

## Former mine workings: Potential to provide heating and cooling in South Gloucestershire

### Introduction

This briefing note describes on-going work by South Gloucestershire Council on the potential use of former mine workings in the district, as a source of renewable heating and cooling for new and existing buildings.

It sets out the work to date, the scale of the potential resource, how this could be used and suggested next steps.

### What are the former mine workings and where are they?

In this case the mine workings are disused and abandoned coal mines located beneath Kingswood and the parishes of Mangotsfield and Westerleigh.

More than a 1000 mine entry-points and 42 coal seams are recorded in this area, and most were worked for the extraction of coal between the 1870's and 1920's. Coal deposits range in depth from tens of meters to 600m below the surface. The mines were closed following 'total extraction' of the coal resource or when mining was no-longer economically viable.

In mines where all the coal was extracted, a mix of void spaces, (often former road-ways), areas where the mine has collapsed, and areas where it has been backfilled with rubble or "goaf"<sup>1</sup>, are left behind.

Without pumping to control the ingress of water into the mine, void spaces flood. Where it is very close to the surface, this flood water is warmed by solar energy conducted through

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<sup>1</sup> "Goaf" – a general term for mine workings.

the ground, and at greater depths it is warmed by geological activity<sup>2</sup>. In this area the water temperatures in the mines are thought to be in the range of 11 deg C at 100m, to 24 deg C at 600m below the surface.

In some mines the flood water remains reasonably static, in others it can flow horizontally, in some instances circulating between mines. Depending on the structure and conditions in the mine, water can also move vertically. The heat in the floodwater provides a thermal energy resource. Using heat pumps the temperature of the water can be raised to the level required for space heating and domestic hot water. Heat from mine workings can be used to supply single buildings such as schools, hospitals, and offices or a heat network serving multiple buildings or a district.

As heat is extracted from the water the thermal energy taken out is replenished by the flow of warm water from the surrounding mine workings and geology, and close to the surface, by solar energy. If the system is designed such that the heat extracted is balanced by the heat being replenished, the system can be treated as a renewable heat resource.

The temperature of the mine water means that as well as being a heat resource, there is potential to use it for summer cooling by supplying buildings with 'coolth'<sup>3</sup>. This is piped to buildings as low or ambient temperature water.

Reject heat is a by-product of cooling buildings and where this heat can be discharged back into the system (mine workings) it helps to raise the temperature of the mine water. Combining heating and cooling in this way enables heat pumps producing heat to operate at much higher efficiencies. In some cases there may be potential to use the water in flooded mines as a heat or 'thermal' store, so that heat discharged into the mine can be used later in the season.

### **How is heat and coolth extracted from former mine workings?**

Thermal energy can be extracted from former mine workings in two ways:

*Using an open-loop heat pump system:* Water is pumped out of the mine from a borehole and into a heat exchanger which is connected to one or more heat pumps.

Heat is extracted from the water, after which the cooler water is discharged to another water body, such as a surface water pool or a borehole. This can be in the same location as the abstraction mine or it can be discharged to another mine. This may be shallower or deeper, and usually is hydraulically connected to the mine from which the water was first taken.

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<sup>2</sup> Such as the natural decay of radioactive isotopes which produces heat.

<sup>3</sup> 'Coolth' – the opposite of heat or warmth.

*Using closed-loop heat pump systems:* In this case heat is extracted from the mine workings but the mine water itself is not abstracted or discharged – only the heat is taken-out. This is done by circulating a water and antifreeze mixture through plastic pipes (a ‘closed-loop’) installed into boreholes drilled into the mine. The water and antifreeze mixture passes through a heat exchanger connected to the heat pump after which it is recirculated around the system.

There are pros and cons to both approaches which are explored in the Coal Authority report, and relate to how much heat is required and at what temperature, and the geology and hydrology of the mine workings.

For both open and closed loop systems, once boreholes have been drilled into the mine, the structure of the mine itself is not affected, and apart from water, no material is removed.

It is important to note that the process of extracting heat from mine workings is not related to hydraulic fracturing or ‘fracking’ which is used to extract natural gas and oil from underground rocks.

Fracking entails pumping a mixture of water and chemicals under high pressure into rocks, to cause the them to fracture and release natural gas and oil deposits. This is completely different to the process described here, of extracting heat from water which has flooded disused mines.

### **How is SGC evaluating this resource?**

SGC has commissioned the Coal Authority to undertake a Phase 1, desktop study of former mine workings beneath Kingswood and the parishes of Mangotsfield and Westerleigh. This was published in July 2022.

The purpose of the study was to identify the proximity, depth and character of any mine workings and mine water levels, to assess the heat potential. In producing their report, the Coal Authority drew on available mining data, records showing the extent and elevation of mine workings, and local and regional mine water monitoring data.

The report identified four broad areas with overlapping workings:

- *Area 1* – Easton and Fishponds which includes 13 worked seams
- *Area 2* – Hanham, Cadbury Heath and Warmley which includes 6 worked seams.
- *Area 3* – Hillfields and North Kingswood which includes 9 seams, of which 4 were extensively worked.
- *Area 4* – Coalpit Heath to Westerleigh and Pucklechurch – which includes 4 seams.

Of the four areas considered, *Areas 1 and 2* offer the best prospects for further investigation due to the range of working depths and presence of roadways.

*Area 3* is likely to link workings in *Areas 1 and 2* but does not provide the range of working depths found in *Areas 1 and 2*.

*Area 4* may also provide opportunities for further investigation but with a reduced number of ‘targets’.

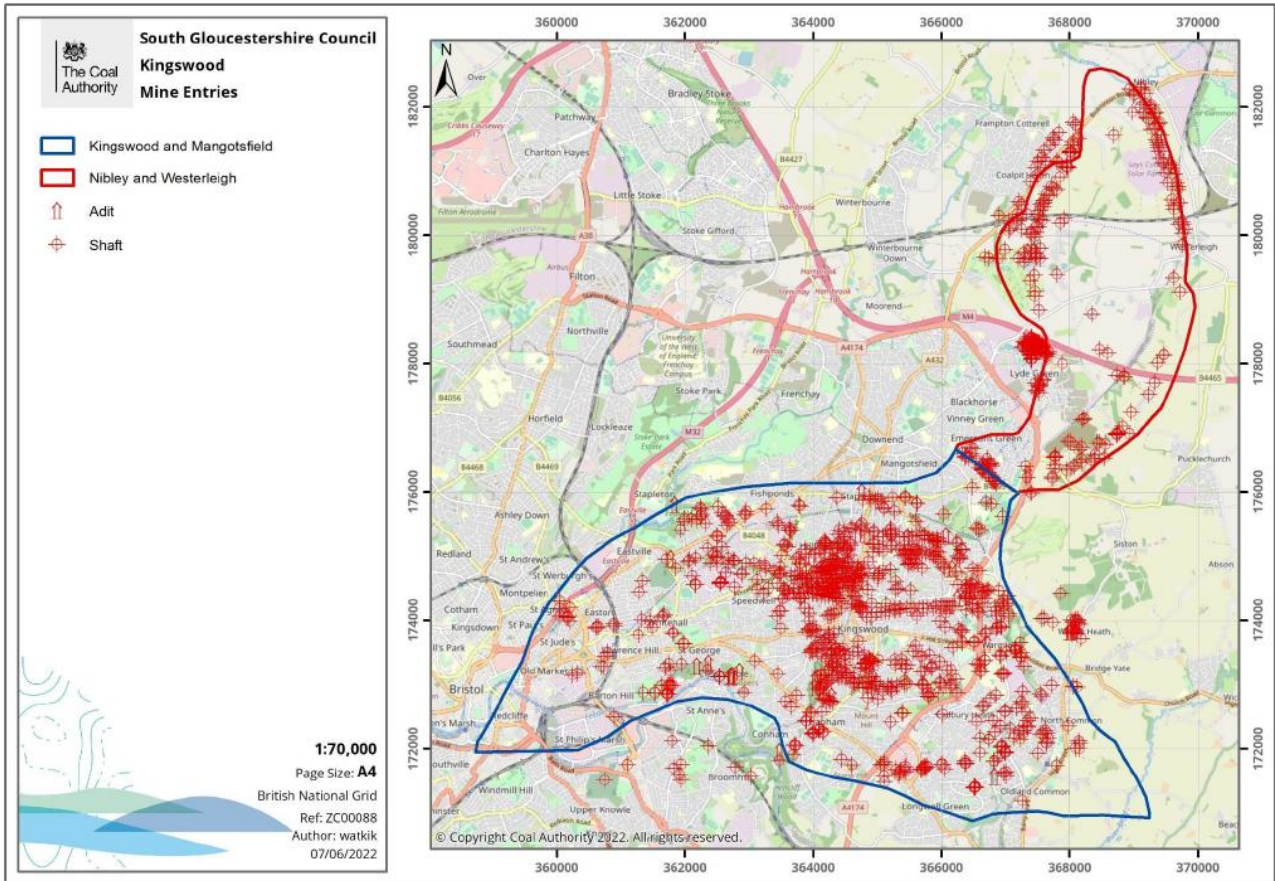


Figure 1: Map reproduced from Coal Authority study showing mine entries in the study area

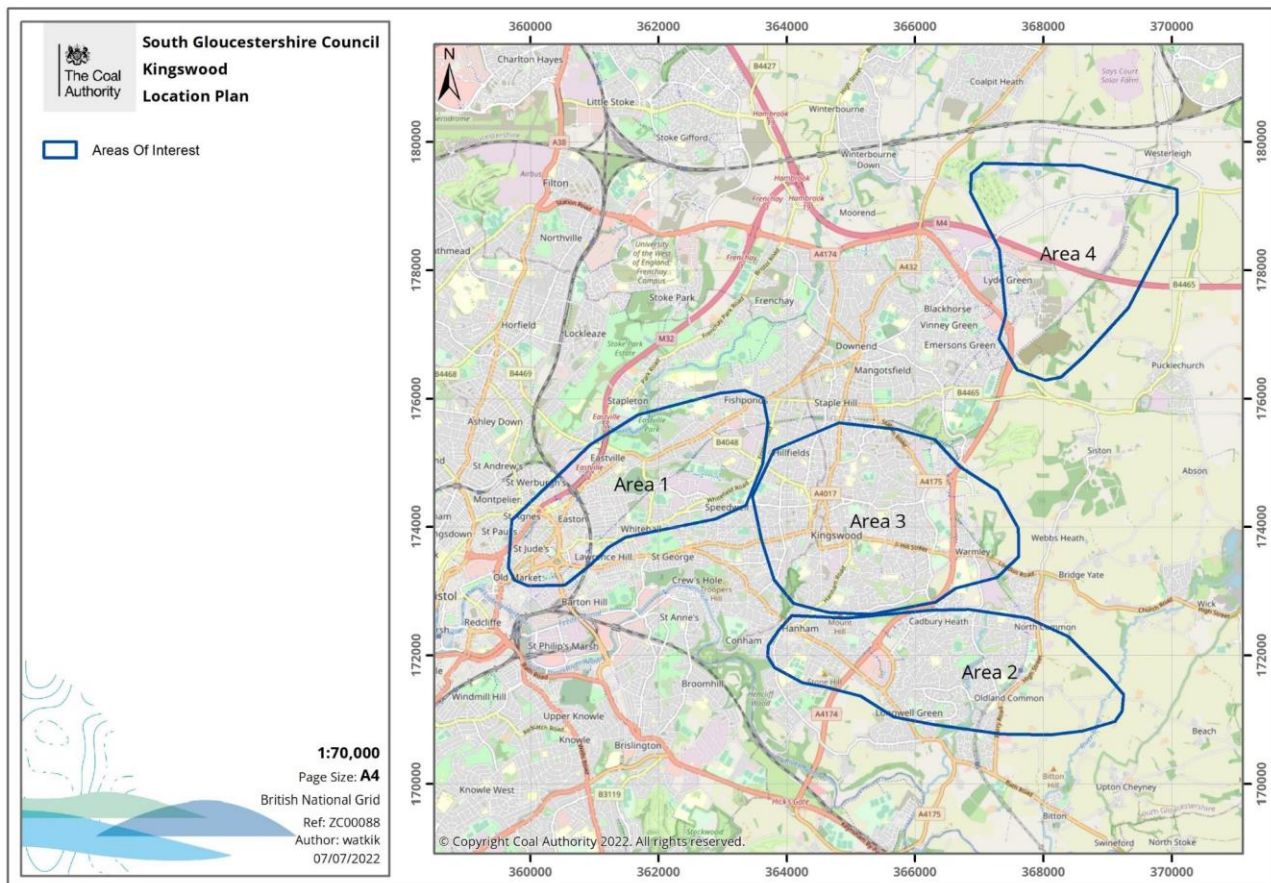


Figure 2: Map reproduced from the Coal Authority study showing the boundaries of areas, 1, 2, 3, and 4.

### Recommendations from the Coal Authority Study

The Coal Authority recommends a Stage 2 study of Areas 1 and 2. This would look at the original abandonment plans for the mines in these areas, to provide additional information and narrow down specific targets for test drilling.

It would also provide initial estimates of borehole drilling costs for a mine water geothermal system.

### How big is the heat resource?

At this stage we don't know and further desk work and trial boreholes are needed to assess the scale of the heat resource.

We estimate that there are 20,000-25,000 buildings in the vicinity of Area 2. The majority of these properties will use gas heating. Some of will be suitable for the installation of heat pumps to replace gas heating, however, based on typical energy performance figures for South Gloucestershire, we anticipate that a significant proportion of the properties in Area 2 will not be suitable for a heat pump, and will require some other form of heating post

2035 when the sale of gas boilers is due to end. This work will help us to understand what proportion of these properties could be served by a heat network drawing thermal energy from mine workings in that area.

### **How does this work relate to Bristol City Council's plans to develop heat networks and the Strategic Heat Main?**

As shown in Figure 2 (above) a significant portion of *Area 1* falls within Bristol. BCC is developing several heat networks to deliver low carbon and renewable heat across the city.

SGC is working closely with colleagues in Bristol to discuss how heat from mine workings could integrate with heat networks in Bristol. We are also considering how mine heat would integrate with the 'Strategic Heat Main' which is being considered for the transport of 'waste' heat from Avonmouth and Severnside to Bristol, via Filton and Patchway, and with other heat networks under consideration in South Gloucestershire.

### **Would heat taken from one area affect the heat resource in other areas and how can this be addressed?**

As yet we don't know the extent to which mine water in one area connects to water in other areas and how heat moves between areas. However, the Phase 1 study suggests that *Area 3* may provide a connection between *Areas 1* and *2*.

We are working closely with colleagues in Bristol and with other stakeholders with an interest in extracting heat and coolth from mine workings, to understand the scale of the resource and how it can be allocated fairly between areas and users.

A stakeholder working group is being established to consider these issues and will meet for the first time early in 2023.

### **What are the next steps? [Check with Barry]**

We would like to commission the Coal Authority to undertake a Phase 2 study of *Areas 1* and *2*.

We are working with colleagues in Bristol City Council to identify suitable sites for drilling test boreholes once further Phase 2 desk studies have been completed.

## **Contact information**

Barry Wyatt

Climate Emergency Manager

01454 864 602

[Barry.wyatt@southglos.gov.uk](mailto:Barry.wyatt@southglos.gov.uk)

[www.southglos.gov.uk](http://www.southglos.gov.uk)