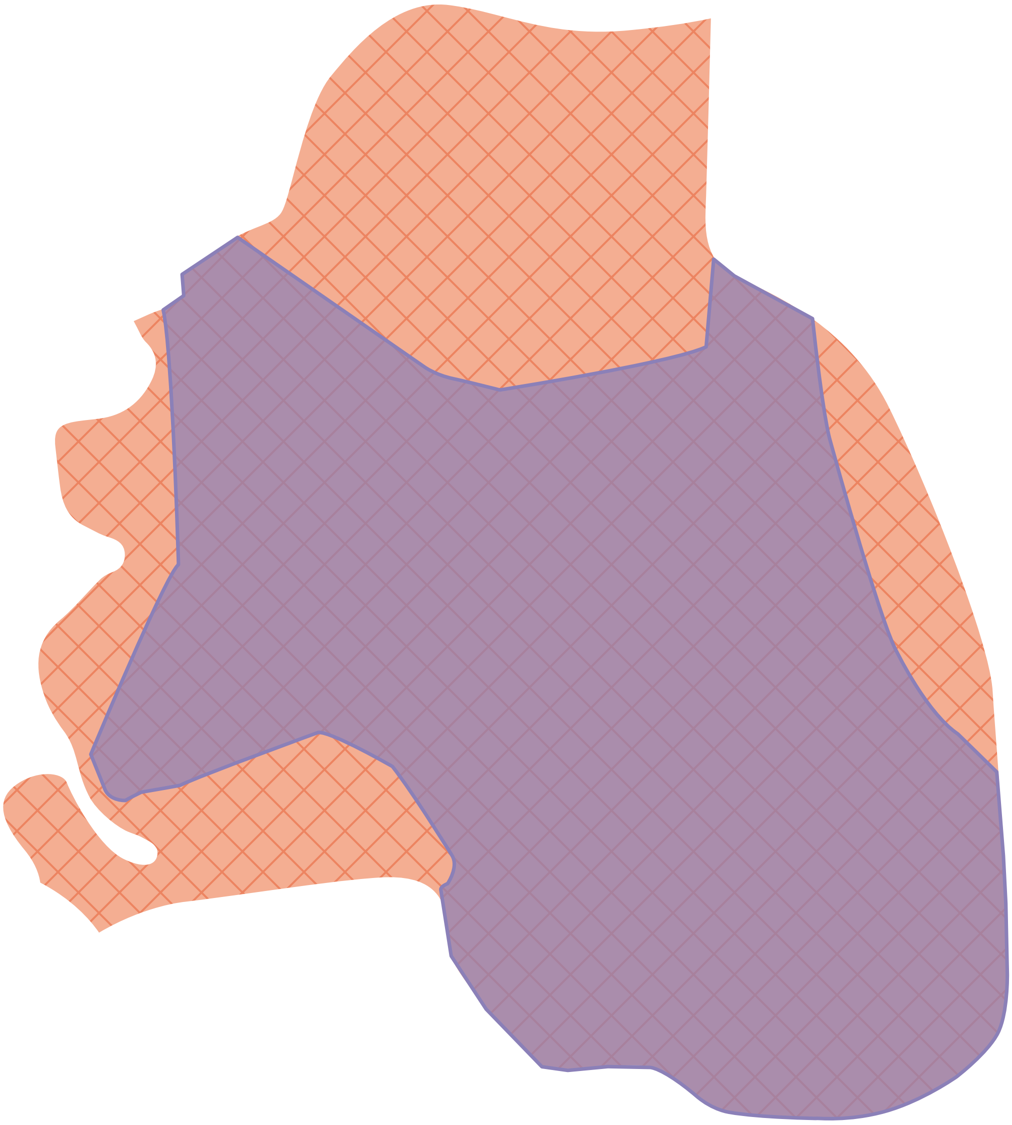
Radioactive Waste Management



Pennines and adjacent areas

SUBREGION 3

Contents

Clicking on words in green, such as sedimentary or lava will take the reader to a brief non-technical explanation of that word in the Glossary section. By clicking on the highlighted word in the Glossary, the reader will be taken back to the page they were on.

Clicking on words in blue, such as Higher Strength Rock or groundwater will take the reader to a brief talking head video or animation providing a non-technical explanation.

For the purposes of this work the BGS only used data which was publicly available at the end of February 2016. The one exception to this was the extent of Oil and Gas Authority licensing which was updated to include data to the end of June 2018.

Our work shows that we are unlikely to find enough suitable rock to accommodate all of the waste in most this subregion, although sufficient suitable rock to host part of it may be found.

Rock can be seen at the surface over much of the subregion, such as the Peak District, and in man-made excavations such as quarries or road cuttings. Combined with numerous deep boreholes and geophysical investigations in the coalfield areas, this gives us an understanding of the rocks present and their distribution.

Our work has identified no rocks in which it is likely that a GDF could be sited under most of the subregion however, there are clay-rich rock layers in a small area to the north-east of Nottingham in which it may be possible to site a GDF. We would need to do more work to find out whether these rocks have suitable properties and thicknesses.

Some of the subregion has been mined for coal and metal resources to depths below 100m, such as the Lancashire and East Pennine Coalfields, and there are also known oil and gas resources, such as around Chesterfield and to the south of Retford. In these areas the mining and drilling is likely to have affected the way in which water moves through the rock. Also possible exploration in the future in these areas means that it is more likely that future generations may disturb a facility.

The western and eastern parts of the subregion have Petroleum Exploration & Development Licences to allow companies to explore for oil and gas. This exploration is currently at an early stage and it is not known whether the oil or gas in these licence areas will be exploited. RWM will continue to monitor how this exploration programme progresses.

Parts of this area, around Burnley and Doncaster in particular, are Coal Authority Licence Areas allowing companies to explore for coal. It is not known whether coal in these licence areas will be exploited. RWM will also continue to monitor how this exploration programme progresses.

There are thermal springs in the Peak District which indicate that groundwater is moving rapidly from depth to the surface in these areas. This would need to be considered in the siting of a GDF in this subregion.

Introduction

This subregion comprises the central and southern part of the Pennines and adjacent areas region.

Rock type

There are no potential Rock Types of Interest within the depth range of interest in most of this subregion. The geology of the subregion is dominated by older sedimentary rocks of Carboniferous age (approx. 300 to 360 million years old). The dominant rock types are sandstones, limestones and mudrocks, many of which are too permeable to be considered as host rocks. Mudrocks are present in the Coal Measures of the Yorkshire and Lancashire coalfields. However they are strongly compacted and mostly lack the swelling clay minerals that give mudstones their characteristic low permeability.

The small area of Lower Strength Sedimentary Rocks (LSSR) in the south-east corner of the subregion (Figure 1) is the western edge of a more extensive area of potential LSSR, described under subregion 3 of the adjacent Eastern England region.

A summary of the geological attributes of the Pennines and adjacent areas region can be found here, including a simplified rock column showing the oldest and deepest rocks at the bottom, with progressively younger rock units towards the top.

Rock structure

There are a number of major faults in this subregion and the Lancashire coalfield to the west is more intensely faulted than the older, stronger limestone that forms the core of the Pennines in the centre of the subregion (Figure 2). Faults may act as barriers to or pathways for groundwater movement, depending upon their characteristics, and the siting of a GDF would need to take account of them[1].

Folding related to the faulting can give rise to locally variable and steeply dipping rock layers, particularly in the Peak district, which is likely to complicate the search for a volume of rock with sufficiently homogenous properties in these areas (Figure 2).

[1] Faults occur on a diverse range of scales, from centimetres to kilometres, and the subsurface is criss-crossed by networks of numerous individual faults. However our work includes only those faults identified by the BGS with throws (vertical offset) of 200m or more. This is because the data available to the BGS are not able to resolve all faults consistently, across all thirteen regions, with throws less than 200m. We recognize the potential importance of smaller scale faults to the integrity of a GDF and will need to survey them in detail as part of the site evaluation process.

Groundwater

There is very little information on groundwater in the depth range of interest for a GDF, 200 to 1,000m below NGS datum, although there is information on groundwater in aquifers above 200m. There are several principal aquifers within 400m of the surface in this subregion including the Sherwood Sandstone Group and the Carboniferous Limestone aquifer. The Sherwood Sandstone Group occurs in a north-south band along the eastern edge of the subregion while the Peak District is dominated by thick beds of Carboniferous Limestone aquifer. The limestone has been affected by karstic processes throughout the Ice Age. Over geological timescales, weakly acid groundwater has dissolved the limestone leading to enlargement of natural fracture systems and the formation of a connected network of fissures and caves, known as karst.

Several thermal springs in the Peak District discharge water at temperatures in excess of 15°C, indicative of groundwater circulating to depths of between 800 to 1,500m (Figure 4b). Although the flow paths along which water arrives at surface springs are not known in detail, they are likely to be concentrated along deep-rooted faults and folds and are unlikely to be suitable places to site a GDF. Groundwater from depths greater than 400m is unlikely to be suitable as drinking water anywhere in the UK[2].

There are no low permeability clay-rich rock layers in most of this subregion to act as barriers to vertical flow between deep and shallow groundwater.

In the Lancashire and East Pennine coalfields and some other areas of the subregion mining is likely to have changed the original patterns of water movement and shallow groundwater may now circulate to greater depths within the depth range of interest than it did before mining. Deep exploration boreholes may influence the connectivity between shallow and deep groundwater which would also need to be considered during the siting process (Figure 3).

[2] Water Framework Directive UK TAG. Defining and reporting on groundwater bodies, 2012.

Resources

Coal has been mined extensively below 100m in the Lancashire and East Pennine coalfields (Figure 4a) and there are abandoned lead, zinc, copper and fluorite mines in this subregion, some of which penetrated deeper than 100m (Figure 4b). There are also a number of small oil fields in the south-east of the subregion (Figure 4c). In these areas the mining is likely to have affected the way in which water moves through the rock. Also possible exploration in the future in these areas means that it is more likely that future generations may disturb a facility. These known resources would be taken into account in the siting of a GDF.

Several Petroleum Exploration and Development Licences[3] are currently held in the western and eastern parts of the subregion (see Figure 4c). There are also Coal Authority Licence Areas around Burnley and Doncaster (Figure 4a). It is not known whether coal, oil or gas in these licence areas will be exploited, but they would need to be considered during the siting process.

The full extent of the historic South Pennine Orefield, which exploited the mineral deposits in the Carboniferous Limestone Supergroup in the Peak District, is shown in Figure 4d but is not relevant to the siting of a GDF as the mines are shallower than 100m (including ongoing at Milldam Mine).

Natural processes

Earthquakes and glaciations are unlikely to significantly affect the long-term safety of a GDF in the UK. Therefore, whilst a GDF would need to be sited and designed to take account of natural processes which may occur during its lifetime, they are not considered further as part of this screening exercise.

[3] This also includes other licences awarded by the Oil and Gas Authority to allow companies to explore for hydrocarbons.

Figure 1 The areas of the Pennines and adjacent areas subregion 3 where Lower Strength Sedimentary Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

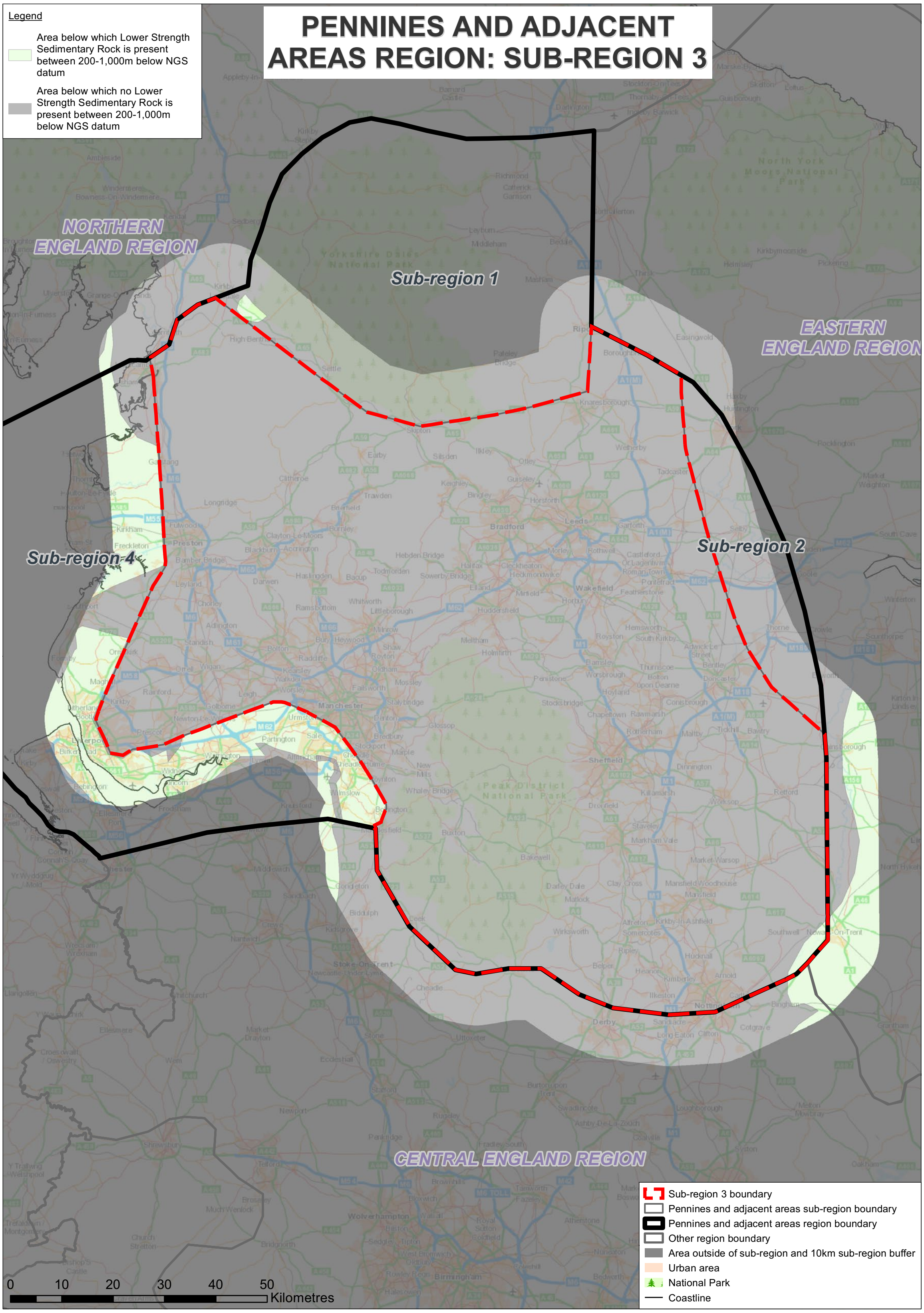


Figure 2 Location of major faults in the Pennines and adjacent areas subregion 3.

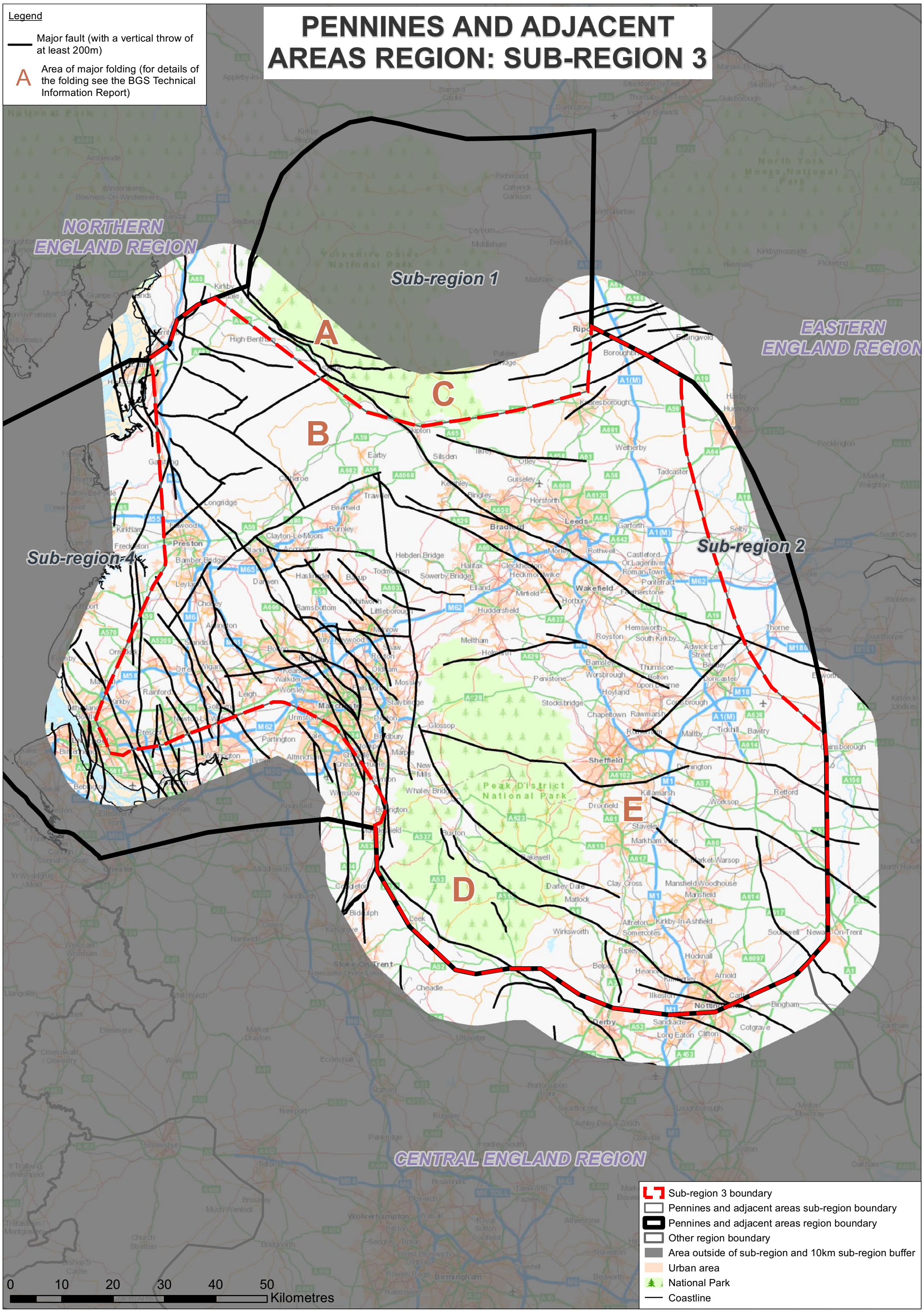


Figure 3 Areas in the Pennines and adjacent areas subregion 3 with concentrations of deep exploration boreholes.

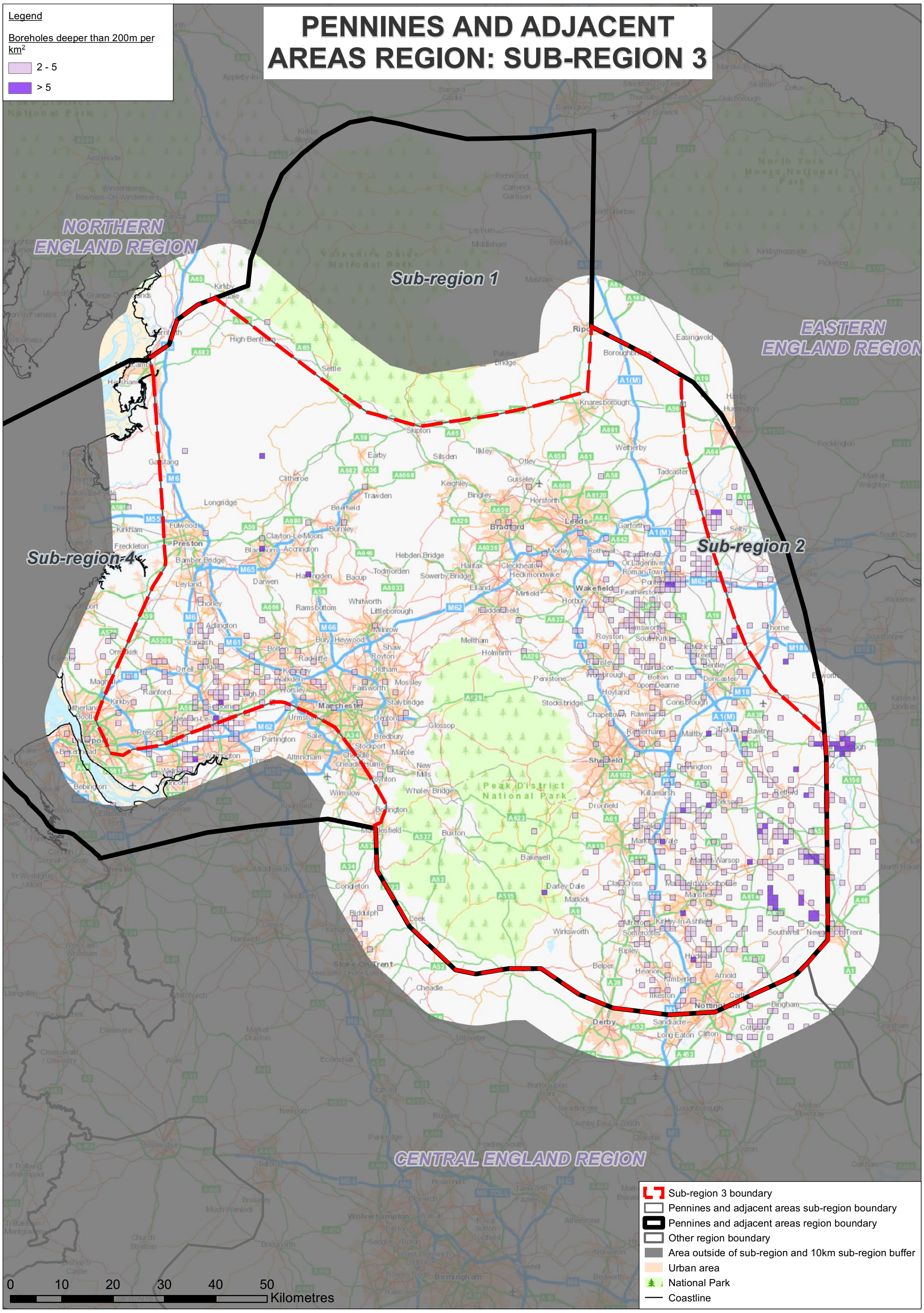


Figure 4a Areas of the Pennines and adjacent areas subregion 3 with coal mines more than 100m deep and Coal Authority Licence Areas.

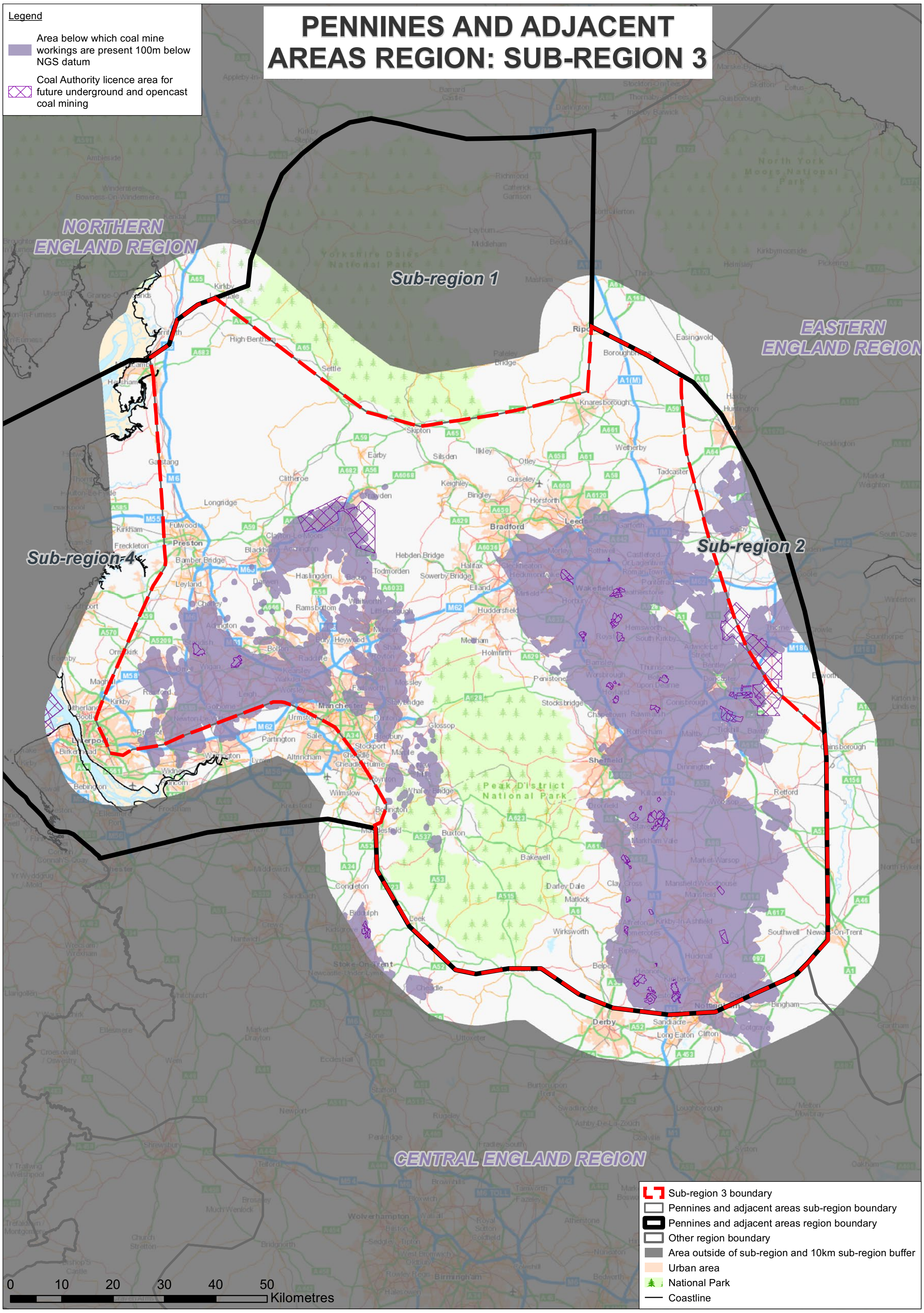


Figure 4b Areas of the Pennines and adjacent areas subregion 3 with thermal springs and metal and vein mineral mines present below 100m.

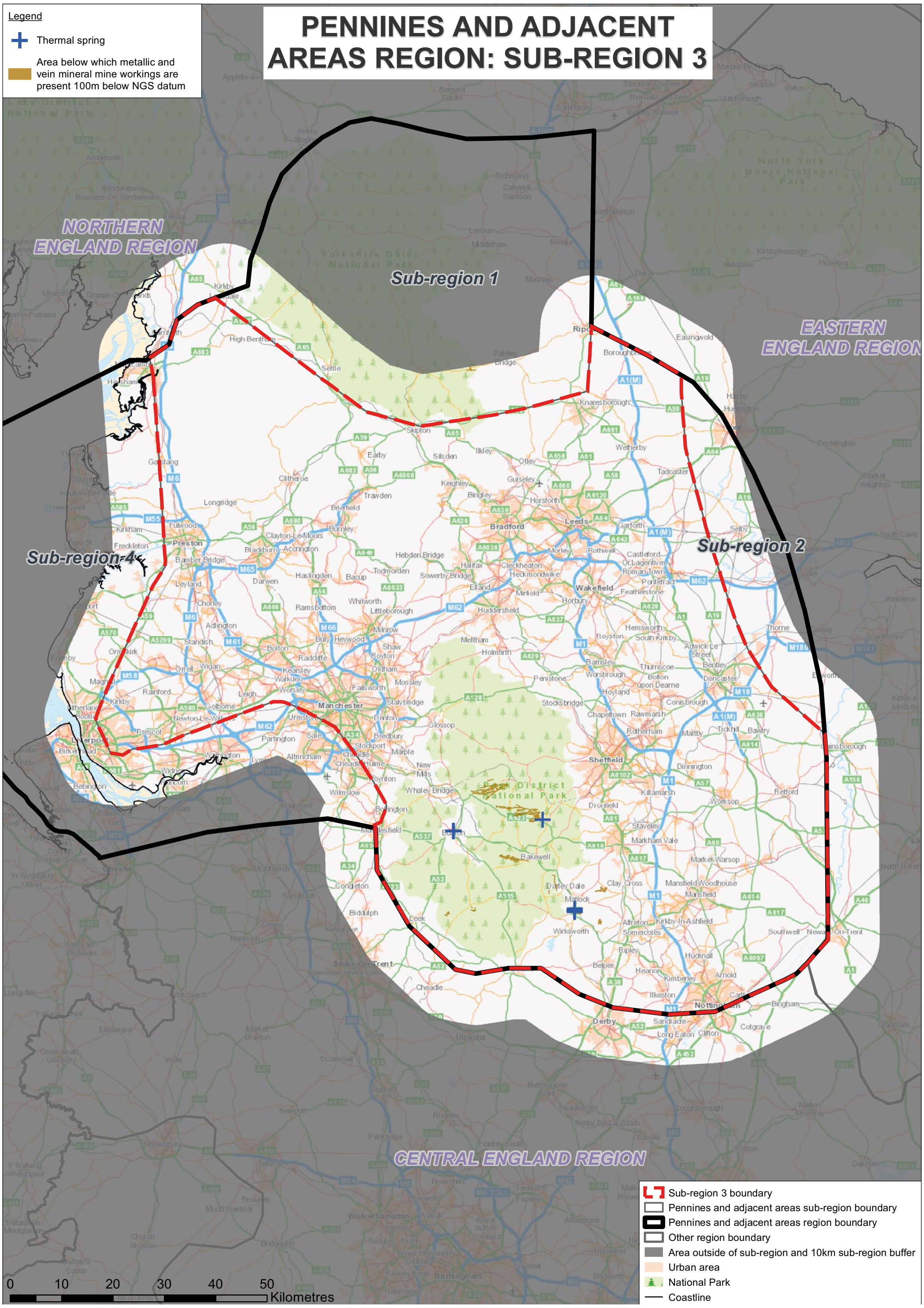


Figure 4c Areas of the Pennines and adjacent areas subregion 3 with oil and gas fields and Petroleum Exploration and Development Licences.

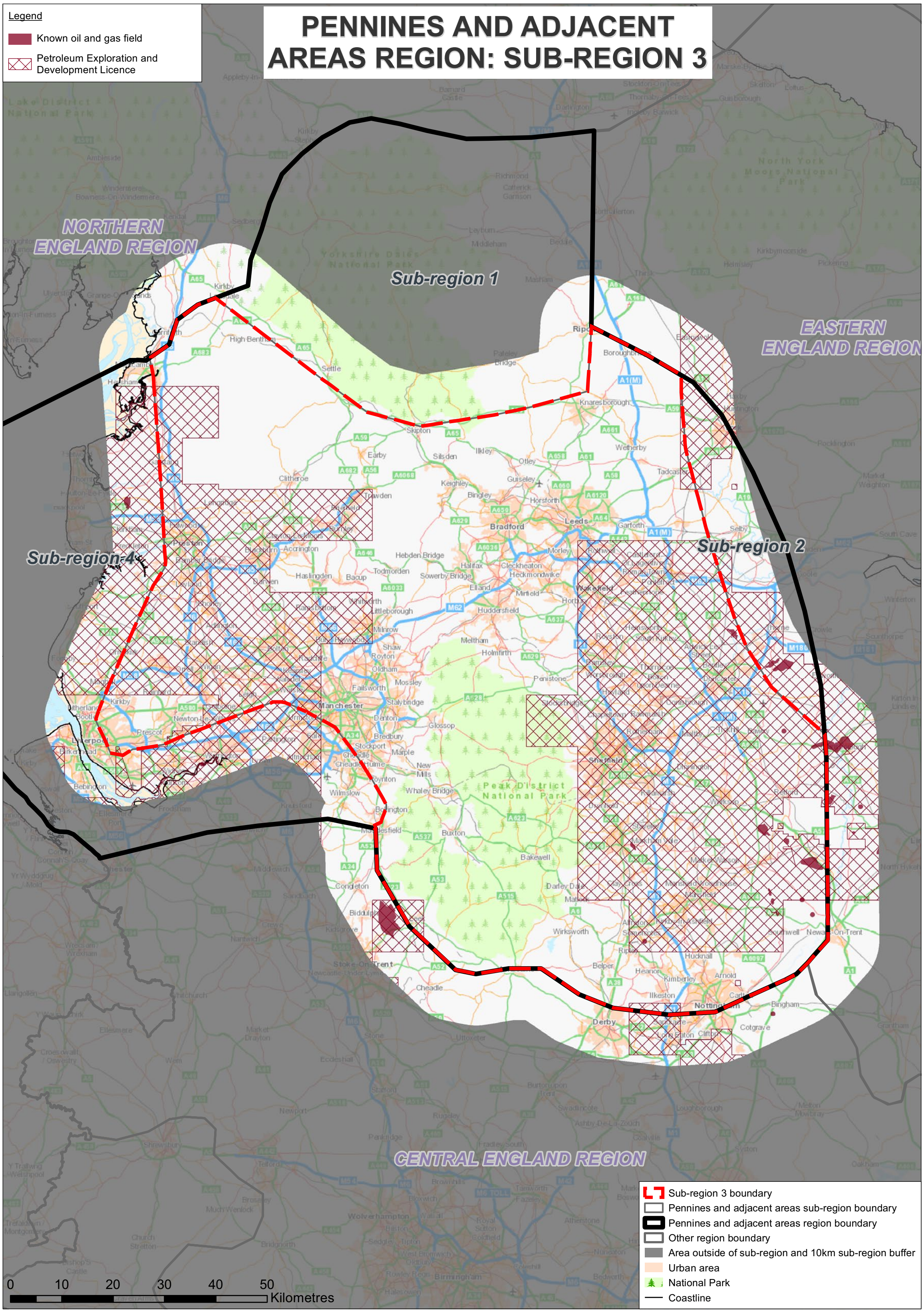
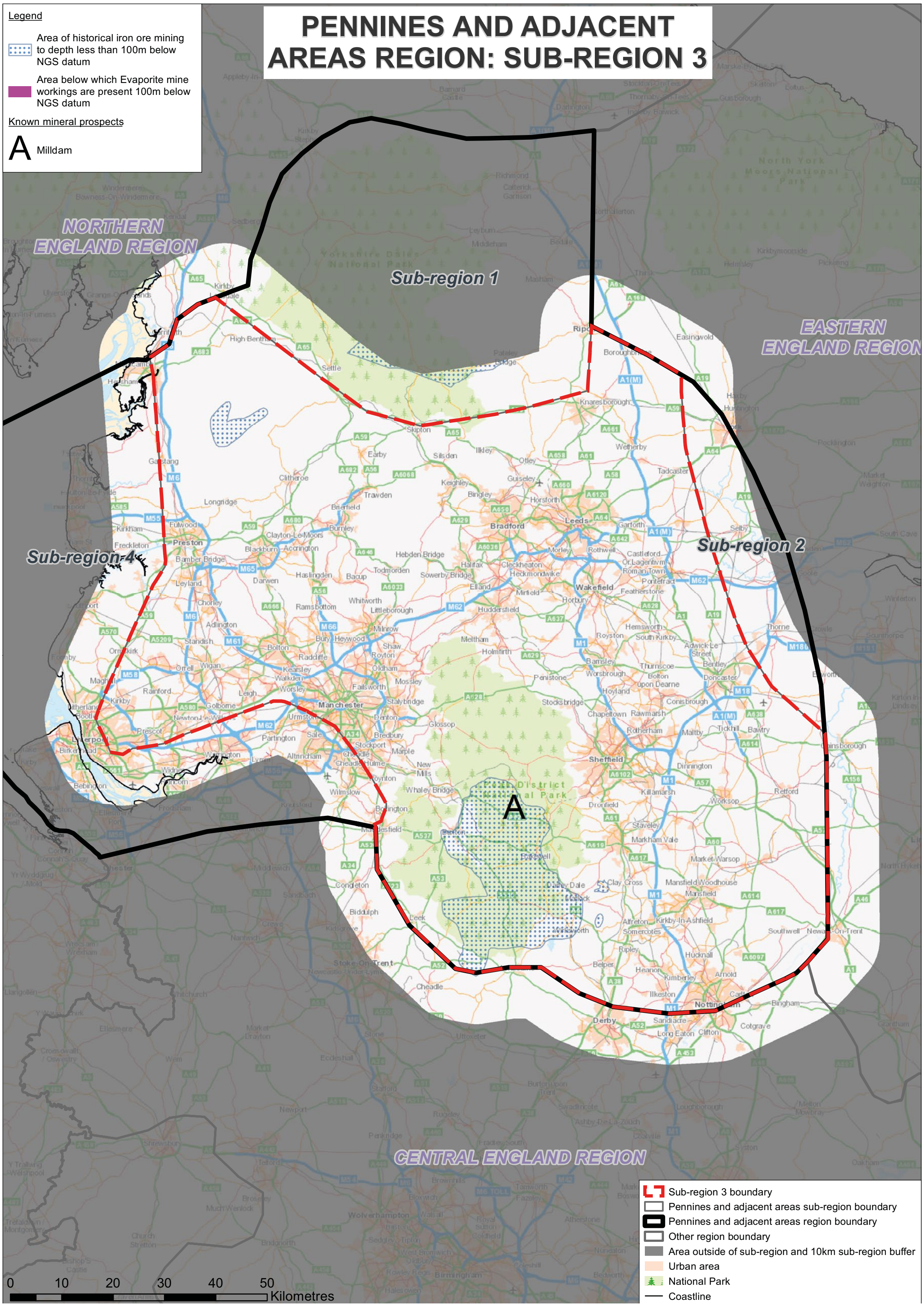


Figure 4d Areas of the Pennines and adjacent areas subregion 3 with historical mines less than 100m deep and known mineral prospects.



Glossary

Aquifers
Aquifers are rocks that contain freshwater in pores and/or fractures and whose porosity and permeability are sufficiently high to make the extraction of groundwater possible.

Fracture
A crack in rock. Fractures can provide a pathway for fluids, such as groundwater or gas, to move in otherwise impermeable rock.

Karst
A distinctive type of landscape consisting of deep cracks and caves in limestones. Karst forms due to the action of mildly acidic groundwater dissolving the limestone.

Principal aquifers
An aquifer classified by the Environment Agency as: "rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage." They represent the most important aquifers in terms of water supply or base flow.

Swelling clay minerals
Some minerals that make up mudstone or claystone expand significantly when they absorb water. This is due to their layered silicate structure which absorbs water causing the layer to expand. These types of minerals occur naturally and include bentonite and montmorillonite. Some radioactive waste disposal concepts include the addition of these minerals, as their expansion creates an effective barrier to preventing migration of radionuclides.

Radioactive Waste Management

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