Department for Energy Security & Net Zero

UK Geothermal Platform: Summary layers methodology and user guidance

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Acknowledgements

The BGS authors of this document are Russell Lawley, Alison Monaghan, Mylene Receveur, Andres Gonzalez Quiros and Tim Armitage. We thank the UK Geothermal Platform advisory board and colleagues at the Department of Energy Security and Net Zero for advice in developing the summary layers. We acknowledge the large amount of BGS legacy geothermal data and knowledge included within the summary layers, as well as the informatics specialists who have built the map explorer. BGS retains copyright on pre-existing images that are used within this report.

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Introduction

Purpose, users

The purpose of the UK Geothermal Platform summary layers is to fill evidence gaps on potential opportunities for geothermal energy. The summary layers are presented for four proved technologies (Figure 1) in digitally accessible form for consideration in the pre-feasibility stage of geothermal projects.

- Vertical closed loop ground source heat pump (GSHP)
- Open loop GSHP
- Deep geothermal (open loop, hot sedimentary aquifer, hydrothermal)
- Deep geothermal (engineered or enhanced geothermal systems EGS, petrothermal)

A fifth layer summarises the geothermal technology options, together with levelised costs commissioned by the Department for Energy Security and Net Zero (DESNZ) as part of Arup's review of technical and cost assumptions for geothermal generation technologies [1].

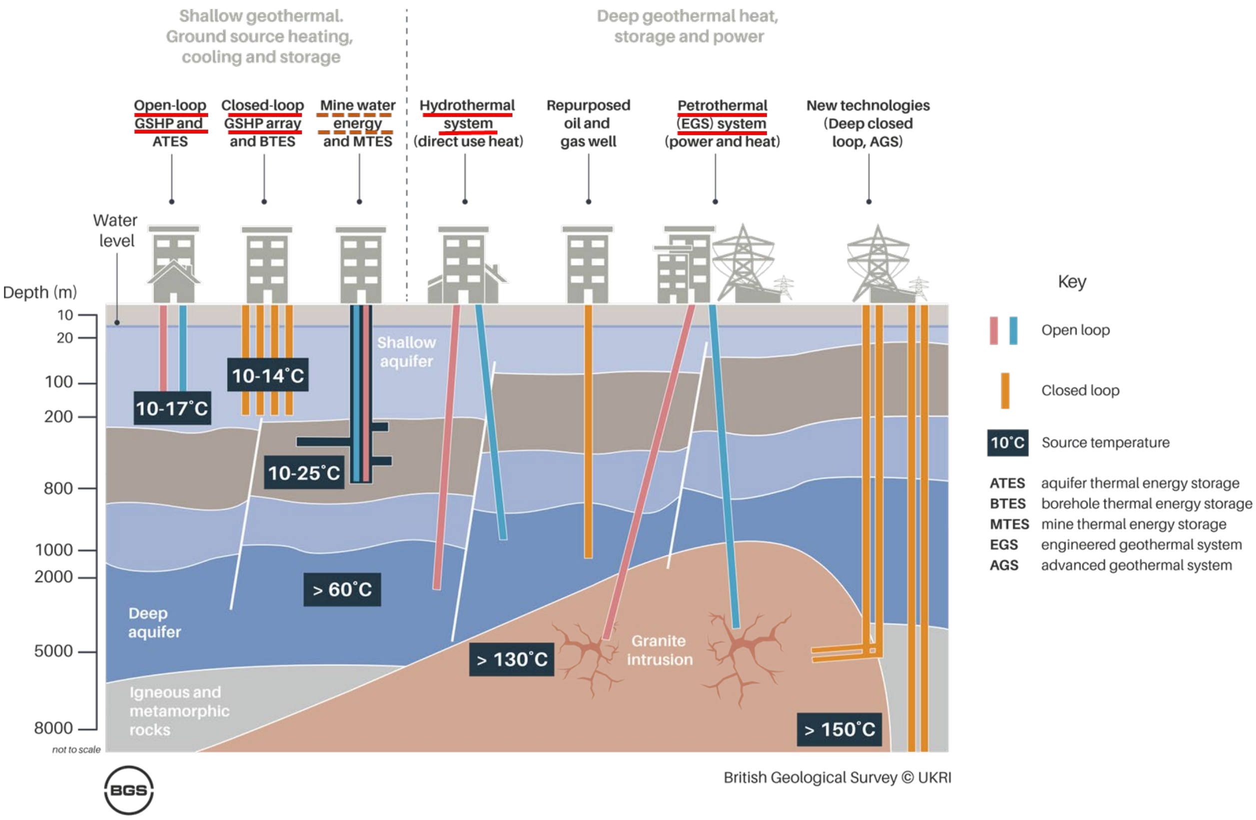


Figure 1 Summary of geothermal technologies. Summary layers cover those underlined in red; cost and coal mine presence for mine water energy are included in the overall summary layer underlined with a dashed line. Background image BGS©UKRI 2025

The summary layers have been developed for the heat policy and heat networks teams in DESNZ. They are also openly available to view for public sector bodies, industry, researchers and the public. The focus is on a larger scale of heat output suitable for district, campus and communal heat networks or large commercial users (as opposed to single dwellings and other small individual users).

The summary layers are a first version of national scale, digitally accessible geothermal information focussed on heat (and power) output and current status of technical feasibility. They currently use legacy datasets with known limitations and are intended to be updated and improved in the future.

The summary layers have been developed by the British Geological Survey (BGS) in collaboration with researchers from DESNZ.

Understanding the theoretical potential of geothermal energy, compared to viable projects

In the UK, there are an estimated 55,210 installed ground source heat pumps [2] with hundreds of larger scale GSHP projects up to megawatts in size [3]. Shallow closed and open loop GSHP are proved, technically feasible technologies and widely geographically spread, page 14 of [4].

In contrast, there are single digit deep geothermal operating schemes, formerly operating schemes and exploration boreholes with production tests [2]. Regional studies have been undertaken to map where the most favourable conditions for potential developments are [5-11], however there is limited production and operational information available.

In using the summary layers, it is important to understand that whilst the values for closed and open loop GSHP are generalised and estimated, the technology is ‘developable’ (after [12]; Figure 2) for geothermal heat (except locally where drilling or environmental constraints apply).

Due to the limited scale of the UK industry, information is generally lacking on the deep geothermal energy that can be viably and feasibly extracted over operational timescales of tens of years, from many of the different geological opportunities identified across regions of the UK. The values presented in the summary layer for hot sedimentary aquifers are ‘theoretical potential’ (after [12]; Figure 2). As indicated on Figure 2, users should note that values of theoretical geothermal potential are larger than the economically and technically feasible or ‘realisable’ values.

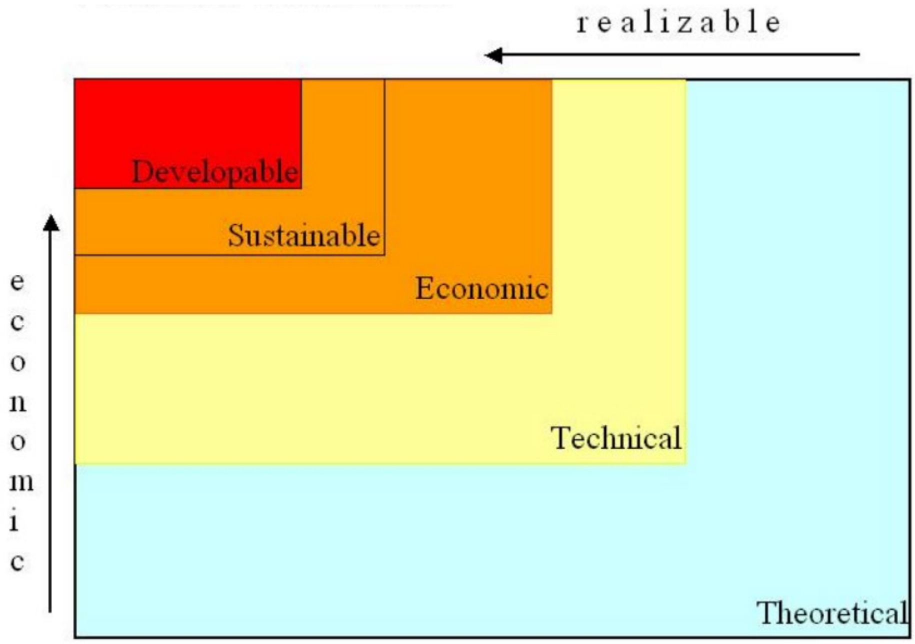


Figure 2 Potential definitions for renewable energy which apply to geothermal energy. Reproduced from [12] under the CC BY 3.0 licence

'Technical feasibility' used in the summary layers is a description encompassing whether the technology is proved and the status of exploration, drilling, operations over the geospatial area and geothermal target interval. The 'confidence' description provides an indication of the geological, production etc. uncertainties; it was not possible with the available data and national coverage to calculate P_{10}-P_{50}-P_{90} ranges.

In addition to the 'high, medium and low' categories assigned to the summary layers 'technical feasibility' and 'confidence' fields in this work, the United Nations Framework Classification for Resources (UNFC) applied to geothermal energy resources in 2009 and updates to 2022 [13, 14] has been used as a framework to assess the technical feasibility ('F' axis) and confidence ('G' axis) of the geothermal energy technologies applied at national-regional scale (Figure 3, Figure 4). The UNFC is designed for single projects, but it can be used for national-regional studies. A full study of the application of the classification is beyond the scope of this work, for example the environmental-social-economic viability ('E' axis) is not presented in the summary layers (commonly it would be E3.2 'cannot yet be determined due to insufficient information'). Levelised cost data from a separate study [1] is included in the overall summary layer.

To assign the 'technical feasibility' and 'confidence' categories spatially, we have incorporated legacy geothermal studies and our knowledge of the data on which those were based, as well as knowledge of prefeasibility studies, exploration wells and operating geothermal schemes in the UK, plus wider knowledge from legacy hydrocarbon wells and hydrogeological studies. For deep geothermal layers we have included tested and operating wells, as well as sites in advanced stages of viability (e.g. planning permission, active project). Other sites and projects in earlier stages of viability and further along the geothermal workflow have not been incorporated at their specific geospatial location, due to lack of public information and because the status of these changes on timescales of months-years.

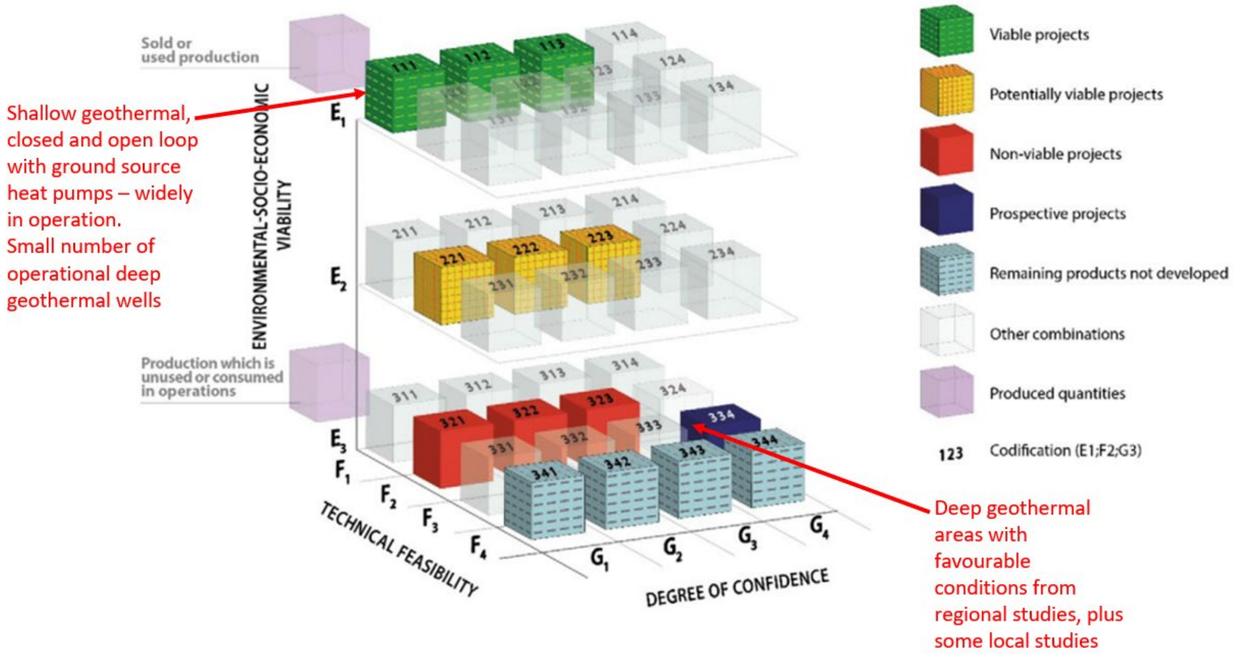


Figure 3 Indicative position (in red) of geothermal technologies on the UNFC 2019 [14] at regional-national scale in the UK. There are tens of prospective, potentially viable and non-viable projects across deep geothermal and mine water geothermal at specific sites that are not labelled here. Modified from United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009, ©2019 United Nations. Reprinted with the permission of the United Nations

Whilst the values presented in the summary layers for deep geothermal technologies are, in the main classified as low technical feasibility, low confidence and as theoretical potential, and so might be taken negatively, this reflects the current stage of the industry in the UK with limited operational projects. There are many areas of the UK assessed as having favourable conditions and potential, inferred from regional and local studies using technologies proved in the UK and globally.

Class		Sub-class	Categories E	F	G
Known sources	Viable projects	On production	1	1.1	1,2,3
		Approved for development	1	1.2	1,2,3
		Justified for development	1	1.3	1,2,3
	Potentially viable projects	Development pending	2	2.1	1,2,3
		Development on hold	2	2.2	1,2,3
	Non-viable projects	Development unclarified	3.2	2.2	1,2,3
		Development not viable	3.3	2.3	1,2,3
	Remaining products not developed from identified projects		3.3	4	1,2,3
Potential sources	Prospective projects		3.2	3	4
	Remaining products developed from prospective projects		3.3	4	4

F description: technical feasibility	G description; product quantity confidence
F1.1 Production is currently taking place	
F1.2 Capital funds have been committed, and implementation of the development is underway	G1 low estimate/high confidence (P90)
F1.3 Studies completed to demonstrate technical viability of development and operation. Reasonable expectation of approvals/contracts to proceed will be forthcoming	G2 best estimate/moderate confidence (P50-P90)
F2.1 Project activities are ongoing to justify development in the foreseeable future	G3 High estimate/low confidence (P10-P50)
F2.2 Project activities are on hold/subject to significant delay	
F2.3 No plans to develop or acquire additional data at the current time due to limited potential	
F3.1 Site-specific studies have identified a potential development with sufficient confidence to warrant further testing	G4.1 Estimate based on indirect evidence; low estimate of quantities
F3.2 Local studies indicate potential for development in a specific area but requires more data acquisition and/or evaluation to have sufficient confidence to warrant further testing	G4.2 Estimate based on indirect evidence: Best estimate of quantities
F3.3 At the earliest stage of studies, where favourable conditions for the potential development in an area may be inferred from regional studies	G4.3 Estimate based on indirect evidence: High estimate of quantities
F4.1The technology necessary is under active development, following successful pilot studies, but has yet to be demonstrated to be technically feasible	
F4.2 The technology necessary is being researched, but no pilot studies have yet been completed	
F4.3 The technology is not currently under research or development	

Figure 4 UNFC [13, 14] summary of classification terms and description of technical feasibility and confidence classification

Summarising environmental data via hex-cells

To harmonise multiple environmental datasets and provide simplified statistics as summary layers, all input data are summarised into a common spatial scale and coverage. This simple coverage takes the form of a cellular grid comprising interlocking hexagons. Each hexagon represents an area of approximately 2.56 km^2 (the sides of each hexagon are 1km in length). There are c. 94,000 hexagons covering Great Britain (Figure 5). Note some Northern Ireland datasets are included in the wider UK Geothermal Platform; however with differences in the availability of underpinning data, the summary layers have GB coverage.

Figure 5 Available coverage of the summary layers (Great Britain). Contains Ordnance Survey data © Crown copyright and database rights 2025

Appendix 1 provides summary images of the digital datasets.

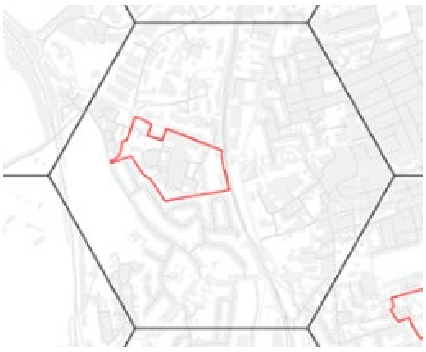
Things to consider when using hex-cell data

Hex-cells represent spatial summaries of underlying data (which tends to be spatially more complex and of higher resolution). Hex-cells are typically used to portray three types of summarised data:

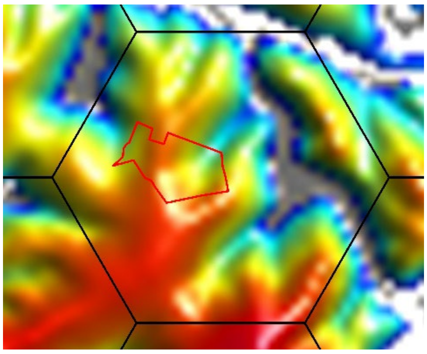
- Boolean (Yes/No) categorised values
- Range values (minima, maxima, percentiles, quartiles)
- Weighted-area statistics (to calculate values influenced by spatial prevalence)

Hex-cells summarise a defined area, not a specific location and so users should consider carefully how they interpret the information given for each cell (in the context of a specific project or site).

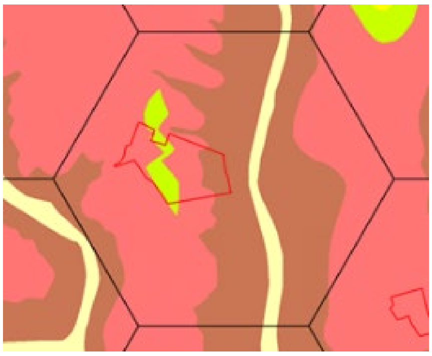
Figure 6 below outlines some basic considerations when using hex-cells.



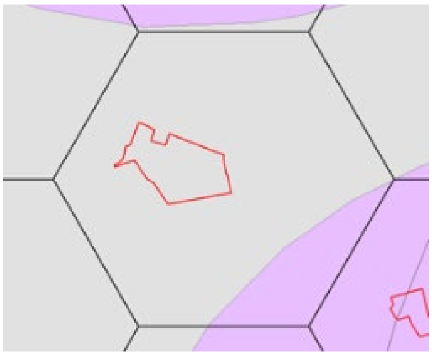
A typical, large project site selected for GSHP assessment (red boundary), set within a hex-cell.



A 'continuous surface' environmental dataset, such as unit-thickness or heat flow. The hex-cell can be used to provide quantified summary data such as minimum, maximum, or average values for the continuous surface (within the hex-cell area). Note that the project site may only represent part of the data range of data seen covering the whole hex-cell.



A 'discrete' domain dataset, such as geology-type. The hex-cell can be used to provide a quantified summary, such as the total area of each domain within the cell, or area-weighted percent of cell, or number of domains present. For example, in this cell there are 4 domains: green (5%), pink (50%), brown (38%) and yellow (7%). Note the project site overlies only 3 of the 4 domains contained within the hex-cell.



A 'discrete' domain dataset, such as GSHP technology type. The hex-cell can be used to provide a boolean summary (i.e. yes/no), to determine if a domain is present or not (anywhere in the cell). Note that in this case the cell intersects both discrete domains (grey and purple), but the proposed site intersects only one.

Figure 6 Considerations when using hex-cells. Map images contain British Geological Survey materials © UKRI (2025). Contains Ordnance Survey data © Crown copyright and database rights 2025

For users that view the summary layers with underlying geoscientific information, it may initially be confusing that clicking at different locations within part of a town, city or hex-cell will return the same result even through the underlying geology may be different (Figure 7). This is because the result is a summary over the hex-cell area.

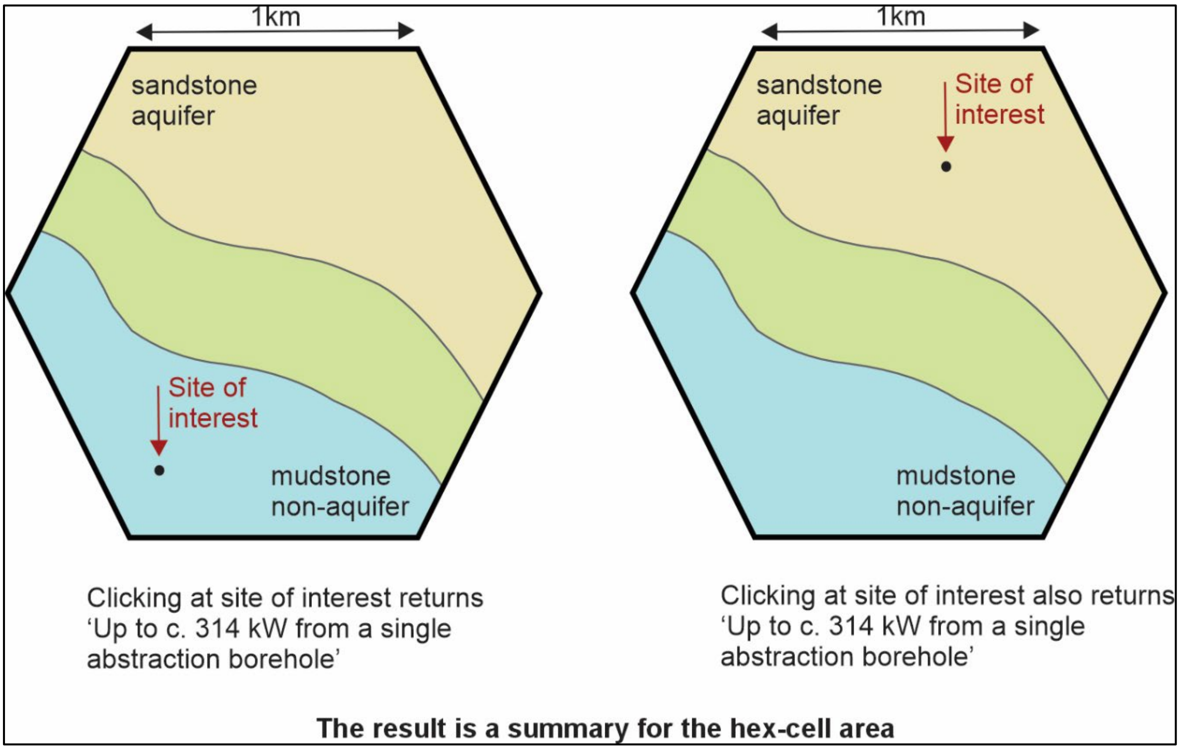


Figure 7 Explanation that clicking anywhere in a hex-cell will return the same summarised result

What the summary layers are suitable for

The summary layers are suitable to guide national, regional and city scale energy planning to be included in pre-feasibility assessment of geothermal energy potential. This is for four, proved geothermal technologies for renewable heat, and deep geothermal EGS technology for power and heat. National-regional scale legacy geoscientific data underpins the summary layers.

The summary layers provide both a visual qualification of the wide extent of potential for geothermal technologies in the UK, as well as a high-level quantification of theoretical potential for use in the DESNZ heat network national zoning model (NZM) and for heat energy planners, developers and researchers.

The summary layers are for initial pre-feasibility work and cannot replace a detailed feasibility study, or detailed design study for local and site-specific projects.

Overview of limitations

The summary layers are the first version national analyses based on variable quality and quantity of legacy data. They are intended as a first step in estimating the feasibility of four geothermal energy technologies at any location in Great Britain. Users should be aware of the limitations of the summary layer outputs:

- For deep geothermal technologies the numbers presented are of theoretical potential with low confidence. Exceptions are small areas around operating wells or wells with production tests.
- Much of the legacy geoscientific data underpinning the summary layers dates from the 1980's geothermal energy programme. Updated data and modelling estimation methods have been applied locally, but these are not available nationally. Whilst these datasets have limitations, the summary layers produced may assist in making geothermal energy information more available, thus encouraging new exploration data and updated studies.
- The spatial extent of the summary layers is limited to GB. Whilst the legacy heat flow dataset presented in the UK Geothermal Platform extends to Northern Ireland, many of the other underpinning legacy datasets are not available.
- The summary layers do not cover all geothermal technologies that are proved or potential in the UK (Figure 1). Mine water heat costs are included in the overall summary and cost layer, this technology was not included in scope of a summary layer due to Mining Remediation Authority work ongoing (MRA opportunity maps are in the map explorer). Repurposing of oil and gas wells, deep coaxial wells, standing column, next generation EGS and AGS technologies, cooling and underground thermal storage are not currently included due to cost, timescale constraints and because legacy national datasets were not available. Aquifer thermal energy storage (ATES) national tools [15,16] have used similar datasets and methodology to the open loop ground source heat pump summary layer. Parts of the deep geothermal aquifer layer that are estimated to be shallower than 40-50°C and return a technical feasibility of 'Low (F4.1). Less than 40°C or limited data' may also be relevant to ATES.
- Selected checks that the output values for each summary layer are realistic have been made, but there has not been a feedback loop of feeding operational data into legacy datasets and models.
- The summary layers do not consider drilling, environmental or permitting constraints such as underground mining hazards, natural geohazards, and SSSI's.
- The estimated geothermal heat extractable and supplied, temperatures and depths have been rounded as follows:
    - Heat extractable and supplied from 1 borehole is rounded to 0.1 kW (Closed loop) and 1 kW (Open loop and deep geothermal)
    - Heat extractable and supplied from an array: is rounded to nearest 10 kW (closed loop) and 1 kW all other technologies)

  - Annual energy output: from all technologies are rounded to nearest 100 kW
  - Temperature: Closed and Open loop ground temperatures are rounded to nearest 0.1°C. For all other technologies, temperatures are rounded to nearest 1°C.
  - Depth: All technologies are rounded to nearest 1 m
- There are some known minor inconsistencies around the coastline and small islands due to the various legacy datasets used.
- Detail of the simplifications and assumptions are provided in the sections for each technology below.

Consulting specialists for feasibility studies for geothermal projects

If the UK Geothermal Platform summary layers indicate that there is potential for shallow GSHP or deep geothermal in your area, a shallow GSHP or deep geothermal specialist should be consulted. Specialists can use information from the summary layers, along with a much wider range of other resources in the geothermal platform map explorer and elsewhere, to gain a full understanding of the site-specific details and subsurface characteristics of your site of interest. This will enable them to confirm and expand upon the estimations provided here.

Please refer to CIBSE TM51 and AM17 technical manual and best practice guides, and relevant British Standards [17, 18]. More information and advice can be found from the following organisations:

- Chartered Institution of Building Services Engineers (CIBSE)
- Ground Source Heat Pump Association (GSHPA)
- Heat Pump Federation

Methodology

Vertical Closed Loop Ground Source Heat Pump

Technology

Closed loop GSHP's rely on conduction of heat from the ground into a heat exchanger via a set of pipes circulating a suitable coolant (Figure 8). This dataset specifies vertical pipes, encapsulated within one or more boreholes drilled vertically into the ground to a depth of 150 m. The depth was chosen to match with the Arup study [1].

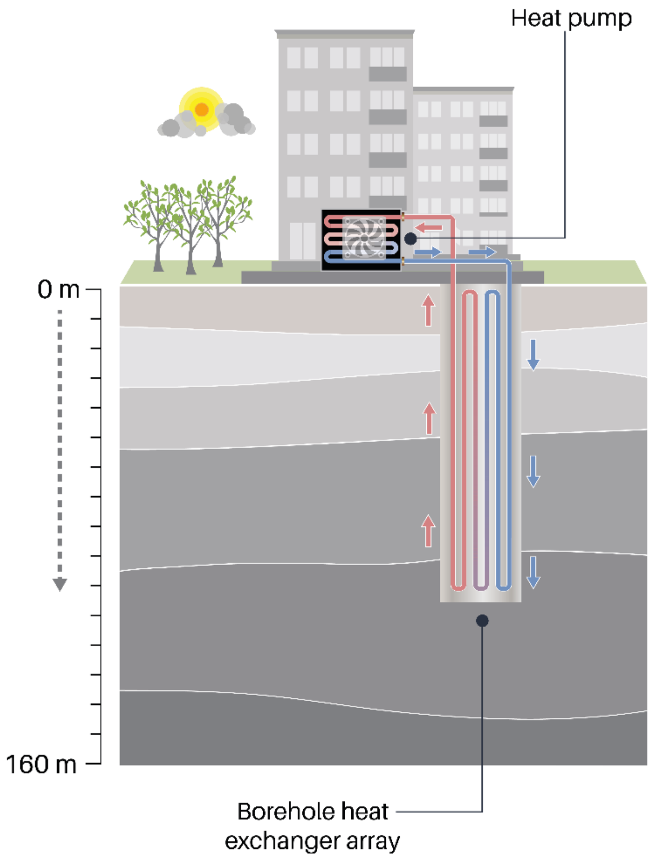


Figure 8 Schematic of a closed loop borehole array BGS©UKRI 2025

Output fields

Table 1 Output data for closed loop GSHP

DESNZ Field Definition [Field Wording]	MAP EXPLORER Field Definition	Example text
Unique identifier [UUID]	Unique identifier for Hex-Cell	45348
Geothermal technology [Tech_Type]	Geothermal technology	GSHP Closed loop.
Technology description [Tech_Desc]	Technology description	Estimated technical potential value for 150 m deep closed loop borehole. A spacing of 6-10 m between boreholes is common. Assumed 2000 operating hours, full load. Heat pump COP = 4.
Peak Capacity Bore [Pk_Cap_Bor]	Heat extractable from 1 borehole (kW)	Estimated c. 4.6 kW from a single borehole.
Peak Capacity Array [Pk_Cap_Arr]	Heat extractable from 50 boreholes (kW)	Estimated c. 230 kW from 50 boreholes.
Total Annual Capacity [Tot_An_Cap]	Total annual heat energy extractable from 50 boreholes (kWh)	Estimated c. 460,000kWh of energy extracted annually from 50 boreholes, assuming 2000 hours operation.
HP Peak Capacity Bore [HP_Pk_CpB]	Heat supplied from heat pump with 1 borehole (kW)	Estimated c. 6.1 kW supplied from an installation with a single borehole.
HP Peak Capacity Array [HP_Pk_CpA]	Heat supplied from heat pump with 50 boreholes (kW)	Estimated c. 306.7 kW supplied from an installation with 50 boreholes.
Total HP Annual Capacity [Tot_HP_Ann]	Total annual heat energy supplied from heat pump with 50 boreholes (kWh)	Estimated c. 613,400 kWh of energy supplied annually from an installation with 50 boreholes, assuming 2000 hours operation.

DESNZ Field Definition [Field Wording]	MAP EXPLORER Field Definition	Example text
Supply Water Temperature [Spply_Temp]	Ground (input) temperature (°C)	Estimated c. 14.6°C subsurface temperature at 75 m depth.
Technical feasibility descriptive [Tec FeasD]	Technical feasibility descriptive (UNFC in brackets). (Static text applied)	High (F1 viable projects). Drilling constraints may apply locally.
Confidence [Confidence]	Confidence (UNFC in brackets). (Static text applied)	Moderate (G2).
Variance [Variance]	Min, Max, Average description of the hex-cell heat output values	Single borehole output in this hex-cell ranges from 4 - 5 kW. Area weighted average is 4.6 kW.
Relative heat extractable [Rel_H_ext]	Relative heat extractable	Single borehole output estimation of 4.6 kW, is less than/equal to the GB average (GB average is 6.25 kW, ranging from 2.3 kW to 11.7 kW).
Geol_Desc1 [Geol Desc1]	Brief summary of Quaternary geology	Dominant superficial cover is: Alluvial Deposits (34% coverage), along with: River-Terrace Deposits (31%), Glacigenic Deposits (23%), Glaciofluvial Deposits (12%).
Geol_Desc2 [Geol Desc2]	Brief summary of Bedrock geology	Dominant bedrock is: Kellaways Formation and Oxford Clay Formation – argillaceous rocks (100% coverage).
Geol_Desc3 [Geol Desc3]	Brief summary of Bedrock geology (continuation)	NA

Technical feasibility and confidence outputs

The technical feasibility and confidence level for closed loop GSHP has been assigned:

Table 2 Assignment of technical feasibility and confidence for closed loop GSHP. The values assigned are the same across GB.

Technical Feasibility	UNFC assignment and rationale
High	F1.1 Viable projects. Shallow closed loop GSHP boreholes are operating across the UK. Design, spacing, number in arrays are adapted based on thermal response tests etc. of the local geology and the heat demand. Drilling constraints may apply locally.
Medium	Not used
Low	Not used
Confidence	**UNFC assignment and rationale**
High	Not used
Moderate	G2 Moderate. The generalised national scale datasets underpinning the heat output calculations mask local variations, are based on a varied distribution of data and have known limitations.
Low	Not used

Assumptions for the summary layer

A number of assumptions have been used to create the closed loop GSHP summary layer:

- Only heating is considered.
- The thermal 'power' (heat extractable) estimation provided in this summary layer is based on a single borehole of 150 m length. The length and number of boreholes in the array (50 boreholes) was chosen to match that used in the Arup study [1].
- The thermal 'power' (heat extractable) calculations are based on a single borehole system and take no account of final array design (which may need to be a linear array, or a grid array of vertical bores designed for local conditions). A spacing of 6-10 m of boreholes in a closed loop array is common; this will vary with local geology, operating hours etc.

- The summary layer only considers bedrock geology. This is due to the variability of superficial deposits at local scale and the lack of thermal conductivity data.
- A ground temperature estimate is taken at 75 m depth (i.e. half the borehole depth).
- For the annual energy supplied it is assumed that the system runs at full load for 2,000 hours over the year. This approximates to full load equivalent operating hours for domestic and some commercial users specified in CIBSE guidance [17, 18] and is in agreement with one of the scenarios used in the Arup study [1].

Calculations

A value of heat extraction per unit metre of borehole length is calculated from a derivation of the Carslaw equation [19] and given below:

$$q\ (mW/m)\ = \frac{\Delta T 4\pi\lambda}{\left[Rb + log\left(\frac{4\lambda t}{r^2\ \rho c}\right) - 0.5772\right]}$$

q = Heat extraction rate per metre of borehole

λ = thermal conductivity

Rb = thermal resistance of the borehole

r = borehole radius

ρ = density

c = specific heat capacity

t = time

ΔT = change in temperature

Heat extractable from 1 borehole (kW) and Heat supplied from heat pump with 1 borehole (kW)

This estimate of extractable heat is calculated by multiplying the heat extraction rate per metre (q) by 150 (the assumed length of the borehole). The estimate of heat supplied from the heat pump is the amount of heat supplied by the installation after using a heat pump, therefore a combination of the heat extracted from the ground plus the amount provided by the work of the heat pump itself (powered by electricity). The heat supplied is calculated using the formula:

$$H_{sup}\ (kW)\ = H_{ext}/(1 - \frac{1}{COP})$$

The heat extractable and heat supplied calculations are presented as a narrative text that describes the heat available from each borehole

Heat extractable from 50 boreholes (kW) and Heat supplied from heat pump with 50 boreholes (kW)

The estimate of extractable heat for a single borehole is multiplied by 50 to provide an estimate of heat extractable from an array of 50 boreholes. Similarly, the heat supplied from the heat pump (single bore) is multiplied by 50 to provide a value for heat supply from the 50 borehole array. Whilst the information is not sufficient to provide a detailed description of an array, it can be used to identify the potential for GSHP at a site and support any subsequent analysis for an array to extract a larger heat resource (i.e. approximated figures for seeking government funding and for feasibility planning purposes).

The heat extractable, and heat supplied, calculations from 50 boreholes are presented as a narrative text that describes the heat available from the array.

Total annual heat energy extractable from 50 boreholes (kWh) and Total annual heat energy supplied from heat pump with 50 boreholes (kWh)

The total annual heat energy extractable and total annual heat energy supplied from heat pump is calculated by multiplying peak extractable and supplied heat of the array by the 2000 hours running time of the GSHP system.

The total annual heat extractable, and total annual heat supplied, calculations from 50 boreholes are presented as a narrative text that describes the total heat from the array assuming 2000 hrs run-time over the course of a year.

Designing an array of boreholes requires specialist software and will be partly driven by the land available, a more detailed assessment of geology and thermal profile, and the capabilities of the equipment being used to build the array and create the collector network. The final spacing and length of each borehole may be altered to reflect the available resource beneath a site. Typically, a minimum borehole spacing of 6 – 10 m is required for boreholes 150 m in length. The bore spacing will be designed to ensure that heat extraction/storage are sustainable, and that boreholes are not too close to each other (ensuring that they do not interfere with each other). The final array design will also try to optimise array spacing and length to reduce capital expenditure (CAPEX) costs and optimise heat recovery and storage.

Supply Temperature (ground input temperature)

The supply temperature is a representative value of ground temperature at 75 m depth obtained using the BGS Heat Flow map, surface topography and mean annual soil temperature data (see the Analysis workflow section).

Analysis workflow

Closed loop GSHP systems work by extracting heat from the uppermost 100 – 300 m of geological materials beneath the surface. When designing a closed loop borehole array, the key factors to consider are:

1. Can we drill safely into the underlying deposits and rocks?
2. How deep can we go?
3. Are there geological factors that we need to be aware of? (e.g. pressurised groundwater, caves)
4. What kind of heat profile is present?
5. How many boreholes will we need?

Critical to success is understanding the likely extractable heat from the system, the physical parameters that control how much heat is stored in, or conducted through the ground include characteristics such as:

- Lithology
- Porosity
- Permeability
- Water saturation
- Thermal conductivity
- Thermal diffusivity
- Specific heat capacity
- Thermal gradient
- Heat flow

It is not currently possible to provide a high resolution 3-dimensional geological model for all of Great Britain with all the parameters needed to fully model available heat. However, the Closed Loop GSHP summary layer can provide an overview of geology and provide an estimation of extractable heat. The geological information is used to provide context for the variability of a hex-cell, and BGS data for heat flow and thermal parameters enable an initial estimate of potential extractable heat in the power prognosis. The indicative results are suitable for developing decarbonisation concepts, energy planning, providing background data in support of a more detailed desk-based geological report if the site of interest progresses to a feasibility design and full design of a GSHP array.

Geological summary

The closed loop summary dataset uses the BGS Thermal Properties V1 dataset [20] as its source for bedrock geology (a revised 1:250 000 scale digital geological map which is supplemented with thermal properties for each rock type). The geological summary also uses the BGS Geology 625k Superficial V4 dataset [21] as its source for superficial materials. Each geological summary per hex-cell is presented in two parts:

- A description of the superficial materials (if present) and percentage coverage of each lithology within the hex-cell.
- A description of the bedrock materials and percentage coverage of each lithology within the hex-cell.

Each description identifies the most spatially prevalent (‘dominant’) lithology present, and up to three further lithologies (if present in the hex-cell). The textual descriptions are intended to provide an overview of the material present; users can also gain a more detailed geological view of their site via the free online resources available for geological mapping provided by the BGS Geoindex service. The hex-cell summary is derived by creating a spatial union between the hex-cell dataset and the geological inputs. The subsequent union of spatial data is then simply characterised by the relative areas (coverages) of each geological unit found within each hex-cell.

An area of ‘simple’ geology in a hex-cell may be described as:

Dominant superficial coverage: Glaciogenic Deposits (100% coverage).

Dominant bedrock: Mercia Mudstone Group – mudstone (100% coverage).

In this instance the description indicates that the borehole will encounter a layer of Glacial till overlying the first bedrock unit, which will be a mudstone from the Mercia Mudstone Group. The 100% coverage of both indicates that the whole hex-cell is likely to have the same general lithologies (see Figure 6 above, for how spatial data is summarised onto a hex-cell).

A more ‘complex’ area of geology may be described as:

Dominant superficial coverage: Glaciogenic Deposits (57% coverage), along with: Alluvial Deposits (3%).

Dominant bedrock is: Raisby Formation and Ford Formation-dolomitised limestone and dolomite (56% coverage), along with: Great Limestone-limestone (17%), (continued): Alston Group-limestone, argillaceous rocks and sandstone (12%), Edlington Formation-argillaceous rocks (11%), additional minor bedrock units occur.

The complexity of the geology in this second example is such that whilst 60% of the hex-cell area is covered by superficial materials, and whilst the main bedrock unit covers 56% of the hex-cell, an individual borehole site in the hex-cell may potentially show a different variation of the geology being described. For example, it may be in the 40% of the area that is not underlain by superficial materials and may be underlain by one of the less dominant bedrock units. The layers under the site might not lie horizontally so the geology can change vertically and laterally across a site (an example cross-section is Figure 10 below). This is a limitation of the dataset and thus site-specific geological prognosis is always advised when designing GSHP systems.

Heat Flow

The closed loop summary dataset uses a hex-cell summarized version of the BGS UK Heat Flow V1 model [22, 23].

The Heat Flow model is derived from a dataset of 212 heat flow measurements augmented by 504 heat flow estimates previously published in a series of reports and papers [5, 6, 7, 22–26].

Temperature measurements were originally published in the UK geothermal catalogue [27, 28]. This contains 3057 subsurface temperatures from 1216 sites, 567 of which are from wells with depths greater than 1 km. The catalogue also contains 4694 thermal conductivity measurements of core samples and formation chippings from 113 sites. The heat flow model was originally created using a range of surface modelling software available between 1987 and 2011.The model has been converted to a hexagonal cellular grid using the tessellation toolkit available in ESRI's ArcPro3.2 GIS. The vector tessellation does not add any new input data to the model and relies entirely on the original interpolation. A known limitation of this legacy dataset is that there has not been a paleoclimate correction applied across all the UK.

Thermal Properties

The closed loop summary dataset uses the BGS Thermal Properties V1 dataset [20, 29, 30]. The thermal properties dataset is created from a revised 1:250 000 scale digital geological map supplemented with thermal properties derived from a range of borehole and laboratory observations. An earlier version of the model, utilising elements of the BGS 1:625 000 scale map was first documented (in a non-spatial form) in 1984 [28] and again in 1987 [24]. The properties available comprise thermal conductivity, specific heat capacity, density and thermal diffusivity.

Thermal gradient

The thermal gradient of each hex-cell in the closed loop summary dataset BGS is derived by spatial union of BGS Thermal Properties V1 and BGS Heat flow V1 datasets [20, 23]. The subsequent union of spatial data is then simply summarised to derive minimum, maximum and average gradient. Based on the following calculation:

$$\Delta\mathrm{T}(K/m) = 0.1 \times \left(\frac{Q}{\kappa}\right)$$

Where κ = thermal conductivity (W/mK) and Q is heat flow (W/m^2)

Temperature at 75m depth (Supply temperature)

The temperature at 75 m depth of each hex-cell in the Closed loop summary dataset is based on the following calculation:

$$\mathrm{T75}(℃) = Tsoil + (0.75 \times \Delta\mathrm{T})$$

Where $Tsoil$ = mean annual soil temperature and $\Delta\mathrm{T}$ = Thermal gradient

Variance

For each hex-cell there may be multiple geological units present, each with a range of thermal conductivities; each cell will also have a range of heat flow values. The combination of the various input layers (each at different spatial scales), utilising the Carslaw equation given in the 'calculation' section (above) generates a range of possible 'extractable heat' values per hex-cell. The summary layer typically presents the *area-weighted* average value for extractable heat, which derived from the most spatially dominant geological units. The variance of extractable heat for the individual hex-cell is shown by the minima and maxima extractable modelled heat values of each hex-cell.

Relative heat extractable

The relative heat extractable field indicates whether the area weighted extractable heat from an individual cell is *above* or *below* the typical 'average' values of all the cells nationally, i.e. how an individual cell compares with all others in the dataset.

Input data

Table 3 Input data for the closed loop summary layer

Dataset	Source
BGS: UK Heat Flow	https://doi.org/10.5285/800d6734-2dd5-4ed0-a698-972594800042 [23]
BGS: Thermal Conductivity	https://doi.org/10.5285/def961e0-3432-4af8-a09a-a489c845af54 [20]
BGS Geology 250k_ Bedrock Version 4	https://www.bgs.ac.uk/datasets/bgs-geology-250k/ [32]
BGS Geology 625k_ Superficial Version4	https://www.bgs.ac.uk/datasets/bgs-geology-625k-digmapgb/ [21]
BGS: Superficial Deposit Thickness Model V5 (Hex)	https://www.bgs.ac.uk/datasets/superficial-thickness-model-1-km-hex-grid/
Ordnance Survey: Terrain 50	https://www.ordnancesurvey.co.uk/products/os-terrain-50

Limitations

- The BGS Geology 250k data [32] underpinning the geological descriptions in the dataset is a compilation of digital tiles derived from previously published and unpublished maps and archive information. The mapping, description and classification of rocks are based upon the interpretations and evidence available at the time of survey, or time of re-evaluation for modifications/correction.
- Estimates of thermal conductivity and potential extractable heat are based on typical-case scenarios, i.e. the most likely geology known to be present within a hex-cell, area-weighted values of heat flow and conductivity.
- Where a hex-cell shows no variation in expected geology (from the mapping), the minimum and maximum estimates for borehole extractable heat (and unit extractable heat) will be the same. Usually, there will be some variation, because the boreholes will intersect with different geological materials at depth, and the heat flow will change with depth. However, it is not possible to create a detailed 3-dimensional assessment of power within this summary dataset. A more detailed site-specific model of geometries will need to be considered as part of the final detailed design, and for many sites,

preliminary investigations such as a thermal response test will be needed to assess the final range of extractable heat that will be available per borehole.

- The summary layer does not include information on drilling constraints (e.g. source protection zones; hazardous ground conditions).

Open loop ground source heat pump

Technology

Open loop ground source heat technology relies on extracting heat from groundwater that is abstracted from a shallow aquifer using a number of boreholes in combination with a heat pump (Figure 9). The basic installation is a simple doublet composed of a borehole for abstraction and a borehole for re-injection of the water back into the aquifer. More combinations are available and a larger number of boreholes can be used to increase the capacity of the system. Depths of less than 300 m are considered in the summary layer.

The energy extracted from the groundwater is dependent on the flow rate, the temperature drop at the heat exchanger and the heat pump performance. The flow rates depend on aquifer properties, borehole design and construction and pump characteristics. A minimum separation between abstraction and injection boreholes is necessary to prevent thermal feedback (i.e. cool water injected being captured by the abstraction well reducing the temperature output and ultimately the performance of the system). This must be assessed for each specific project depending on aquifer properties and pumping requirements.

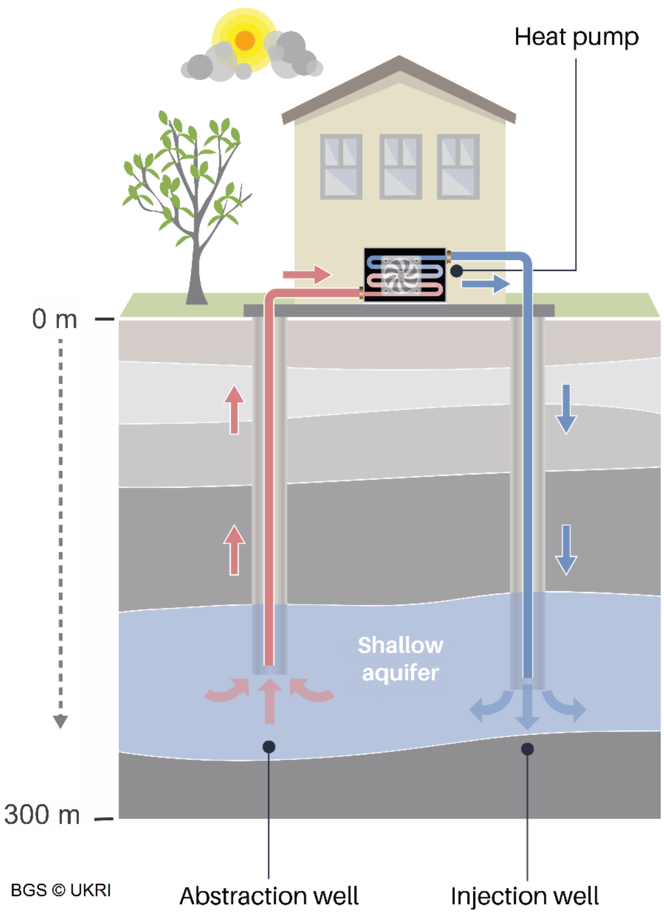


Figure 9 Open loop GSHP with a single doublet (one abstraction and one injection borehole) BGS©UKRI 2025

Output fields

The information and the fields contained in the open loop summary layer are compiled in Table 4.

Table 4 Field names, definition and exemplar wording for the open loop summary layer

DESNZ Field Definition [Field Wording]	MAP EXPLORER Field Definition	Example text
Unique identifier [UUID]	Unique identifier for Hex-Cell	34421
Geothermal technology [Tech_Type]	Geothermal technology	GSHP Open loop.
Technology description [Tech_Desc]	Technology description	Generalised technical potential value for open loop doublet sited in highly productive part of aquifer, up to 300 m deep. A spacing of 50 - 500 m between boreholes is common. Assumed 2000 operating hours, full load. Heat pump COP = 4.
Peak Capacity Bore [Pk_Cap_Bor]	Heat extractable from 1 borehole (kW)	Up to c. 314 kW from a single abstraction borehole.
Peak Capacity Array [Pk_Cap_Arr]	Heat extractable from 3 boreholes (kW)	Up to c. 943 kW from three abstraction boreholes.
Total Annual Capacity [Tot_An_Cap]	Total annual heat energy extractable from 3 boreholes (kWh)	Up to c. 1,885,500 kWh of energy extracted annually from three abstraction boreholes, assuming 2000 hours operation.
HP Peak Capacity Bore [HP_Pk_CpB]	Heat supplied from heat pump with 1 borehole (kW)	Up to c. 419 kW supplied from an installation with a single abstraction borehole.
HP Peak Capacity Array [HP_Pk_CpA]	Heat supplied from heat pump with 3 boreholes (kW)	Up to c. 1,257 kW supplied from an installation with three abstraction boreholes.

DESNZ Field Definition [Field Wording]	MAP EXPLORER Field Definition	Example text
Total HP Annual Capacity [Tot_HP_Ann]	Total annual heat energy supplied from heat pump with 3 boreholes (kWh)	Up to c. 2,514,000 kWh of energy supplied annually from an installation with three abstraction boreholes, assuming 2000 hours operation.
Supply Water Temperature [Spply_Temp]	Ground (input) temperature (°C)	Up to c. 16.1°C subsurface temperature at 150 m depth.
Technical feasibility descriptive [Tec FeasD]	Technical feasibility descriptive (UNFC in brackets)	High (F1 viable projects). Drilling constraints may apply locally.
Confidence [Confidence]	Confidence (UNFC in brackets)	Moderate (G2).
Variance [Variance]	Min, Max, Average description of the hex-cell heat output values	Single abstraction borehole heat extracted in this hex-cell ranges from 210 - 419 kW.
Relative heat extractable [Rel_H_ext]	Relative heat extractable	Estimated thermal output (314 kW), is more than the GB average, (GB average is 200 kW, ranging from 2 kW to 838 kW).
Aquifer Target [Aquifer_Ta]	Target aquifer for installation	Largest coverage in the hex-cell is the concealed CARBONIFEROUS LIMESTONE, a high productivity aquifer.

Technical feasibility and confidence outputs

The variance value within each hex-cell gives the range of values of theoretical heat extractable, to guide the user how variable this key output is over the area of that hex-cell.

The technical feasibility and confidence level for open loop GSHP has been assigned according to the following criteria:

Table 5 Assignment of technical feasibility and confidence for open loop GSHP

Technical Feasibility	UNFC assignment and rationale
High	F1.1 Viable project. Very high and high productivity aquifers are known to contain numerous operating open loop GSHP projects.
Medium	F2 Potentially viable and viable projects. Moderate productivity aquifers that contain operating projects and are potentially viable for more projects, depending on the scale of heat output needed.
Low	F2.3 Limited potential. Low productivity aquifers and non aquifer units for which the geological conditions are known to limit the technical feasibility
Confidence	**UNFC assignment and rationale**
High	Not used
Moderate	G2 Moderate. Very high and high productivity aquifers, generally well constrained by geological data, but data coverage across whole nation is variable, plus aquifer properties vary.
Low	G3 Low. Moderate, low productivity aquifers and non aquifers. Geological and aquifer properties are variably constrained and vary geospatially.

Assumptions for the summary layer

A number of assumptions have been used to create the open loop GSHP summary layer:

- Only heating is considered.
- The estimates provided in the summary layer are based on a fixed number of boreholes. Two types of installations are considered: a single doublet with two boreholes (one abstraction and one reinjection) and a system with 3 abstraction boreholes that may be representative of larger scale projects.
- The summary layer only considers aquifers in the shallowest 300 m of the subsurface.

- The flow rates used to calculate the heat output and total energy supplied have been assigned according to representative values for the aquifers delineated as part of previous national hydrogeological analysis.
- Local aquifer variability is not considered. Lower and higher flow rates than those assigned are probable and dependent on local conditions.
- The flow rate and heat and energy supply estimates presented here are representative of boreholes sited in productive parts of the aquifer, the flow rates will not be achievable everywhere within that unit.
- The analysis mainly comprises bedrock units. Superficial deposits have only been considered when included on the BGS 1:625 000 hydrogeological productivity map (one unit, the Crag, only).
- When more than one aquifer is present in the hex-cell, weighted and range (min and max) values have been calculated according to the spatial prevalence of the aquifers contained in the cell.
- For the annual energy supplied it is assumed that the system runs for 2,000 full load operational hours over the year. This is to match with Arup [1]. The operational hours some users (e.g. heat networks) are likely to be higher.

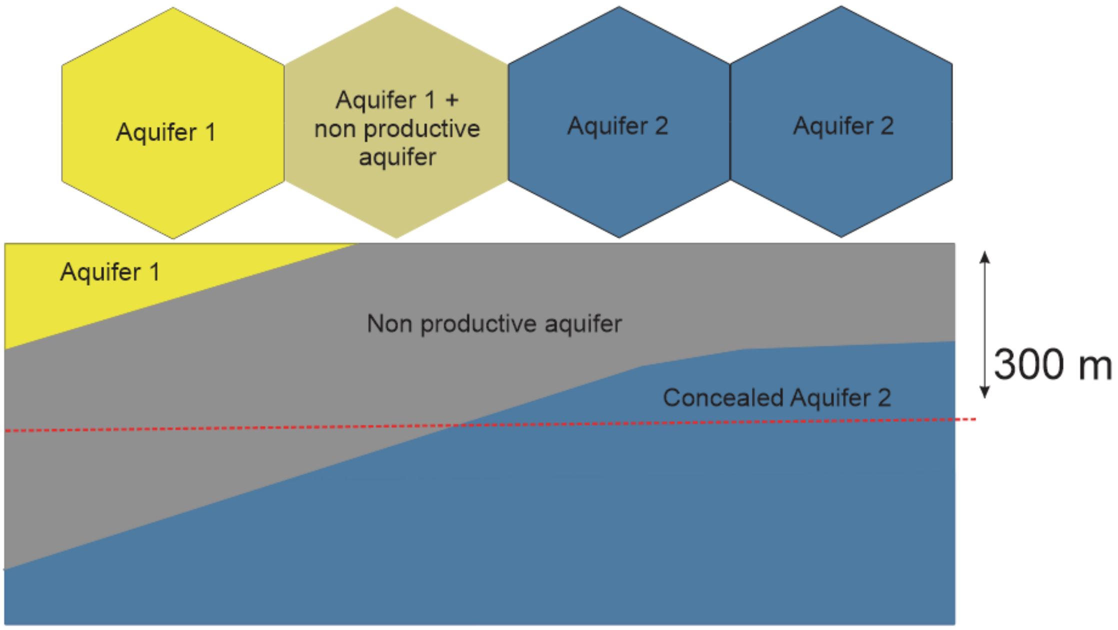


Figure 10 Schematic cross-section to show how hex-cells relate to the geology of the subsurface aquifers, including an aquifer concealed beneath a less productive layer

Calculations

Peak Capacity of Heat Extracted (kW) (Heat extractable from 1 borehole)

For a single doublet (assuming heating mode; Figure 11)

$$H_{ext}(kW) = Q\, c_w (T_{inlet} - T_{outlet})$$

The assumption is that the temperature drop at the heat exchanger is $(T_{inlet} - T_{outlet})$= 5°C (e.g. [33]). c_w is the volumetric heat capacity of water (~4.19 MJ/(m^3 K)).

Q [m^3/s] is the flow rate. This value is obtained according to the aquifer productivity. A range of minimum, maximum and representative flow rates have been assigned to each aquifer according to their productivity classification.

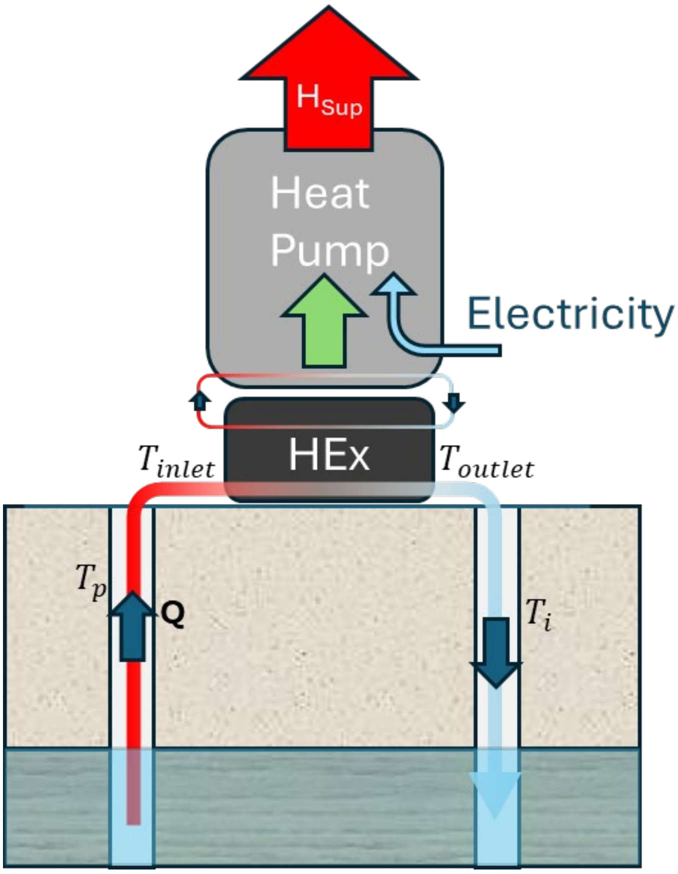


Figure 11 Conceptual diagram of a single doublet with a heat exchanger and the final heat supplied by the heat pump

Peak Capacity of Heating Supply (kW) (Heat supplied from heat pump with 1 borehole)

H_{sup} is the amount of heat supply by the installation after using the heat pump (Figure 11), therefore a combination of the heat extracted from the groundwater plus the amount provided by the work of the heat pump itself (powered by electricity).

$$H_{sup}\ (kW)\ = H_{ext}/(1 - \frac{1}{COP})$$

The assumption is to use a Coefficient of Performance (COP) value of 4 for the calculations. The COP will vary depending on several factors, but a value of 4 is considered typical for an input temperature from groundwater of 12°C and output of 50°C [33].

Total Annual Energy Capacity of Heating Supply (kWh) (Total annual heat energy supplied from heat pump)

The annual heat supply is calculated under the assumption of 2,000 hours of operation. It is calculated by multiplying the heat pump output (heat supply) by the number of hours.

$$E_{sup}\ (kWh)\ =\ H_{sup}\ (kW)\ \times 2000\ hours$$

Supply temperature (ground input temperature)

The supply temperature is a representative value of ground temperature at 150 m depth obtained using the BGS Heat Flow map, surface topography, BGS thermal property datasets and mean annual soil temperature based on the following calculation:

$$\mathrm{T150}(\text{°C}) = Tsoil + (1.5 \times\ \Delta\mathrm{T})$$

Where $Tsoil$ = mean annual soil temperature and $\Delta\mathrm{T}$ = Thermal gradient

Analysis workflow

Spatial Delineation of Aquifers

The BGS 1:625 000 hydrogeological productivity map of the UK [34] has been used as the base layer for delineation of the aquifer extent polygons used as reference.

In addition, information of principal aquifers at depth has been obtained from the principal aquifer models developed as part of the legacy BGS aquifer/shale separation maps [35]. The principal aquifer layers from this map were combined into a single layer in which the aquifers were rearranged to identify the first (shallower) aquifer of the sequence.

From the 1:625 000 hydrogeological productivity map [28], the areas of non-productive units and low productivity aquifers have been identified to define whether there is a potential concealed aquifer at depth down to 300 m (Figure 9).

Finally, when a non- or low-productivity aquifer as per the definition of the 1:625 000 hydrogeological productivity map [34] is overlying a principal aquifer, it has been reassigned as “concealed” aquifer and the principal aquifer is considered the main productive unit in that spatial domain.

Definition of Aquifers

The aquifer productivity map classification [34] has been slightly modified to include a broader range of aquifers. An extra type, "very high productivity" has been added to the classification. In addition, some of the aquifers have been reclassified according to their representative flow rates. For example, aquifers classified as high productivity aquifers on the 1:625 000 hydrogeological productivity map [34], but which representative flow rates are small when compared with other major aquifers have been reclassified as moderate productivity (for example the Grey Chalk Subgroup). Similarly, high productivity aquifers with very high representative flow rates have been reassigned to the new "very high productivity" group (these include some areas of Inferior Oolite, Lower Greensand and White Chalk). Where possible, a geographical differentiation has been made within the same aquifer according to known aquifer characteristics (for example lower representative flow rates have been assigned to concealed parts of the White Chalk). Finally, it should be observed that some well-known aquifers are contained within a broader group (e.g. the Sherwood Sandstone is contained in the Triassic Rocks (undifferentiated) aquifer in the 1:625 000 hydrogeological productivity map) but an internal separation has been made to assign the most representative productivity.

Assignment of Flow Rates

The flow rates assigned to the four types of aquifers defined in the aquifer productivity layer are compiled in Table 6. Minimum and maximum values have also been assigned to reflect the variability and uncertainty on the estimates. These values have been chosen partly to align with those used in the Arup study [1] (Table 7), so that the outputs are comparable.

In some cases, different productivity and therefore flow rates have been assigned to aquifers with the same name in some areas / under some conditions due to more refined information (for example, the Stratheden Group in Scotland has been assigned flow rates according to moderate productivity classification except in Fife where it has been assigned very high productivity flow rates or some parts of the Lower Greensand aquifer where lower maximum yields are achievable).

Table 6 Types of aquifers and representative flow rates assigned

Type	Representative (L/s)	Minimum (L/s)	Maximum (L/s)
Very High Productivity	30	20	40
High Productivity	15	10	20
Moderate Productivity	5	1	10
Low Productivity	0.5	0.1	1

Table 7 Flow rates used for the LCOH calculations in the Arup study [1]. A value of ΔT = 8°C was used in the Arup study, whereas ΔT = 5°C is used for the summary layer.

LCOH Model	Medium (L/s)	Low (L/s)	High (L/s)
Open loop flow rates	20	10	40

Non aquifers are also present and considered as an additional category. Representative, minimum and maximum flow rates of 0 L/s were assigned to these areas.

Calculation of output values

With the flow rates (Q) assigned, the equations explained above (heat extracted, heat supplied and total energy capacity of heat supplied) have been used to calculate the required outputs at each representative location and hex-cell.

The final values provided as heat extractable, heat supplied and total annual energy supplied represent weighted averages over the extent of the hex-cell considering the spatial predominance of each aquifer (when more than one is present on the hex-cell) and their representative productivity / flow rates.

Minimum and maximum values were obtained from the ranges of flow rates assigned to each category, so they represent the variability within each hex-cell.

An example is shown below for a hex-cell with a distribution of 60% of very high productivity aquifer and 40% of moderate productivity aquifer with their representative (min-max) flow rates:

Aquifer 1: very high productivity aquifer (60% coverage). Flow rate: 30 (20-40) L/s

Aquifer 2: moderate productivity aquifer (40% coverage). Flow rate: 5 (1-10) L/s

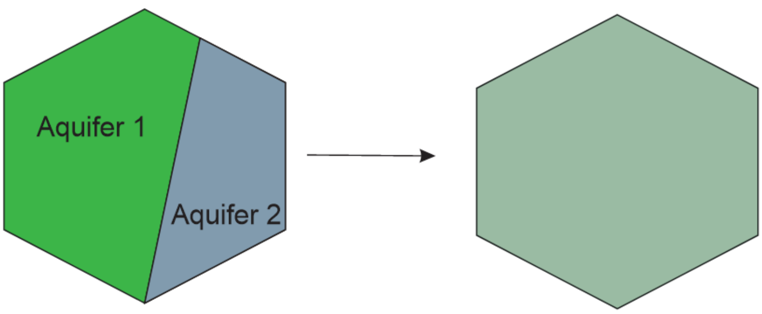


Figure 12 Example of transferring the information from two aquifers to a representative value in the screening layer hex-cell

Representative flow rate of the hex-cell:

$$Q_{HC} = Q_{aq1} \times 0.6 + Q_{aq1} \times 0.4 = 20\ L/s$$

Representative heat extracted and heat supplied for 1 borehole:

$$H_{ext}(kW) = Q_{HC}\ c_w(T_{inlet} - T_{outlet}) = 419\ kW$$

$$H_{sup}\ (kW) = \frac{H_{ext}}{1 - \frac{1}{COP}} = 559\ kW$$

Input data

Information and datasets used to create the open loop summary layer are listed in Table 8.

Table 8 Input data for open loop GSHP

Title	Details
BGS 1: 625 000 hydrogeological productivity map Used for spatial delineation and flow rates	https://www.bgs.ac.uk/datasets/hydrogeology-625k/ The map indicates the aquifer potential using a division of geological formations. Three types are considered: • Aquifer with intergranular flow in the saturated zone is dominant • Aquifers in which flow is controlled by fissures or discontinuities • Less permeable formations including aquifers concealed at depth beneath covering layers The aquifers are divided on three productivity categories: highly, moderately and low productivity aquifers. Rocks with essentially no groundwater are also shown in the map. The 1:625 000-scale data may be used as a guide to the aquifers at a regional / national level but should not be relied on for local information.
BGS models of principal aquifers in England and Wales Used for spatial delineation down to 300m	https://www2.bgs.ac.uk/groundwater/shaleGas/aquifersAndShales/maps/aquifers/home.html This dataset includes models to the depth to the bottom of the 11 principal aquifers in England and Wales. The aquifers in the dataset arranged from youngest at the top to oldest at the bottom are: • Crag • Chalk • Lower Greensand • Spilsby Sandstone • Corallian Limestone • Oolites • Triassic Sandstone • Magnesian Limestone • Permian Sandstone • Carboniferous Limestone • Fell Sandstone and Border Group
BGS: UK Legacy Heat Flow Model. Used in calculation of groundwater temperature	BGS: UK Heat Flow https://doi.org/10.5285/800d6734-2dd5-4ed0-a698-972594800042 [23]
Ordnance Survey: Terrain 50	https://www.ordnancesurvey.co.uk/products/os-terrain-50

Limitations

- The BGS 1:625 000 hydrogeological productivity map [34] was developed at a national scale with inevitable generalisation of geological and aquifer property information. Local characteristics of the aquifers and distribution of properties are known to vary spatially and with depth. As a result, a hex-cell with a good productivity aquifer derived spatially from the 1:625 000 aquifer productivity map may have limited thickness and result on a limited real productivity. These situations must be assessed on further feasibility studies with detailed geological information.
- Superficial deposits might constitute good aquifers in some areas. The BGS 1:625 000 hydrogeological productivity map [34] does not include superficial deposits (excepting the Crag) and so they are not generally modelled in this study. Detailed local analysis might identify a superficial deposit as a good location for an open loop installation. Superficial geological maps at 1:50 000 and 1:625 000 are available to view in the map explorer.
- The summary layer does not include information on drilling constraints (e.g. source protection zones; hazardous ground conditions).

Deep geothermal (hot sedimentary aquifer/hydrothermal)

Technology

Deep geothermal wells that abstract hot geothermal brines from aquifers (sometimes called reservoirs) at depths around 1.5 – 4 km deep and temperatures over 40°C can provide direct use heat (without a heat pump). An open loop doublet comprises an abstraction and a reinjection well. In the UK, the Southampton geothermal borehole was operational for more than 30 years using brine extracted from the Sherwood Sandstone Group at 76°C and supplying a heat network [2].

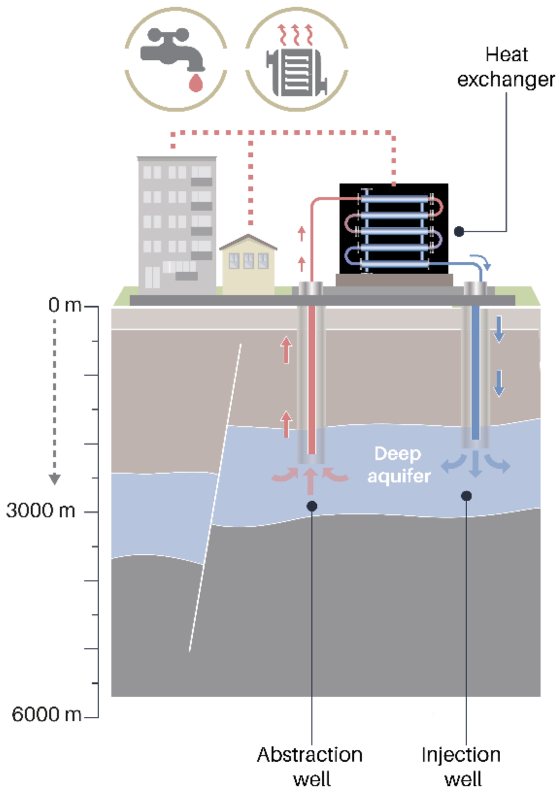


Figure 13 Deep geothermal energy from a hot sedimentary aquifer, for direct use heat. Image BGS©UKRI 2025

Output fields

The following fields are used to describe the hex-cells in this summary layer:

Table 9 Output data for deep geothermal, hot sedimentary aquifers

DESNZ Field Definition [Field Wording]	MAP EXPLORER Field Definition	Example text
Unique identifier [UUID]	Unique identifier for hex-Cell	45348
Geothermal technology [Tech_Type]	Geothermal technology	Deep geothermal (hot sedimentary aquifer/hydrothermal).
Technology description [Tech_Desc]	Technology description	Estimated theoretical potential value for doublet sited in productive part of aquifer. A distance of 1,740 m between wells equates to one hex-cell. Assumed 6000 operating hours, full load.
Unit 1 Triassic Sandstone Peak Capacity [SG_Pk_Cap]	Unit 1 Triassic Sandstone: heat extractable from 1 well doublet (kW) (see section Heat extractable from 1 doublet)	Theoretical potential estimated c. 2806 kW from a single well doublet.
Unit 1 Triassic Sandstone Annual Capacity [SG_Ann_Cap]	Unit 1 Triassic Sandstone: total annual heat energy extractable from 1 well doublet (kWh) (see section Total annual heat energy extractable from 1 doublet)	Theoretical potential estimated c. 16,838,383 kWh of energy from a single well doublet, assuming 6000 hours annual operation.
Unit 1 Triassic Sandstone: Supply Temperature [SG_Sply_T]	Unit 1 Triassic Sandstone: ground temperature (degC)	Estimated temperature c. 48°C at aquifer depth of approximately -1500 m relative to Ordnance Datum.
Unit 1 Triassic Sandstone: Technical feasibility (descriptive) [Tec_FeasD1]	Unit 1 Triassic Sandstone: Technical feasibility (descriptive) Low/Med/High (UNFC in brackets)	Low (F3.3). Favourable conditions inferred from preliminary regional studies.

DESNZ Field Definition [Field Wording]	MAP EXPLORER Field Definition	Example text
Unit 1 Triassic Sandstone: confidence [Confidnce1]	Unit 1 Triassic Sandstone: Confidence: Low/Moderate/High (UNFC in brackets)	Low (G4.1). Primarily indirect evidence with high confidence.
Unit 1 Triassic Sandstone: variance [Variance1]	Unit 1 Triassic Sandstone: Min, Max, Average description of the hex-cell heat output values	Single well doublet heat extracted ranges from 2665 kW - 2901 kW in the hex-cell, area-weighted average is 2787 kW.
Unit 2 Permian Sandstone: Peak Capacity [PT_Pk_Cap]	Unit 2 Permian Sandstone: heat extractable from 1 well doublet (kW) (see section Heat extractable from 1 doublet)	Theoretical potential estimated c. 3567 kW from a single well doublet.
Unit 2 Permian Sandstone: Annual Capacity [PT_Ann_Cap]	Unit 2 Permian Sandstone: total annual heat energy extractable from 1 well doublet (kWh) (see section Total annual heat energy extractable from 1 doublet)	Theoretical potential estimated c. 24,536,722 kWh of energy from a single well doublet, assuming 6000 hours annual operation.
Unit 2 Permian Sandstone: Supply Temperature [PT_Sply_T]	Unit 2 Permian Sandstone: input temperature (degC)	Estimated temperature c. 56 °C, at aquifer depth of approximately -1900 m relative to Ordnance Datum.
Unit 2 Permian Sandstone: Technical feasibility (descriptive) [Tec_FeasD2]	Unit 2 Permian Sandstone: Technical feasibility (descriptive) Low/Med/High (UNFC in brackets)	Low (F3.3). Favourable conditions inferred from preliminary regional studies.
Unit 2 Permian Sandstone: Confidence [Confidnce2]	Unit 2 Permian Sandstone: Confidence: Low/Moderate/High (UNFC in brackets)	Low (G4.1). Primarily indirect evidence with high confidence.
	Unit 2 Permian Sandstone: Min, Max, Average	Single well doublet heat extracted ranges from 2665 kW - 4001 kW in the hex-cell, area-weighted average is 3787 kW.

DESNZ Field Definition [Field Wording]	MAP EXPLORER Field Definition	Example text
Unit 2 Permian Sandstone: Variance [Variance2]	description of the hex-cell heat output values	
Unit 3: Peak Capacity [CD_Pk_Cap]	**Unit 3 Carboniferous sandstone or limestone or Devonian sandstone: heat extractable from 1 well doublet (kW) (see section Heat extractable from 1 doublet)	Theoretical potential estimated c. 32,471 kW from a single well doublet.
Unit 3: Annual Capacity [CD_Ann_Cap]	**Unit 3 Carboniferous sandstone or limestone or Devonian sandstone: total annual heat energy extractable from 1 well doublet (kWh) (see section Total annual heat energy extractable from 1 doublet)	Theoretical potential estimated 194,825,588 kWh of energy from a single well doublet, assuming 6000 hours annual operation. High values due to thickness of aquifer not likely to be technically recoverable.
Unit 3: Supply Temperature [CD_Sply_T]	Unit 3 Carboniferous sandstone or limestone or Devonian sandstone: ground temperature (degC)	Estimated temperature c. 64 °C, at aquifer depth of approximately 2700 m relative to Ordnance Datum.
Unit 3: Technical feasibility (descriptive) [Tec_FeasD3]	Unit 3 Carboniferous sandstone or limestone or Devonian sandstone: Technical feasibility (descriptive) Low/Med/High (UNFC in brackets)	Low (F3.3). Favourable conditions inferred from preliminary regional studies.
Unit 3 Confidence: [Confidnce3]	Unit 3 Carboniferous sandstone or limestone or Devonian sandstone: Confidence: Low/Moderate/High (UNFC in brackets)	Low (G4.3). Indirect evidence, high estimate and low confidence.

DESNZ Field Definition [Field Wording]	MAP EXPLORER Field Definition	Example text
Unit 3 Variance [Variance3]	Unit 3 Carboniferous sandstone or limestone or Devonian sandstone: Min, Max, Average description of the hex-cell heat output values	Single well doublet heat extracted ranges from 24,535 kW – 32,913 kW in the hex-cell, area-weighted average is 32,245 kW.
Geology [Geology]	Geology/ Unit (s) description	Resource available: Triassic Sandstone, Carboniferous aquifer.

** The Early Carboniferous Limestone model used as input was created using a different, stochastic approach to account for changes in rock type (e.g. limestone-mudstone [9]). In areas where limestone rock types are not modelled as dominant, this results in scattered cells of geothermal potential in areas where the rock unit is at suitable temperatures. The description over these areas has been set to 'Limited data' as the locations of output cells is a representation of a model, as opposed to a data-driven interpretation at that location.

Why are there three heat output values?

Sedimentary basins across the UK contain a number of different aquifers of different geological ages or rock types (Figure 13, Figure 14). Depending on location, there may be up to three hex-cells outputs, for aquifers from different depths.

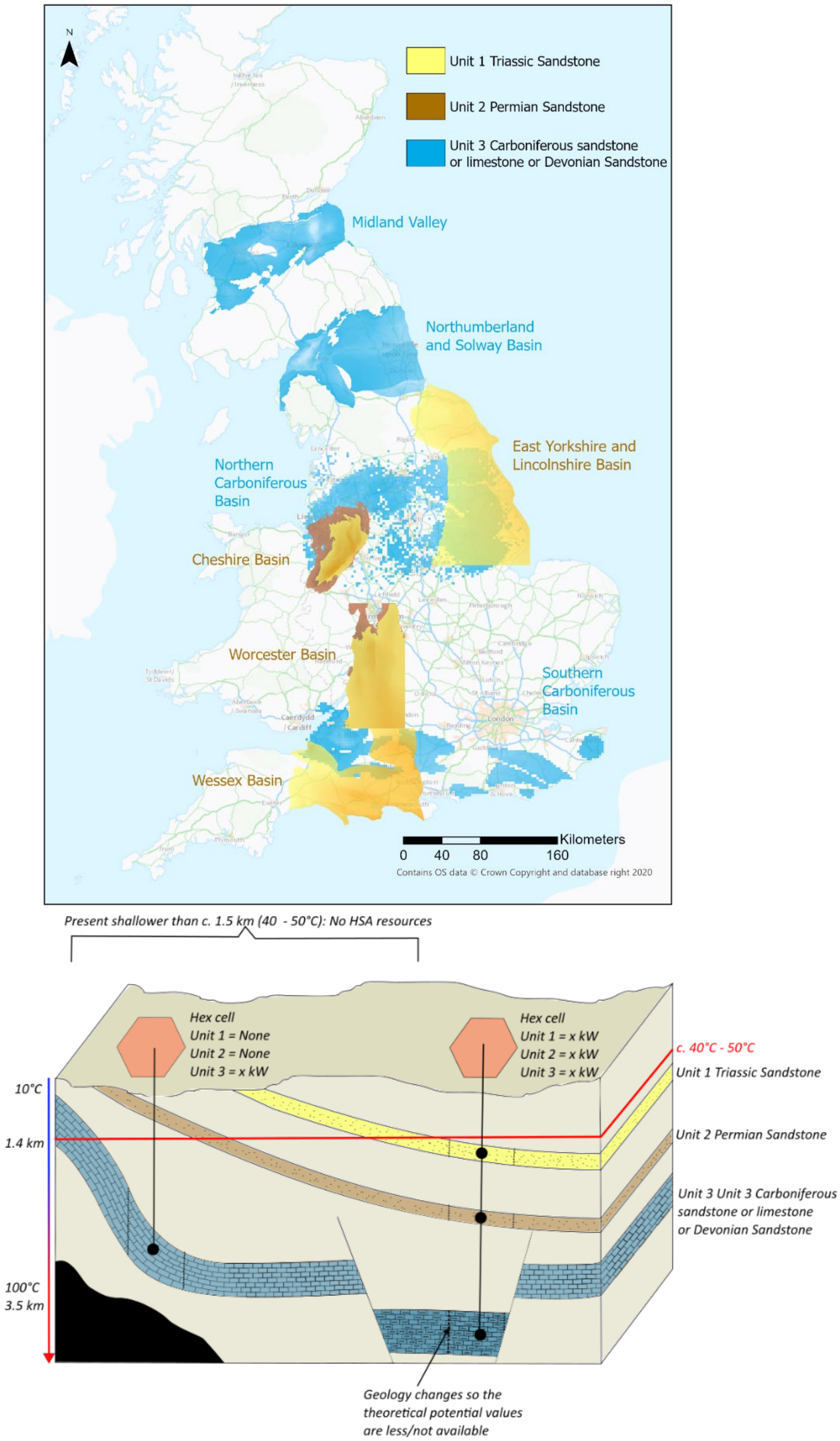


Figure 14 Top: Map of the UK showing distribution of geological units in sedimentary basins. Colours indicate Unit 1,2,3 as included in hex-cells. Below: A 3D block image showing geological layering in a sedimentary basin to explain multiple outputs for hot sedimentary aquifers. The temperature/depth cut off for direct use heat is shown in red, with an example of a hex-cell where the aquifer exists at shallower depths and <40 °C

Table 10 Hot sedimentary aquifers as divided into three units in the summary layer

Unit name used in summary layer	Geological unit	Sedimentary basins
Unit 1 Triassic Sandstone	Sherwood Sandstone Group (SSG) of Triassic age	Cheshire, Wessex, East Yorkshire and Lincolnshire and Worcester basins
Unit 2 Permian Sandstone	Bridgnorth Sandstone (BS)	Cheshire Basin,
	Collyhurst Sandstone (CS) of Permian age	Worcester Basin (present East Yorks Lincs and Wessex but poor aquifer quality)
	Stewartry Group	*Dumfries, Lochmaben, Mauchline*
Unit 3 Carboniferous sandstone or limestone or Devonian Sandstone	Fell Sandstone Formation, Mid Border Group (MBG), Carboniferous	Northumberland-Solway Basin
	Early Carboniferous Limestone (ECL)	Northern and southern England
	Kinnesswood Formation and Stratheden Group, Upper Devonian	Midland Valley Scotland
	Lower and mid Devonian rocks	*Strathmore, Moray, Caithness*

In italics, aquifer units lacking geothermal data

Technical feasibility and confidence outputs

The variance value within each hex-cell gives the range of values of theoretical heat extractable, to guide the user how variable this key output is over the area of that hex-cell.

The technical feasibility and confidence level for each hot sedimentary aquifer have been assigned:

Table 11 Assignment of technical feasibility and confidence for hot sedimentary aquifers

Technical Feasibility	UNFC assignment and rationale
High	F1.1 - Viable project. Around the Southampton geothermal well.
Medium	F3.2 - Local studies and previous data indicate potential for development but requires more data and/or evaluation. The Sherwood Sandstone Group around the Southampton and South Wessex area due to the geothermal well, exploratory borehole at Marchwood and hydrocarbon wells. Also around the Cleethorpes geothermal exploration well, which had a production test.
Low	F3.3 - At the earliest stage of studies: favourable conditions for the potential development have been inferred from preliminary regional studies. The remainder of the aquifers examined in regional studies [5-11] F4.1 - Less than 40°C or limited data: areas where there is limited subsurface data and no regional study has been undertaken, or areas where the target is shallower than the 40-50°C cut off. NA: aquifer absent
Confidence	UNFC assignment and rationale
High	G1 - Producing well (Southampton well operational for over 30 years, currently non-operational)
Moderate	Not used
Low	G4.1: Primarily indirect evidence but with high level of confidence areas well constrained by production, test and other well data (around Southampton and south Wessex, around Cleethorpes well) G4.2: Primarily indirect evidence but with moderate level of confidence. Other areas of Permo-Trias basins where there is a reasonable level of data from legacy hydrocarbon wells and hydrogeological studies G4.3: Primarily based on indirect evidence with high estimate and low confidence. Carboniferous and Devonian basins with limited well, seismic and deep subsurface flow data NA: aquifer absent or temperature below thresholds for this unit

Assumptions for the summary layer

It is assumed that the aquifer (reservoir) temperature can be taken as the well head or supply temperature. In reality, there are temperature losses as the hot brine is pumped from the reservoir depth to the well head. However, the scale of the losses is estimated to be of similar magnitude to errors on the modelled temperature (a few degrees for a kilometre deep well up to 5-10°C for a 4 km deep well e.g.[36]).

The legacy models underlying the theoretical recoverable heat value only exist where the aquifer reaches a certain depth (e.g. 1400 m) or temperature (e.g. 40°C) and are considered for direct use heat (Table 13). Aquifers are present at shallower depths, at lower temperatures (see Figure 14) for these no results are given and the technical feasibility is summarised as 'Less than 40°C or limited data'.

Input data

Key input data to this summary layer are a series of legacy regional maps and models created by BGS [6, 8, 9,11]. Two different methods were used in their creation and conversions have been used here to provide roughly equivalent values of theoretical 'recoverable heat' (details below). The terminology used in the legacy studies on which the summary layers are based is not consistent with the UNFC, for example legacy 'recoverable' heat values are theoretical potential assuming well parameters, operating lifetime etc.

Table 12 details the original published layers available in the map explorer, and/or used as input to the calculation of theoretical recoverable heat from geothermal doublets for each HSA resource (see Analysis workflow section). Temperature and depth maps are provided at the top, middle or base of the aquifer according to the legacy maps published in each respective study (Table 12). The temperature at the top and base provides the minimum and maximum estimated temperature in the aquifers, respectively. On the Sherwood Sandstone Group (Unit 1 Triassic sandstone) :

- The temperature and depth summary values in the hex-cells are from the base of the unit in the Cheshire and Worcester Basins
- The depth is from top of the unit and the temperature is from the base of the unit for the Wessex Basin (south of British National Grid line 170,000) and for East Yorkshire and Lincolnshire.

Table 12 Input data for hot sedimentary aquifers, Sherwood Sandstone Group (SSG), Mid Border Group (MBG) and Early Carboniferous Limestone (ECL)

	Depth (mAOD)	Temperature (°C)	Theoretical potential Recoverable Heat
Unit 1 Triassic Sandstone (Cheshire, Worcester, Wessex, East Yorkshire Lincolnshire basins)	Top SSG (all) Base SSG (Cheshire and Worcester only)	Base SSG	Referred to as 'Identified Resource' in Rollin et al. 1995 (PJ/km^2)
Unit 2 Permian Sandstone (Cheshire, Worcester basins)	Base Permian	Base Permian	
Unit 3 Carboniferous Sandstone (Northumberland-Solway basin)	Base MBG	Mid MBG	
Unit 3 Carboniferous Limestone	Top ECL	Top ECL	Recoverable Heat (MW/km^2)
Unit 3 Upper Devonian Sandstone (Midland Valley Scotland)	Top Upper Devonian	Base Upper Devonian	

The input data for the technical feasibility and confidence outputs fields, includes legacy geothermal studies [5-11] and our knowledge of the data on which those were based, as well as knowledge of prefeasibility studies, exploration wells and operating geothermal schemes in the UK [2, 4, 10], plus wider knowledge from legacy hydrocarbon wells and hydrogeological studies.

Analysis workflow

The theoretical heat extractable from a single doublet in the summary layer is calculated from several types of legacy maps/models that are available to view in the map explorer. These are regional spatial and volumetric models using averaged and assumed rock and well properties. In order that specialist users understand the workflow, Figure 15 provides an overview, followed by the calculation steps used.

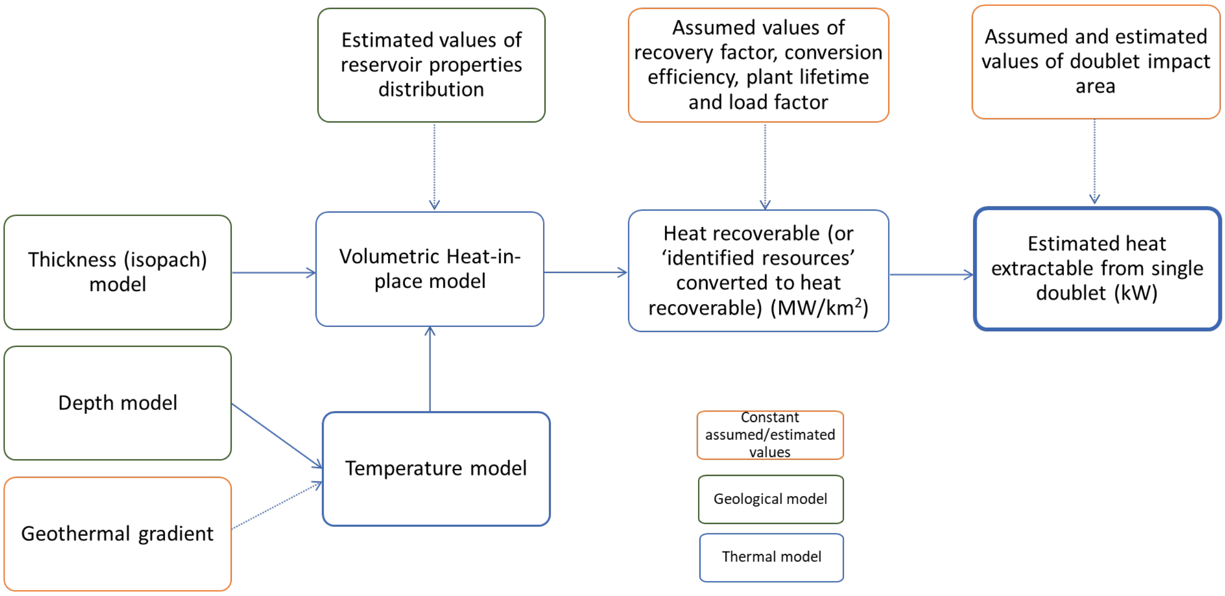


Figure 15 Overview of the input models used in calculation of the summary layer output field 'estimated heat extractable from a single doublet'. The inputs outlined in green are derived from the geological model; assumed or estimated values for the thermal model are outlined in orange, and outputs from the thermal models (temperatures, theoretical volumetric Heat-In-Place and recoverable heat) in blue

Heat extractable from 1 doublet

The summary layer provides the total heat extractable from a geothermal doublet tapping into a given aquifer over the area of the hex-cell (Figure 16). It assumes that each hex-cell hosts one abstraction well from a geothermal doublet. The total theoretical heat extractable (kW) corresponds to the heat that may be extracted from the aquifer over the long-term (30 years) over the entire hex-cell area (2.56 km^2).

A typical range of well separation in geothermal doublets for hot sedimentary aquifers is between 1 and 2 km [37], so assuming a well spacing of c. 1,740 m appears valid. The radius of influence of a thermal plume from a well situated in the centre of the hex-cell corresponds to the radius of the hex-cell of c. 860 m (i.e. half the well spacing well spacing of c. 1,740 m).

The weighted average theoretical recoverable heat (MW/km^2) from Hot Sedimentary Aquifer resources is calculated as the average values from the original raster grid H_{rec} weighted by the area of each cell ($A_{grid\ cell}$) overlapping a given hex-cell ($A_{hex\ cell}$ = 2.56 km^2), such as:

$$H_{rec,hex\ cell}(MW/km^2) = \frac{\sum H_{rec} \times A_{grid\ cell}}{A_{hex\ cell}}$$

The output value in the summary layer, the total theoretical heat extractable per hex-cell or peak capacity (kW), is calculated by integrating the estimated theoretical recoverable heat per unit area from the original grid H_{rec} (MW/km^2) over the area of the corresponding hex-cell (Figure 16), such as:

$$H_{ext}(MW) = \sum H_{rec} \times A_{grid\ cell}$$

$$H_{ext}(kW) = \sum H_{rec} \times A_{grid\ cell} \times 1000$$

Total annual heat energy extractable from 1 doublet

The total annual heat energy extractable from 1 well doublet for each aquifer (kWh) is derived from the peak capacity, assuming 6000 h of operation in accordance with the Arup study [1].

$$E_{ext}\ (kWh) = H_{ext}\ (kW) \times 6000\ hours$$

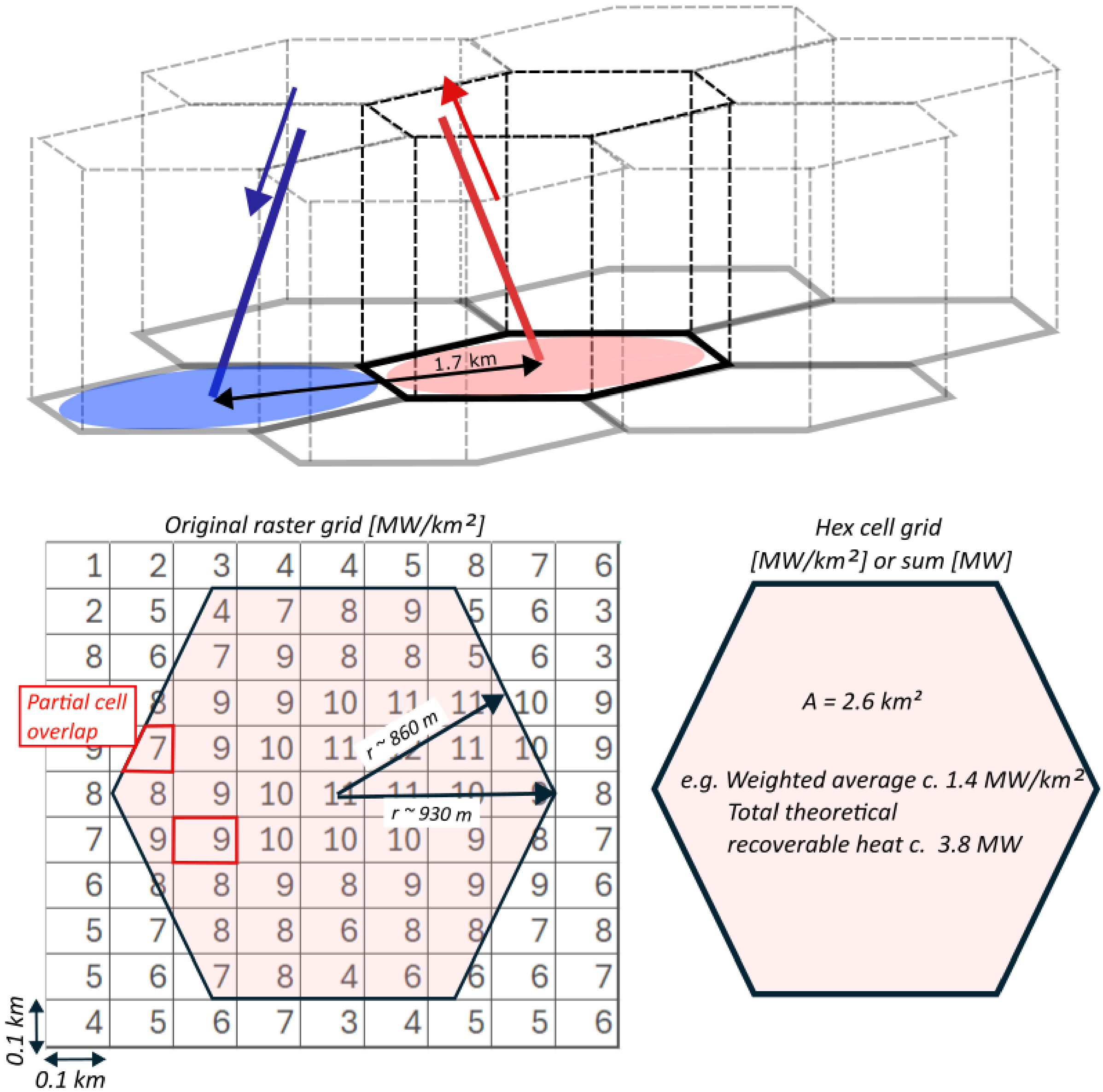


Figure 16 Diagrams showing a) the assumptions for a well doublet with radius of influence approximating to the size of a hex-cell for calculation of theoretical heat extractable b) the conversion of the Recoverable Heat values from an original square cell grid (raster) into weighted averages/weighted sums into a hexagonal cell

Supply Temperature (Input temperature)

The supply/input temperature (°C) for each hex-cell is calculated using the same weighted average approach, based on the estimated temperatures at the top or base of the reservoirs.

Calculations

Depth

The average depth values for each hex-cell are derived from 3D geological models for each basin [6, 9, 11] and are in metres relative to Ordnance Datum. Depth maps are provided at the top or base of the aquifer according to the legacy maps published in each respective study (Table 12)

Temperature

The geothermal gradient was estimated using data compiled in the UK Geothermal Catalogue [24, 25] corrected for time since circulation [6, 9] and using any newer data acquired from newly drilled boreholes [11]. The temperature at the depth of the top, middle or base of each formation was interpolated from the available dataset, using a constant surface temperature and average geothermal gradient, or calculated by convolution of observed/estimated heat flow and thermal conductivity data. The parameters are summarised in Table 13, which also includes the assumptions used for the calculations of the heat in place and recoverable heat.

Table 13 Input parameters for the geothermal models, as published in the original studies [6, 9, 11]. The temperature field for Unit 1 Triassic Sandstone, Unit 2 Permian Sandstone and Unit 3 Carboniferous Sandstone were derived from interpolation of the observed data collected in the UK Geothermal Catalogue at selected depth (e.g. in Eastern England) or calculated by convolution of observed/estimated heat flow and thermal conductivity data (e.g. in Wessex, Cheshire, Worcester), depending on the amount and quality of data available. The temperature field for Unit 3 Carboniferous Limestone and Devonian Sandstone was interpolated assuming a constant surface temperature and geothermal gradient.

	Temp cut off	Reject Temp	Surface Temp	Geothermal gradient	Reservoir depth cutoff	Recovery factor
Unit 1 Triassic Sandstone	40°C	25°C	10°C	-	-	0.33
Unit 2 Permian Sandstone	40°C	25°C	10°C	-	-	0.33
Unit 3 Carboniferous Sandstone	40°C	25°C	10°C	-	-	0.33
Unit 3 Carboniferous Limestone	c. 50°C	21°C	10.1°C (northern province) and 10.9°C/km (southern province)	28.7°C/km (northern province) and 31.3°C/km (southern province)	1000 m (northern province) and 1200 m (southern province)	0.1
Unit 3 Upper Devonian Sandstone	c. 50°C	25°C	8.6°C	26.6°C	1400 m	0.1

Heat-In-Place

The theoretical potential ‘Geothermal Resource’ (GR) (J) for the ‘Unit 1 Triassic Sandstone’, ‘Unit 2 Permian Sandstone’ and the ‘Unit 3 Carboniferous Fell Sandstone’ was calculated using the BGS method described in [6]:

$$\mathrm{H}_0 = V(T_r - T_0)\left[(1-\phi)\rho_r c_r + \phi\rho_f c_f\right]$$

This is also the volumetric Heat-In-Place (HIP) approach implemented within the 3DHIP tool [22] and used by [9, 11] for the Unit 3 Carboniferous Limestone and Upper Devonian Sandstone estimations.

Where:

ϕ : porosity

T_r: reservoir temperature (°C)

T_0: reference temperature (°C), either the ground surface temperature T_s in [6] or reinjection temperature T_i in [9] and [11]

ρ_m: matrix density (kg/m^3)

ρ_f: pore fluid density (kg/m^3)

c_m: specific heat capacity matrix (kJ/(kg °C))

c_f specific heat capacity fluid (kJ/(kg °C))

V reservoir volume (m^3)

The reservoir properties ($\phi,\ \rho_r,\ c_r$) are either assumed constant over the reservoir layer (i.e. [6, 11] - average values for the Upper Devonian determined from statistical analysis using limited dataset) or spatially varying according to the geological model facies distribution [9]. The preferred approach depends on the amount and distribution of data available for each reservoir. The reservoir volume V is calculated from the geological model and the reservoir temperature T_r is calculated using a surface temperature and average geothermal gradient.

For each grid cell, the GR or HIP (PJ) represents the total heat contained over the aquifer thickness, assuming an upper depth cut off that corresponds to a reservoir temperature of 40°C (Permo-Triassic basins, [6] and Fell Sandstone) or > 50°C [9, 11] (Table 13). This is considered as the minimum temperature required for direct-use applications of geothermal energy in hot sedimentary aquifer systems. The areas where the sedimentary formations are present, but the temperature is too low for the aquifer to be considered as a prospective resource are reported in the summary layer as low technical feasibility (F4.1) “Less than 40 deg C or limited data”. “NA” indicates the absence of the considered aquifer.

Theoretical potential recoverable heat (Hrec)

The theoretical recoverable heat, or identified resource R_0 (J) represents the part of the geothermal resource that might be available for development, according to the BGS approach used by [6] for the Permo-Triassic and Fell Sandstone resources. It assumed that:

$$R_0 = H_0\, R\, \frac{(T_r - T_i)}{(T_r - T_0)}$$

R : method of abstraction or recovery factor (R = 0.33)

T_i : reject temperature of disposal fluid (T_i = 25°C)

The theoretical recoverable heat H_{rec} (W) for the Upper Devonian and ECL resources was calculated by [9, 11] using the approach integrated into the 3DHIP tool [38] as:

$$H_{rec} = \frac{\mathrm{H_0}\,\eta\,R}{T_{live}P_f}$$

Where the conversion efficiency η (0.85), recovery factor R (0.1), plant lifetime T_{live} (30 years) and load/plant factor P_f (0.95) are assumed constant.

In the original grids, R_0 (PJ) and H_{rec} (MW) represent the total recoverable heat from the area represented by the cell over the aquifer thickness. To allow comparison between models of different spatial resolution and provide a result independent from the cell size, each layer was also converted into heat per unit area (PJ/km^2 or MW/km^2) (published grids).

However, the older BGS method from [6] and 3DHIP methods [38] are not equivalent (based on different equations/different units). Integrating the equation for $\mathrm{H_0}$ into $\mathrm{R_0}$ gives:

$$R_0 = V(T_r - T_i)\left[(1-\phi)\rho_r c_r + \phi\rho_f c_f\right] \times R = HIP \times R$$

With HIP the Heat-In-Place calculation method used by [11], with T_0 = T_i. A conversion factor of 0.287 is used to convert the Identified Resource R_0 (PJ/km^2) values for Permo-Triassic basins into theoretical recoverable heat H_{rec} (MW/km^2). This factor was determined to account for missing parameters in the method from [6] (i.e. η, T_{live}, P_f), and to correct for $R = 0.1$ (instead of 0.33 used in [6]), for a reject T (T_i) of 25°C (value used in [6] to calculate R_0).

$$H_{rec}(W/km^2) = R_0(J/km^2) \times \frac{0.1}{0.33} \times 9.46 \times 10^{-10}$$

$$H_{rec}(W/km^2) = R_0(J/km^2) \times 2.87 \times 10^{-10}$$

$$H_{rec}(MW/km^2) = R_0(PJ/km^2) \times 0.287$$

Limitations

- The theoretical potential recoverable heat value has a strong control from the aquifer thickness. The Carboniferous and Devonian units have large thicknesses up to over a kilometre, resulting in high output values. In reality, the open or screened interval of any abstraction well would not be accessing this thickness of rock strata and values would be correspondingly lower.
- The heat output depends on the flow rate; however permeability and transmissivity of aquifer and variation of those values is not accounted for in the underlying models.
- Different temperature or depth thresholds have been used between legacy studies and basins (Table 13).

- The legacy models underlying the summary layer have not been reassessed to include operational information from the Southampton geothermal well, or the results of the Science Central well in Newcastle-upon-Tyne.
- Where the amount of data is not sufficient to interpolate the reservoir properties, the geological models used to derive the Heat-In-Place and recoverable heat assumed constant properties (i.e. density, heat capacity, porosity) across the reservoir. This simplification does not account for the spatial variability and heterogeneity of the geology in the reservoir but provides a high-level estimate of the heat content.
- Due to the low resolution of the original Early Carboniferous Limestone temperature grids, the heat resources may have been calculated for cells located at the cut-off temperature boundary, and the heat extractable for the corresponding hex-cells may be provided despite indicating a lower temperature than the 40 or 50°C threshold.
- Resources may exist outside the areas delineated by extracted heat estimated; this depends on the selected temperature/depth cut off chosen. Aquifer temperatures below the selected cut-off may offer potential for open-loop systems or for aquifer thermal energy storage projects.

Deep geothermal (granite EGS/petrothermal)

Technology

The Earth's natural heat is partly derived from the decay of the long-lived radioactive isotopes of uranium, thorium and potassium. These elements concentrate in the chemically evolved parts of silica-rich magmas, so granite intrusions commonly contain high concentrations of these elements relative to other lithologies. Some with unusually high values are classed as high heat production (HHP) granites.

In the UK, granites underlie high heat flow areas in parts of Cornwall, northern England and also north-east Scotland [8, 24, 39]. The 'Hot Dry Rock' programme running from 1978-1991 evaluated and tested the potential of these rocks for engineered geothermal systems [40, 41], also called petrothermal (Figure 17). In Cornwall, the United Downs Deep Geothermal Power Plant uses this technology for geothermal electricity production and the Eden Geothermal Project currently uses it for heat. In both cases, natural fault and fracture systems are utilised for subsurface fluid flow.

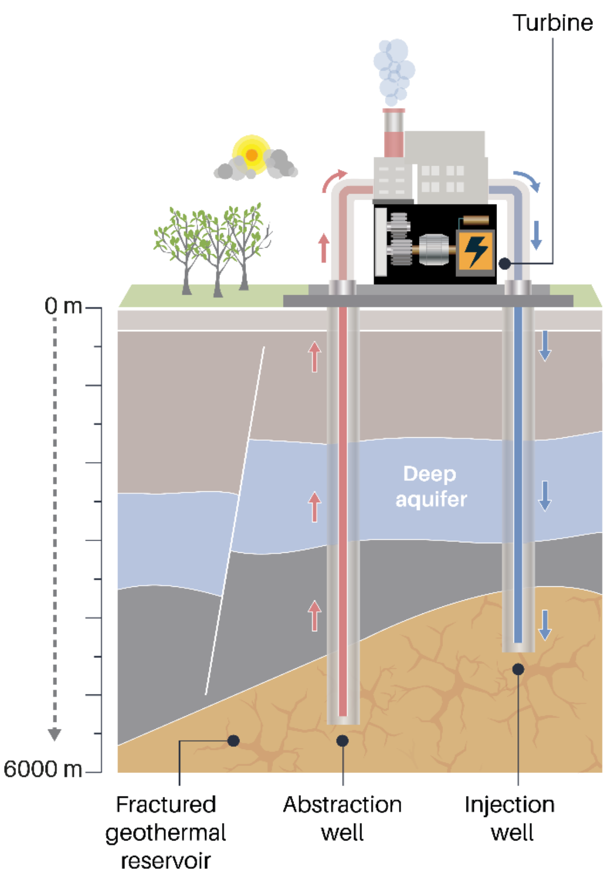


Figure 17 Summary of deep geothermal engineered geothermal system (EGS, petrothermal) technology. BGS©UKRI 2025

Output fields

The following fields are used to describe the hex-cells in this summary layer:

Table 14 Output fields for deep geothermal granites-EGS

DESNZ Field Definition [Field Wording]	MAP EXPLORER Field Definition	Example text
Unique identifier [UUID]	Unique identifier for Hex-Cell [UUID]	2600
Geothermal technology [Tech_Type]	Geothermal technology	Deep geothermal (EGS).
Technology description [Tech_Desc]	Technology description	Qualitative description for deep geothermal power and heat in granite using some natural fracturing for the engineered geothermal system (EGS, or petrothermal).
Technical feasibility description [Tec_FeasD]	Technical feasibility description: High/Moderate/Low (UNFC in brackets)	Low (F3.3). Favourable conditions from preliminary regional studies.
Confidence [Confidence]	Confidence High/Moderate/Low (UNFC in brackets)	Low (G4)
Technical feasibility (relative) [Tec_FeasR]	Technical feasibility (relative) High/Moderate/Low in UK based on 4 factors	Low (Relative in UK).
Geology Target [Geology_Ta]	Name of Granite body	Dartmoor granite

Input data

The spatial extent of British granites was taken from the deep geothermal area v2 dataset [42] combined with subsurface extents of the Cornubian and Cairngorm batholiths from existing BGS publications [43, 44]. The spatial extent includes exposed granitic bodies and the subsurface extent of composite subsurface granitic batholiths.

Specific granite body heat production data was sourced from a range of published references. Scottish granite data [24, 39, 44, 45]; northern England granites [24, 45]; southwest England [24, 45, 46].

Other input data used in the qualitative values was the heat flow map of the UK [23], operational and boreholes with flow tests [47, 48, 49] and knowledge of current status of site-specific geothermal projects.

Analysis workflow

Four factors were taken into consideration:

- Values of heat production from rock samples. The thresholds used in [39] sample values were followed. These are high heat production: >5 μWm^{-3}; medium heat production: 3-5 μWm^{-3}, low heat production: <3 μWm$^{-3.}$
- Whether 'proved' at surface exposure or by drilling, or whether fully concealed and inferred from gravity studies
- Areas of high heat flow on the UK map [8, 23, 24]
- Presence of operational projects or exploration wells with a flow test

Combining the factors above, the assignment for technical feasibility (descriptive) and confidence is:

Table 15 Assignment of technical feasibility and confidence for granites-EGS

Technical Feasibility	UNFC assignment and rationale
High	High (F1.1 in production). Around United Downs Deep Geothermal Power Plant and the Eden Geothermal well High (F1.3 studies completed, reasonable expectation to proceed). Around the Eastgate geothermal well, and two sites in Cornwall with planning permission (Manhay, Penhallow)
Medium	Not used
Low	Low (F3.3 favourable conditions from preliminary regional studies). The remainder of UK granites. (Areas with no granite extent mapped are attributed as not available)
Confidence	**UNFC assignment and rationale**
High	High (G1) Around United Downs Deep Geothermal Power Plant and the Eden Geothermal well
Moderate	Moderate (G2) Around the Eastgate geothermal well, and two sites in Cornwall with planning permission (Manhay, Penhallow)
Low	Low (G4). The remainder of UK granites.

Due to the variability of level of data available for preliminary regional studies, as well as the values of that data, a comparative within UK assignment has been made to provide an indication of relative technical feasibility and confidence, within the overall category of Low (F3.3). The assignment for technical feasibility (relative in UK) comprises:

- High (Relative in UK): granites with two or more of: an operating geothermal project, a high heat production value, in an area of high heat flow, proved by drilling or at surface
- Medium (Relative in UK): granites with two or more of a tested well or geothermal project under development, at least a medium high heat production value, in an area of high heat flow, and associated with granites proved at surface or drilled. Where subsurface areas show variations of heat production, such as the around the Lake District, a qualitative assessment of the regions heat flow was also considered and a ‘medium’ value was assigned.
- Low (Relative in the UK): granite may only be inferred from geophysical data and have not been sampled, may have medium or low heat production values, not in areas of mapped high heat flow. Where no heat production data was found due to a lack of in situ sampling, a ‘low’ value was used.

Limitations

- The BGS tectonic map [43] along with other BGS maps and publications summarise the extent of granitoid bodies across the UK. These have been included in the summary layer. However, the three-dimensional subsurface interpretation of the granites and underlying batholiths, as well as numerical values of their spatially varying geothermal potential are not comprehensively available.
- The EGS technology proved by United Downs and Eden projects utilise natural fault and fracture systems, which are local geological features and require site specific evaluation.
- As a result, there are not regionally available, spatially varying numerical values or temperatures for EGS/petrothermal projects to provide numerical values of theoretical potential. This summary layer is qualitative.
- Other intrusive bodies, such as granodiorites have not been included as information about their thermal potential is not known.

Geothermal overview and costs layer

Purpose of this layer

The overview layer is designed to summarise the geothermal technical feasibility for different technologies at any location across GB and provide an indication of levelised cost, CAPEX and fixed and variable OPEX.

Input data

Input data is taken from the 'technical feasibility' field of each component geothermal technology summary layer.

The cost values presented are from Arup's Review of Technical and Cost Assumptions for Geothermal Generation Technology report [1], commissioned by DESNZ. This report presents levelised cost values for a selection of commercially available shallow GSHP and deep geothermal technologies, based on international stakeholder and published data (UK focused). The levelised costs are specific to the assessed input parameters. The cost fields contain the same text for all hex-cells across GB. While they may not be directly applicable to every site, they offer reasonable benchmarks. It should be noted that the summary layer only provides a small amount of the data and selected scenarios that are available as part of Arup's review of levelised costs [1].

The following input parameters have been chosen:

- The medium cost scenario (with low and high cost in brackets)

- N'th of a kind (NOAK) costs have been chosen for shallow closed and open loop, as well as mine water heat, because these are established technologies in the UK. The NOAK cost from [1] incorporates 6000 operational hours. (whereas note that the thermal energy outputs for the closed and open loop summary layers have used 2000 full load operating hours). The discrepancy arises because the Arup NOAK assumptions are based on European examples and modelled district heat networks, which typically operate for more hours annually than the smaller-scale UK NOAK schemes used for individual buildings or shared ground loops in the summary layers.
- First of a kind (FOAK) costs are used for deep geothermal technologies as the UK has not yet seen cost reductions in drilling (that are the main difference between FOAK and lower NOAK costs). Deep geothermal technology deployment in the UK is limited in comparison to shallow geothermal technologies. There is potential for significant cost reductions, giving rise to greater differences between modelled FOAK and NOAK levelised costs for deep geothermal than for shallow geothermal.
- District heating network at 80 °C, the network temperature currently used in the heat network national zoning model.

This summary layer includes costs for mine water heat. However, the coal mine option presented in the summary layer simply indicates whether the hex-cell intersects the Mining Remediation Authority coal mining reporting area [50]. The reporting area represents the known extent of coal mining activity, so hex-cells are provided as either 'outside coal mining reporting area', 'partially intersects with coal mining reporting area' or 'within coal mining reporting area'.. This field does not provide indication of whether there is mine water heat potential at that location.

There is no calculation and analysis for this summary layer.

Output fields

Table 16 Output fields for the overall summary and costs layer

DESNZ Field Definition [Field Wording]	MAP EXPLORER Field Definition	Example text
Unique identifier [UUID]	Unique identifier for hex-cell	48687
[Closd_Loop]	Tech Feasibility Closed Loop	High (F1 viable projects). Drilling constraints may apply locally.
[Open_Loop]	Tech Feasibility Open Loop	High (F1 viable projects). Drilling constraints may apply locally.

DESNZ Field Definition [Field Wording]	MAP EXPLORER Field Definition	Example text
[HSA_Tr_Dbl]	Tech Feasibility Deep Aquifer Doublet Unit 1 Triassic Sandstone	Low (F3.3). Favourable conditions inferred from preliminary regional studies.
[HSA_P_Dbl]	Tech Feasibility Deep Aquifer Doublet Unit 2 Permian Sandstone	Low (F3.3). Favourable conditions inferred from preliminary regional studies
[HSA_CD_Dbl]	Tech Feasibility Deep Aquifer Doublet Unit 3 Carboniferous sandstone or limestone or Devonian Sandstone	Low (F3.3). Favourable conditions inferred from preliminary regional studies.
[Gr_EGS]	Tech Feasibility Granite EGS	Low (F3.3). Favourable conditions from preliminary regional studies.
[Coal_Mine]	Coal mining reporting area	Outside coal mining reporting area
	Summary cost values	From Arup 2025. The same values are provided for all hex-cells
[LCOH_Clos]	Levelised cost of Heat (LCOH) closed loop	50 bh array, 150 m deep, NOAK, DHN85, median cost of Arup 2025: 44 £/MWh (low 32; high 52)
[CAPEX_Clos]	CAPEX costs closed loop	50 bh array, 150 m deep, NOAK, DHN85, median cost of Arup 2025: 2378 £/kW (low 1520; high 3155)
[OPEX_Clos]	OPEX costs closed loop	50 bh array, 150 m deep, NOAK, DHN85, median cost of Arup 2025: fixed OPEX is 2550 £/MW (low 2040; high 3060), var OPEX is 2.15 £/MWh (low 1.55; high 2.4)
[LCOH_Open]	Levelised cost of Heat (LCOH) open loop	1 doublet, NOAK, DHN85, median cost of Arup 2025: 31 £/MWh (low 18; high 47)
[CAPEX_Open]	CAPEX costs open loop	1 doublet, NOAK, DHN85, median cost of Arup 2025: 1570 £/kW (low 772; high 2702)

DESNZ Field Definition [Field Wording]	MAP EXPLORER Field Definition	Example text
[OPEX_Open]	OPEX costs open loop	1 doublet, NOAK, DHN85, median cost of Arup 2025: fixed OPEX 2550 £/MW (low 2040; high 3060), var OPEX is 5.17 £/MWh (low 3.82; high 7.63)
[LCOH_Coal]	Levelised cost of Heat (LCOH) open loop to mine,	1 doublet, NOAK, DHN85, median cost of Arup 2025: 30 £/MWh (low 18; high 45)
[CAPEX_Coal]	CAPEX costs open loop to mine	1 doublet, NOAK, DHN85, median cost of Arup 2025: 1507 £/kW (low 767; high 2666)
[OPEX_Coal]	OPEX costs open loop to mine	1 doublet, NOAK, DHN85, median cost of Arup 2025: fixed OPEX 2550 £/MW (low 2040; high 3060), var OPEX is 4.72 £/MWh (low 3.77; high 6.45)
[LCOH_HSA]	Levelised cost of Heat (LCOH) *Hot sedimentary aquifer, 2km **Hot sedimentary aquifer, 3km	1 doublet FOAK, 2km deep, median cost of Arup 2025: 157 £/MWh (low 94; high 387). 1 doublet FOAK, 3km deep, median cost of Arup 2024: 126 £/MWh (low 81; high 271)
[CAPEX_HSA]	CAPEX costs *Hot sedimentary aquifer, 2km **CAPEX costs Hot sedimentary aquifer, 3km	1 doublet FOAK, 2km deep, median cost of Arup 2025: 6870 £/kW (low 4011; high 18670). 1 doublet FOAK, 3km deep, medium cost of Arup 2024: 5531 £/kW (low 3552; high 12669)
[OPEX_HSA1]	OPEX costs *Hot sedimentary aquifer, 2km **OPEX costs Hot sedimentary aquifer, 3km	1 doublet FOAK, 2km deep, medium cost of Arup 2025: fixed OPEX 16783 £/MW (low 8858; high 21512), var OPEX is 9.37 £/MWh (low 6.20; high 14.93)
[OPEX_HSA2]	OPEX costs *Hot sedimentary aquifer, 2km	1 doublet FOAK, 3km deep, medium cost of Arup 2025: fixed

DESNZ Field Definition [Field Wording]	MAP EXPLORER Field Definition	Example text
	OPEX costs **Hot sedimentary aquifer, 3km	OPEX 16783 £/MW (low 8858; high 21512), var OPEX is 4.60 £/MWh (low 2.42; high 8.34)
[LCOE_Petr]	***Levelised cost of Electricity (LCOE) Deep geothermal EGS	LCOE with heat revenue, FOAK, median cost of Arup 2025: 169 £/MWh (low 68; high 475)
[CAPEX_Petr]	***CAPEX costs Deep geothermal EGS, LCOE with heat revenue	LCOE with heat revenue, FOAK, median cost of Arup 2025: 12198 £/kW (low 8945; high 25919)
[OPEX_Petr]	OPEX costs Deep geothermal EGS, LCOE with heat revenue	LCOE with heat revenue, FOAK, median cost of Arup 2025: fixed OPEX 241200 £/MW (low 81600; high 408800)
Version	Name and version of data	DESNZ_Summary_Hex_V1
Created	Created date	11/3/25

Users should note:

- *The deep geothermal (aquifer) 2km cost - system includes use of high temperature heat pump(s) for DHN85.
- **The deep geothermal (aquifer) 3km cost - system provides direct heating. Heat pump(s) not used.
- ***Capex for deep geothermal (granite) - capital costs exclude grid connection infrastructure costs (typically ranging from £1M to £10M). These costs are site specific and variable and therefore excluded from generalised values. The levelised costs for combined heat and power systems are levelised against electricity generation with discounted heat sales.
- Capital costs (CAPEX) include pre-development, construction, and decommissioning costs.
- Fixed operation costs (OPEX) include costs such as labour, planned and unplanned maintenance, spares and consumables.

Limitations

The limitations of the summary layer are as for the component layers, described above.

The method of the cost analysis is described within the source report [1]. The main limitation of the cost information as applied in the summary layers is that single values are provided representing a borehole depth, flow rate, operating hours etc. for all the varied type of geology across the country.

Licencing

The summary layers are available as view-only Open Government Licence .

Disclaimer

If there is geothermal potential indicated your area and you wish to take next steps, site-specific work should always be undertaken. A shallow GSHP or deep geothermal specialist should be consulted.

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The heat-flow and thermal properties components underpinning the heat extractable analysis in the dataset are a compilation of models derived from previously published and unpublished maps and archive information. The models are based upon the interpolation of evidence available at the time.

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The geological information and modelling underpinning each hex-cell has been summarised from data of differing scales. As a synthesis of data harmonised over an area (in this case 2.56 km^2), there may be data artefacts created by the concatenation and simplification of the input data. This may result in neighbouring cells showing differing results for what appear to be similar circumstances. The harmonisation and modelling processes are all computationally derived, but small changes may lead to marked changes in final model values.

Glossary and abbreviations

Term	Explanation
PJ	Petajoule, a unit of energy equal to a thousand billion joule (10^{15} J)
PJ/km2	Unit of energy per unit area equivalent to 10^{15} J/km^2. Used to report estimates of theoretical potential Heat-In-Place
kW	Kilowatt, a unit of power equal to one thousand (10^3) watts
MW	Megawatt, a unit of power equal to one million (10^6) watts and one thousand (10^3) kilowatts
MW/km^2	Equivalent to one million (10^6) W/km^2. Used to report estimates of theoretical potential recoverable heat
kWh	Kilowatt hours; a unit of energy equal to a thousand (10^3) watt-hours
L/s	Litres per second
Aquifer	Underground layers of water-bearing, permeable rocks that contain and transmit groundwater and from which groundwater can be extracted.
Boreholes	Deep, narrow holes made in the ground, either vertically or inclined, often to locate water or oil.
CAPEX	Capital expenditure
Deep geothermal	A term used widely to refer to systems at a depth of more than 500 m below the surface. Systems that produce heat in the 50–200°C range of medium temperature (steam or water). This may be regarded as medium-high grade heat, suitable for multiple uses including direct use for space heating, industrial and horticulture use or power generation.
Deviated wells	A well which is drilled at an angle from the vertical towards a specific target
Direct-use geothermal	A system that is hot enough for geothermal heat to be used directly (for example for district heating) without requiring an electrical heat pump

Geothermal doublet	A geothermal system consisting of two boreholes - one for abstracting the warm/hot water from permeable, water-filled rocks and one for re-injecting the cooled water (after heat extraction) back into the geothermal aquifer.
Geothermal gradient	The increase in temperature with increasing subsurface depth, commonly expressed in degrees Celsius per kilometre (°C/km)
Geothermal reservoirs	Underground zones of porous or fractured rock that contain hot water and/or steam. They can be naturally occurring or human-made
GSHP	Ground source heat pump. A device that transfers and “upgrades” heat from a colder space to a warmer space using mechanical energy. The appliance takes its heat from the ground.
Heat flow	The amount of heat that is transferred per unit of time in the subsurface, measured in this report in milliwatts per square metre (mW/m^2)
Hydrothermal systems	(also referred to as “hot sedimentary aquifers”): geothermal systems that contain fluid, heat and permeability in a naturally occurring geological formation or sedimentary basin for the production of heat or electricity
LCOE	Levelised cost of electricity
LCOH	Levelised cost of heat
National Zoning Model	A data-led spatial energy model developed by DESNZ to support the identification of indicative heat network zones across England
OPEX	Operational expenditure. The cost required to keep a geothermal plant operational, including ongoing maintenance costs.
Sedimentary basins	Low areas in the Earth’s crust, of tectonic origin, in which thick deposits of sediments accumulate over geological time periods
Technical potential	(Beardsmore protocol): the fraction of the physically accessible potential (see theoretical potential) that can be used under the existing technical, structural and ecological restrictions as well as legal and regulatory allowances.
Temperature	A measure of hotness or coldness, in this report measured in degrees Celsius (°C)

Theoretical potential	(Beardsmore protocol): the theoretically realizable energy supply considering only physical constraints (i.e. the physically usable energy supply)
Thermal conductivity	The rate at which heat passes through the rock or water, expressed as the amount of heat that flows per unit time through a unit area with a temperature gradient of one degree per unit distance, measured in W/mK
Well	Deep, narrow holes made in the ground, either vertically or inclined. Similar to a borehole but that have been used for the testing or production of water, oil, gas or other resources.

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Appendix 1: Maps of the four technology summary layers

The following images are provided as visual context for the data presented in the four technology summary layers.

The datasets (supplied only to DESNZ) comprise polygon data in ESRI Shapefile format (shp).

The primary data fields are alpha-numerical relating to technical feasibility, extractable heat energy, temperature, or depth. Typically, the information can be portrayed with any colouration. An ESRI 'layer' file (lyrx) file is provided with each dataset for the purpose of visualising values as colour ramps or classified domains (users can utilise any colour scheme that is appropriate to their needs).

The codes used on the maps refer to the UNFC classification scheme, see the 'Understanding the theoretical potential of geothermal energy, compared to viable projects' section.

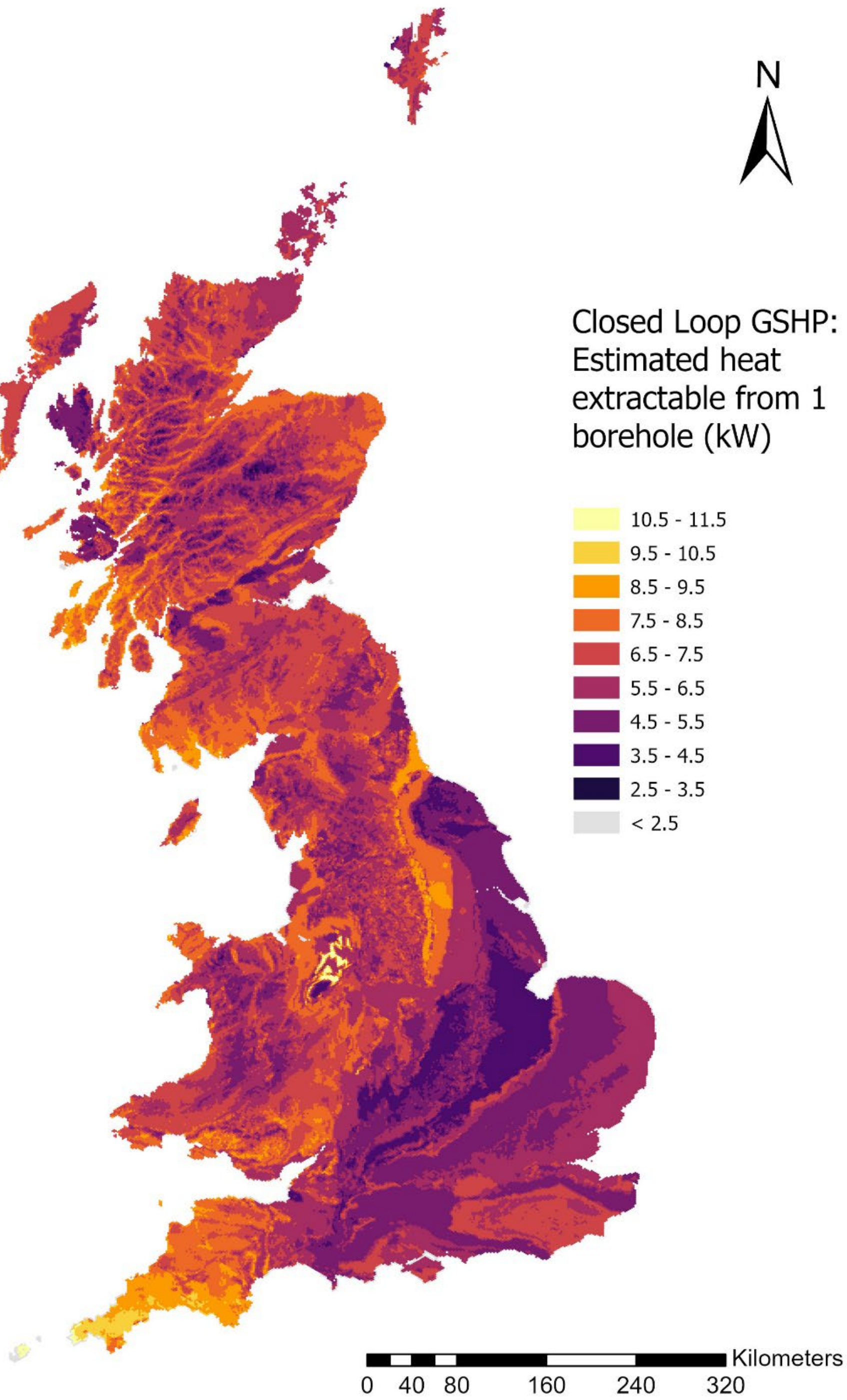

Figure 18 Closed loop: Estimated heat extractable from a single borehole (kW)

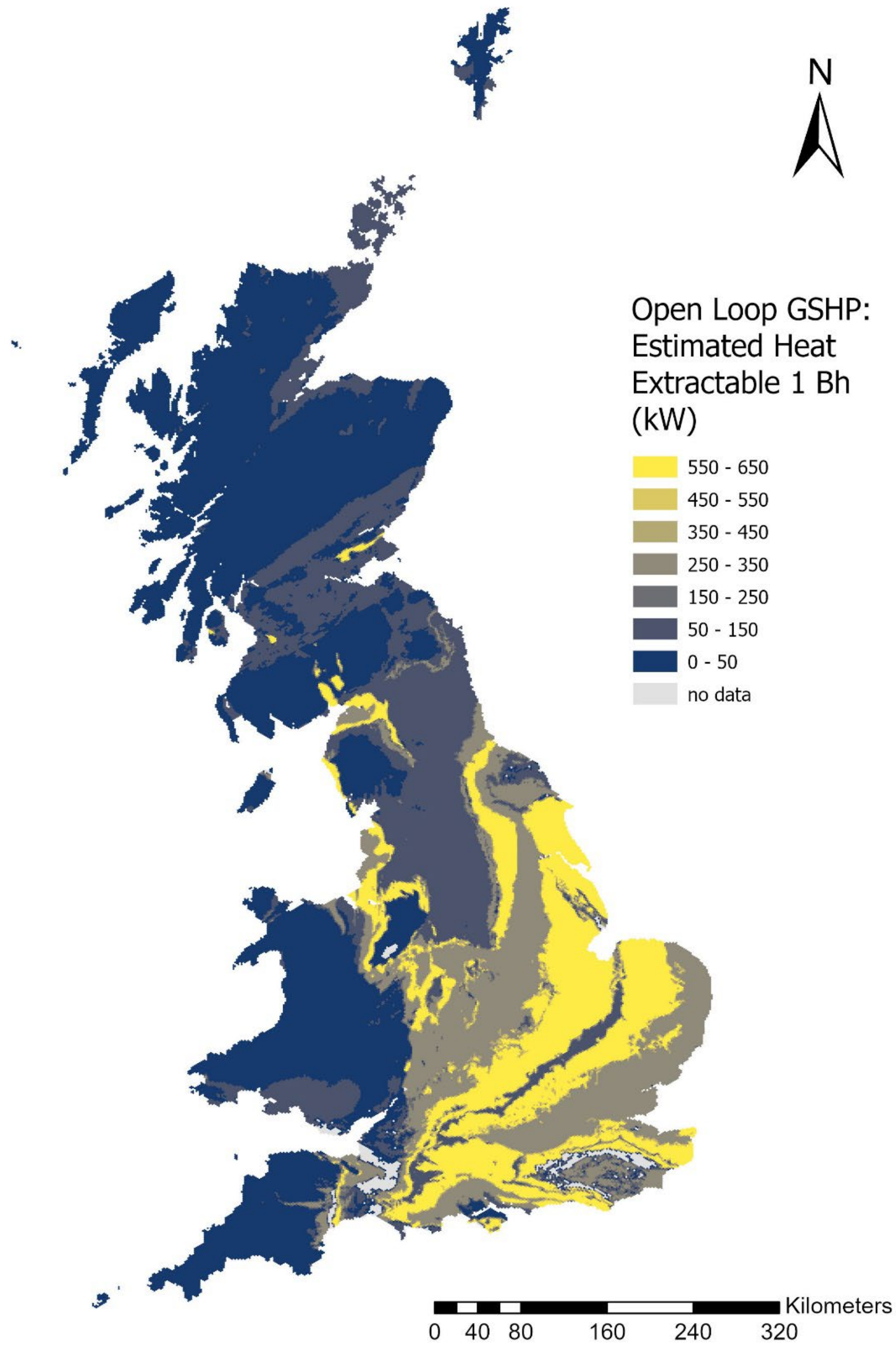

Figure 19 Open loop: heat extractable from a single borehole (kW)

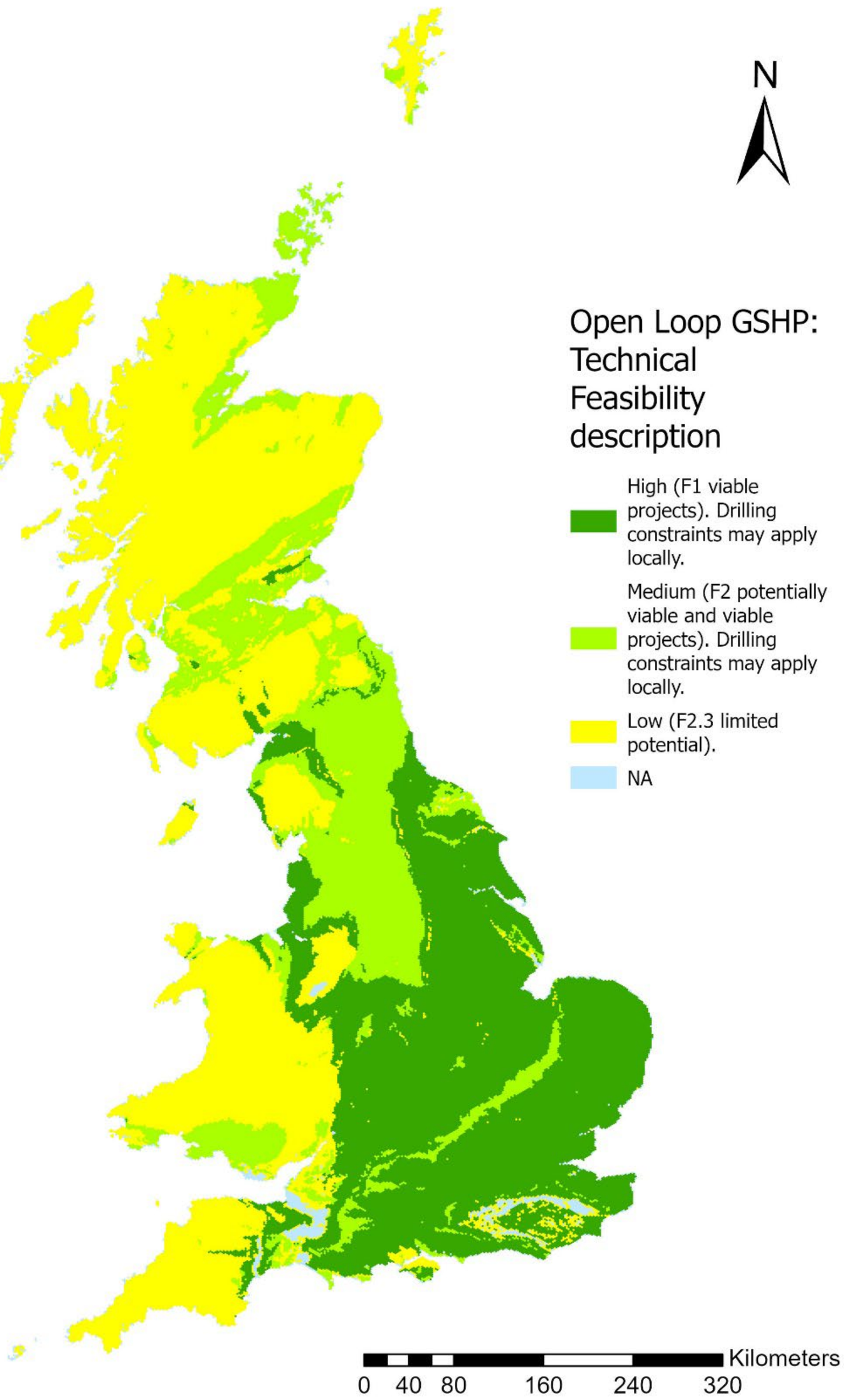

Figure 20 Open loop technical feasibility. Technical feasibility is based on generalised aquifer properties e.g. areas of unconfined or shallow (<300m depth), concealed, high to very-high productivity aquifers have high potential (F1 - viable projects); areas of low or non- productive aquifer have low feasibility (F2.3 - limited potential)

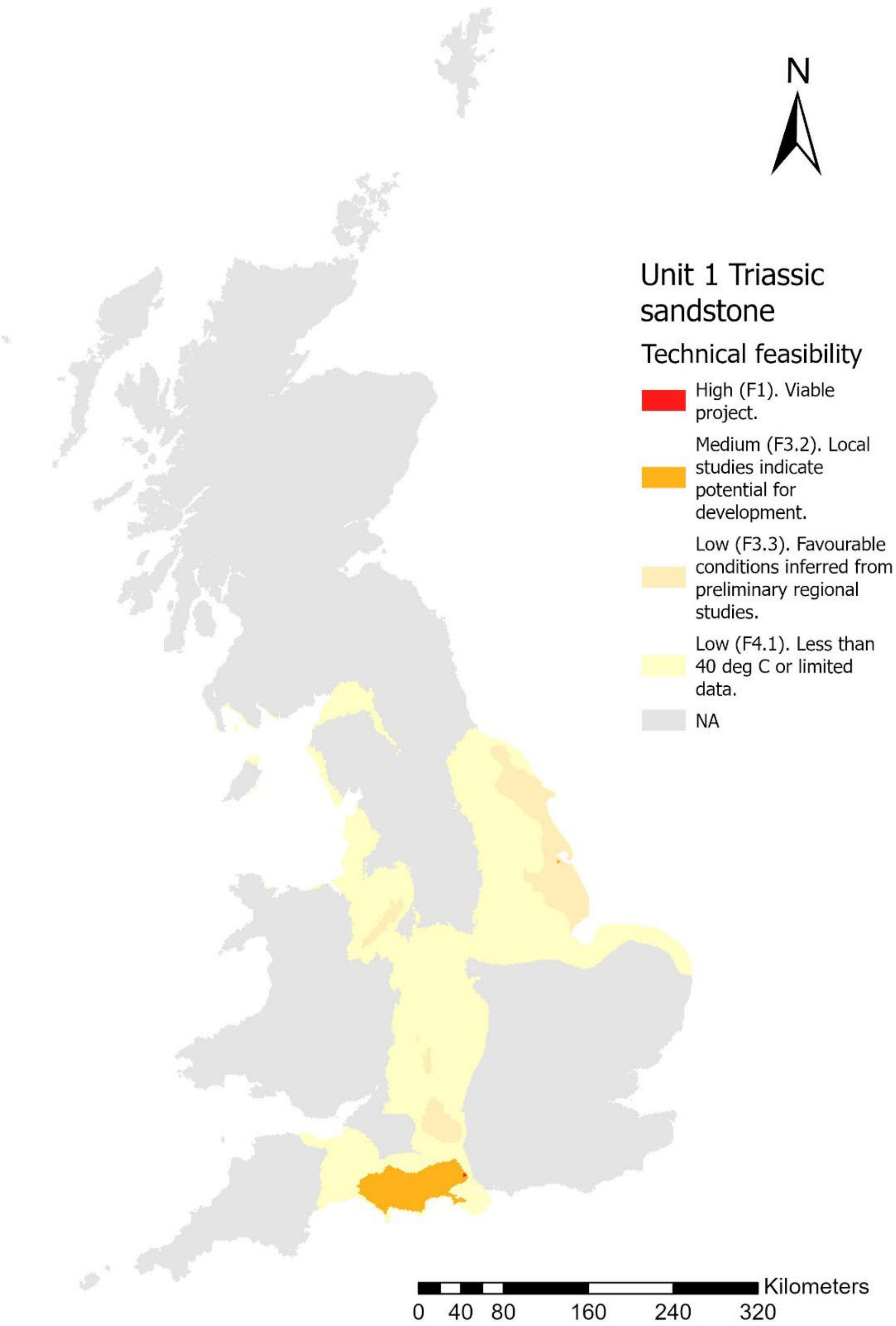

Figure 21 Deep geothermal (Triassic sandstone hot sedimentary aquifer) technical feasibility. Areas classed as low technical feasibility (F3.3) are favourable based on preliminary regional studies, local and site specific studies are needed to develop viable projects

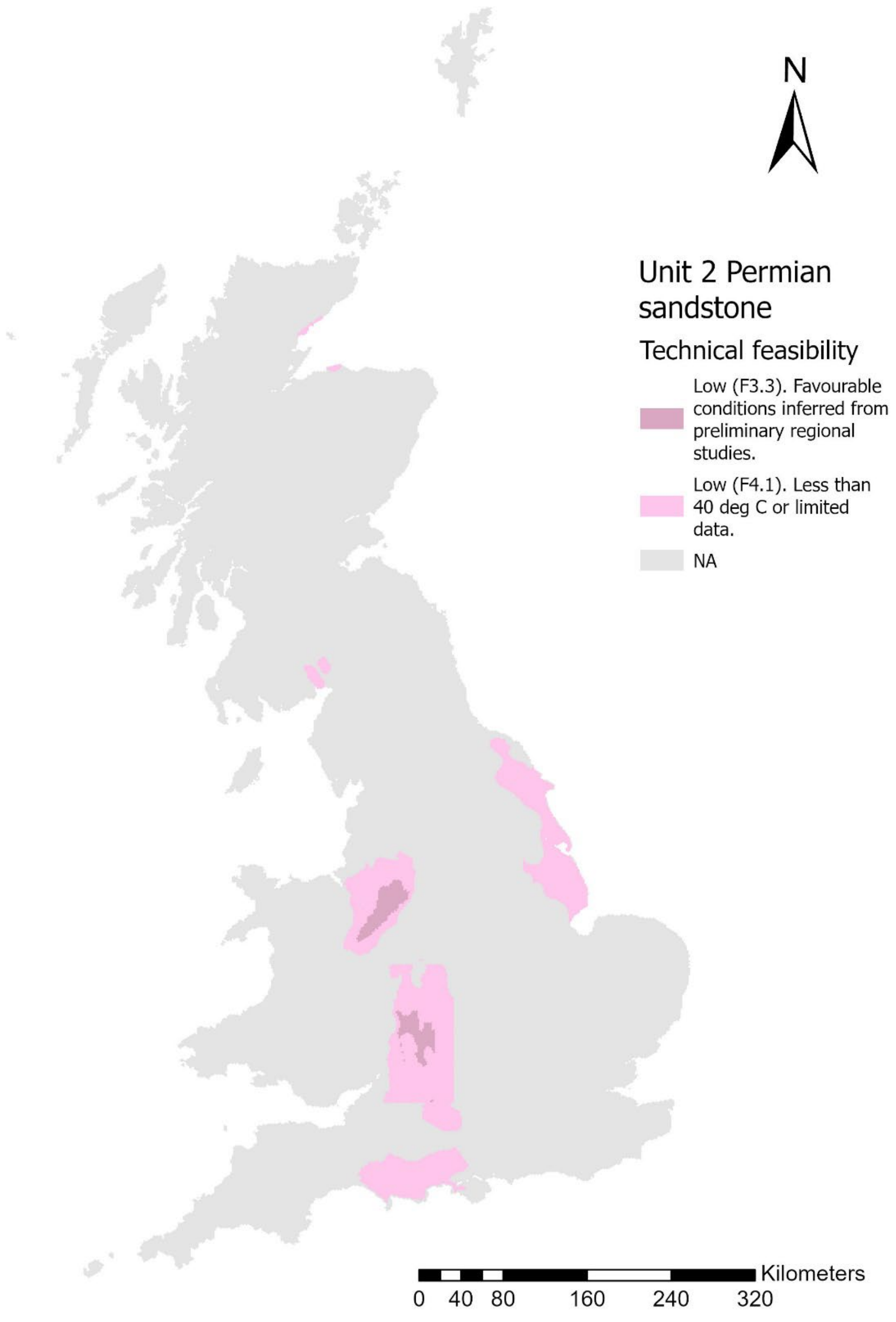

Figure 22 Deep geothermal (Permian sandstone hot sedimentary aquifer) technical feasibility. Areas classed as low technical feasibility (F3.3) are favourable based on preliminary regional studies, local and site specific studies are needed to develop viable projects

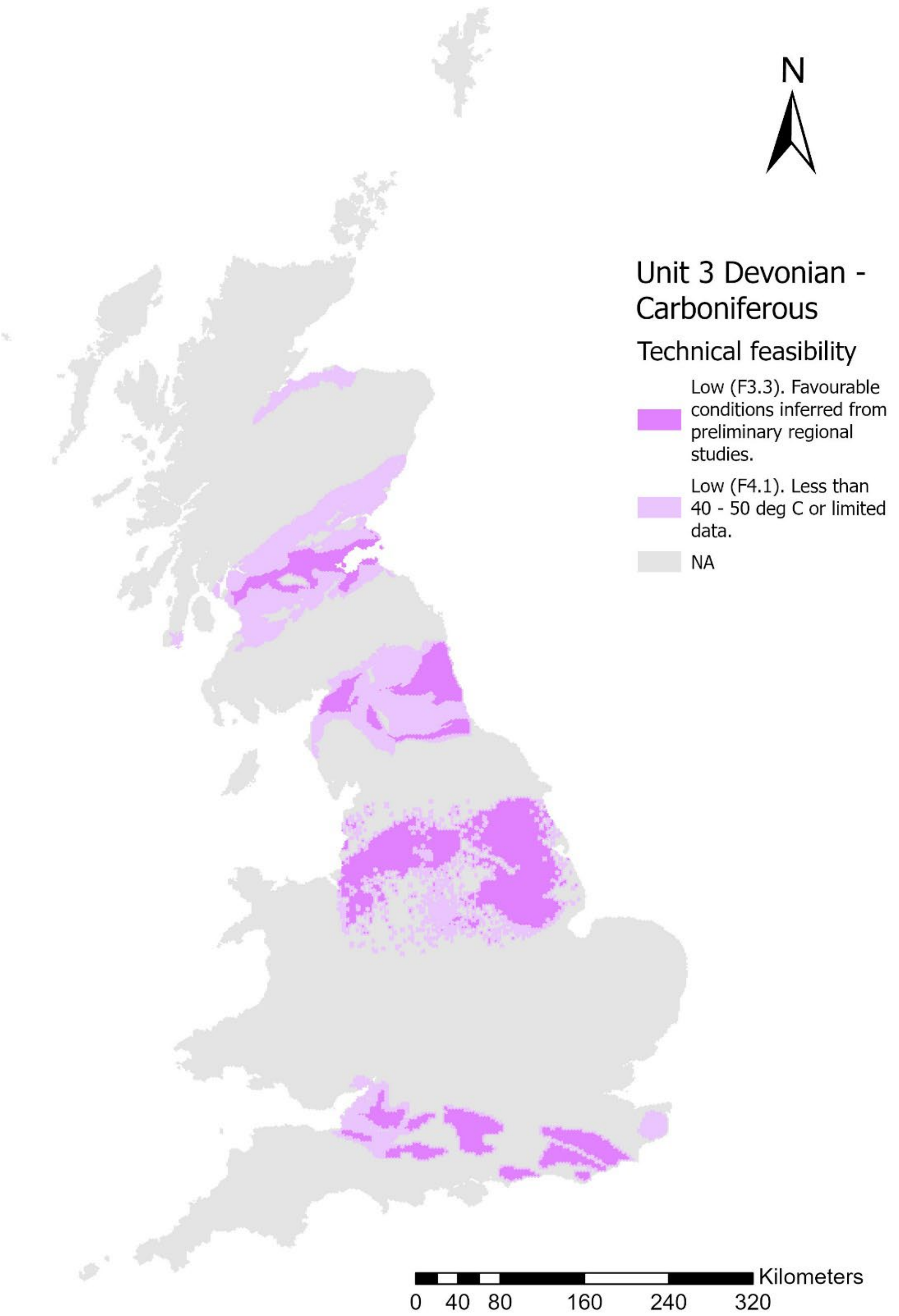

Figure 23 Deep geothermal (Devonian sandstone and Carboniferous sandstone or Carboniferous limestone hot sedimentary aquifer) technical feasibility. Areas classed as low technical feasibility (F3.3) are favourable based on preliminary regional studies, local and site specific studies are needed to develop viable projects

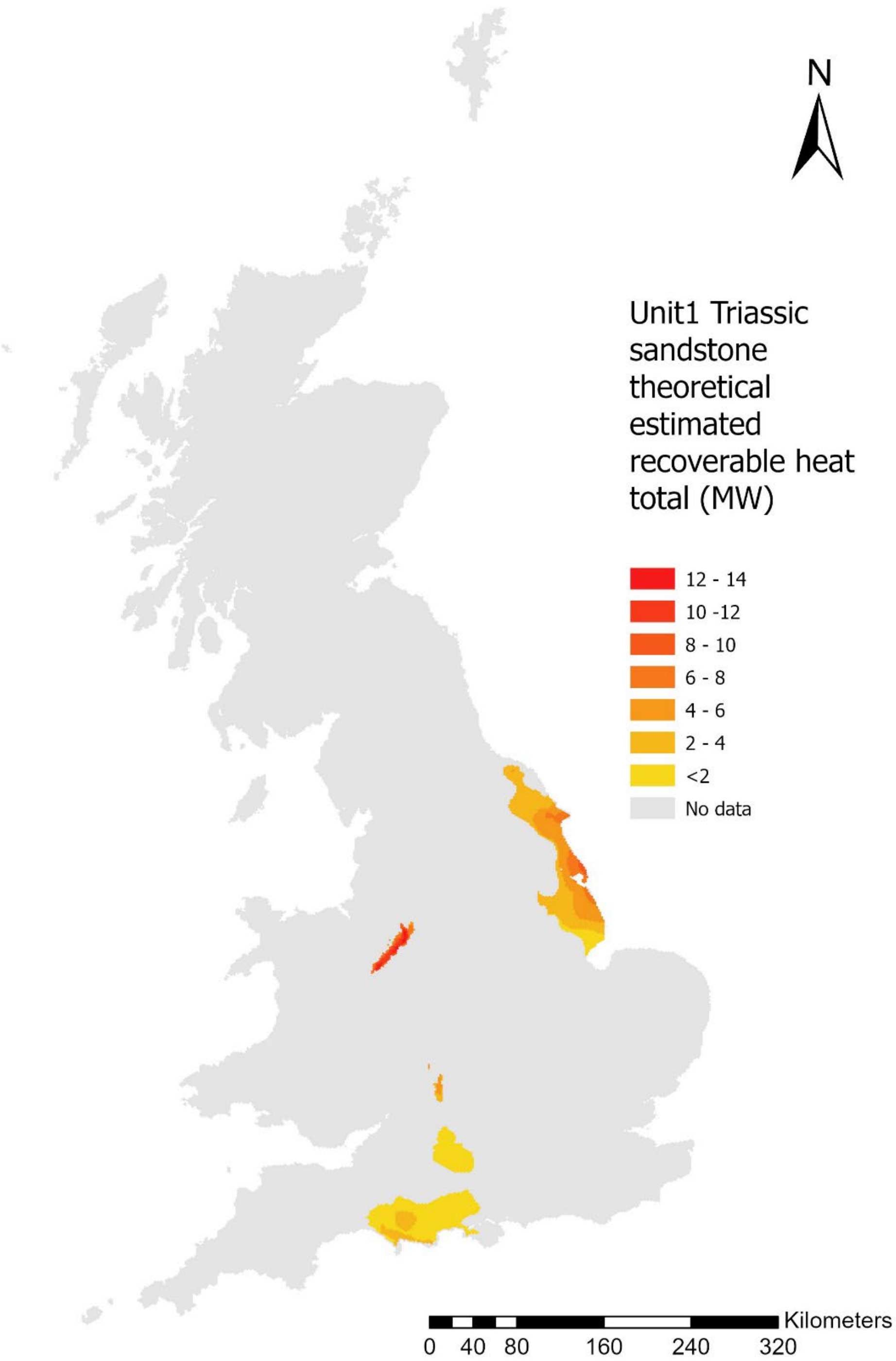

Figure 24 Deep geothermal (Triassic sandstone hot sedimentary aquifer) theoretical potential estimated recoverable heat (MW), above 40°C, from a well sourcing heat energy from the area of the 2.56 km^2 hex-cell

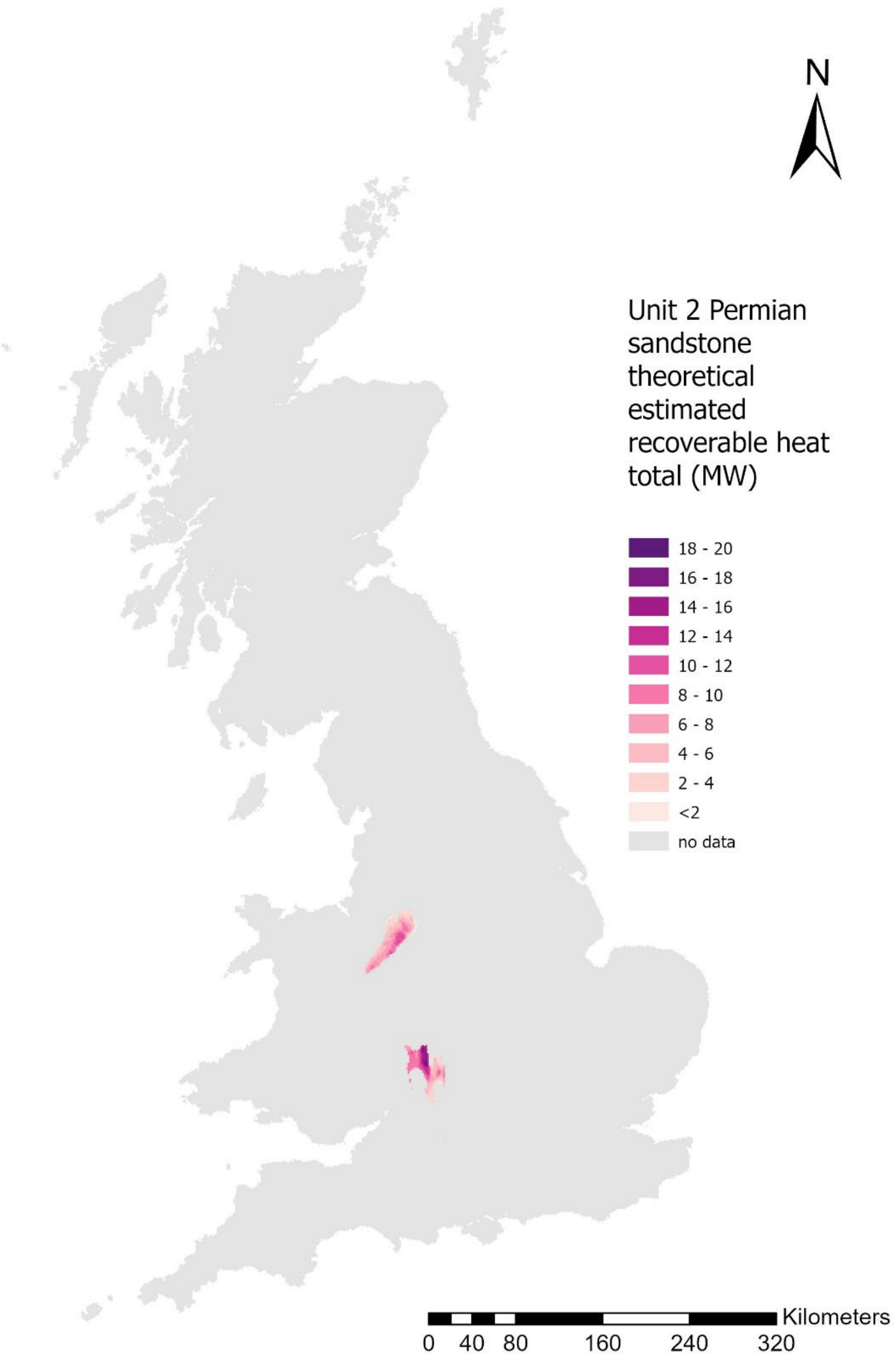

Figure 25 Deep geothermal (Permian sandstone hot sedimentary aquifer) theoretical potential estimated recoverable heat (MW) above 40°C, from a well sourcing heat energy from the area of the 2.56 km^2 hex-cell

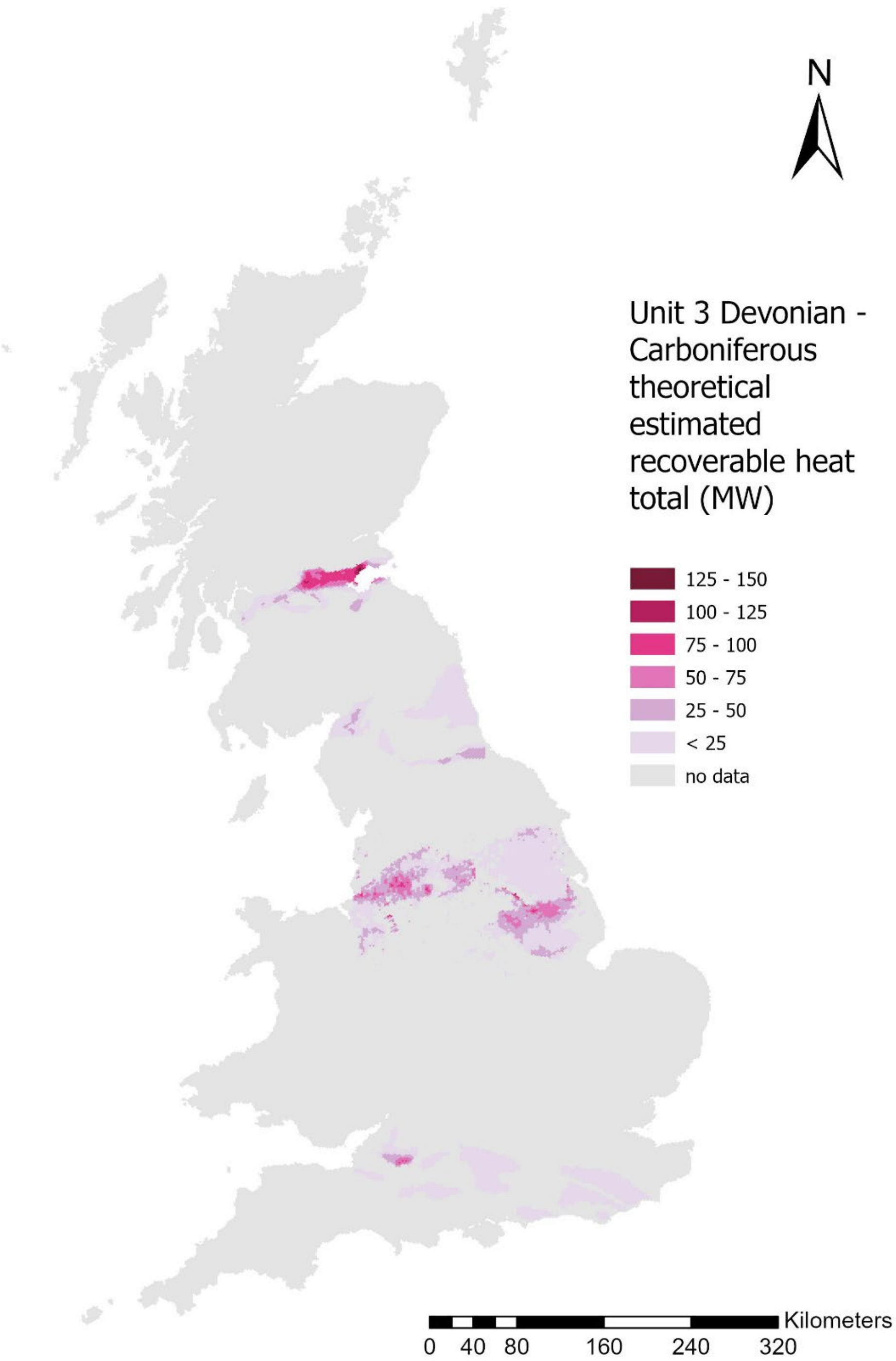

Figure 26 Deep geothermal (Devonian sandstone and Carboniferous sandstone or Carboniferous limestone hot sedimentary aquifer) theoretical potential estimated recoverable heat (MW) above 40°C (Northumberland-Solway) or 50°C (other areas), from a well sourcing heat energy from the area of the 2.56 km² hex-cell

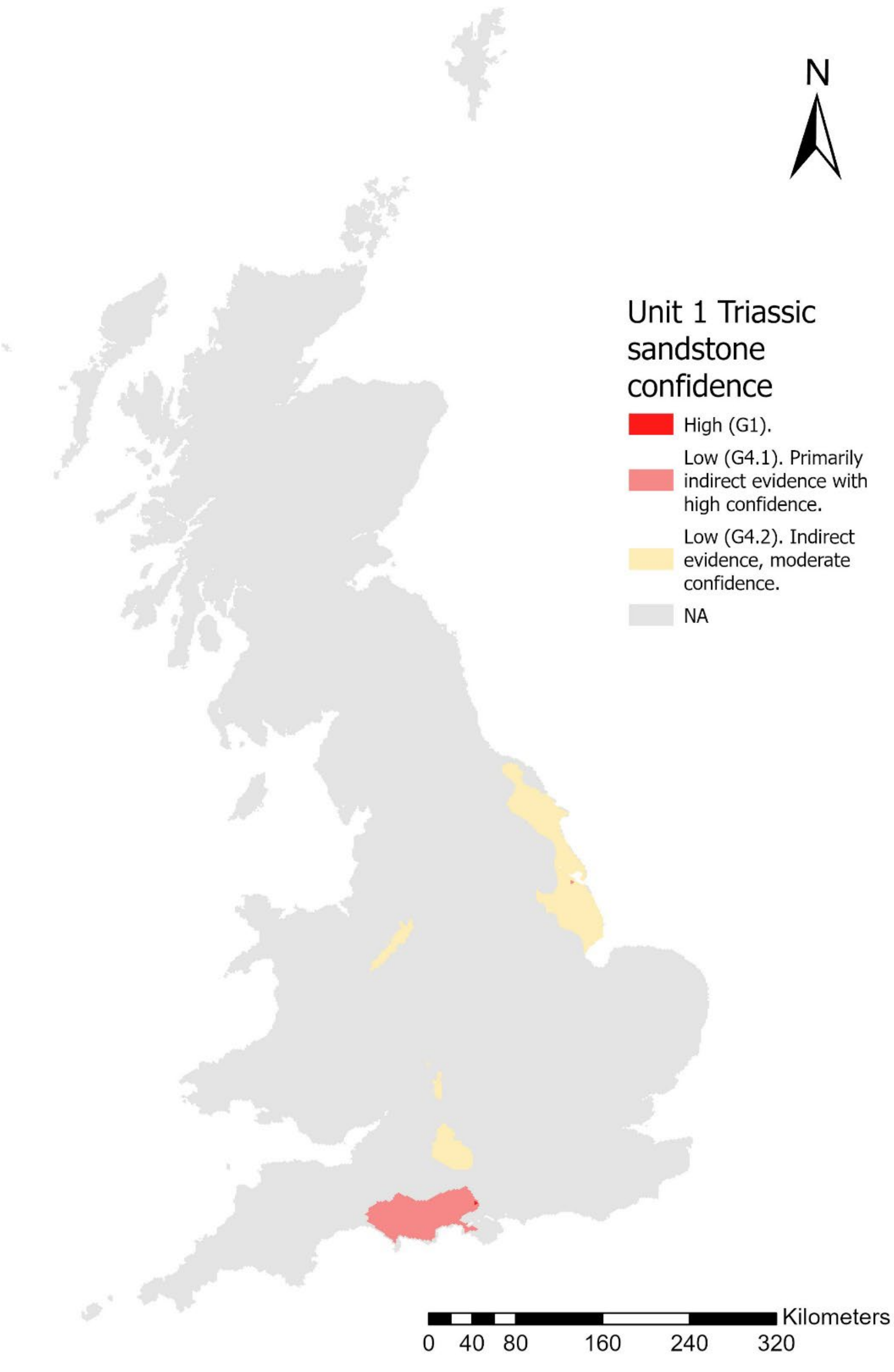

Figure 27 Deep geothermal (Triassic sandstone hot sedimentary aquifer) confidence

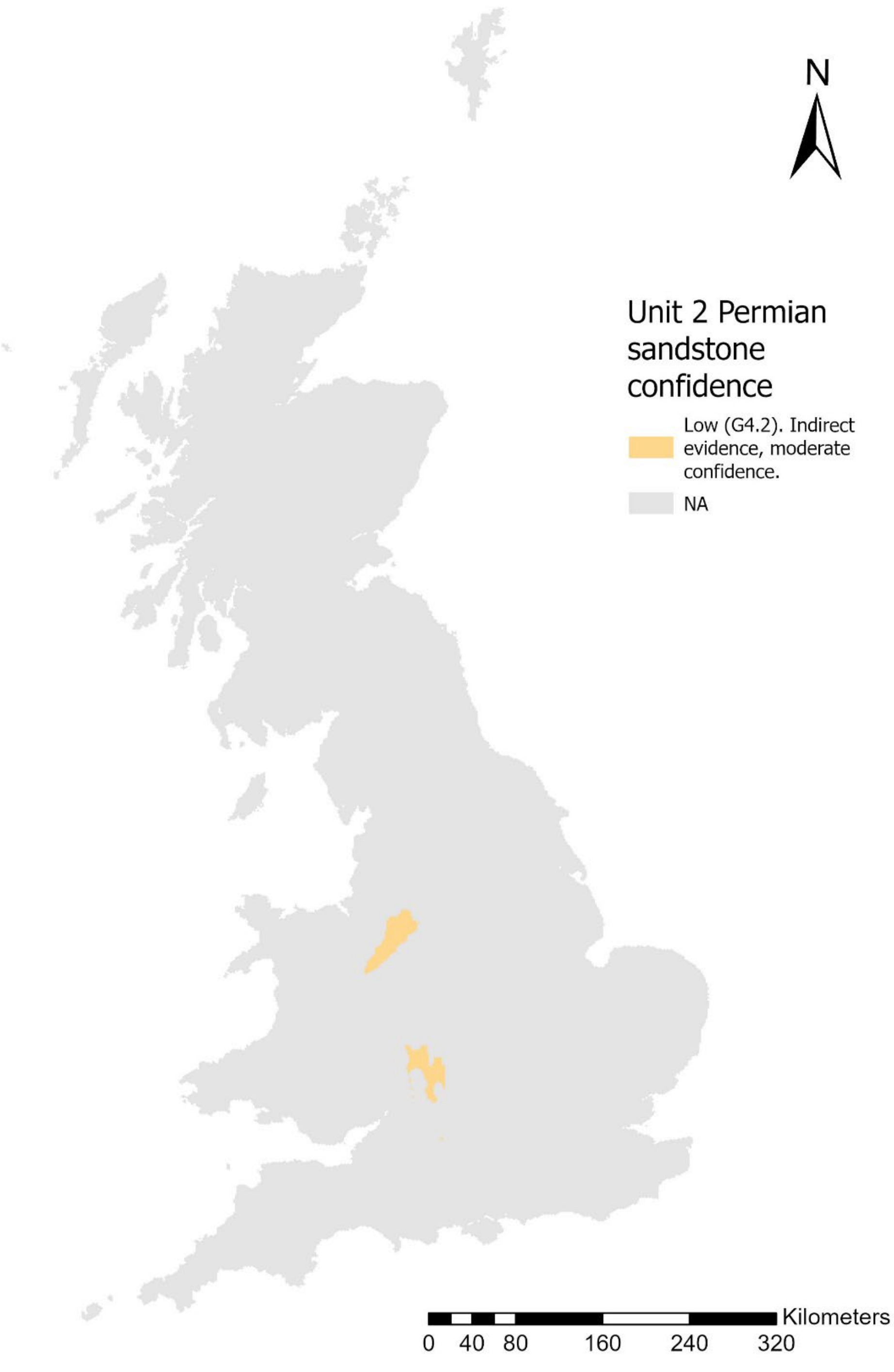

Figure 28 Deep geothermal (Permian sandstone hot sedimentary aquifer) confidence

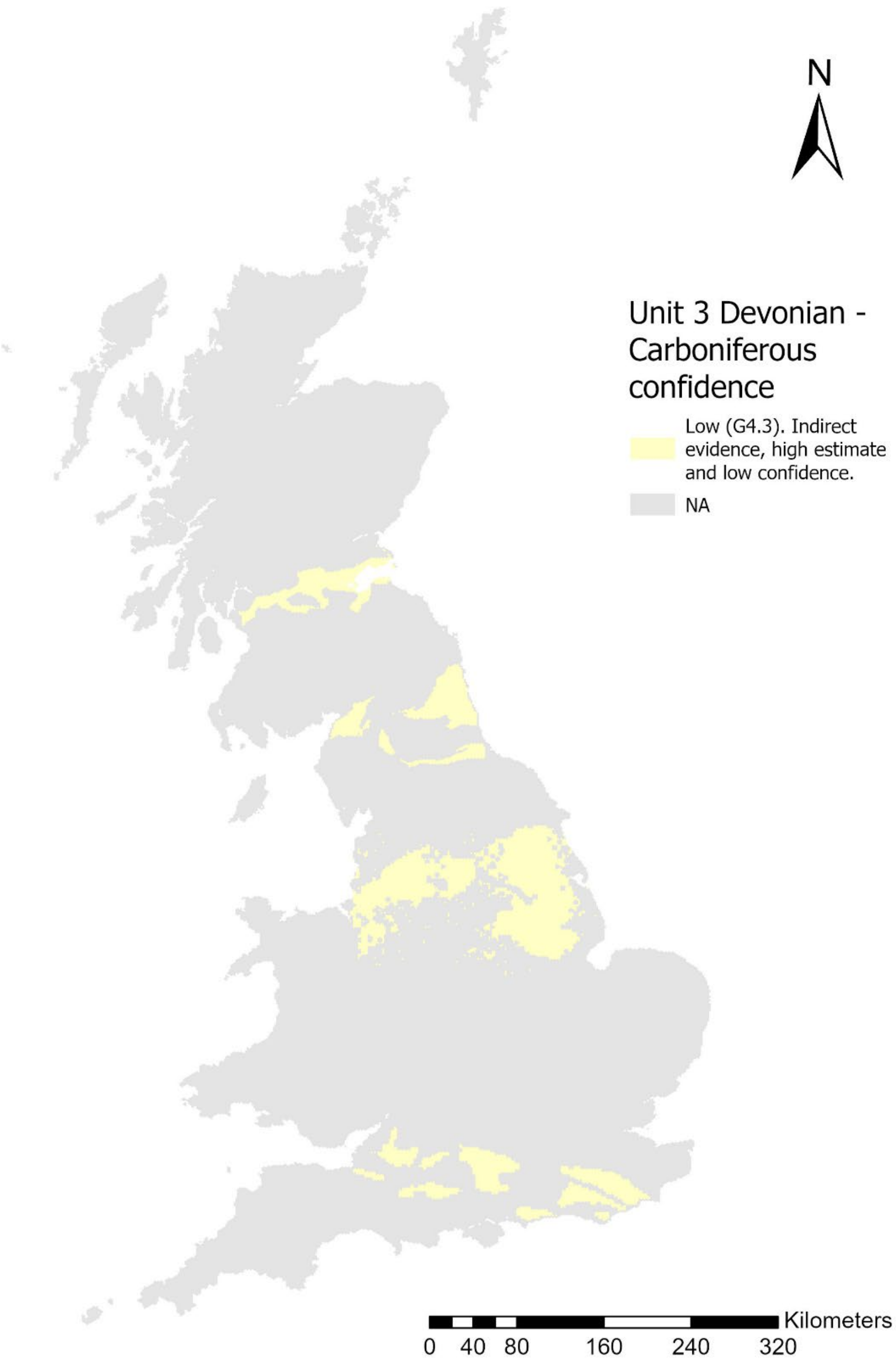

Figure 29 Deep geothermal (Devonian sandstone and Carboniferous sandstone/limestone hot sedimentary aquifer) confidence

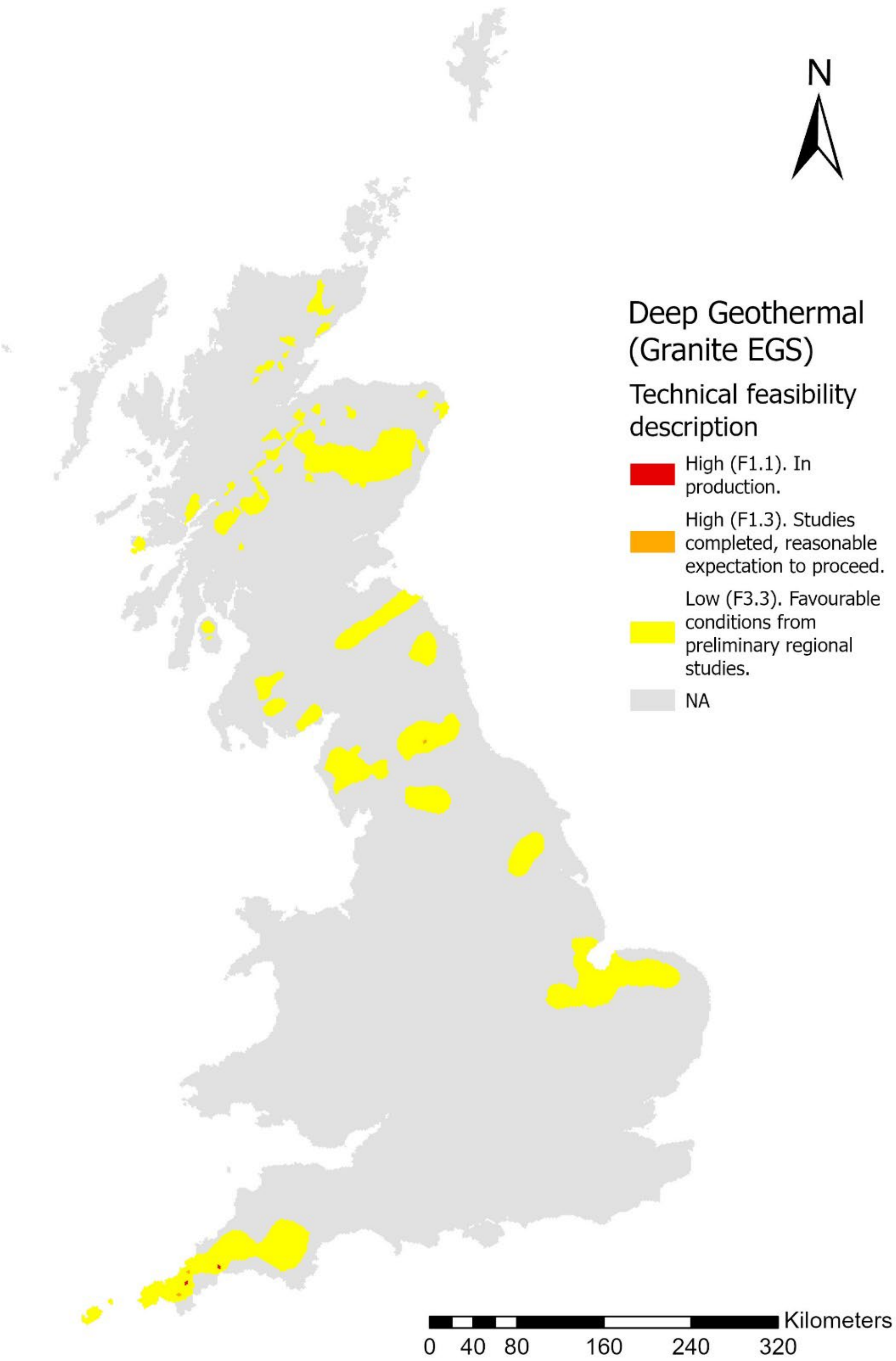

Figure 30 Deep geothermal (Granite EGS) technical feasibility, high (F1.1) are small areas around producing wells, high (F1.3) are small areas around tested wells or sites that have proceeded through planning permission

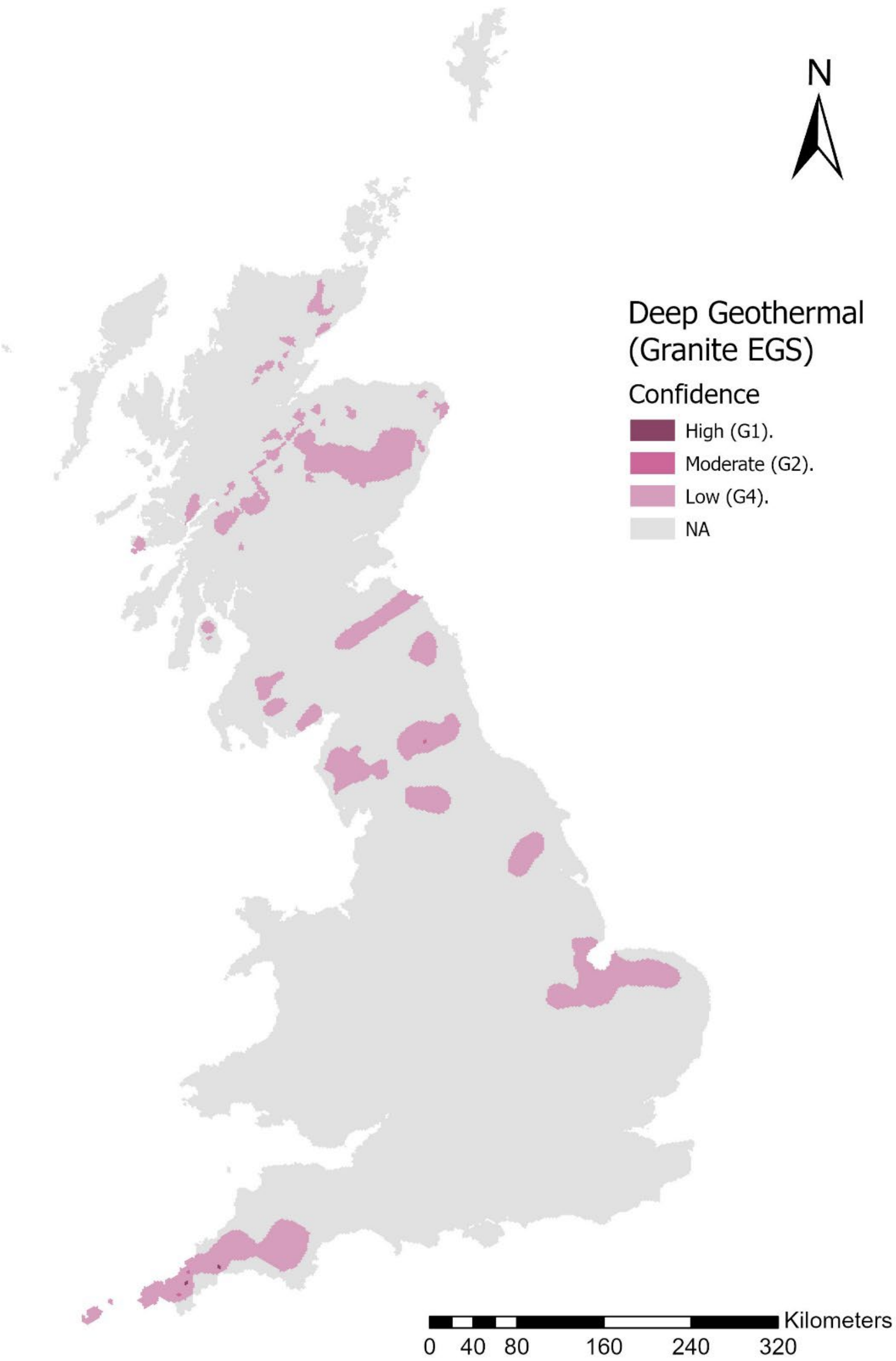

Figure 31 Deep geothermal (Granite EGS) descriptive geothermal feasibility. The Low confidence is because further evaluation is needed at any site before progressing to a prospective project (e.g. for characterisation of heat flow or fracture systems)

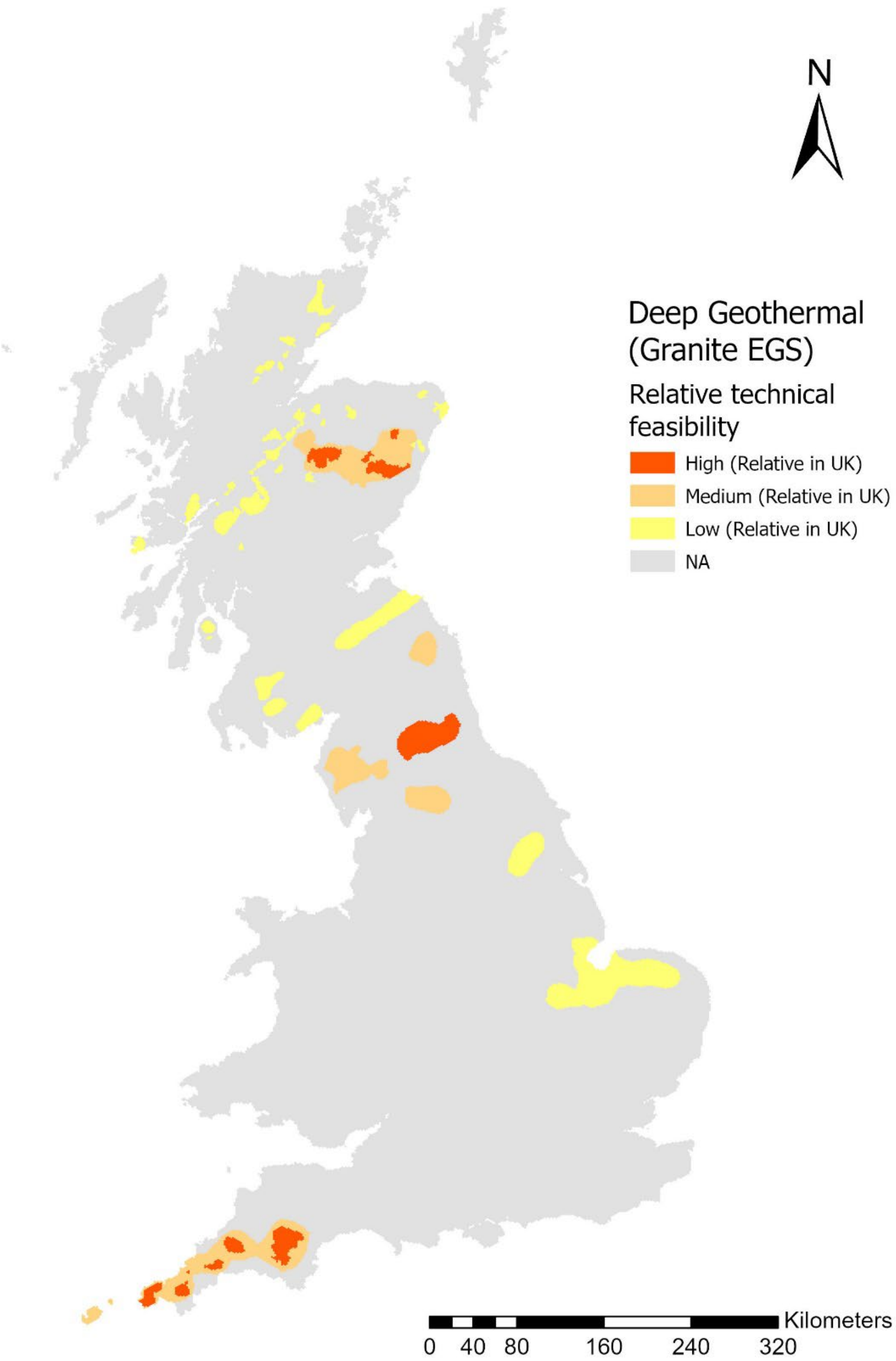

Figure 32 Deep geothermal (Granite EGS) relative technical feasibility in the UK. Qualitative description based on operational projects/tested wells, heat flow, heat producing value of granite and whether granite is exposed/drilled/sampled

Appendix 2: Attribute fields for Heat Network National Zoning Model

The following data fields are supplied only to DESNZ in shapefiles and are not directly supported in the map explorer.

Table 17 Closed loop GSHP

Field Wording	Explanation	Example
Version	Version of the dataset	Closed_loop_Summary_hex_v1
Created	Created date of the dataset	11/3/25
X	Easting position of centre of hex-cell	455000
Y	Northing position of centre of hex-cell	768000
Top_Up	**NZM field Assumed top up heat pump low temperature**	None
T75_AV	Temperature at 75 m depth (℃) **NZM field Supply primary water temperature (°C)**	12.1
F20_P_MN	Thermal output (minimum) 1 bh (kW)	4
F20_P_AV	Thermal output (area weighted average) 1 bh (kW)	4.6
F20_P_MX	Thermal output (maximum) 1 bh (kW)	5
Pk_Cap_ArV	Heat extractable from 50 boreholes (kW) **NZM field Capacity (Peak)**	230
Tot_An_CpV	Total annual heat energy extractable from 50 boreholes (kWh) **NZM field Capacity (total)**	460,000

Table 18 Open loop GSHP

Field Wording	Explanation	Example
Version	Version of the dataset	Open_loop_Summary_hex_v1
Created	Created date of the dataset	11/03/2025
X	Easting position of centre of hex-cell	455000
Y	Northing position of centre of hex-cell	768000
Top_Up	**NZM field Assumed top up heat pump low temperature**	None
T150_Av	Area weighted Temperature at 150m depth (°C) **NZM field Supply primary water temperature (°C)**	314.25
H_ex_1_BH	Total peak capacity of heating supply (kWp) - 1 doublet, input to heat pump	314.25
H_ex_3_BH	Total peak capacity of heating supply (kWp) - 3 doublet array, input to heat pump **NZM field Capacity (Peak)**	942.75
E_ex_3_BH	Total annual energy capacity of heating supply(kWh) - 3 doublet array, input to heat pump **NZM field Capacity (total)**	1,885,500
MN _HE_PK	Minimum peak capacity of heating supply (kWp) - 1 doublet, input to heat pump	209.5
MX _HE_PK	Maximum peak capacity of heating supply (kWp) - 1 doublet, input to heat pump	278

Table 19 Deep geothermal, hot sedimentary aquifer

Field Wording	Explanation	Example
Version	Version of the dataset	HSA_Summary_hex_v1
X	Centroid X	455000
Y	Centroid Y	768000
SG_HR_MN	Minimum Heat recoverable value for Unit1 per cell (MW/km^2)	0.9
SG_HR_MX	Maximum Heat recoverable value for Unit1 per cell (MW/km^2)	0.9
SG_HR_WAV	Area weighted Heat recoverable value for Unit1 per cell (MW/km^2) – calculated using the $H_{rec,hex\ cell}(MW/km^2)$ equation in section Heat extractable from 1 doublet	0.9
SG_HR_TOT	Total Heat recoverable value for Unit1 per cell (MW) (assuming 2.56 km^2) – calculated using $H_{ext}(MW)$in section Heat extractable from 1 doublet - **NZM field Total peak capacity of heating supply1**	2.3
PT_HR_MN	Minimum Heat recoverable value for Unit2 per cell (MW/km^2)	2.1
PT_HR_MX	Maximum Heat recoverable value for Unit2 per cell (MW/km^2)	4.0
PT_HR_WAV	Area weighted Heat recoverable value for Unit2 per cell (MW/km^2) – calculated using the $H_{rec,hex\ cell}(MW/km^2)$ equation in section Heat extractable from 1 doublet	3.8
PT_HR_TOT	Total Heat recoverable value for Unit2 per cell (MW) (assuming 2.56 km^2) – calculated using $H_{ext}(MW)$in section Heat extractable from 1 doublet - **NZM field Total peak capacity of heating supply2**	8.7
CD_HR_MN	Minimum Heat recoverable value for Unit3 per cell (MW/km^2)	20.1

Field Wording	Explanation	Example
CD_HR_MX	Maximum Heat recoverable value for Unit3 per cell (MW/km^2)	25.9
CD_HR_WAV	Area weighted Heat recoverable value for Unit3 per cell (MW/km^2) – calculated using the $H_{rec,hex\ cell}(MW/km^2)$ equation in section Heat extractable from 1 doublet	23.4
CD_HR_TOT	Total Heat recoverable value for Unit3 per cell (MW) (assuming 2.56 km^2) – calculated using $H_{ext}(MW)$in section Heat extractable from 1 doublet - **NZM field Total peak capacity of heating supply3**	60.7
Top_Up	**NZM field Assumed top up heat pump low temperature**	None
SG_TMP_AV	Area weighted Temperature (°C) **NZM field Supply primary water temperature1**	48
PT_TMP_AV	Area weighted Temperature (°C) **NZM field Supply primary water temperature2**	55
CD_TMP_AV	Area weighted Temperature (°C) **NZM field Supply primary water temperature3**	64
SG_TP_AV	Mean elevation (in metres relative to Ordnance Datum) for the top of the Triassic sandstone	-1234
SG_BS_AV	Mean elevation (in metres relative to Ordnance Datum) for the base of the Triassic sandstone	-1444
PT_BS_AV	Mean elevation (in metres relative to Ordnance Datum) for the base of the Permian sandstone	-2234
CD_TP_AV	Mean elevation (in metres relative to Ordnance Datum) for the top of the Devonian and Carboniferous strata	-3234

Table 20 Deep geothermal, granite-EGS

Field Wording	Explanation	Example
Version	Name and version of data	Petrothermal_Summary_hex_v1
Created	Created date	11/3/25
X	Easting position of centre of hex-cell	455000
Y	Northing position of centre of hex-cell	768000

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