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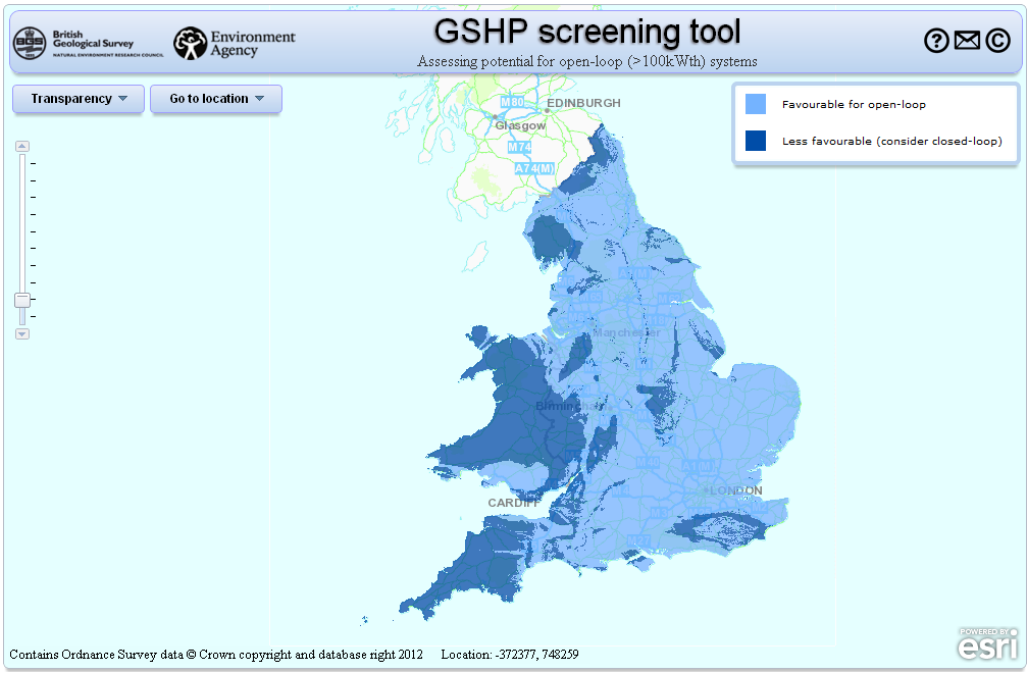
Non-Technical Guide:

A screening tool for open-loop ground source heat pump schemes (England and Wales)

Energy Sciences Programme

Open Report OR/12/064



BRITISH GEOLOGICAL SURVEY

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Non-Technical Guide: A screening tool for open-loop ground source heat pump schemes (England and Wales)

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Foreword

This report is a non-technical guide for the use of the open-loop ground source heat pump screening tool for England and Wales.

The tool was developed by the British Geological Survey in collaboration with the Environment Agency. It aims to provide an initial indication of the suitability of an area for the installation of open-loop ground source heat pump systems with a capacity of 100 kW_{th}* or more.

Acknowledgements

A large number of individuals have contributed to the development of the GSHP screening tool. BGS specialists in hydrogeology, groundwater chemistry and geographic information systems have provided assistance at all stages of the study by compiling, attributing and processing of data, creating new GIS layers and developing the web viewer tool. Colleagues in the Environment Agency have provided data sets and licences and offered advice in regulatory matters. Many individuals, including experts from the GSHP industry have freely given their advice, and provided the subject knowledge to assist the development and validation of the GSHP dataset.

Of the many individuals who have contributed to the project, we would particularly like to thank the following (in alphabetical order):

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Furthermore, we would also like to thank Natural England (NE) and the Countryside Council for Wales (CCW) for providing the data on protected sites in England and Wales (available under an Open Government Licence).

* kW_{th} = kilowatt-thermal (capacity of the scheme)

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1 Introduction

Ground source heat pump (GSHP) systems exchange energy with the ground to heat or cool buildings. There are two main types of GSHP systems: closed-loop and open-loop.

Closed-loop systems consist of a buried pipe system in the ground, which is filled with water (mixed with a little antifreeze). When the fluid travels around the system, it absorbs heat from, or gives heat out to, the ground. These are typically used in houses and smaller to medium-sized office buildings.

In open-loop systems, water is abstracted from the ground, pumped through a heat exchanger and then normally pumped back into the ground. These systems require permissions from the Environment Agency (EA) to ensure that when water is taken from, and returned to, the ground or surface water, it does not damage the environment or the rights of others to take water.

Typically, open-loop systems are used in larger buildings such as multi-story offices, shopping centres and larger swimming pools. For larger GSHP schemes (above 100 kW_{th}[†] capacity) open-loop systems can be more efficient and cost effective than closed-loop systems.

2 Purpose of the open-loop GSHP screening tool

This initial screening tool is intended to help planners and developers identify locations that may be suitable for open-loop GSHP systems in England and Wales. It does not consider the availability of water or other limiting factors, such as the ability to discharge water.

The tool considers hydrogeological and economic factors and provides an initial assessment of whether the area is likely to be suitable or unsuitable for open-loop GSHP installation with a capacity of 100 kW_{th} or greater.

The tool is based on medium-scale data (1:250,000) and hence does not provide information at the site-scale.

This tool is only the first step in a multi-step process. Figure 1 illustrates the steps that you need to take to obtain the environmental permissions for an open-loop GSHP system.

If the screening tool shows your location as being in a suitable area, this does not guarantee that you will get the necessary environmental permissions. There are two principal reasons for this.

- Firstly, the screening tool cannot pick up local (i.e. site-specific) features, including site-scale variations in environmental conditions.
- Secondly, factors such as the availability of water (i.e. the amount of water that is available for licensing by the Environment Agency) and discharge of water from a scheme are not considered by this tool but have an important bearing on the local environment. More details on this are given in Section 5.

If you wish to install an open-loop scheme, you will always have to do a detailed environmental assessment of your proposed site.

Furthermore, you should also seek specialist's advice to confirm the hydrogeological suitability and thermal potential of your site. This is because (1) the data underpinning the screening tool are not sufficiently detailed to pick up site-specific variations in hydrogeological conditions and (2) the tool does not consider whether the thermal resource is sustainable.

[†] kW_{th} = kilowatt-thermal (capacity of the scheme)

Before using the tool, please make sure you also read and understand its limitations and uncertainties as detailed in the Annex.

The figure below outlines the steps you need to take to apply for the environmental permissions. You may still need to contact other groups, such as conservation bodies if your proposal is within a designated site.

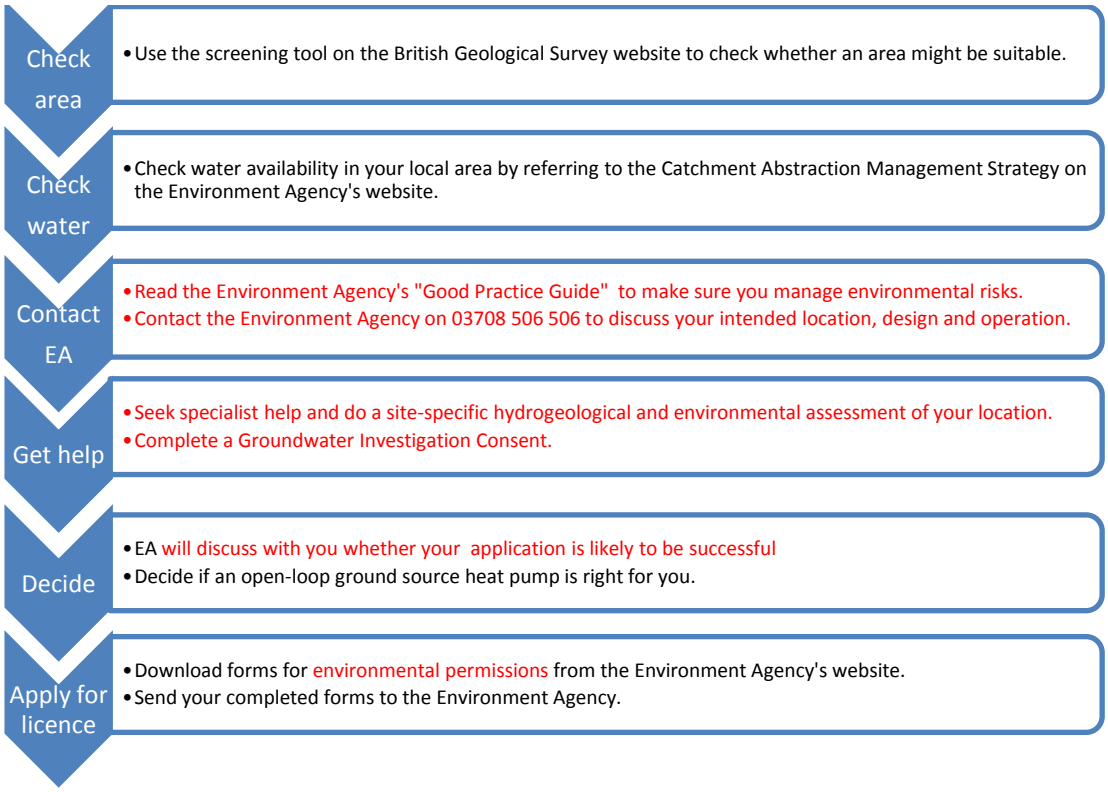


Figure 1: Steps to obtain environmental permissions for an open-loop GSHP (see section 6 for links to the different sources)

3 Who should use this tool?

This tool is for developers and planners to identify suitable locations for open-loop systems in the early planning stages. It can also support the assessment of existing sites with regards to their GSHP potential and hence may also be of interest to local councils, government agencies, building engineers, architects or organisations who are considering renewable potential across their estate.

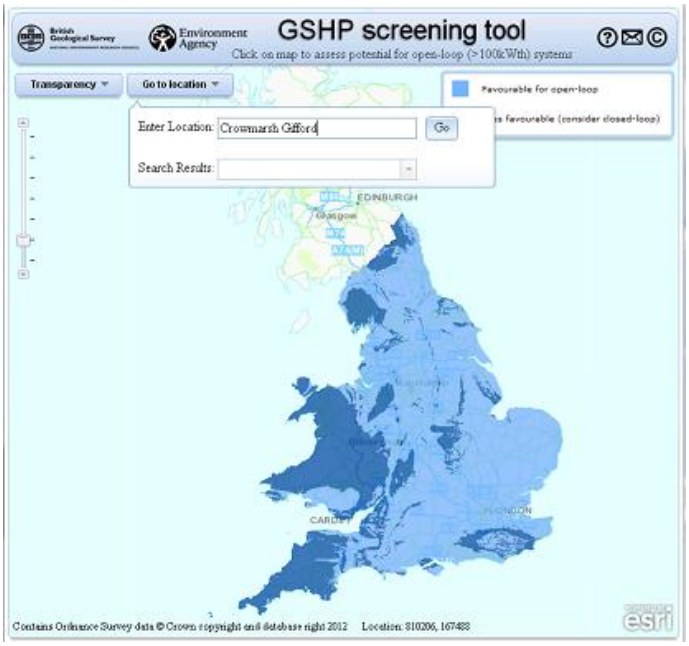
This tool is not for those homeowners and developers interested in installing closed-loop schemes. You can get more information on closed-loop schemes from the Energy Savings Trust (see web address in Section 6). You can get more information on environmental issues related to closed-loop schemes from the Environment Agency's "Good Practice Guide" (see web address in Section 6).

4 How to use the screening tool

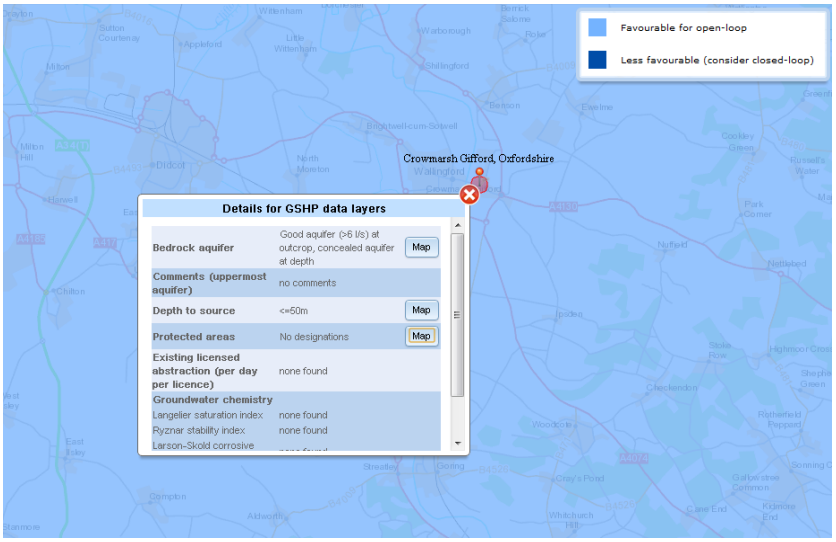
If you type your postcode or town name in the location search field, the tool will navigate to your search location and plots it as a pin on the map. If your location is in a light blue area, this means that your location may be suitable for an open-loop GSHP system. If your location is on a dark blue area, this means that it may not be.

In areas assessed as favourable, clicking on the map will bring up more detailed information on relevant hydrogeological and economic factors (Figure 2). Table 1 gives a summary of these factors and outlines how they relate to suitability for open-loop GSHP schemes. A full explanation of these terms and the underlying datasets is given in the Technical User Guide.

If your area is assessed as 'less favourable', the less likely it is that your scheme may be viable. Please read the Technical Guide to understand the factors assessed by this screening tool and its limitations. In areas shown as 'less favourable', closed loop GSHP may provide a suitable alternative. If you still wish to consider an open-loop GSHP scheme, contact the Environment Agency on 03708 506 506 for an initial discussion.



(a)



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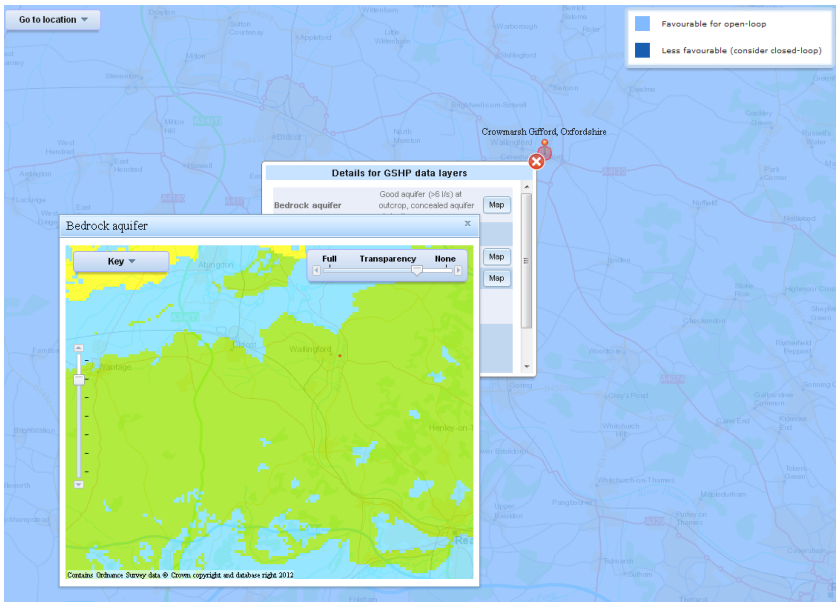

(c)

Figure 2: Illustration of the tool operation (a) Enter search location, (b) Click on location to bring up table with additional details on suitability, (c) Investigate underlying data layers by clicking on the Map symbols (e.g., Bedrock aquifer)

Table 1: Explanation of suitability factors included in the screening tool

Issue	What this means	How it links to suitability for an open-loop scheme
Bedrock aquifer	An open-loop scheme requires the presence of water bearing rocks (aquifer) from which it can abstract water. This shows whether an aquifer is present and if so, whether it is moderate or good in terms of providing water. It also considers how easily accessible the water is, whether the aquifers are present "at outcrop" and/or "concealed at depth". "At outcrop" means that the water bearing rocks are present at the ground surface or below poorly consolidated superficial deposits. Hence, to access the water one has to drill to the depths of the water surface. "Concealed at depth" means that water bearing rocks are covered by rocks which are less permeable. Hence, to access the water one has to drill through the overlying rock sequence. The water level may then rise closer to the surface.	In general, the greater the potential of the aquifer to provide water and the easier it is to access the water, the greater the potential for an open-loop scheme. This is subject to the local water situation (see Section 5)
Depth to source	This shows the minimum drilling depth to access the water.	How far down an installer has to drill is a key economic consideration, as it influences the drilling costs, borehole installation costs and the pumping costs. In general, the deeper the source, the higher the installation costs.
Protected areas	Protected areas are locations that are granted special protection under law. This may be to safeguard their natural beauty, protect special wildlife or plants, or to keep drinking water sources safe and clean.	If a scheme is located within or near a protected area you may not be able to get the environmental permissions or there may be special conditions attached to them.
Existing Licensed Abstraction	The Environment Agency controls how much water is abstracted from aquifers through the issuing of abstraction licences. This shows the daily amount of water other licence holders, within an area of 1km^2 around your location, have been permitted to abstract.	This information can give an idea of the volume of water that can be abstracted near your location. However, if there are very large abstractions, it may mean that there is less water available for new abstractions. If there are other abstractions, this may also increase the risk of interference between abstractions, where an open-loop scheme may impact on the effectiveness of another scheme nearby. Interference issues are outside the remit of the screening tool and EA regulation. You need to discuss this with your installer.
Groundwater chemistry	This shows if groundwater near your location is likely to cause corrosion or scaling, or has high iron levels.	Poor-quality groundwater can impact on the performance of open-loop schemes, for example causing corrosion or scaling, or reducing the efficiency of the heat exchanger.

5 What the screening tool does not show

5.1 ENVIRONMENTAL ISSUES

In environmental terms, there are two significant issues which are not assessed by this tool.

Firstly, while the screening tool shows how much water is currently licensed to be abstracted near your location, it cannot show the amount of water you will be able to abstract. This will depend on the water availability in your area at a given time.

The Environment Agency is responsible for ensuring there is enough water for people, industry, agriculture and the environment. This is done through licensing the amount of water that can be abstracted.

Every area in England and Wales has a Catchment Abstraction Management Strategy which assesses how much water is available. If you would like to install an open-loop GSHP scheme, please look at your local Catchment Abstraction Management Strategy which is available on the Environment Agency's website (see web address in Section 6).

Abstraction licences will normally be issued on the assumption that all of the abstracted water is pumped back into the ground (that is the scheme is non-consumptive). Abstractions which result in the scheme being consumptive, for example, abstracting out of an aquifer and discharging into a river or sewer may not be allowed.

Secondly the tool does not consider the discharge of water associated with GSHP schemes. The proposed method, quality and temperature of discharge can influence and/or curtail the viability of a scheme in a particular location.

The discharge of water from your scheme to an aquifer or surface water is regulated through an environmental permit from the Environment Agency. For this, you will need to provide details of the impact of the discharge on the environment. The permit will commonly have conditions attached regarding the permitted quality, flow rate and temperature of the discharge water.

If you discharge to a sewer or drain, you will also require the permission of the relevant water company.

5.2 SUSTAINABILITY

Sustainability of the open loop GSHP system is not considered by this tool and this is not within the remit of the EA or BGS. This may be an issue in areas where a large number of schemes have been installed within a certain area and where thermal interference between these systems can occur. Similarly, incorrect design can reduce the sustainably of a scheme significantly and some systems had to be abandoned due to this. You should discuss this with your installer, as changes to environmental permission may not be allowed.

5.3 POTENTIAL RISK FACTORS AND HAZARDS

In areas where soluble rocks (limestone, chalk, dolomite, gypsum, salt) are present there is an increased risk of geohazards induced by the abstraction/injection of groundwater. These need to be considered before committing to the installation of an open loop GSHP system as explained in Appendix 1.

6 Further information

Abesser, C (2012) Technical Guide: A screening tool for open-loop ground source heat pump schemes. BGS Open report OR/12/60 (Available at GSHP screening tool website)

Catchment Abstraction Management Strategy website:

http://www.environment-agency.gov.uk/business/topics/water/119927.aspx

Energy Saving Trust website:

http://www.energysavingtrust.org.uk/Generating-energy/Choosing-a-renewable-technology/Ground-source-heat-pumps

Environmental Good Practice Guide for Ground Source Heating and Cooling:

http://www.environment-agency.gov.uk/business/topics/128133.aspx

Geotrainet Manual for Designers of Shallow Geothermal Systems:

http://www.geoexchange.ro/Geotrainet%20Manual%20pentru%20proiectanti.pdf

Regulation of Ground Source Heat Pumps:

http://www.environment-agency.gov.uk/business/topics/128133.aspx

To note that from 1 April 2013, responsibility for environmental permitting in Wales will transfer to the single environmental body for Wales.

Appendix 1: Limitations and uncertainties

1. The GSHP screening tool is not updated. It is based on, and limited to, the data that were available from various databases at the time this data set was created between August 2011 and April 2012.

2. The GSHP screening tool is developed for open-loop, non-domestic schemes with >100kW capacity.

3. The GSHP screening tool has been developed at the 1:250, 000 scale and must not be used at larger scales. It does not provide definite answers at the site scale and all spatial searches against the data should be done with a minimum 250m buffer.

4. This tool is intended to be viewed onscreen only. Some of the data supporting this screening tool is restricted due to national security. Information that is freely available can be found in Section 3.

5. The tool only considers the main hydrogeological units (Chalk, Corallian, Great Oolite, Inferior Oolite, Lower Greensand, Magnesian Limestone, Sherwood Sandstone Group) as providing bedrock aquifers at depths. Other formations can also provide concealed aquifers locally, but these have not been included here.

6. The potential of superficial deposits to provide productive aquifers is also not considered by this tool.

7. Estimates of bedrock aquifer productivity are based on best-case scenarios, i.e. the maximum possible yield from a single borehole.

8. The tool does not consider the reduction in aquifer productivity near the outcrop boundaries due to decreasing thickness of the aquifer, i.e., aquifer thinning. As a result, there is a higher degree of uncertainty regarding the predicted aquifer potential near these boundaries which needs to be considered when using the tool. This is particularly important at boundaries between the base of a productive unit (aquifer) and the top of a less productive unit (no suitable aquifer).

9. The tool does not consider the suitability of the subsurface to accept water, i.e. the suitability for re-injecting water. Such information needs to be obtained from site-specific investigations or field tests. There are also alternative methods for discharging the water that do not rely on the subsurface properties, e.g. discharge via the sewer system or to surface water courses. Permission from the EA and/or the relevant water company will be required for the proposed discharges.

10. The tool does not consider the sustainability of the open loop GSHP system. This may be an issue in areas where a large number of schemes have been installed and where thermal interference between these systems can occur. Similarly, incorrect design can reduce the sustainably of a scheme significantly and some systems had to be abandoned due to this.

11. Being in a favourable area does not guarantee you will obtain the environmental permissions you require for an open-loop scheme, as the tool does not consider local variations, water availability or discharge of water from the scheme. The Environment Agency will always require developers to obtain more detailed, site-specific information, for example by applying for Groundwater Investigation Consent.

12. The existing abstraction data **can represent the combined licensed yield from multiple boreholes**. For example, where two or more abstraction values are displayed for a search location, these may refer to the same licence (in which case they have the same value). Conversely, they could be boreholes that abstract from different aquifers and/or depths.

13. The groundwater quality and existing abstraction licence data layers both incorporate information on superficial deposits (overlying the bedrock) which are not otherwise considered by this tool. Values returned by these layers do not necessarily relate to the main source identified in the bedrock aquifer potential / depth to source layers.

14. There are a number of **risk factors** that may affect the suitability of a site for GSHP installation which are not considered in this tool. These include:
    - locations of mine workings and shafts
    - locations of known or suspected contamination
    - underground infrastructure restrictions
    - ambient temperature changes
    - areas where geohazards may occur
    - presence of evaporites (salt, gypsum (including anhydrite)) in the subsurface.
    - Areas where landslides, cambering or shallow mining are present

For example, where soluble rocks (limestone, chalk, dolomite, gypsum, salt) are present at or below the surface, these can contain caves, cavities and open fissures. Where these are filled with sediments, changes in the groundwater flow regime, as induced by the abstraction and/or injection of groundwater, can cause the filling material to be washed out of the cavities resulting in destabilisation, collapse or surface subsidence. In chalk and limestone this is particularly an issue where the potential aquifer is only covered by a small thickness of other lithologies. In highly soluble rocks, such as salt or gypsum, fluctuations in groundwater levels or increased water flow can also enhance the dissolution of the rock, leading to expansion of the cavities, destabilisation and collapse. In areas where gypsum is present, it is important that drilling does not introduce water into underlying anhydrite, and that the sulphate content of the abstraction and injection water is similar. Hence, groundwater abstraction/injection may not be viable at locations where salt or gypsum are known to be present.
Areas where landslides, cambering or shallow mining are present also need to be treated with caution as the addition of water to the ground can trigger landslides and subsidence movements in these situations.

Relevant information is available from various sources, including BGS, the EA, Coal Authority and local authorities (pollution incidents, contaminated land register). BGS also offers detailed information for geohazard assessments relating to mining, collapsible deposits, compressible ground, soluble rocks, running sand, landslides, and shrink-swell.