-axial pipe) to ensure that collapsed ground completely seals any open spaces adjacent to the heat exchange pipe. Each installation should be sealed at the surface by filling an excavated area around the borehole head with a low hydraulic conductivity ($<10^{-9}$m/s) grout or backfill.

3.5 Loop construction and pressure testing of indirect closed loop schemes

To prevent pollution, use quality materials and test the scheme sufficiently during installation to ensure its integrity throughout its lifetime (which is generally assumed to be a minimum of 50 years). We recommend you follow the GSHPA technical standards document, (GSHPA, 2011) which details material requirements including: pipe materials and tolerances; off-site factory manufacture and quality control; pipe fittings; sizing and fusion processes.

We recommend you carry out pressure testing of closed loop heat exchangers. You should follow a recognised approach, a number of specifications are detailed in GSHPA, 2011 and VDI, 2001 and following guidance produced by WRC, 1999, BS1, 2000, BSI, 2007 and IGSHPA, 2007.

The ground loop may be pressure tested at three different stages of installation: testing of each individual ground loop following installation (stage two) is regarded as essential. This should follow the criteria set out in GSHPA, 2011.

- Stage 1: ground loop tested on site prior to installation.
- Stage 2: ground loop flush and pressure tested following installation in the borehole. We regard this as the most important stage at which to perform a pressure test, to demonstrate the integrity of the completed ground loop. Perform this test either before or after backfilling with grout. In the case of setting grouts (such as cement-based grouts), do not carry out the pressure test while the grout is setting: to do so risks the pipe expanding under pressure and thereafter contracting, leaving a void between the pipe and the set grout. The completed tests should be recorded by those undertaking the test, such that documentation can be lodged with the owner.

- Stage 3: flush and pressure test the final, complete ground loop borehole array according to the provisions of, for example, WRC (1999).

Fit the GSHC installation with some form of thermal transfer fluid pressure monitoring that will shut down the compressor and circulation pump(s) in the event that a leakage occurs and thermal transfer fluid pressures drop below a critical threshold. In many cases, the heat pump will already include such a system.

3.6 Thermal transfer fluid

Generally for most schemes where the minimum fluid temperature drops to 6°C or lower, appropriate freeze protection of the heat pump should be used. We recommend that completed GSHC systems should display a clear, permanent label stating the type and concentration of chemicals in the thermal transfer fluid (which often contains anti-freeze) and the most recent date of filling. In certain schemes, dominated by cooling, the thermal transfer fluid may simply be water, providing that the temperature does not approach 0°C.

A common choice of thermal transfer fluid has been monoethylene glycol, with a freezing point of around -14°C at 25% dilution. In high concentrations and doses, monoethylene glycol is toxic to humans, animals and ecosystems. Therefore, we do not recommend its use where there are risks to drinking water supplies and refer to GSHPA Standards (2011) for requirements in choosing a suitable transfer fluid. Lower toxicity alternatives include propylene glycol and ethanol. Alternatives are available which claim lower toxicity and equivalent or better hydraulic performance, based on vegetable extracts or organic salts or as mentioned previously, water.

Glycols typically biodegrade relatively rapidly under oxidising conditions. Under reducing conditions, however, the rate and completeness of their degradation is less certain. We therefore recommend the use of non-glycol anti-freezes in geochemically reducing or anoxic aquifers of significant water resource value.

The thermal transfer fluid will usually be pre-blended with a corrosion inhibitor and may also contain a scale, slime inhibitor or mobiliser and/or a biocide to hinder biodegradation and biofilm growth. You should consider the toxicity of these additives: they should not be hazardous substances and their potential toxicity and environmental persistence should not be worse than the thermal transfer fluid itself.

If you replace the thermal transfer fluid in a ground loop system, dispose of the used fluid responsibly and via a documented and approved disposal route. Do not discharge thermal transfer fluids containing anti-freeze or biocides to the ground, soakways, sewers, or drains as this is potentially polluting and you could be causing an offence.

At present (February 2011), the determination of both propylene glycol and monoethylene glycol as either a hazardous substance or non-hazardous pollutant is being reviewed. They were previously determined as neither List 1 nor List 2 under the old Groundwater Directive (80/68/EEC). This review is being undertaken by the UK Environment Agencies (Environment Agency, Scottish Environment Protection Agency and the Northern Ireland Environment Agency), subject to external consultation and peer reviewed by the Joint Agencies Groundwater Directive Advisory Group (JAGDAG). Once a decision has been made, there may be implications for closed loop systems in terms of which substances can be used and we will update this guidance as appropriate. Further information on the JAGDAG process can be found via http://www.wfduk.org/jagdag.

3.7 Direct circulation (DX) closed loop installations

We would not recommend the use of direct circulation or direct expansion (DX) closed loop GSHC schemes in any setting other than shallow trenches in low environmental risk settings. These schemes typically circulate currently classified hazardous (formerly list 1) substances (such as fluorinated hydrocarbon refrigerants) within pipework in the ground: the environmental risks of a leak at depth into groundwater are significant. These schemes are not illegal provided that no leakage or discharge to the ground or groundwater occurs. However, it is strongly encouraged that hazardous substances are not used in the sub-surface portions of GSHC schemes and particularly if any of the underground pipework is located below the water table.

Where the installation of a direct circulation scheme is to take place, the installer and owner should ensure that:

- the groundworks are located and marked in such a way that they will not be disturbed or damaged by any future excavations;
- the pipework used is not at risk of corrosion in your ground type. If any risk of corrosion is present, we recommend cathodic protection;
- the installed refrigerant pipework is rigorously pressure-tested at high pressure (according to the relevant British and European standards), and documentation provided to the client to that effect.

Direct circulation schemes based on other, more environmentally benign types of refrigerant (such as carbon dioxide) are becoming available. We encourage the responsible development and installation of such technology.

3.8 Post installation care and maintenance

The operator of a GSHC scheme should be sufficiently familiar with the operation of the scheme so that they can avoid, easily identify and resolve problems such as leaks. The installer should leave detailed operational instructions for the routine maintenance of the scheme and an emergency guide with the operator. This should include a detailed plan of the system, the risk assessment undertaken and remain with the property when sold. In the event of a pressure drop (indicating a possible leak), there should be a simple plan of action including contact numbers for the installer. This must include a requirement to notify us so we can deal with the possible pollution incident in the environment. Under no circumstances should a potentially leaking system be topped up with more anti-freeze. It is also good practice to monitor temperatures to ensure the efficient operation of the system.

4 Open loop schemes

4.1 Introduction

This section provides good practice guidance for operators of open loop GSHC schemes. As open loop schemes are regulated by us, the information that is provided to obtain the relevant permissions should cover the majority of the environmental risks that need to be managed. By following the requirements set out in our permissions, this should in general ensure that good practice is followed.

In order to drill or test pump a water supply borehole, you will require a consent to investigate a groundwater source under section 32 of the Water Resources Act.
To operate an open loop GSHC scheme you will need an abstraction licence (if the abstraction is greater than 20m^3/d) and an environmental permit to discharge water. (See Figure 4.1).

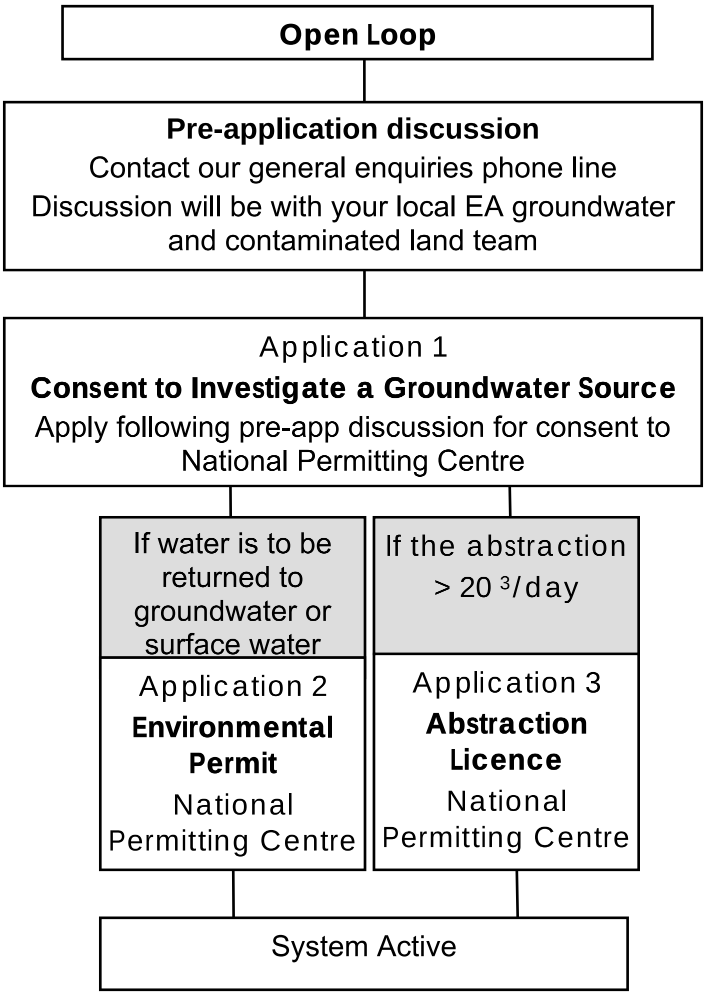

Figure 4.1 Current regulatory pathway for open loop GSHC systems (modified after Fry 2009), showing the separate permitting systems required for different stages.

In addition to permission requirements you should consider the design of any scheme to ensure its longevity and efficient performance. Such design considerations are your responsibility as the operator, designer and installer of the scheme and do not fall within our remit. However, we recommend that you consider the following points:

- employ the services of a professional hydrogeologist and/or groundwater engineer to ensure you have a well-designed open-loop GSHC scheme;
- understand the adequate separation of the abstraction and discharge wells in a well doublet system to ensure that large quantities of discharged water do not feed back to the abstraction well affecting the temperature of the abstracted water;
- ensure your recharge well is well designed so that it does not clog within a short period of operation. In particular you need to carefully control the gas content, water chemistry and the particulate content of the water as small bubbles of gas and particulates can result in rapid clogging of the well or aquifer. Bio-fouling with bacterial growth can also become problematic.
- even with good design, you should expect the hydraulic efficiency of your scheme to reduce over time, due to the clogging of the face of discharge as detailed above
- even with good design, you should recognise that the thermal efficiency of your schemes may change over time, especially if thermal breakthrough occurs between the abstraction and discharge wells. Background temperature of the groundwater may also change over time if more schemes are constructed in your area.

4.2 General well construction and operation principles

Any water well constructed to abstract (or recharge) groundwater for heating or cooling should conform to our booklet on borehole construction (EA, 2000). The construction of efficient recharge boreholes may require specialist techniques (see section 4.6).

Our permitting procedures will ensure that good practice in relation to abstraction and discharge is followed by open loop GSHC operators and that risks are minimised to acceptable levels. However, we regulate to protect the environment and our permits are not intended to protect schemes from feedback effects between your recharge and abstraction wells. This is something you and your designer and installer should address.

We recommend that large open-loop well-doublet schemes operate with approximately balanced heating and cooling load to the environment, in order to minimize the net discharge of heat to the aquifer and to minimize long term temperature rises or falls. The importance of such a thermally balanced approach is greatest:

- for large schemes (order of hundreds of kW peak capacity);
- in areas where there is a high density of open loop GSHC schemes – typically large cities on principal aquifers;
- for large buildings in cities as these tend to have a far greater requirement for cooling than heating.

In order to obtain an approximately balanced annual heating/cooling profile for such buildings, it may be necessary for operators to:

- engage in dialogue with architects at an early stage of building design;
- identify innovative approaches to shedding surplus heat from buildings;
- identify markets for surplus heat (for example, transfer and sale of heat to adjacent neighbourhoods).

4.3 Groundwater investigation consent and abstraction licence

Open loop systems involve the abstraction of groundwater for heating and cooling purposes.

Open loop systems require an abstraction licence from us if the quantity abstracted is more than $20m^3/d$ in any 24 hour period.

A licence conveys to the licence holder the authorisation to abstract a specified quantity of water and does not guarantee the quantity or quality of water.

We publish catchment abstraction management strategies (CAMS) which describe our approach to abstraction licensing for every catchment in England and Wales. If you contact us at the beginning of the building design phase to discuss your proposal this allows you greater flexibility for changes in design to meet environmental requirements to be taken into account.

The following step-by-step list demonstrates the process for applying for an abstraction licence (further guidance is given on our website):

- early, pre-application liaison with us will usually reveal whether or not we would be minded to grant an abstraction licence and what the main potential obstacles may be. You should also discuss you discharge proposals with us at this stage (see Section 4.4 and 4.4.1.).
- before any drilling commences, you must apply for a groundwater investigation consent (GIC) under section 32(3) of the Water Resources Act 1991. This consent allows you to drill the abstraction borehole and abstract from the borehole for testing purposes to prove the yield prior to obtaining an abstraction licence. We do not charge for these consents.
- upon receipt of your GIC application, we will usually ask you to carry out a water features survey within a given radius to identify any wells, boreholes, springs, or groundwater-dependent ecosystems your abstraction might affect.
- once you have submitted a satisfactory survey we will issue a consent to investigate groundwater, specifying drilling and test pumping details. This will also specify any off-site monitoring and may include a requirement for water quality sampling.

- you will then assess the results of the pumping test, and provide us with a hydrogeological impact assessment that tells us the impacts your abstraction could have on other nearby structures, abstractions or ecosystems and on the aquifer's sustainability as a water resource. You can find more information on impact assessment of abstractions in EA, 2007.

- based on your impact assessment, we will discuss with you whether or not we recommend you apply for an abstraction licence and if necessary, what requirements we may have.

For open-loop well-doublet schemes, where the thermally changed water is re-injected to the same aquifer via an injection well, the hydraulic impacts are usually limited to a few hundred metres.

Abstraction licences attract a charge which is partially dependent on the loss factor[6], so the less water you take, the less you will pay.

Abstraction licences may contain certain limits or requirements (for example, for metering of water abstraction) and are time-limited in line with a common end date for your specific catchment, as set out in the CAMS documentation. Licences usually are valid for a period of about 12 years, depending on when in the CAMS cycle they are issued. In exceptional circumstances we can grant licences of up to 24 years duration if you can meet all four of the following tests:

- the lifetime of the infrastructure (for example the building) is inseparably associated with the licence (the open loop scheme for the building needs an abstraction licence to operate) and will extend over the desired period of the licence being applied for;

- there will be a continued need for the service or product associated with the infrastructure throughout the desired period of the licence being applied for;

- a full appraisal of likely changes in environmental and economic circumstances that may have a bearing on the acceptability of the abstraction over the desired period of the licence being applied for shows no significant concerns;

- the infrastructure development contributes to sustainable development.

An application for a long duration licence may be appropriate to consider when constructing a new building with a specific life span and where an open loop GSHC scheme is integral to the building's operation. Our decision on whether a long duration licence is granted is based on the information you provide about your site and your proposal.

To renew a time-limited licence, you must be able to meet the following three tests:

- continued environmental sustainability - the CAMS process will identify environmentally unsustainable abstractions within catchments and will also identify our approach for dealing with them.

[6] Loss factor is related to how much of the water is returned back to where it was abstracted, the consumptiveness. For a scheme discharging the same volume back to the same geological unit this is likely to have a very low loss factor.

- continued justification of need - this is an assessment to see if the abstraction is still required, based on the reasonable requirements of the licence holder, and to check that the maximum levels of abstraction authorised in the licence are still reasonable.

- efficient use of water - efficient use of water means using the right amount of water in the right place at the right time. It is essential to achieve the proper management of water resources. Licence holders need to demonstrate efficient use of water when they apply to renew their licence.

4.4 Discharge of water from your scheme

The water that emerges from a GSHC scheme's heat pump or heat exchanger will usually be warmer (in a cooling scheme) or colder (in a heating scheme) than the ambient groundwater temperature. This thermally changed water may be:

- discharged back into the aquifer from which it was abstracted;

- discharged into surface water body (lake, river, sea);

- discharged to a sewer or drain, provided such a feature exists and that it has the capacity to receive the required quantity of flow. The permission of the relevant sewerage undertaker (water / utilities company) will be required and a charge will normally be levied.

- used as grey water (or, with suitable treatment, potable water) within a building (and thereafter discharged to sewer).

In most cases, the thermally changed water from an open loop GSHC scheme will be discharged back to a natural water body. This could be either a surface water such as a river or lake, or to the aquifer which the water came from (or, conceivably, to a different aquifer if the discharge and receiving groundwater chemistries are compatible).

If water is discharged to a river and the structure discharging the water is on or adjacent to a riverbank, we may require a flood defence consent, see table 1.2.

If this water is discharged to anywhere other than the same aquifer unit that it was abstracted from it would be generally regarded as consumptive as the water is not being returned back to its original source. We have a presumption against consumptive open loop schemes because they use the water resource, reducing its availability to other users and the environment. In practice, you may be unable to obtain an abstraction licence where water resources are heavily used, and if you can obtain a licence, the charge will be higher than for non-consumptive schemes.

4.4.1 Environmental permits

The discharge of water from your scheme to a surface water or to an aquifer is regulated via the Environmental Permitting Regulations.

Table 4.1: Detailed approach to permitting of discharges

Regulatory approach	Approach to discharge to groundwater with changed temperature only	Current approach to discharge to surface water with changed temperature only
Deregulated	All discharges are regulated at present though we are working on proposals to reduce regulation on low risk discharges over the next few years.	No permit is needed if the discharge is from a single dwelling with the system used only for heating.
Standard permit	No standard permit for groundwater as these standard permits do not allow for site specific information and conditions to be incorporated. Due to the variable nature of aquifers and groundwater it is important that site specific information is taken into consideration during permit determination.	The discharge must be water from a cooling circuit or heat exchange to inland surface freshwaters, coastal waters or relevant territorial waters (as defined in Section 104 of the Water Resources Act 1991). There must be no polluting chemicals present in the discharge. The temperature change between the inlet and outlet must be less than eight degrees Celsius and the outlet temperature must not exceed 25 °C. The discharge must be to the same water body from which the water was abstracted but not within 200 metres of another cooling or heating discharge. The discharge must not be made into freshwater within 500 metres upstream from a designated shellfish water, European site, Ramsar site, site of special scientific interest (SSSI), national nature reserve, local nature reserve or any body of water identified as containing a protected species or within 100m from a local wildlife site. For a site in tidal water, '500 metres upstream' means within 500 metres by the shortest distance over water in any direction from the nearest boundary of any of these sites. This restriction only applies to conservation sites that are water-based and linked to the receiving water downstream of the discharge point
Bespoke permit	Required.	If does not meet criteria in standard permit

When applying for a permit you will need to provide details of the anticipated temperature, water quality and discharge rates. If you have not already obtained data on the water quality, the pumping test required as part of the abstraction licensing procedure provides an ideal opportunity to collect samples for water quality analysis. It is important that the operation of the scheme is considered so that if any chemicals are added to the discharged water, it is discussed with us at this point.

The application process will often contain a requirement for the applicant to carry out a risk assessment of the impact of the discharge on the environment. The environmental permit attracts a charge and will commonly have conditions attached regarding the permitted quality, flow rate and temperature of the discharge water. Depending on the risk to the environment, it may also contain a requirement for monitoring of the discharge. Environmental permits can be reviewed at any time.

In the case of discharge of thermally changed (and especially warm) water from ground source cooling schemes to aquifers, we will typically respond in one of two ways, depending on the presence of aquifer users or proximity to ecosystems:

- for lower risk schemes such as low volume discharge schemes, not in sensitive locations, we will require a simple site assessment of the environmental risks and issue an environmental permit with temperature limits. The temperature limit will usually be no greater than 10°C higher than ambient groundwater temperature, or 25°C;

- for higher risk schemes, such as high volume, those in sensitive locations, or if there is a proposal to increase the temperature difference from that listed above, a requirement for a risk assessment of heat migration in the groundwater environment. The permit will be granted based on the consideration of impacts on abstractions and dependent ecosystems (such as wetlands and rivers).

In most cases (for both surface and groundwater discharges), if any chemicals are added to the water being returned, it is likely a bespoke environmental permit to discharge would be needed.

4.5 Open loop schemes and contaminated water

An open-loop GSHC scheme does not necessarily require water of high quality. In some settings, such as in old coal mining areas the chemical reactions mean groundwater can be warmer than it would otherwise be. This has advantages when using the water for heating purposes. If you use contaminated water this must be done carefully and in consultation with us to prevent contaminant migration in the groundwater. You will also need to consider the likelihood and impacts of gas migration, such as methane, and put actions in place to prevent gas build up and a health and safety and explosion risk.

The Environmental Permitting Regulations 2010 allow an environmental permit to be granted for the ‘reinjection into the same aquifer of water used for geothermal purposes’ provided that the reinjection meets WFD environmental objectives, principally that there is or will not be an unacceptable discharge of pollutants to groundwater (there should be no pollution and any entry of hazardous substances to groundwater should be environmentally insignificant. This could arise from:

- additional contaminant loading;

- additional pollution risk, or;
- increased mobilisation of contaminants in an aquifer or surface water.

You must show you can meet these requirements before we issue a permit.

4.6 Recharge well hydraulic impacts

An environmental permit allows you to discharge a specified quantity and quality of water of a specified quality with the aim of protecting the environment against pollution. We do not assess the hydraulic influence of the recharged water, whether the recharge well is able to recharge the specified quantity, any possible impacts on local structures or risk of groundwater flooding as these are not statutory requirements but the owner or operator may be liable for any damage caused under civil law. It is important you address this with a suitably qualified hydrogeologist to prevent impacts on third party structures.

4.7 Pumping of particulate matter

In urban areas, we recommend the content of particulate matter in abstracted water should be minimised in order to prevent the risk of ground settlement. The pumping of 1mg/l suspended solids in 20l/s of water during one year will result in the removal of over 0.6 tonnes of ground. Minimising suspended particles in groundwater will also minimise abrasion wear in equipment and will facilitate discharge of the thermally changed water.

5 Further information

This document should be read in conjunction with other codes of practice, health and safety guides and British Standards in relation to excavations, drilling, installation and decommissioning of these schemes. Organisations which provide these documents include:

British Drilling Association (BDA)

Energy Saving Trust (EST)

Ground Source Heat Pump Association (GSHPA)

International Ground Source Heat Pump Association (IGSHPA)

Microgeneration Certification Scheme (MCS)

Well Drillers Association (WDA)

6 References

BRITISH DRILLING ASSOCIATION, 2008. Guidance for safe intrusive activities on contaminated or potentially contaminated land. BDA, 50pp.

BSI, 2008 Refrigerating systems and heat pumps. Safety and environmental requirements. Installation site and personal protection. BS EN 378-3:2008

BSI 2007. Heating systems in buildings - Design of heat pump heating systems. British Standards BS EN 15450:2007.

BSI, 2000. Water supply. Requirements for systems and components outside buildings. British Standards BS EN 805:2000.

BSI, 1999 + Amendment 2: 2010. 5. Code of practice for site investigations. BS5930:1999 + Amendment 2:2010

DEFRA, 2010. Environmental Permitting Guidance Groundwater Activities For the Environmental Permitting (England and Wales) Regulations 2010.

ENVIRONMENT AGENCY, 2010. How to comply with your environmental permit Additional EPR guidance: Horizontal Guidance Note H1 - Annex (j).

ENVIRONMENT AGENCY, 2008. Groundwater Protection: Policy and Practice (GP3). Part 4 Legislation and Policies.

ENVIRONMENT AGENCY, 2007. Hydrogeological impact appraisal for groundwater abstractions

ENVIRONMENT AGENCY, 2006. Piling in layered ground: risks to groundwater and archaeology

ENVIRONMENT AGENCY, 2002, Piling into contaminated sites

ENVIRONMENT AGENCY, 2001. Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention

ENVIRONMENT AGENCY, 2000. Water Supply Borehole Construction and Headworks: Guide to Good Practice.

ENVIRONMENT AGENCY, 1999. Decommissioning Redundant Boreholes and Wells.

FRY, V.A. 2009 Lessons from London: regulation of open-loop ground source heat pumps in central London. Quarterly Journal of Engineering Geology and Hydrogeology 42 325-34.

GROUND SOURCE HEAT PUMP ASSOCIATION 2011. Closed Loop Vertical Borehole: Design, Installation and Materials Standards (in press)

HSE, 1991. Protection of workers and the general public during the development of contaminated land. Health and Safety Executive guidance HSG 66 (1991)

IGSHPA, 2007: Closed-loop/geothermal heat pump systems: design and installation standards (most relevant to individual loops).

NHBC and EA, 2008. Guidance for the Safe Development of Housing on Land Affected by Contamination. R&D Publication 66: 2008

Thomas Telford Ltd, 1993. Guidelines for the safe investigation by drilling of landfills and contaminated land. Site Investigation in Construction, Part 4.

VDI, 2001. Thermal use of the underground. Ground source heat pump systems. Verein Deutscher Ingenieure. VDI 4640 Blatt 2 / Part 2.

WRC, 1999. A guide to testing of water supply pipelines and sewer rising mains. Water Research Centre.

7 Abbreviations

BDA	British Drilling Association
BSI	British Standards Institute
CAMS	Catchment Abstraction Management Strategy (or Strategies)
EA	Environment Agency
EGPG	Environmental Good Practice Guide (this guide)
GSHC	Ground Source Heating and Cooling
GSHPA	Ground Source Heat Pump Association
IGSHPA	International Ground Source Heat Pump Association
NHBC	National House Building Council
R&D	Research and development
Ramsar	Not actually an abbreviation, but a reference to the international Convention on Wetlands, signed at Ramsar, Iran, in 1971
SAC	Special Area of Conservation (under the EC Habitats Directive)
SPA	Special Protection Area (under the EC Birds Directive)
SPZ1	Source Protection Zone 1
SSSI	Site of Special Scientific Interest
VDI	Verein Deutscher Ingenieure (Association of German Engineers)
WIYBY	What's in Your Backyard?
WFD	Water Framework Directive
WRC	Water Research Council

8 Glossary

Abstraction: Removal of water from groundwater or surface water, usually by pumping

Aquiclude: Geological formation through which virtually no water moves

Aquifer: Subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater (from WFD)

Aquitard: Poorly-permeable geological formation that does not yield water freely, but may still transmit significant quantities of water to or from adjacent aquifers

Artesian conditions: Where groundwater in a confined aquifer is at sufficient pressure to cause water to discharge at the ground surface without any pumping

Closed loop: These schemes consist of a closed piping system buried in the ground (or in surface water, see water source) and filled with water and anti-freeze. When the liquid travels around the pipe loops, it absorbs heat from, or gives heat out to the ground (or surface water)

Consolidated: Tightly bound geologic formation examples include sandstone, limestone, granite.

Consumptiveness: The proportion of the total quantity of water abstracted that is consumed, and not available for return to the environment

Deep geothermal: Schemes that use the earth's internal heat, which increases with depth

Evaporite: A sedimentary rock that was formed from the evaporation of seawater, examples include gypsum and halite

Groundwater: All water below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil (from WFD)

Hazardous substance: Substances or groups of substances that are toxic, persistent and liable to bio-accumulate, and other substances or groups of substances which give rise to an equivalent level of concern (from WFD)

Karst: Terrain composed of or underlain by carbonate rocks that have been significantly altered by dissolution

Lithified: a rock formed from solidified loose mineral fragments or particles of sand

Non hazardous pollutant: Any pollutant other than a hazardous substance

Non- consumptive: an abstraction where the same quantity of water is returned to the same source of supply (e.g. geological strata) from which is was abstracted

Open loop: a system where water is abstracted to obtain heating or cooling and then is discharged.

Recharge: The process by which water is added to groundwater (i.e. from a well discharging water into an aquifer from a GSHC scheme)

Risk: A combination of the probability (or frequency) of occurrence of a defined hazard and the magnitude of the consequences of the occurrence

Subsidence: The settlement of the land surface or buildings as a direct consequence of a decline in groundwater levels produced by groundwater abstraction

Water source (heating and cooling scheme): A scheme that uses a surface water source for heating and cooling (river, lake, sea) rather than heat from the ground or groundwater

9 Appendix A1 – best practice checklist

	Closed loop	Open loop		Section reference
Activity	Operational[7]/ prevent pollution or reduce risk of liability	Operational[8]/ prevent pollution or reduce risk of liability	Required by us	
Siting of scheme (contaminated land, source protection zones)	√	√	√	2.2
Determine environmental impact of scheme	√	√	√	2.1 4.3 and 4.4 (open)
Assessment of geological conditions (multiple layers, artesian conditions)	√[9]	√	√	2.3
Ensure pipework integrity to prevent leaks	√			3.4
Pressure testing of scheme	√			3.5
Type of thermal transfer fluid to be used	√			3.6
Operational monitoring of pressure in loop	√			3.8
Development of care and maintenance and emergency plan	√	√		3.8
Monitoring volumes abstracted and discharged		√	√	4.1 and 4.3
Monitoring of temperatures	√	√	√	3.8 (closed) 4.3 (open)
Testing recharge well		√		4.1 and 4.6
Test pumping to determine quality and quantity of water available		√	√	4.3
Determine and potential risk of flooding, impact on third party assets (subsidence/ movement)		√		3.2 (closed) 4.6 and 4.7 (open)
Determine long term sustainability of scheme – will include testing and possibly thermal modelling	√	√		1.2 4.1 (open)

[7] To ensure that the system is operating efficiently, for owners and operators own information
[8] To ensure that the system is operating efficiently, for owners and operators own information
[9] If a vertical scheme

Would you like to find out more about us, or about your environment?

Then call us on

08708 506 506* (Mon-Fri 8-6)

email

enquiries@environment-agency.gov.uk

or visit our website

www.environment-agency.gov.uk

incident hotline 0800 80 70 60 (24hrs)

floodline 0845 988 1188

* Approximate call costs: 8p plus 6p per minute (standard landline). Please note charges will vary across telephone providers

Environment first: This publication is printed on recycled paper.