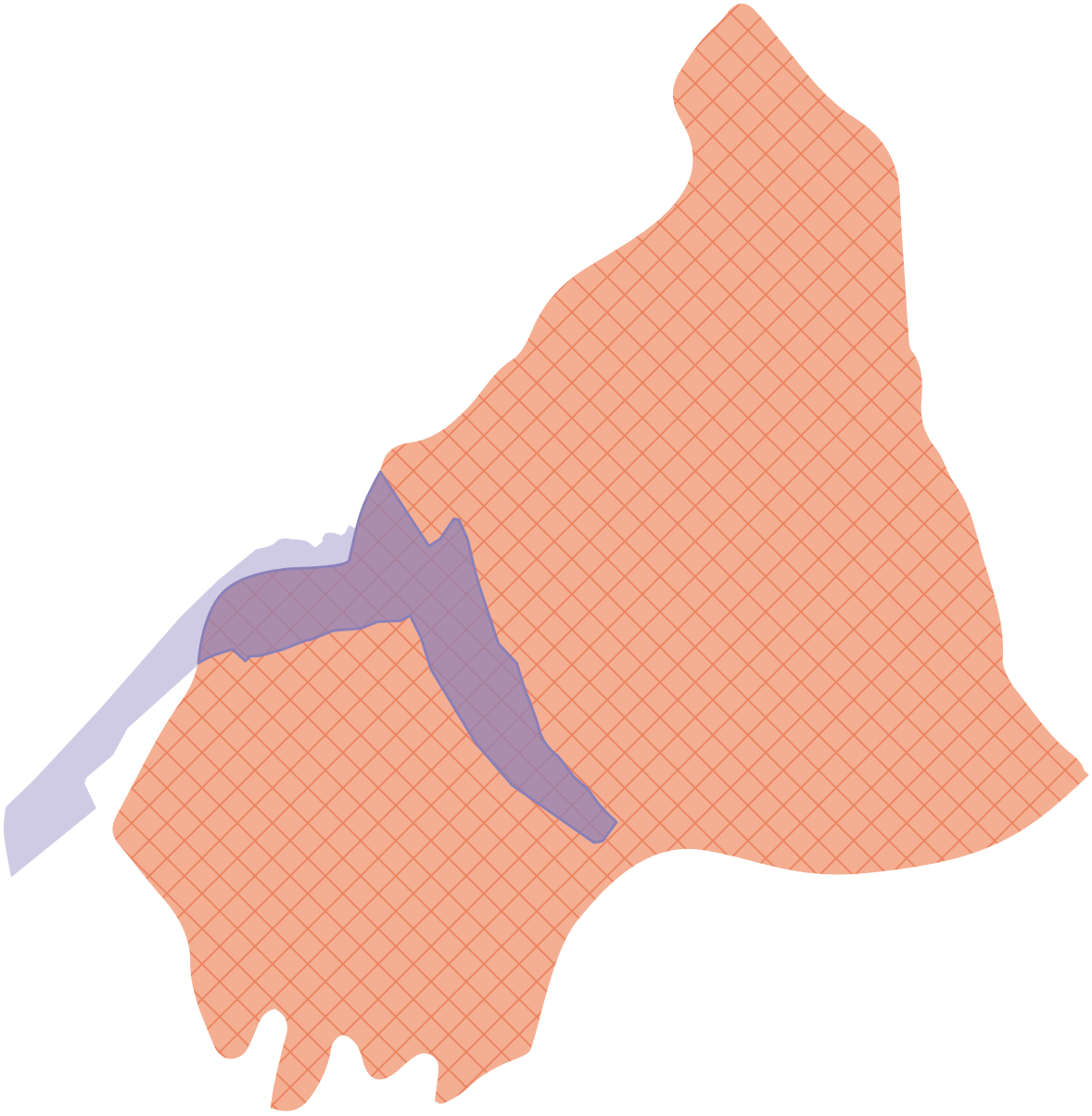
Radioactive Waste Management



Northern England

SUBREGION 5

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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 may find a suitable geological setting for a GDF in much of this subregion.

Part of the subregion is the inshore area which extends to 20km from the coast, but rock can be seen at the surface inland and in man-made excavations such as quarries or road cuttings. Combined with some deep boreholes and numerous geophysical investigations, this gives us an understanding of the rocks present and their distribution.

There are clay-rich rock layers and layers of rock salt under most of subregion in which we may be able to site a GDF. We would need to do more work to find out whether these rocks have suitable properties and thicknesses in the depth range of interest for a GDF.

Even where individual clay-rich rock layers are found not to be thick enough to host a GDF they may support the siting of a GDF in deeper rocks as they could act as a barrier to groundwater flow from depth. This is important because movement of groundwater is one of the ways in which radioactive material could be carried back to the surface.

There are no known coal, oil, gas or metal resources in this subregion which means that it is unlikely that future generations may disturb a facility.

Parts of this area, off the coast to the west of Whitehaven and to the north of Carlisle, 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 continue to monitor how this exploration programme progresses.

Parts of the Vale of Eden, which are mined for gypsum, would also need to be taken into account in the siting of a GDF, although the nature of mining in evaporites does not affect the movement of groundwater in the surrounding rocks in the same way as other mining.

Introduction

This subregion extends along the south side of the Solway Firth from Whitehaven to Maryport, Silloth and Carlisle, and continues south-east up the Vale of Eden to Brough.

Rock type

Figures 1a to 1d show where in the subregion there are likely to be Rock Types of Interest for the development of a GDF within the depth range of interest. The Mercia Mudstone and Cumbrian Coast Groups are both present in the depth range of interest, but are thinner than they are in subregion 4 to the south.

The Triassic Mercia Mudstone Group (approx. 200 to 250 million years old) is dominated by red and brown mudstones with minor dolomite and evaporite minerals occurring in nodules and veins. It contains only sparse rock salt (halite), with just a single bed 6m thick recorded within a total thickness of 325m in a deep borehole at Silloth. The mudstone units are known to act as a barrier to groundwater movement and have the potential to act as Lower Strength Sedimentary Rock (LSSR) hosts where they are thicker in the southern inshore part of the subregion.

The Permian Cumbrian Coast Group(approx. 250 to 300 million years old) is dominantly composed of siltstones with minor mudstones, sandstones and conglomerates. The mudstones are 60 to 100m thick in this subregion and are generally thicker off the coast. In the Vale of Eden there are 4 evaporite beds; these are dominated by gypsum and anhydrite, with only the lowest containing rock salt. It appears unlikely that the rock salt here occurs in sufficiently thick and pure layers to provide a potential Evaporite host rock, but there is little detailed information available.

The Carboniferous Warwickshire Group (approx. 300 to 360 million years old) is also present in the depth range of interest in the northern part of this subregion, in the Solway Basin. This rock unit contains a number of persistent mudstone beds which act as effective barriers to groundwater movement and may qualify as LSSR. They are thickest in the Becklees borehole, close to the Scottish border where they are over 500m thick.

Subsurface engineering in mudstones can be challenging because they are relatively weak. Where these mudstones occur in the lower part of the depth range of interest the constructability of a GDF would be considered during the siting process.

There is also a very small area of potential Higher Strength Rock (HSR) to the south of Carlisle (Figure 1c) which is part of the larger area of HSR discussed under subregion 3 of this region.

A summary of the geological attributes of the Northern England 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 and some folding in this subregion (Figure 2). The subregion is partly bounded by arrays of faults which juxtapose the sedimentary rocks against older basement rocks of the Lake District and the North Pennines. Faults may act as barriers to or pathways for groundwater movement, depending upon their characteristics, and these would need to be considered during the siting of a GDF[1].

In the north of the subregion, the sedimentary rocks of Triassic to Carboniferous age are gently folded; there is also some folding of the same rocks in the Vale of Eden. Variable and steeply dipping rocks are likely to complicate the search for a volume of rock with sufficiently homogenous properties in these areas.

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 in this subregion including the Sherwood Sandstone and Appleby Groups where they occur onshore. However, much of this subregion is inshore where the water present in the pores of rocks beneath the seabed is saltwater rather than fresh and they are not therefore suitable for use as aquifers.

LSSR and Evaporite rocks occur above the basement and so provide a barrier to vertical movement between deep and shallow groundwater and the seabed even where they are not thick enough to host a GDF. Where the main aquifer sandstones lie beneath the units of mudstones and evaporites, so that they are not readily recharged with fresh water from the surface, they typically contain saline waters which may be tens or hundreds of thousands of years old. Groundwater from depths greater than 400m is unlikely to be suitable as drinking water anywhere in the UK[2].

In some small areas in the subregion deep exploration boreholes may influence the connectivity between shallow and deep groundwater which would need to be considered during the siting process (see Figure 3). There are no thermal springs in this subregion to suggest rapid flow of deep groundwater to the surface.

[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.

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

Resources

The subregion also includes a very small part of the West Cumbrian Coalfield which is discussed under subregion 3 (Figure 4a).

There are Coal Authority Licence Areas in the inshore to the west of Whitehaven (Figure 4a). It is not known whether coal in these licence areas will be exploited, but they would need to be considered during the siting process.

Gypsum is mined below 100m in the Vale of Eden (Figure 4b). Although the nature of mining in evaporites does not affect the movement of groundwater in the surrounding rocks in the same way as other mining, the presence of any excavations in these rocks would need to be considered in the siting of a GDF.

Areas of historical metal ore mining are also shown in Figure 4b but are not relevant to the siting of a GDF as the mines are shallower than 100m.

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.

Figure 1a The areas of the Northern England subregion 5 where any of the 3 Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

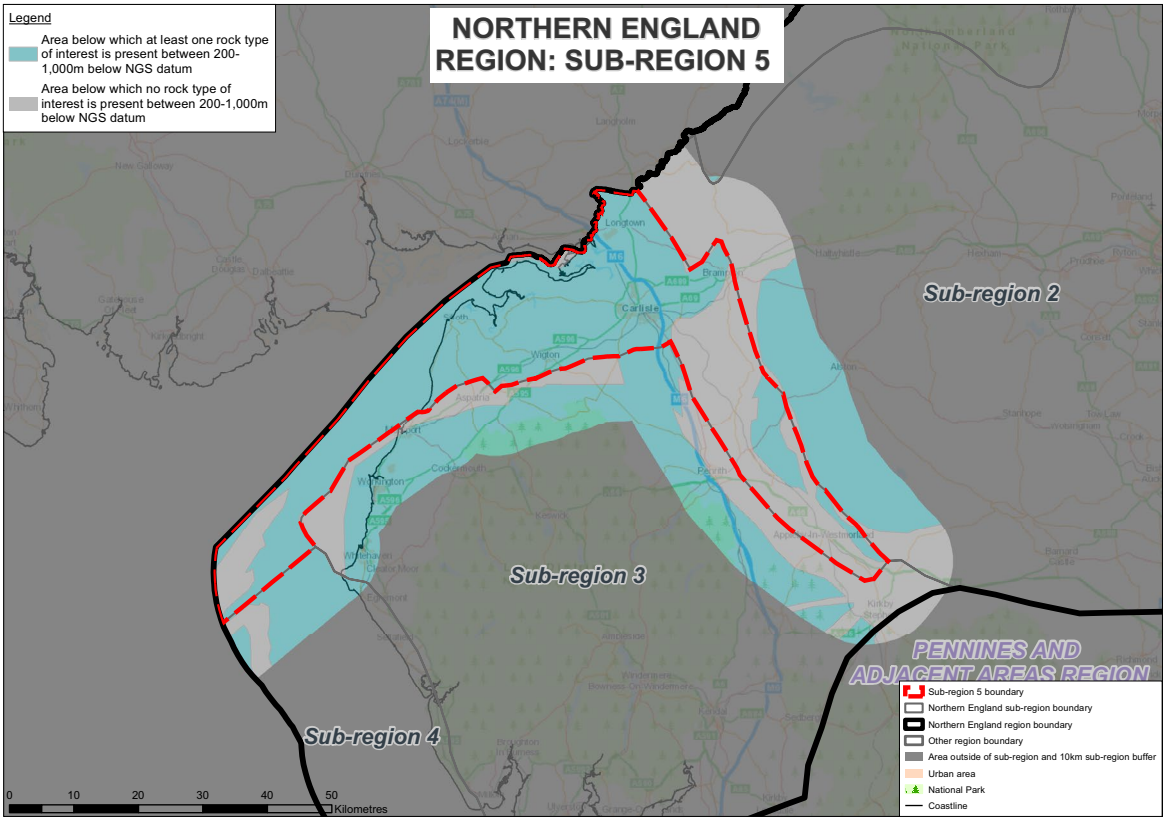


Figure 1b The areas of the Northern England subregion 5 where Lower Strength Sedimentary Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

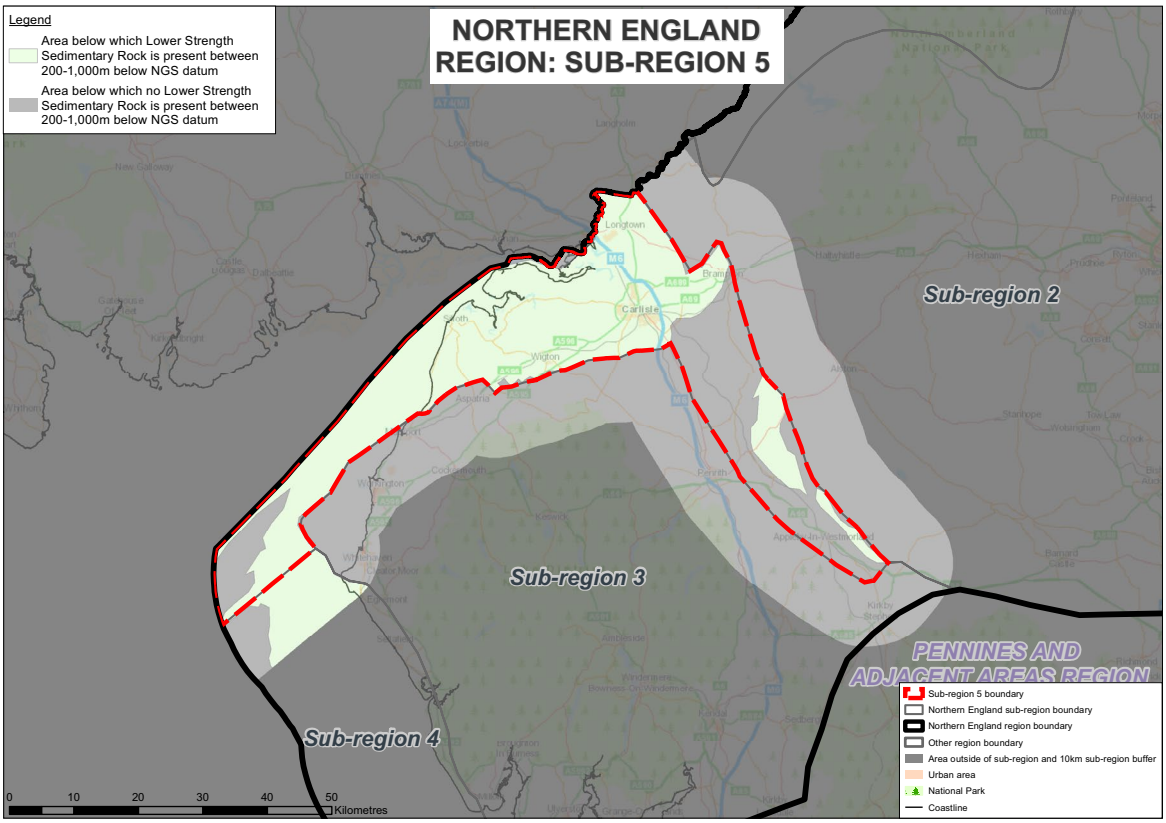


Figure 1c The areas of the Northern England subregion 5 where Higher Strength Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

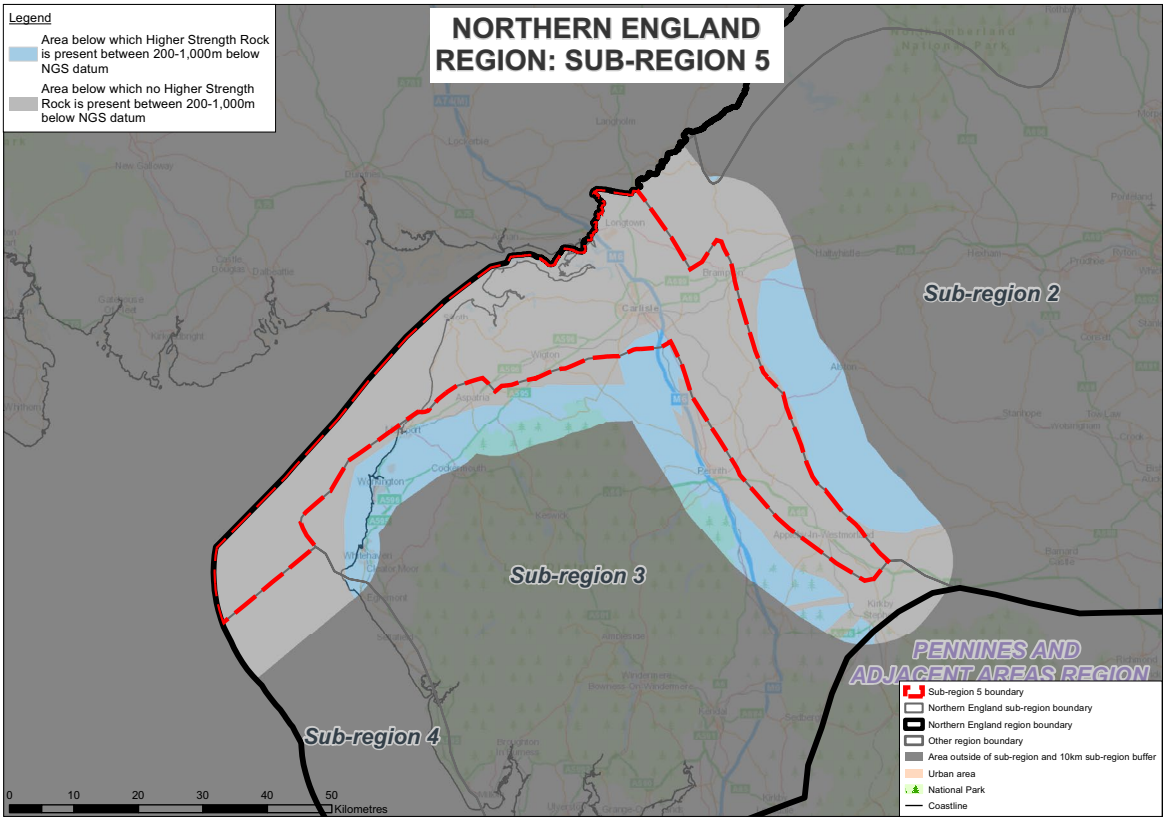


Figure 1d The areas of the Northern England subregion 5 where Evaporite Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

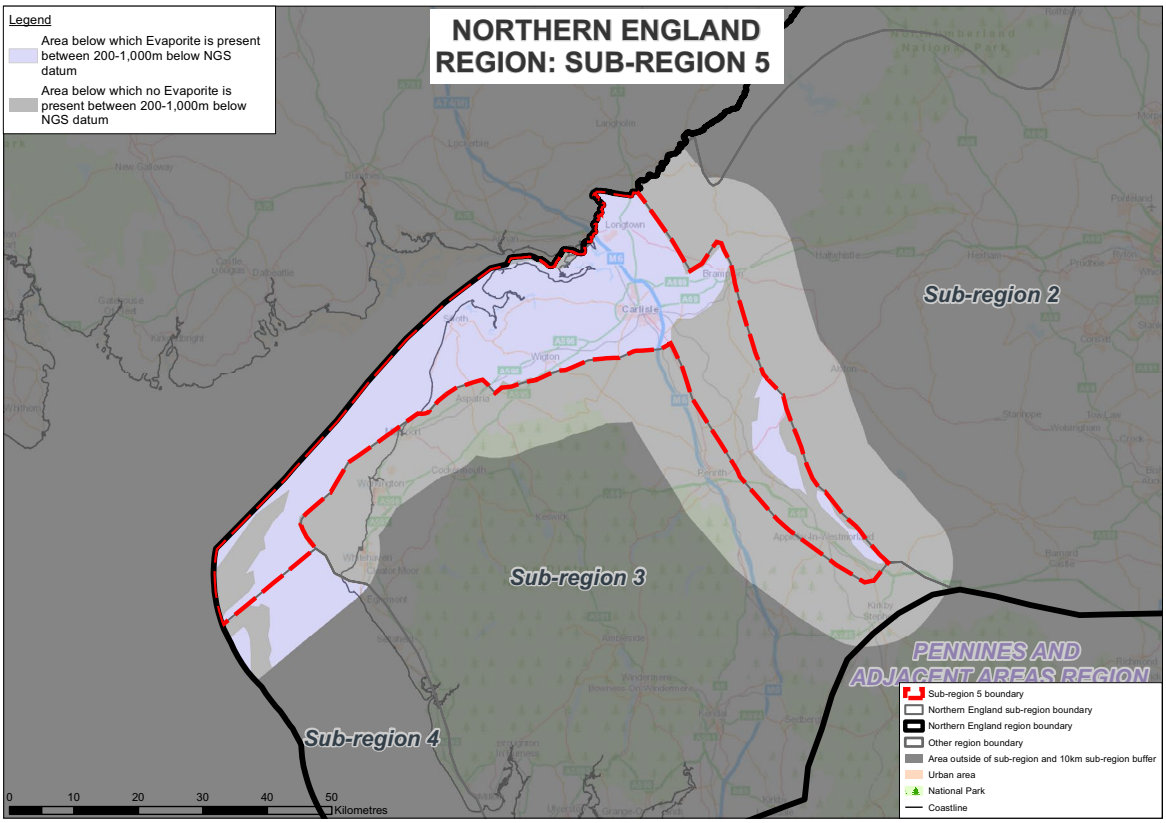


Figure 2 Major faulting and folding in the Northern England subregion 5.

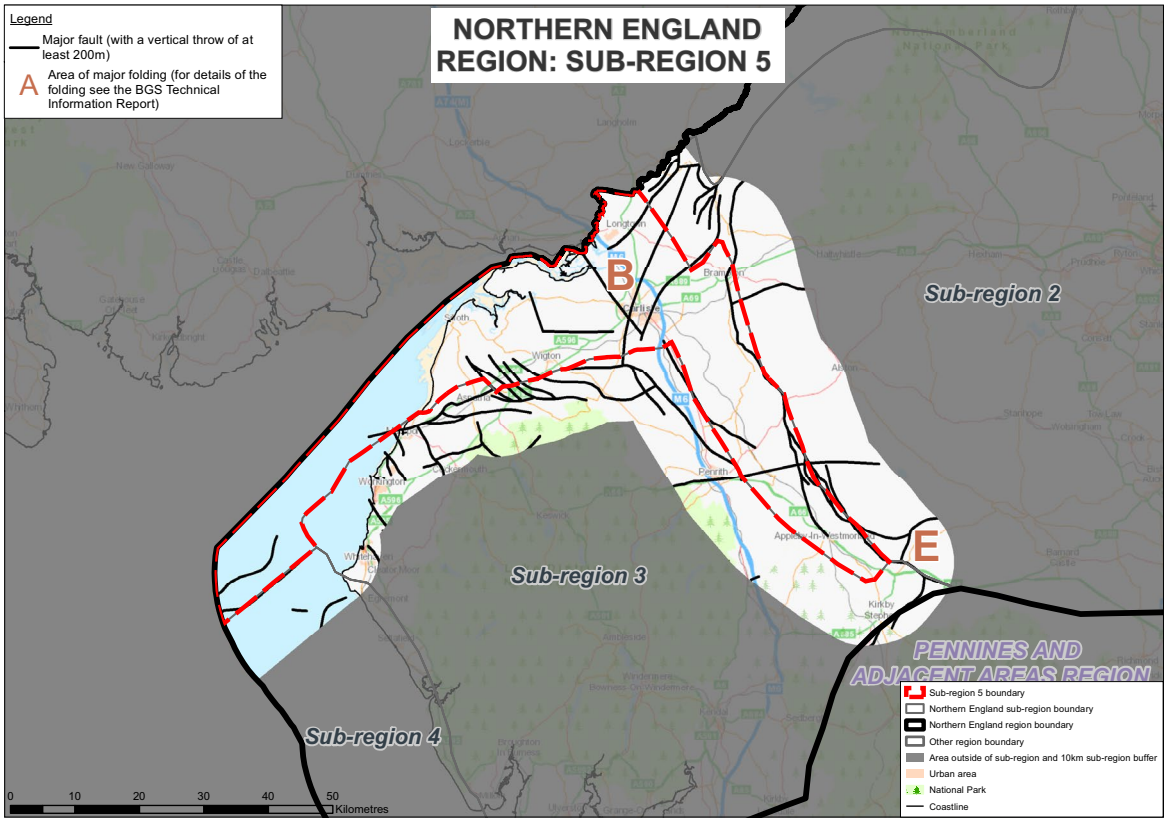


Figure 3 Areas in the Northern England subregion 5 with concentrations of deep exploration boreholes.

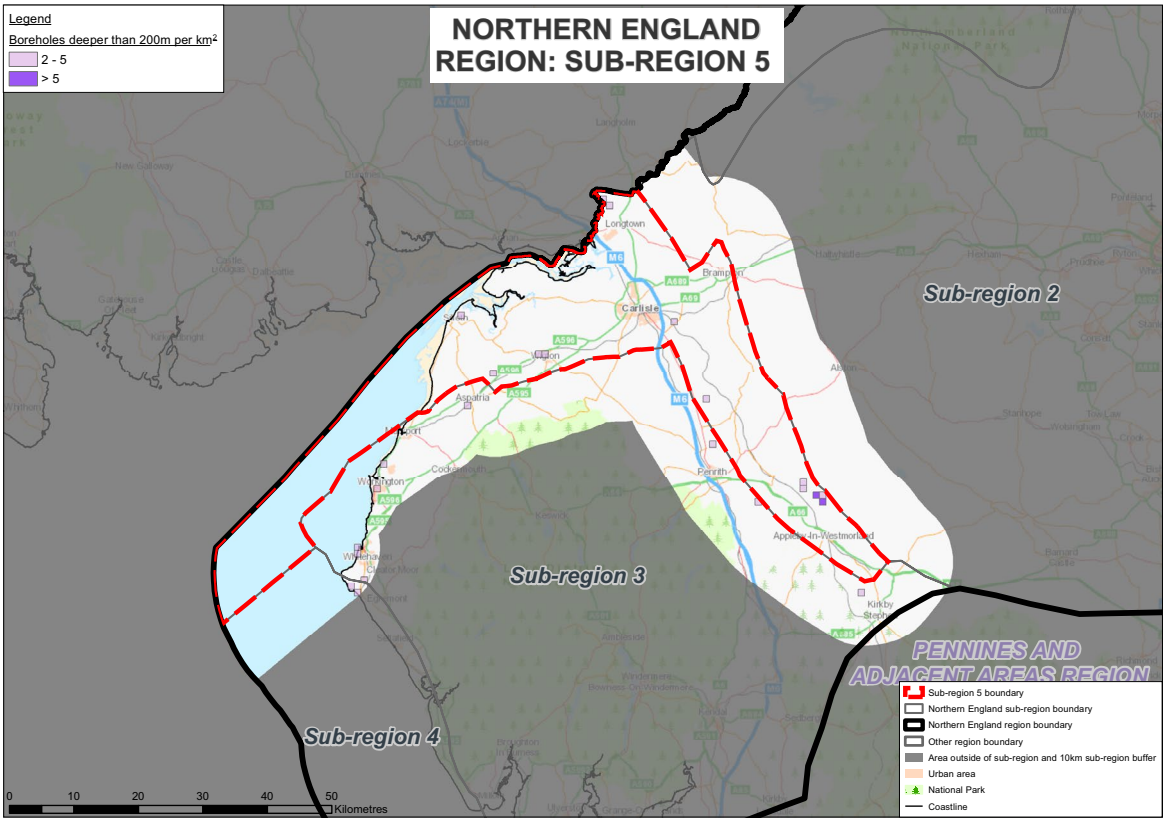


Figure 4a Areas of the Northern England subregion 5 with coal mines more than 100m deep and Coal Authority Licence Areas.

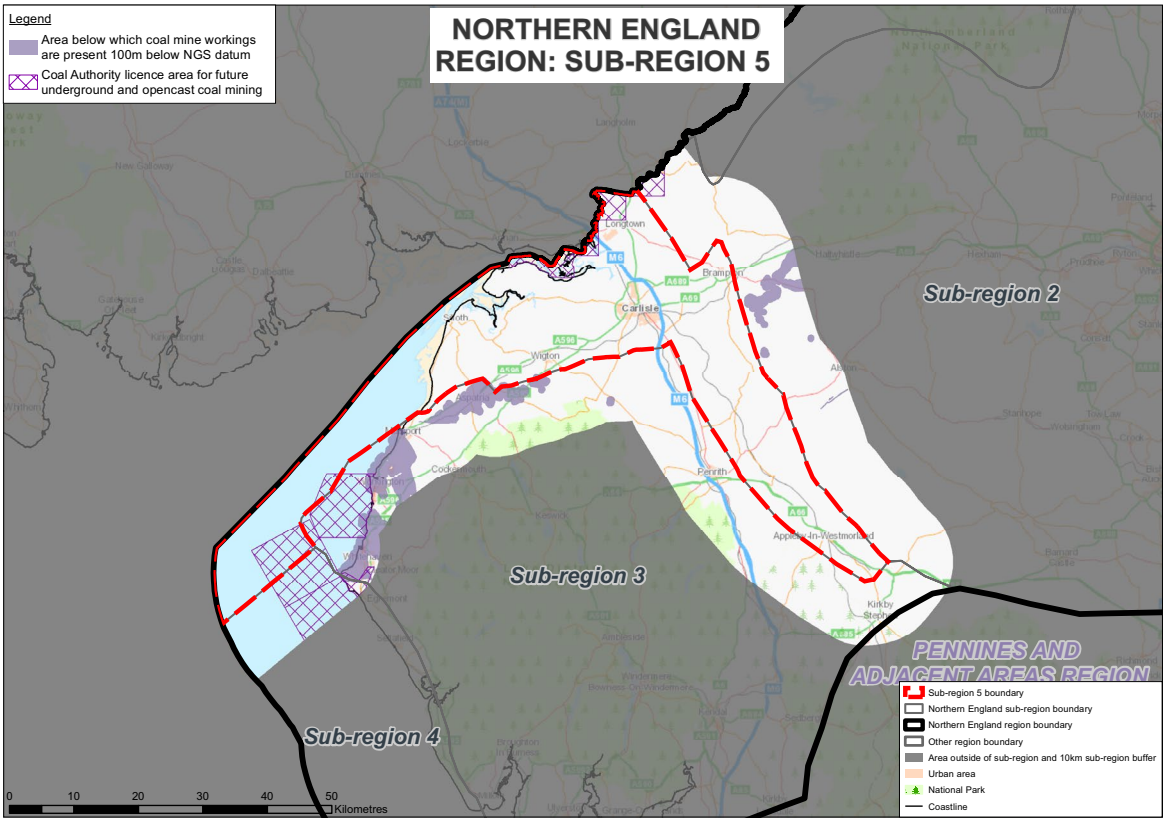
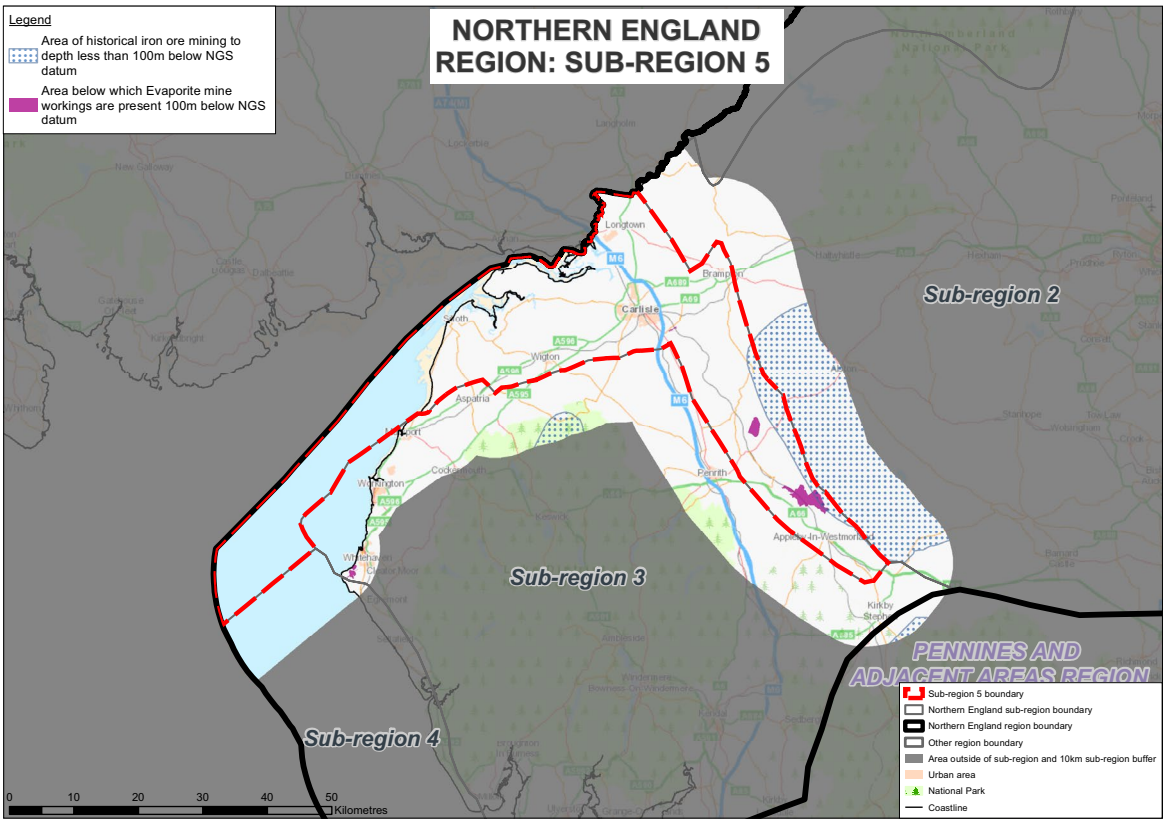


Figure 4b Areas of the Northern England subregion 5 with historical iron ore mines less than 100m deep and evaporite mines present below 100m.



Glossary

Anhydrite
A calcium sulphate mineral that forms from the evaporation of salty seas. It contains no water and occurs at greater depths and higher temperatures than gypsum.

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.

Conglomerate
Coarse sedimentary rock comprising large, rounded pebbles, and even boulders, set in a finer grained background, or matrix. Conglomerates accumulate in land and submarine environments, often at the margins of fault-bounded basins where fast-flowing rivers enter low-lying valleys.

Dolomite
Magnesium carbonate mineral which often is found in limestones.

Evaporite
The generic term for rock created by the evaporation of water from a salt-bearing solution, such as seawater, to form a solid crystalline structure. Gypsum, anhydrite and halite are all types of evaporite.

Fault
A fracture in the earth's crust across which the rock layers each side of it have been offset relative to one another.

Gypsum
A calcium sulphate mineral that forms from the evaporation of salty seas. It contains water and occurs at shallower depths and lower temperatures than anhydrite.

Halite
A sodium chloride evaporite mineral that forms when salty water dissolves. Also known as rock salt, or just 'salt'.

Nodules
Small, often irregular mineral precipitations found within sedimentary rocks. They usually have a contrasting composition to the rock in which they are found e.g. flint nodules in chalk.

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.

Saline
Containing salt (e.g. seawater is saline).

Sedimentary
A type of rock resulting from the consolidation of material that has accumulated in layers to form gravel, sandstone, mudstone and limestone. The layers may be built up by movement from erosion (e.g. by rivers, the sea or wind) or by chemical precipitation. Generally, the material that accumulates has originated from the weathering of other rocks. Sedimentary rocks constitute one of the three main classes of rocks identified by geologists, the others being igneous and metamorphic.

Vein
Sheet-like accumulations of minerals that have been intruded into fractured rock. Commonly they are made up of quartz or calcite crystals but can also contain small concentrations of precious metals.

Radioactive Waste Management

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