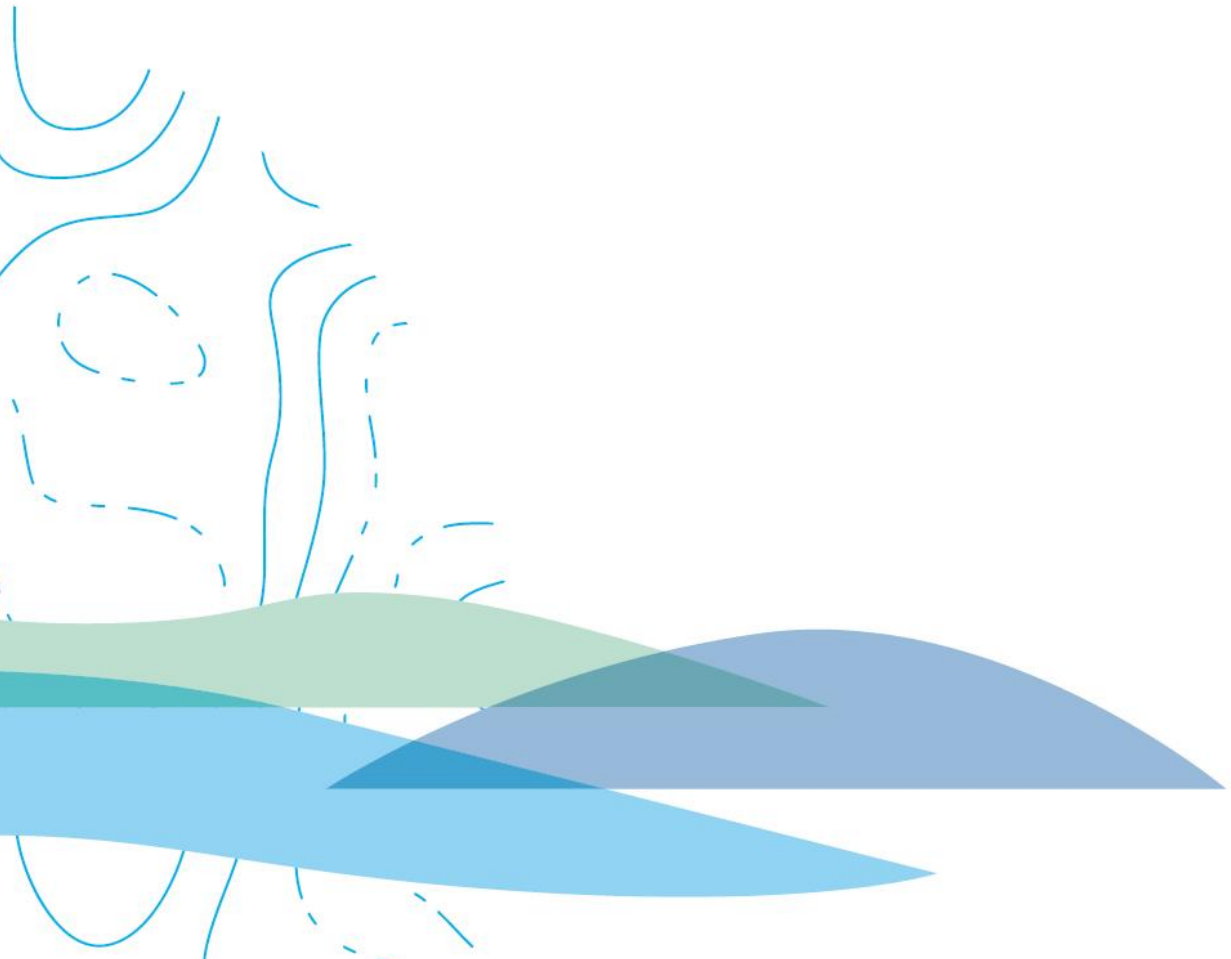
The Coal Authority

Mine Water Heat Opportunity Mapping for 10 Cities in England

July 2024



Disclaimer

This report has been prepared by the Coal Authority for DESNZ under a purchase order No. 1540175 for dated 19th August 2022 for proposal BEIS 001 dated 26th July 2022.

Any conclusions or recommendations made are those based on information obtained for the report and our current knowledge and practices. Data used within the report, either obtained by the Coal Authority or 3rd Party, has been cited within the report. Limitations of the data are identified within the report. The Coal Authority does not accept liability for the accuracy of any 3rd party data. Should new data or information become available these results, conclusions and recommendations may require amending.

This report should only be used in the stated context.

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Executive Summary

As part of the Advanced Zoning Programme which is being undertaken to support the Heat Network Zoning Policy DESNZ have asked AECOM to commission the Coal Authority to investigate the potential opportunity for mine water heat in the following 10 cities. These cities were chosen from those within the Heat Network Zoning Pilot and Advanced Zoning Programmes on the basis that they sit above coalfields.

The Coal Authority have been commissioned by the Department of Energy Security and Net Zero (DESNZ) to investigate options to deliver low or zero carbon heat to the following 10 major cities in England;

- Birmingham
- Bristol
- Coventry
- Leeds
- Greater Manchester
- Newcastle
- Nottingham
- Sheffield
- Stoke-on-Trent
- Sunderland

Coal mining has been a major industry in many cities and accordingly mine water heat may potentially be part of the mix at some of the listed cities. Subsequently DESNZ commissioned The Coal Authority as specialist sub-contractor to carry out studies of the mining and hydrogeology and produce a series of 'opportunity maps' to highlight the areas in each city administrative area where mine water heat opportunities may exist, together with the quality of the opportunities.

The legacy of coal mining can often be associated with liabilities, however the vast underground networks of mines can also provide opportunities for achieving net zero. Where water filled, abandoned underground coal mines occur, it is possible to use this water as a source from which to recover low carbon, secure heat and distribute via heat networks. This technology ready concept has recently been proven at scale in Gateshead, where a 6MW mine water heat network supplies affordable, low carbon, secure heat via a network of over 5km of pipes to businesses, homes, and public buildings.

This report provides opportunity 'tier' maps for each city. To create these maps, technical experts in the Coal Authority applied a methodology that enabled the ranking of underground workings into three categories; **"Good"**, **"Possible"** and **"Challenging"** opportunities. All known areas of coal mine workings across each of the city areas were assessed. Factors including depth to workings, mine water status and occurrence of multiple schemes were included, a detailed description of the method can be found in the main body of this report. These categories can be applied to areas where new boreholes would be required to support a mine water heat scheme. The ranking terminology is intentionally simple and is designed to complement high level decision making for example as part of Local Area Energy Planning.

A high level assessment of the areal extent and potential ranking in each of the 10 cities is set out in **Table 4.1** with associated potential maps for each city at **Figure 4:1** to **Figure 4:10**.

We recommend that the opportunity maps and this report are used to highlight locations at which to carry out more detailed feasibility studies to support mine water heat networks or smaller mine water heat schemes to individual end users. Following this exercise discussions with the Coal Authority – who own the majority of coal and mine workings on behalf of the UK Government – are recommended along with discussions with the environmental regulator, the Environment Agency, before more detailed site specific feasibility studies are completed.

Contents

List of Figures

List of Tables

1 Introduction

1.1 How to use this Report and Maps

This report and the associated series of opportunity maps are intended to be a tool to guide the non-specialist as to where mine water projects could be feasible. It is intended to aid consultants, planners and energy officers as to where further targeted feasibility studies should be commissioned. It is recommended that any potential sites identified in this report or using the mine water heat opportunity maps are followed up with discussions with the Coal Authority.

Sections are included to detail the methodology adopted in assessing the opportunities and the applicable regulatory framework for England.

Individual maps opportunity maps have been produced for the following cities;

- Birmingham
- Bristol
- Coventry
- Leeds
- Greater Manchester
- Newcastle
- Nottingham
- Sheffield
- Stoke-on-Trent
- Sunderland

These maps have been produced using the described methodology and available data with respect to mine workings and hydrogeology.

1.2 Open Loop Systems

There are two principal configurations for recovering heat from mine water. These are open loop and closed-loop systems. This report and associated opportunity maps are focused on open-loop systems only.

Open-loop systems typically require the mine water to be pumped to surface. The mine water is typically passed through a primary heat exchanger which transfers the heat to a 'clean' loop in which the heat pump is situated. The heat pump raises the temperature from a typical 12-20^{o}C to around 60^{o}C for circulation to homes and businesses. The thermally spent water from the primary heat exchanger may be:

- Discharged/returned to the same set of mine workings from which it was abstracted;
- Discharged/returned to a different set of mine workings, either shallower or deeper, but with clear evidence that it is connected to the abstraction workings; or,
- Discharged to a surface watercourse, although this is likely to present different / additional regulatory requirements and additional investigations.

Depending on the water quality and the vulnerability of the receptor, the discharge water may require treatment. The type of open-loop system used, as well as the environment of operation, will determine environmental, permitting, licensing and treatment requirements.

2 Methodology

Each city area has been assessed for potential borehole-based mine water heat schemes, which have been ranked into a number of "Priority Opportunity Areas". These areas have been designated to indicate where possible open loop mine water heat schemes, using purpose built boreholes to access the workings, could be investigated further. The following section outlines the assessment methodology, and the associated caveats.

2.1 Opportunity ranking criteria

Opportunity rankings for mine water heat potential have been developed by reviewing:

- Underground working depths
    - *Depth to working influences drilling costs and potential complexity;*
- Known mine water levels across mine water blocks (MWB)
    - *Pumping costs and energy used increase with depth to mine water;*
- Recovery status of MWB (recovering or recovered)
    - *Recovered systems indicate that water levels will not change. Recovering systems indicate that water levels may yet rise and potentially become closer to surface. However, recovering systems can have additional challenges such as dry workings and migrating gas as water levels rise;*
- Evidence of opencast mine workings
    - *Suggesting the possibility of recorded workings close to surface having been removed.*

There are three levels of opportunities for mine water heat developments: "Good", "Possible" and "Challenging". These rankings do not forgo the need for further detailed feasibility studies for specific sites, and do not guarantee the possibility of a successful mine water heat scheme at any location. The methodology and decision making process is detailed below and in **Figure 2:1**.

A number of "cut-offs" or groups have been designated for underground working depths and mine water levels. These allow for areas to be graded on the basis of whether the known data falls within a certain category. Areas are first assessed on whether there are overlapping workings present in an area, or if there is a single extensive seam.

Underground working depth cut-offs are taken as the following:

- <30 mBGL
- >30 – 300 mBGL
- 300 – 500 mBGL
- >500 mBGL

This is in line with current experience of the Heat and By-product Innovation Team at the Coal Authority. Shallow workings (typically <30 m below ground level) should be avoided, but can be mitigated for during the drilling process when there are deeper targets. Deeper workings may be well recorded as they are often more modern, but come at increased cost for drilling.

Mine water levels have been taken at the following cut offs:

- <75mBGL
- 75-100 mBGL
- >100 mBGL

This is in line with work by Walls et al. (2021) and the Heat and By-product Innovation Team's own pumping cost analysis tool. Recovery status is factored in to allow for the possibility that mine water levels may rise and reduce running/pumping costs for a system in future, improving the ranking of the area. Water levels should ideally not be artesian or too shallow (deeper than 20 mBGL) to allow for reinjection of mine water back into the target workings with minimal risk of surface egress. This will need to be assessed in detail at a site-scale, and has not been assessed extensively at this scale.

Additional factors that are considered in the criteria include whether there is knowledge of unflooded workings and mine gas in the area. These affect the fundamental feasibility of mine water heat in any particular opportunity area.

2.2 Priority ranks

The following criteria apply to each of the three different ranking categories. The flow chart in **Figure 2:**1 can be used to guide the user towards the appropriate rank, or the following criteria can be reviewed and satisfied. It should be noted that "Good Opportunities" are where all criteria are satisfied, and "Possible" and "Challenging" opportunities may have one or more of the criteria satisfied.

2.2.1 Good opportunities

These areas represent where there appear to be favourable conditions for a mine water heat scheme to take place, with fewer challenges. All of the following criteria will be met, in order to classify an area as "Good". However, these areas will still require a site-specific assessment to determine local water levels, condition of the workings, and feasibility of developing a specific scheme.

- Multiple recorded underground coal mine workings overlap each other, and;

- Workings between 30 m and 300 m below ground level, and;
- Water level estimated to be approx. <75 m below ground level, and;
- Water levels have recovered or are recovering, and;
- Workings are flooded.

2.2.2 Possible opportunities

These areas represent where mine water heat may be possible but some aspects may be less favourable than those in a 'good' opportunity area (for instance workings or mine water levels may be deeper with consequent increased drilling or pumping costs). These areas will need a thorough and more detailed investigation should a specific potential project be identified. This may lead to the ranking changing to a good or poor opportunity in the future.

- Workings are overlapping, and;
- Workings are flooded, and;
- Workings are near to or shallower than 500 m below ground level, or;
- Water levels are between 75-100 m below ground level, either recovering or recovered, or;
- Water levels are deeper than 100 m below ground level, but recovering, or;
- There is evidence of open cast coal mine workings, but with workings between 30 – 500 m,

2.2.3 Challenging opportunities

These areas represent where conditions do not appear favourable for developing a mine water heat scheme, and may not improve in the future. If any one of these criteria are met, the area is classified as "challenging". It is not that a scheme could not be successful here, but that there would be a number of challenging barriers to overcome versus other opportunity areas for mine water heat.

- Workings may not be flooded, or;
- Workings are <30 m below ground level only, or;
- Workings are only >500 m below ground level with no shallower targets, or;
- Water levels >100 m, and are recovered, or;
- There are known issues with mine gas, or;
- There is a single seam, which is fully flooded, and not impacted by opencast workings.

Single seam opportunities have been included as "challenging", and would require a thorough appraisal to determine whether the nature of the workings would support a scheme. Having a

borehole based scheme into a single seam can result in rapid "short circuiting" of a heat scheme, as colder spent water can rapidly move to the abstraction well after reinjection.

2.2.4 No opportunities

These areas are marked only where there is recorded workings that meet the following two criteria:

- There is evidence of open cast coal mine workings, with workings <30 m only, or;
- There is only a single seam of limited extent.

These conditions are tied to shallow workings or single seam workings or workings likely removed by opencast coal mining. Areas where there are no workings are not considered to be included in "no opportunities".

2.3 Caveats for ranking criteria

A number of aspects relevant to borehole-based mine water heat schemes have not been considered as part of opportunity assessment criteria. A number of these are due to the quality of the data at the resolution needed for a regional assessment, where some information is often more site-specific.

The following list of caveats indicate what information has not been included as part of the assessment criteria, and would normally be reviewed as part of more detailed feasibility studies:

- **Mine Water Treatment Schemes (MWTS)** – If an active, passive or proposed mine water treatment scheme, owned and operated by the Coal Authority as part of its statutory duties is located within the same or connected mine water block, an assessment and interaction agreement will need to be made to ensure that the proposed mine water heat scheme will have no detrimental impact on the MWTS;
- **Mine Water Levels and Local Topography:** Potential areas highlight where the conditions above are broadly met, but mine water level will vary depending on surface topography and interconnectivity between monitoring points and adjacent mine workings;
- **Geology:** Geology and geological structures (such as faults) are not accounted for in the ranking system, which may impact on drilling costs and complexity, and the wider hydrogeology of the region;
- **Type of Workings:** The type of mine workings are not accounted for due to the incomplete and inconsistent nature of the digital records, where it is often necessary to refer back to the original abandonment plans at a site-specific scale;
- **Age of Workings:** Age of workings have not been assessed at a regional scale and will need assessment on an area-by-area basis;
- **Probable workings:** are not accounted for within the grading criteria, and will need to be assessed on a site-specific scale;

- **Gas:** Gas risk assessments will be needed at every site, and only broad knowledge of gas risks in the area have been applied during any opportunity assessment;
- **Mine Water Chemistry:** the ranking does not take into account mine water chemistry as this can be highly variable and often site-specific;
- **Developer Risk Appetite:** The ranking criteria does not take into account the risk appetite of the potential mine water heat developer, which will have an impact on the assessment of the mine water heat opportunity;
- **Heating and Cooling Demands:** the ranking does not take into account existing or planned areas of heating and cooling loads, which would drive demand and dictate the value of a mine water heat opportunity.

The following conditions apply to the opportunity mapping layers:

- **Time Limited:** The potential represented is valid from the date of publication for a maximum of 2 years. This is because mine water levels can change – especially where they are still recovering. Regular reviews of the ongoing mine water level changes and records of mine collapse may change Priority ratings in future;
- **No Guarantees:** The priority rankings do not guarantee the success of a mine water heat scheme and any proposed project will need to be assessed in detail through further feasibility work;

Assessment to the best of our knowledge: This opportunity assessment has been carried out with the information available at the time, relevant to the scale of the study. Further information may be relevant at a more site-specific scale.

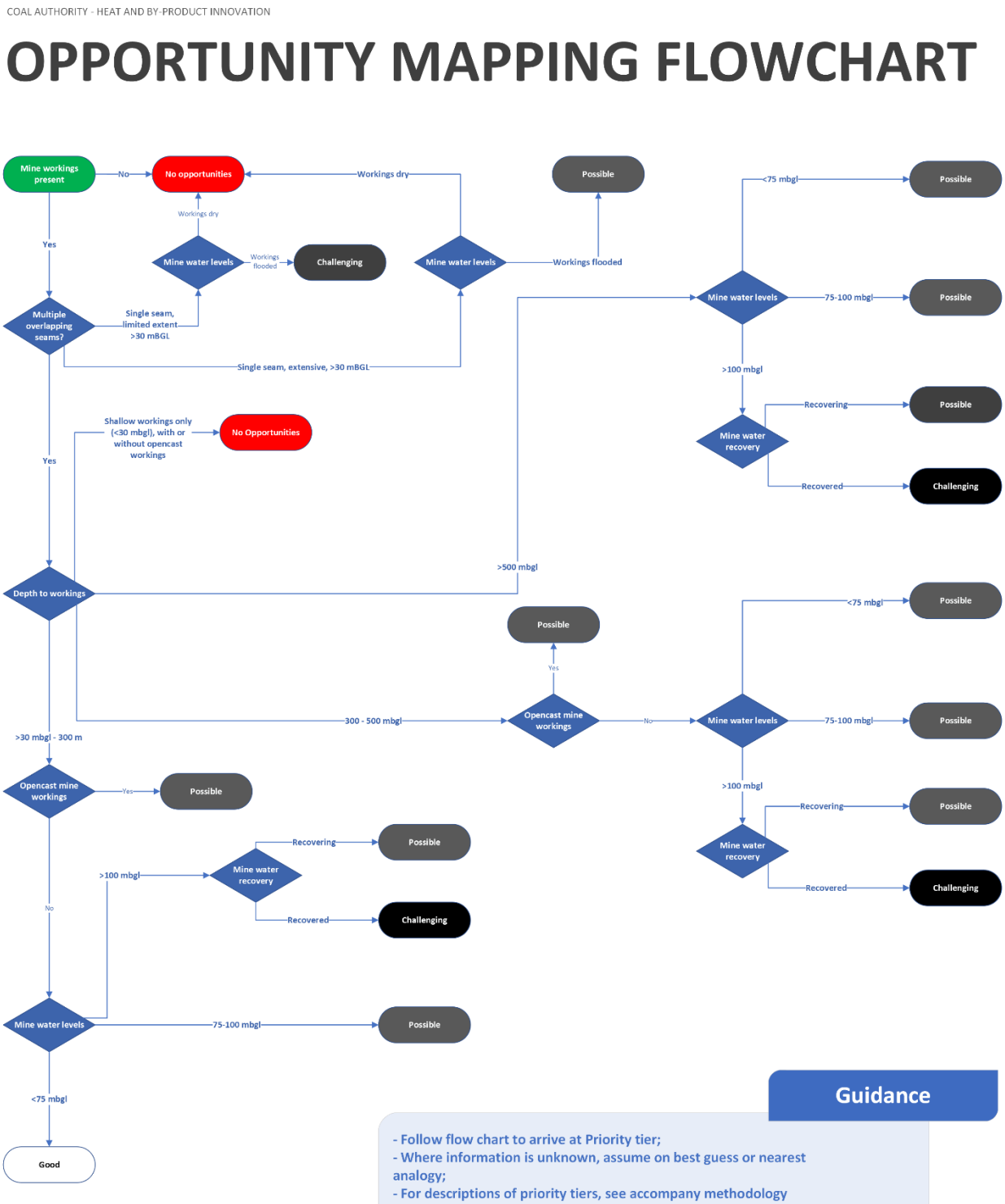

Figure 2:1 : Mine water heat opportunity assessment protocol flowchart

3 Regulatory position

3.1 Environmental regulation

For a proposed groundwater-source, open-loop geothermal system (regardless of whether aquifer or mine water derived), the Environment Agency (EA) is the principal regulator for England. They are responsible for managing abstraction and reinjection applications and licences.

It is advisable in the first instance to have a discussion with the EA about the proposed scheme. They can therefore make the most up-to-date recommendations on the procedures needed to be complied with.

At present, a number of consents, permits and licences will be required for a full-scale scheme from the EA. These may include:

- Groundwater Investigation Consent (WR32)
- Abstraction licence
- Reinjection/discharge permit (via an Environmental Permit)

Abstraction Licences, and Ground Investigation Consents are only required when production scale pumping requirements will exceed 20 m^3 per day. This equates to a 24-hour pumping rate of approximately 0.2 L/s. The Ground Investigation Consent (Form WR32) will be required from the EA in advance of any test pumping on drilled boreholes (whether pilot or production scale).

An Abstraction Licence and Discharge Permit can be applied for under a combined permit request, via Form B8. Otherwise, separate licences can be arranged under their respective forms. Latest guidance on permit requirements should be sought from the Environment Agency during pre-application consultation.

The detailed processes are set out at: https://www.gov.uk/guidance/open-loop-heat-pump-systems-permits-consents-and-licences.

It is recommended that prior to any further progress on a mine water heat scheme, that the Environment Agency is consulted as early as possible for clarification as per the requirements of any licensing and permits.

3.2 Coal Authority – access to workings and heat

If any borehole(s) or trenches intersect the Coal Authority's property, which includes past coal mine workings, unworked coal seams or mine entries (shafts and adits), then prior permission in the form of a Permit to deal with coal or coal mines will be required from the Coal Authority. Equally, there could other mineral owners which may also need to grant permission. Where any borehole is drilled into past coal mine workings to access mine water for heat recovery, a Mine Water Heat Recovery Access Agreement will be required from the Coal Authority.

The Coal Authority licensing team should be contacted as soon as possible via this email address minewaterheatlicensing@coal.gov.uk regarding access to coal or coal workings for the purposes of mine water heat. Arrangements for mine water heat recovery access agreements cover both the exploratory works, and the production phase of any mine water heat project.

Fees and charges for Coal Authority agreements are now published, and available on their website:

https://www.gov.uk/government/publications/mine-water-heat-access-agreement

At the time of writing, a Mine Water Heat Access Agreement - exploratory phase application costs £3000, and the Mine water Heat Access Agreement - production phase application costs £2750, with an ongoing annual fee of £1500 for each borehole used in the scheme.

3.3 Other regulations

In addition to the above, there are also legal requirements in respect of drilling boreholes for the purposes of water investigation.

Notifications will need to be provided to the Health and Safety Executive (HSE) of operations to drill a new borehole and abandon a borehole (Borehole Sites and Operations Regulations 1995, Reg 6(3) and 6(5), HSE Guidance on Regulations 2008).

Under the Water Resources Act 1991, the Natural Environment Research Council (NERC) (via the British Geological Survey) is required to be informed of intention to drill any well or borehole for the purposes of abstracting water that is greater than 15m depth. Records of hydrogeological information are also to be provided to NERC.

Should the site fall within an owned Petroleum Exploration Development Licence (PEDL) block, the owner of the block should be notified if drilling is expected to intersect the depth at which the block starts below ground. This will vary from PEDL block to PEDL block and should be checked before drilling commences.

4 Summary

Below is a summary narrative which considers, at high level, the coincidence of urban areas (likely to have considerable heat loads) with the opportunity levels set out in each of the 10 city opportunity maps illustrated in **Figure 4:1** to **Figure 4:10**.

The places mentioned below are not exhaustive but intended to give some indication of where early investigations may be opportune.

A summary table of the extent of the opportunity in each city is included at **Table 4.1.**

4.1 Birmingham

Mine water heat opportunities in the Birmingham district are very limited. Those opportunities which do exist are situated on the north western boundary of the Birmingham administrative area as shown in **Figure 4:1** and are ranked as 'challenging'. This is due to the workings being only in a single seam and at depths of 550m to 770m making drilling costs extremely expensive.

4.2 Bristol

Moderate areas of the Bristol administrative area offer differing degrees of mine water heat opportunities as illustrated in **Figure 4:2**:

To the north east of the city centre area two areas ranked as being 'good' opportunities exist:

- An area of approximately 1.5Km^2 immediately to the south east of the M42 motorway which includes the urban areas of **Upper Easton** and **Lower Easton** extending eastwards as far as **Eastville**.
- A further area of around 2Km^2 which extends from **Upper Eastville** to the administrative area boundary and includes the urban areas of **Hillfields** and **Burchells Green**. The area includes the **Clay Hill (Fishponds) Trading Estate**.

To the immediate south of the two areas described above an area of around 2.5Km^2 offering possible opportunities exists extending south to the A420 highway.

To the south west of the city good and possible areas exist:

- a relatively small 'good' opportunity (0.5Km^2) area lies in the locality of **Ashton Vale** which has both commercial and residential developments. This is adjoined by;
- a 'possible' opportunity area to the immediate north which includes considerable commercial development and to the immediate north east which includes the **Ashton Gate** locality which features residential development and the Ashton Gate Stadium.

4.3 Coventry

Coal mining is largely restricted to the northern part of the administrative area with the exception of a small area in the south east as illustrated in **Figure 4:3**.

A zone of good potential exists in the north east of the area taking in the residential areas of **Henley Green**, **Bell Green** and **Wood End**. The workings in this zone are old (c.1900) but relatively shallow (60m to 300mBGL) resulting in reasonable drilling costs.

To the west the workings become deeper with opportunity ranking changing from possible and becoming increasingly challenging due to the great (<600m) working depth and consequent drilling costs to access the more modern and much deeper workings from Coventry and Daw Mill Collieries.

In the south eastern part of the area a zone of possible opportunity exists in the locality of **Binley**. Here the workings are at a relatively shallow depth of 150mBGL to 250mBGLand working took place up to 1940.

4.4 Leeds

Coal mining is largely restricted to the south west and south east quadrants of the Leeds administrative area as illustrated in **Figure 4:4**.

Significant areas of 'good opportunity' exist in the south western quadrant with a large area taking in **Middleton** and a further large area stretching from **West Ardsley** through to **Morley.**

To the north east of the city centre a large area of good opportunity exists stretching from **Harehills** to **Halton Moor**, **Osmondthorpe** and **Cross Green**. A further large area which offers good opportunity from a mining perspective exists to the east of **Halton/Halton Moor** but much of the area is open countryside/golf course.

Most of the south eastern quadrant of the administrative area offers possible opportunities including the major populated areas of **Garforth** and **Rothwell**.

4.5 Greater Manchester

By far the greatest areas offering potential exist outside the M60 orbital motorway. The worked area and opportunity tiers are illustrated in **Figure 4:5**.

The main 'good' opportunity areas are;

- Outside the north east part of the M60 extending from the northern fringes of **Ashton-under-Lyne** through **Oldham** to **Middleton** and **Royton**.
- Just inside the western administrative boundary between J24 and 26 of the M6 motorway which includes the western half of **Winstanley**.

Possible opportunities exist within a very large area to the west of the city centre extending to the western boundary and bounded to the north roughly by the line of the M61 and to the south by the A580. This area includes many extensively built up areas including **Leigh**, **Standish**, **Ashton-in-Makerfield**, **Wigan**, **Ince-in-Makerfield**, **Walkden** and **Westhoughton**.

A number of possible opportunity areas exist inside the M60 orbital motorway:

- Nearest to the city centre is an area covering **West Gorton**, **Beswick**, **Bradford** and **Collyhurst**. This area includes the Etihad Campus which is situated on the site of the former Bradford Colliery.
- A belt of workings just inside the eastern part of the M60 from **New Moston** to **Droylsden**
- A large area stretching from **Pendleton** to the M60 including **Swinton** and **Clifton**.

4.6 Newcastle upon Tyne

Virtually the whole of the Newcastle upon Tyne administrative area is underlain by coal mine workings as illustrated in **Figure 4:6**.

The large majority of the worked areas may be classed as 'good opportunities' due to the relatively shallow (<300m) depth, multiple seam working, and recovered mine water levels.

Notable good opportunity localities are;

- To the west of the city centre an area stretching from **Forth Yards** to **Scotswood** adjacent to the River Tyne which extends to and includes **Town Fields**.
- A large area which extends north west from the western boundary near **Walbottle** through to **Newcastle Airport** to the north eastern boundary. While a very large area geographically, with the exception of **West Denton**, the **airport** and **Dinnington** this area does not feature many urbanised areas.
- A large area to the north of the city taking in **Brunton Park**, **Melton Park** and parts of **Newcastle Great Park**.
- A large area to the east of the city taking in **Byker**, **St. Anthony's** and **Walker**.

4.7 Nottingham

Coal mining activity is largely restricted to the western half of the Nottingham area as illustrated in **Figure 4:7**. Within the worked area two large good opportunity areas exist which cover approximately half of the total administrative area. These areas extend from the western boundary eastwards to a line roughly following the Western Boulevard ring road.

The southern of the two areas takes in **Wollaton**, **Bilborough**, **Broxtowe** and **Aspley** while the northern area takes in **Bulwell**, and **Highbury Vale.**

A further good opportunity area exists to the south west of the city centre taking in the **South Lenton** locality including business parks.

4.8 Sheffield

Coal mining activity in the Sheffield area is largely restricted to the south eastern part of the administrative area as illustrated in **Figure 4:8**. The workings extend from a line between the City centre and Meadowhall becoming deeper to the south east and the Sheffield boundary. The opportunities in this large area may be classed as good and includes **Darnall**, **Handsworth**, **Hackenthorpe**, **Drakehouse** and **Mosborough**.

A smaller area of good opportunities exists at the north eastern boundary to the east of **Chapeltown**.

Limited areas of challenging opportunities lie in the more sparsely worked areas of very old mining towards the Derbyshire Dales/Peak District particularly around **Stocksbridge**. While considered challenging due to the limited extent of working, these areas may be suited to small schemes with limited heat demand.

4.9 Stoke-on-Trent

Coal mining has taken place across around half of the Stoke-on-Trent administrative area as illustrated in **Figure 4:9**. A wide belt of good opportunity areas **being** is present from the northern boundary to the southern boundary and takes in many of the populated conurbations in wider Stoke on Trent from **Chell Heath** in the north through **Hanley** in the centre to **Florence** in the south.

4.10 Sunderland

Approximately 95% of Sunderland has been subject to past coal mining as illustrated in **Figure 4:10**.

A large 5Km wide belt of good opportunities exists from the western boundary of the administrative area. Here workings tend to be shallower (<300m), being nearer to the outcrop of the Coal Measures, with the strata dipping from west to east. Major populated areas include **Hetton-le-Hole**, **Houghton-le-Spring** and **Washington**.

The areas in the eastern half of Sunderland offers possible or challenging opportunities, the ranking being largely related to increasing depth of workings and associated drilling challenges and costs. Many areas of workings towards the eastern (coastal) boundary are ranked as challenging largely on drilling depth/cost. However the workings are relatively modern with recovered mine water levels and may offer good quality drilling targets for inclusion in a larger scheme.

Possible opportunities exist to the south of the River Wear including the **Sunderland city centre** and the urban areas of **Silksworth**, **Farringdon**, **Springwell**, and **Pennywell**.

To the north of the River Wear possible opportunities exist in the urban areas of **Roker**, **High Southwick**, **Marley Potts**, and **Hylton Redhouse/Hylton Castle Estate** and includes the **Nissan** factory campus.

Table 4.1 : Summary of mine water heat opportunities in each city

	As approx. % of total administrative area				
City	**Overall mined area**	**'Good' area**	**'Possible' area**	**'Challenging' area**	**Comments**
Birmingham	3%	-	-	3%	Very sparse worked area at NW boundary
Bristol	6%	2%	2%	2%	Moderate worked areas in SW-NE trending belt to S of city
Coventry	6%	2%	2%	2%	Worked areas largely in northern third of area. Good opportunities to the east shallower workings
Leeds	20%	5%	-	15%	Worked areas constrained to S third of area. Good opportunities to SW and NE of city.
Greater Manchester	18%	3%	5%	-	Worked areas mainly in northern half of area. Good opportunities to NE of M60.
Newcastle	85%	60%	3%	22%	Very abundant good opportunity areas to W and NW of city plus smaller area in SE at Walker/Byker.
Nottingham	50%	40%	8%	2%	Large good opportunity areas to the west half.
Sheffield	23%	20%	-	3%	Most mining confined to the SE part of the area which is good opportunity ranked. Some disparate small challenging areas to the W.
Stoke	70%	45%	7%	18%	Mined over a large proportion of the area. Good opportunities in a central belt from N to S boundaries.
Sunderland	95%	45|%	35%	10%	Almost the entire area has been mined. Good opportunities to the W (shallower <300m) becoming possible then challenging as depth increases to the E.

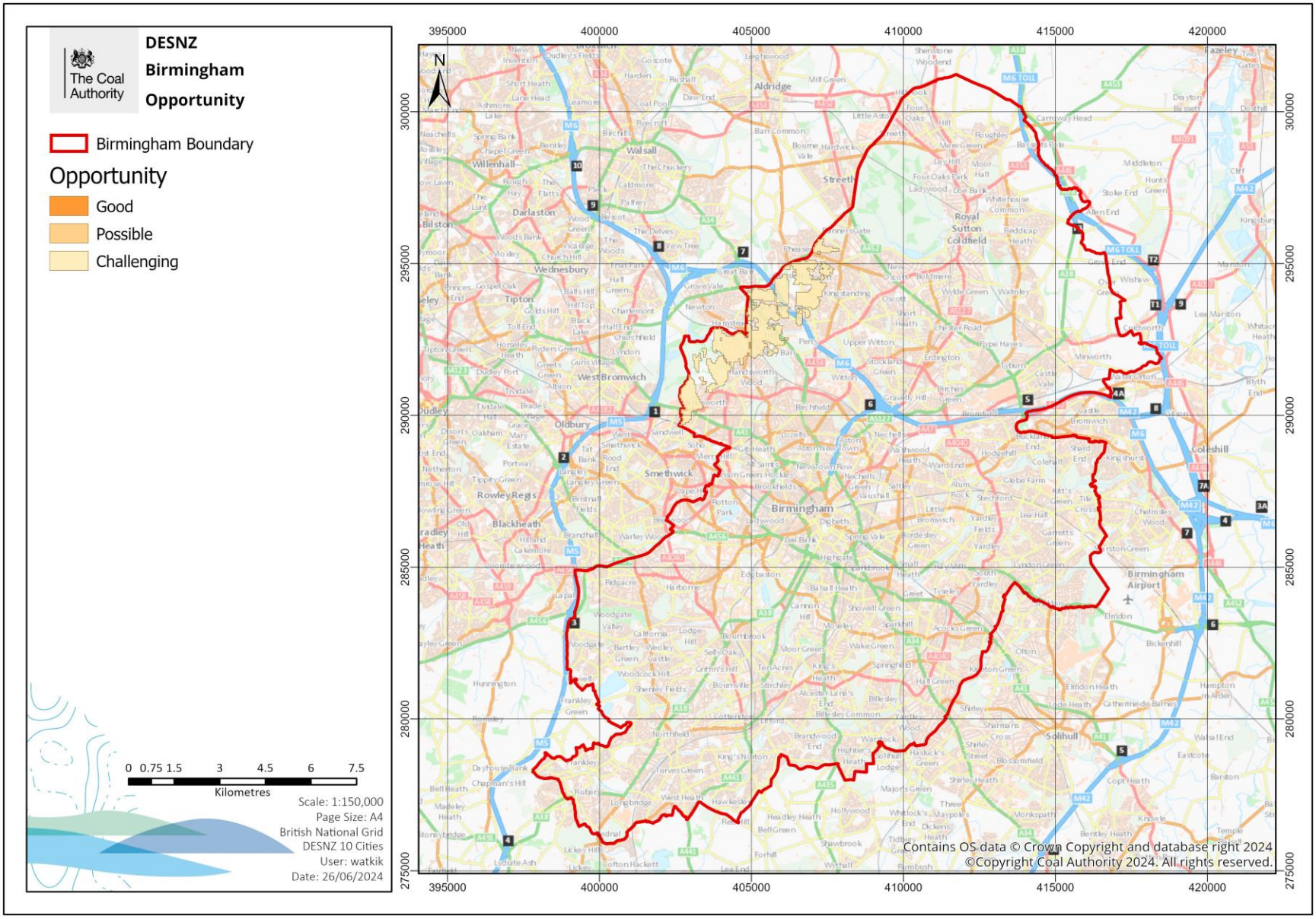

Figure 4:1 : Mine water heat opportunity map for Birmingham

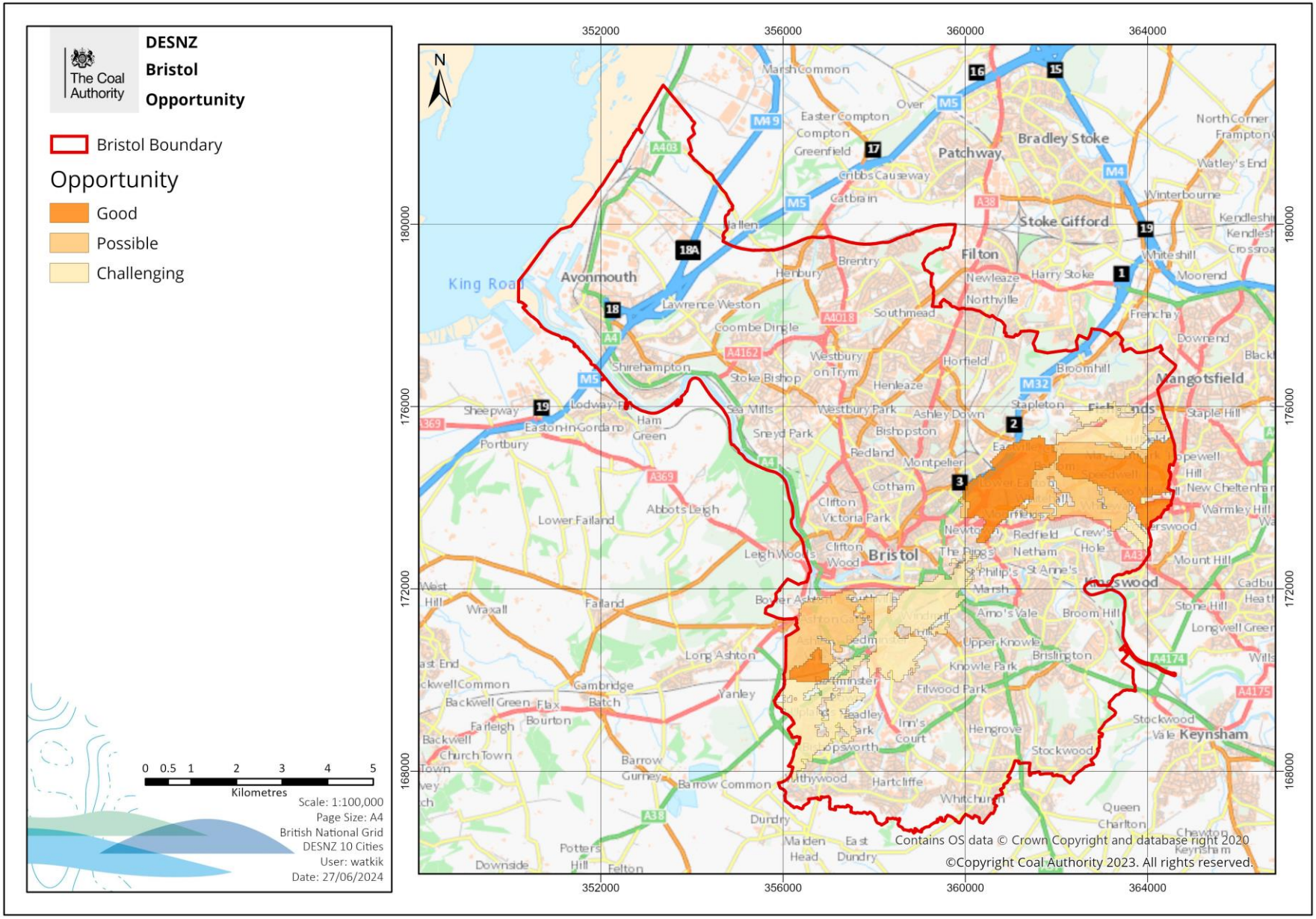

Figure 4:2 : Mine water heat opportunity map for Bristol

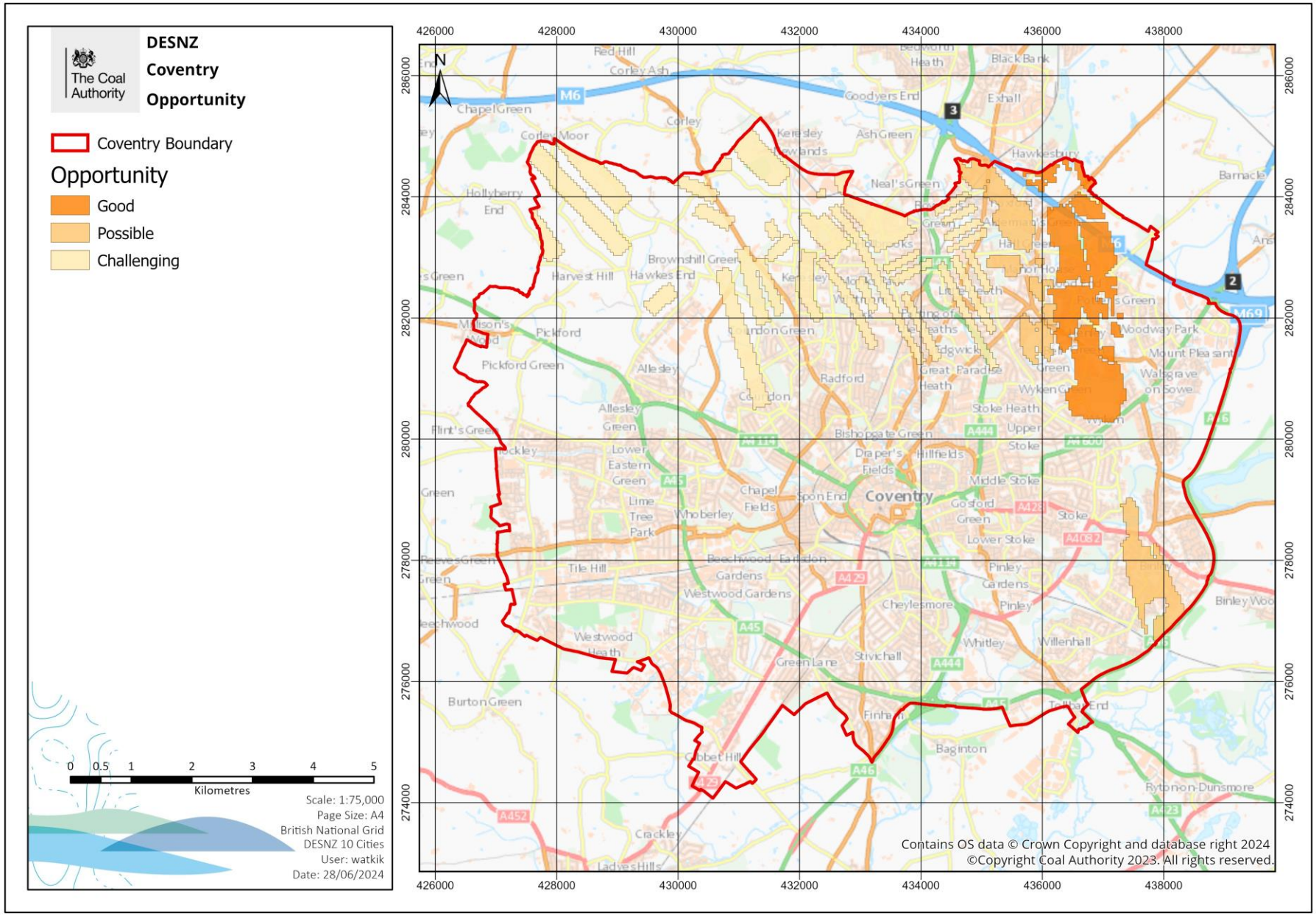

Figure 4:3 : Mine water heat opportunity map for Coventry

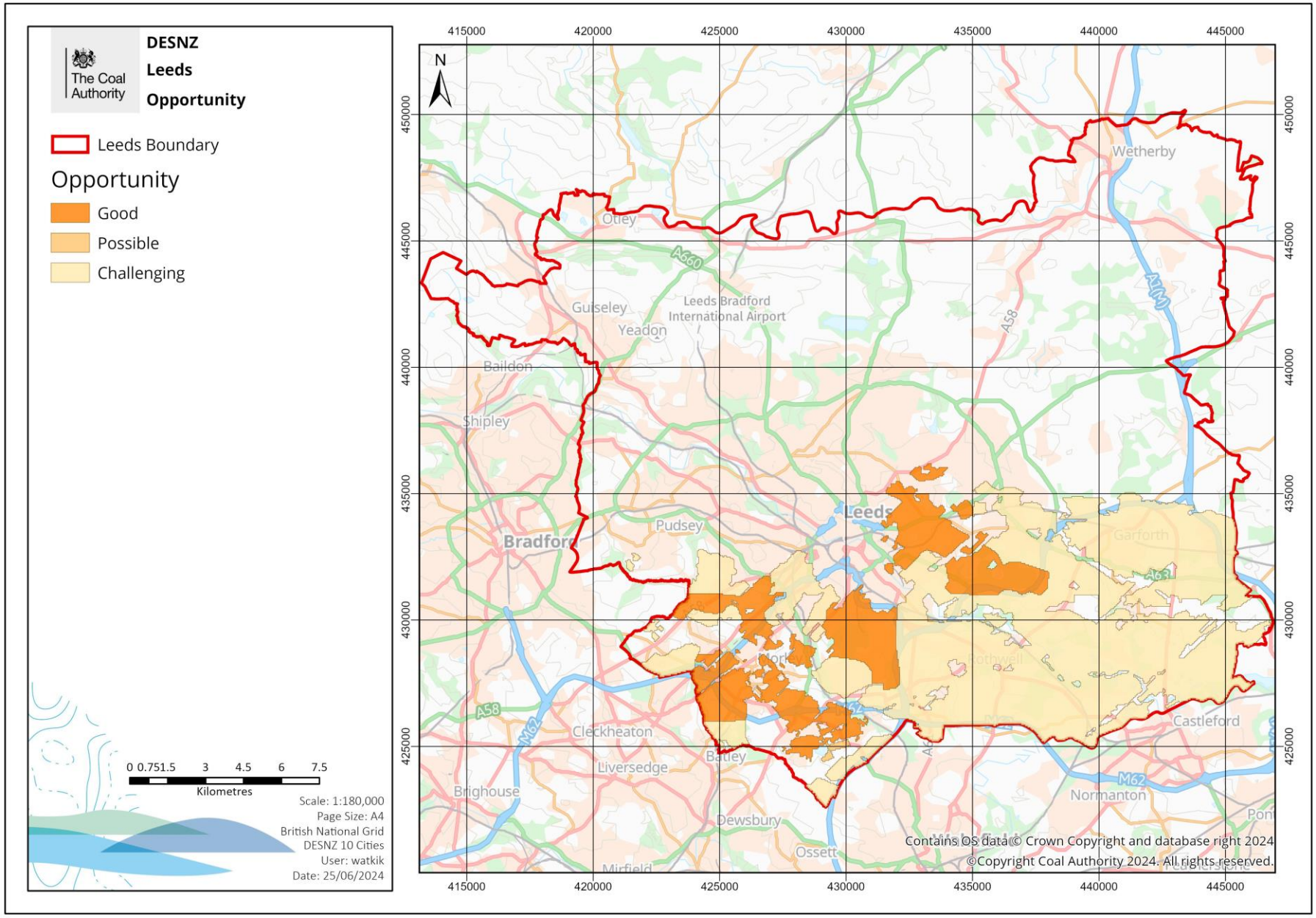

Figure 4:4 : Mine water heat opportunity map for Leeds

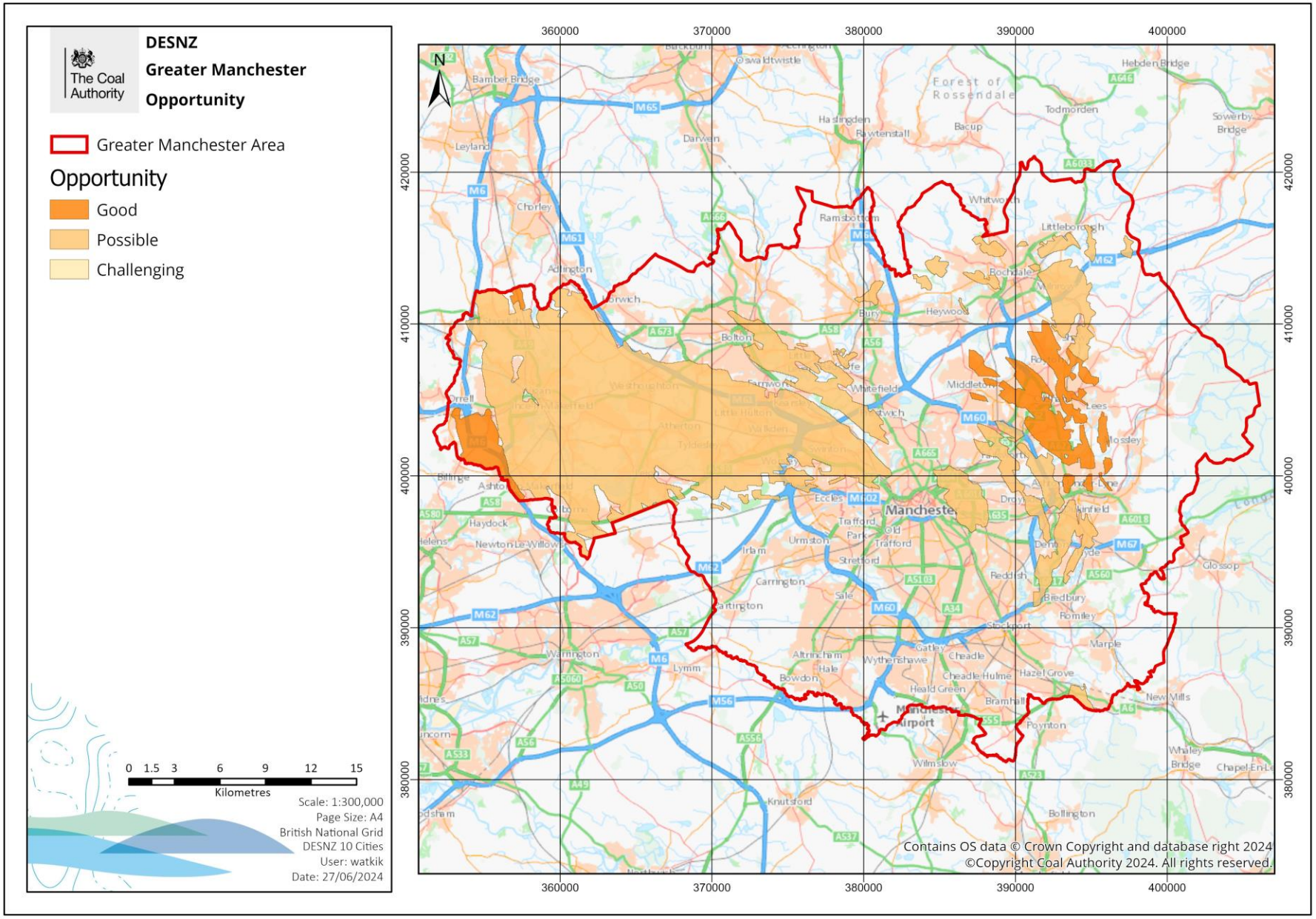

Figure 4:5 : Mine water heat opportunity map for Greater Manchester

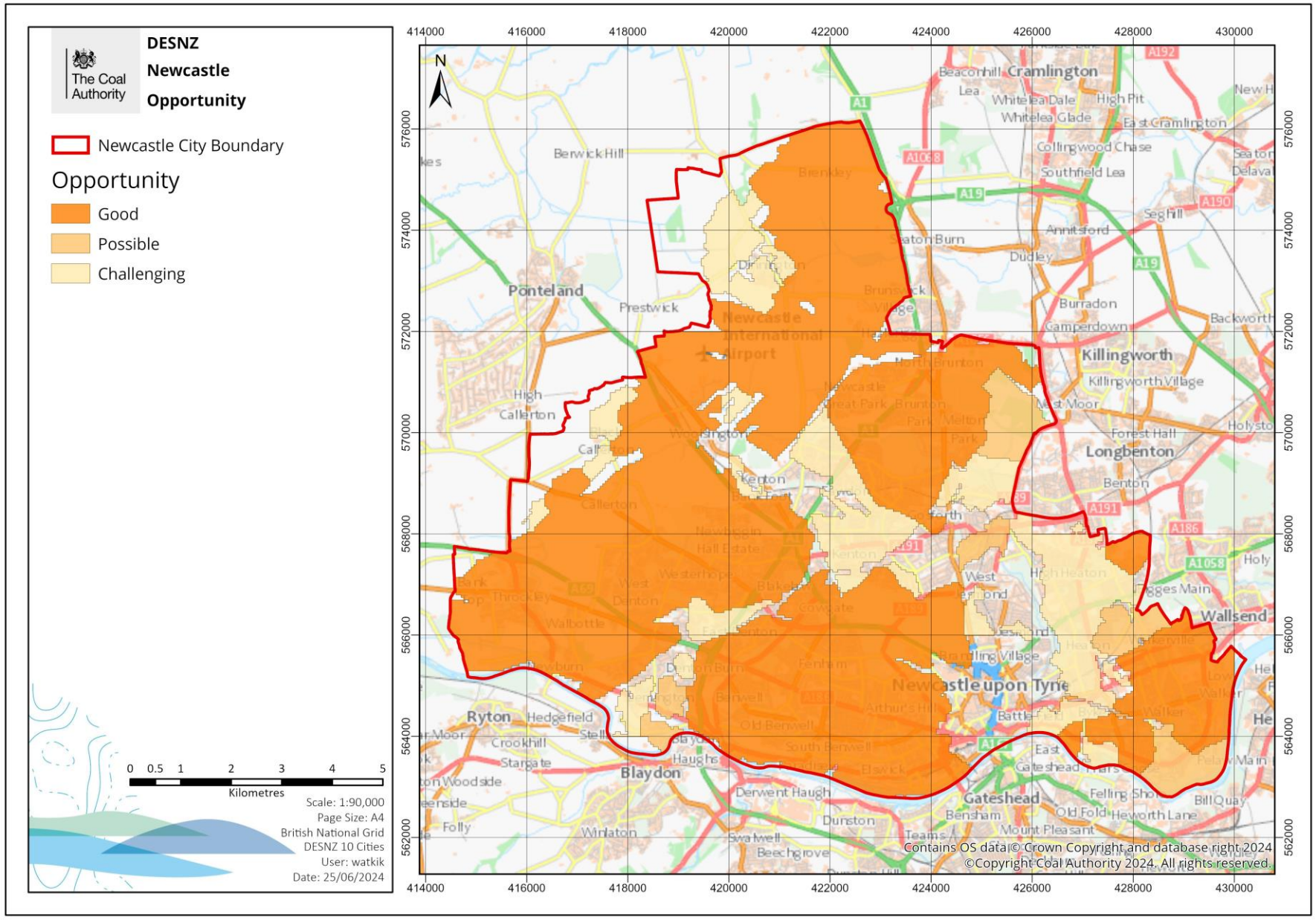

Figure 4:6 : Mine water heat opportunity map for Newcastle upon Tyne

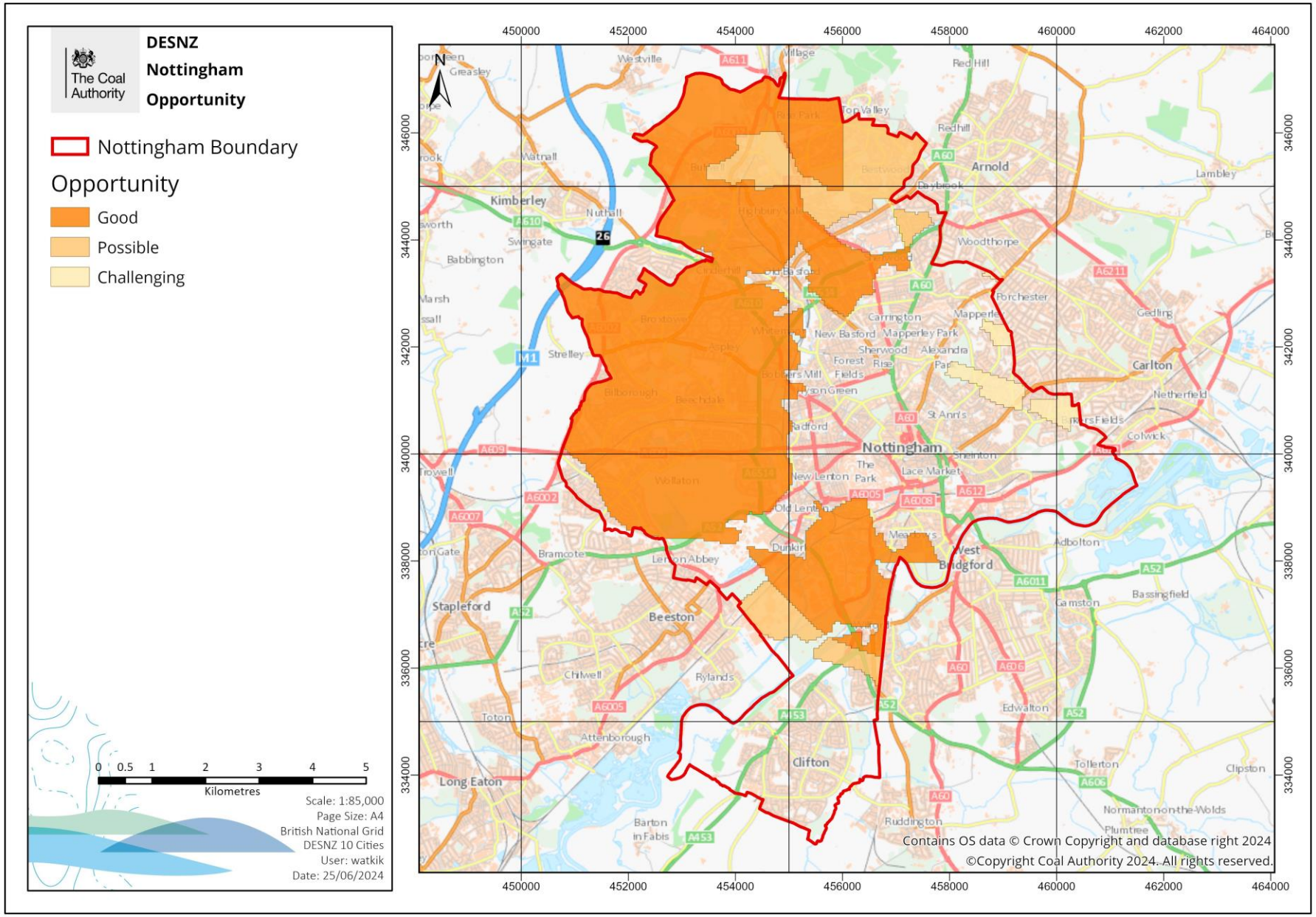

Figure 4:7 : Mine water heat opportunity map for Nottingham

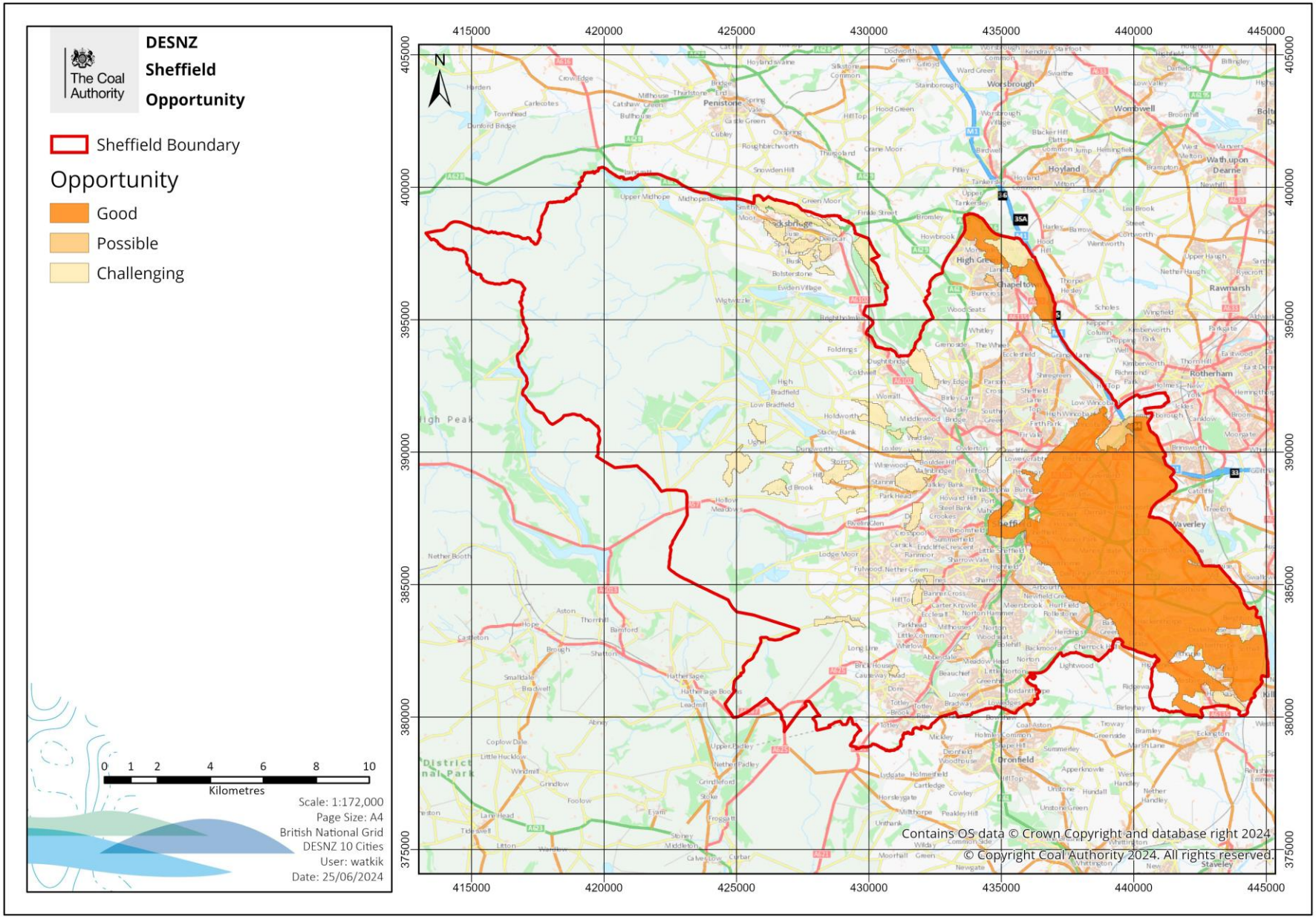

Figure 4:8 : Mine water heat opportunity map for Sheffield

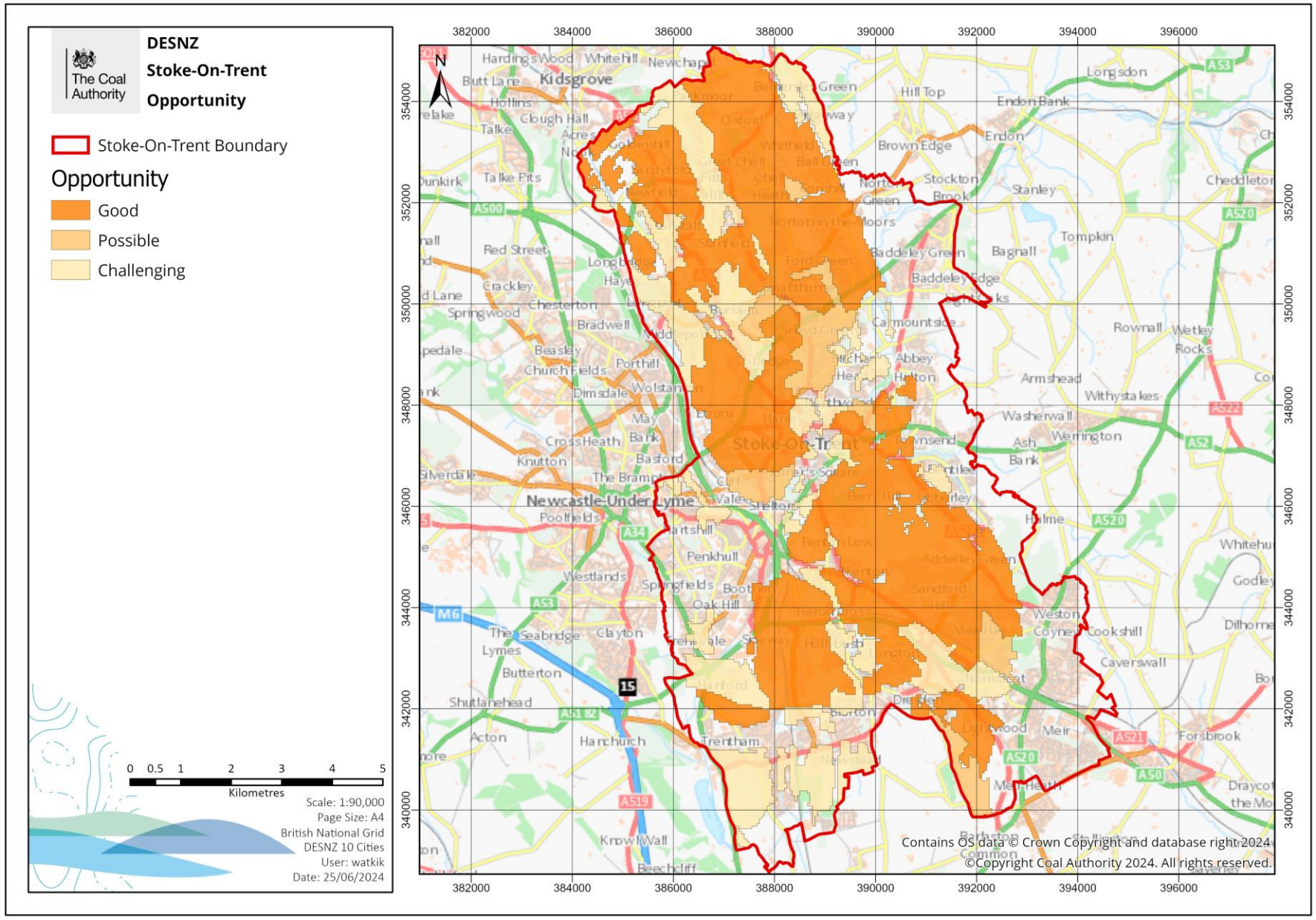

Figure 4:9 : Mine water heat opportunity map for Stoke-on-Trent

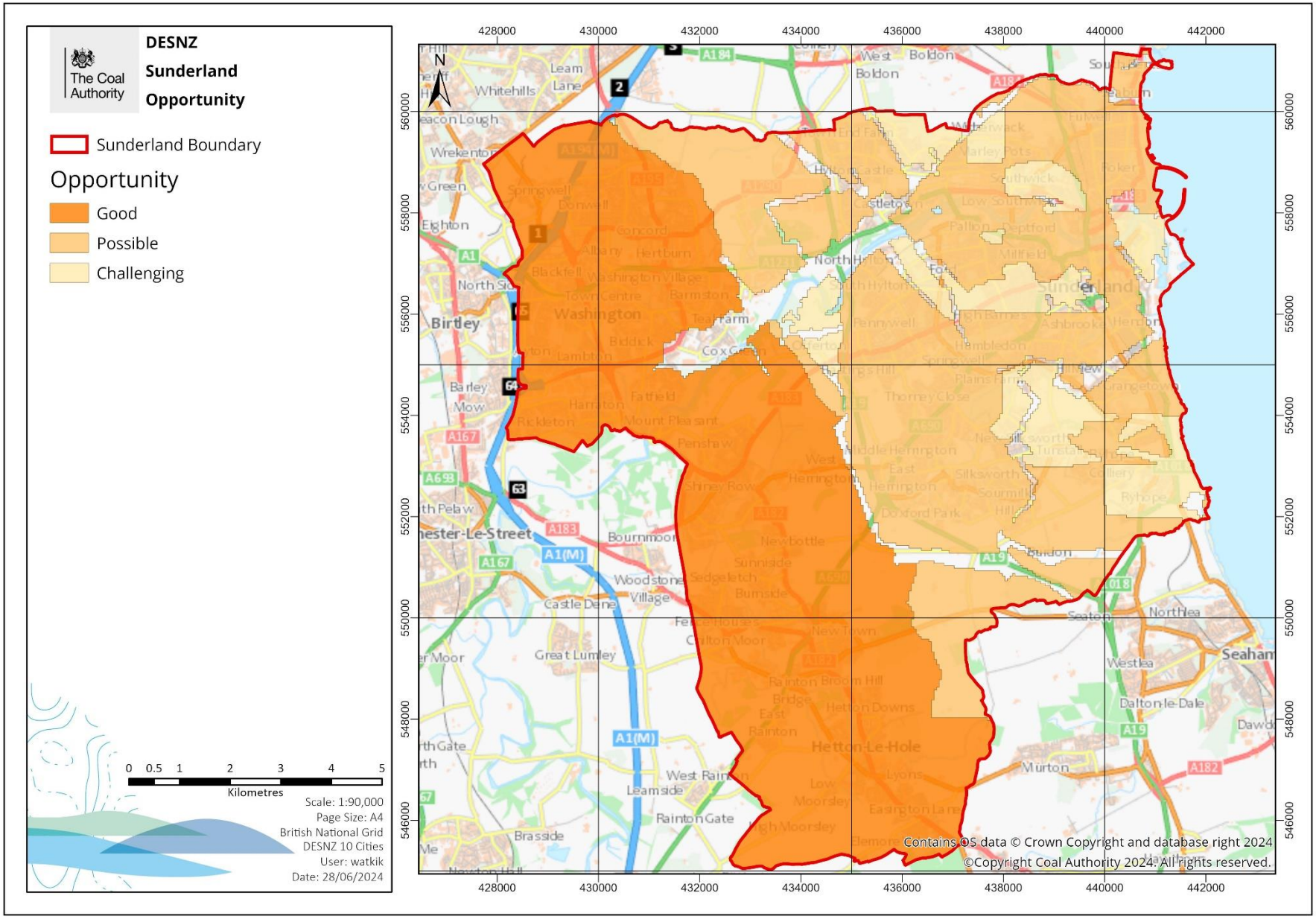

Figure 4:10 : Mine water heat opportunity map for Sunderland

5 Conclusions and Next Steps

Open access 'mine water heat opportunity maps' have been created for the following cities in England;

- Birmingham
- Bristol
- Coventry
- Leeds
- Greater Manchester
- Newcastle
- Nottingham
- Sheffield
- Stoke-on-Trent
- Sunderland

The maps illustrate where there is Good, Possible or Challenging conditions for open loop mine water heat schemes and can be used as part of Heat Network Zoning in the aforementioned cities. We recommend that the opportunity maps and this report are used to highlight locations which may be suitable for detailed feasibility studies to support mine water heat networks.

Following the recent successful development of the 6MW Gateshead Mine Water Heat Network, owned by the Gateshead Energy Company we can share a step by step guide for how others may consider progressing the mine water aspects for heat networks using the following approach:

- **First** consult the relevant map, if your proposed site lies within any of the Good, Possible or Challenging areas then we recommend an early discussion with the Coal Authorities' 'Heat and By-Product Innovation Team' who can be contacted via this email address minewaterheat@coal.gov.uk. If you decide to proceed then the process is described below:

- Following this exercise early discussions with the environmental regulator, the Environment Agency, are recommended before more detailed site specific feasibility studies are completed.

The following outline the key feasibility, drilling and testing stages;

- **Phase 1**: desk based feasibility study which will provide a review of mine workings and mine water and indicative areas suitable for drilling.
- **Phase 2**: desk based feasibility study detailing drilling site options, recommendations, cost estimates, permitting and licencing requirements.
- **Phase 3**: desk based feasibility study outlining designs of boreholes, technical input to tender documents, H&S plans, and assistance with permitting
- **Phase 4**: support for the pilot borehole drilling and production borehole drilling and pumping tests.

6 References

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