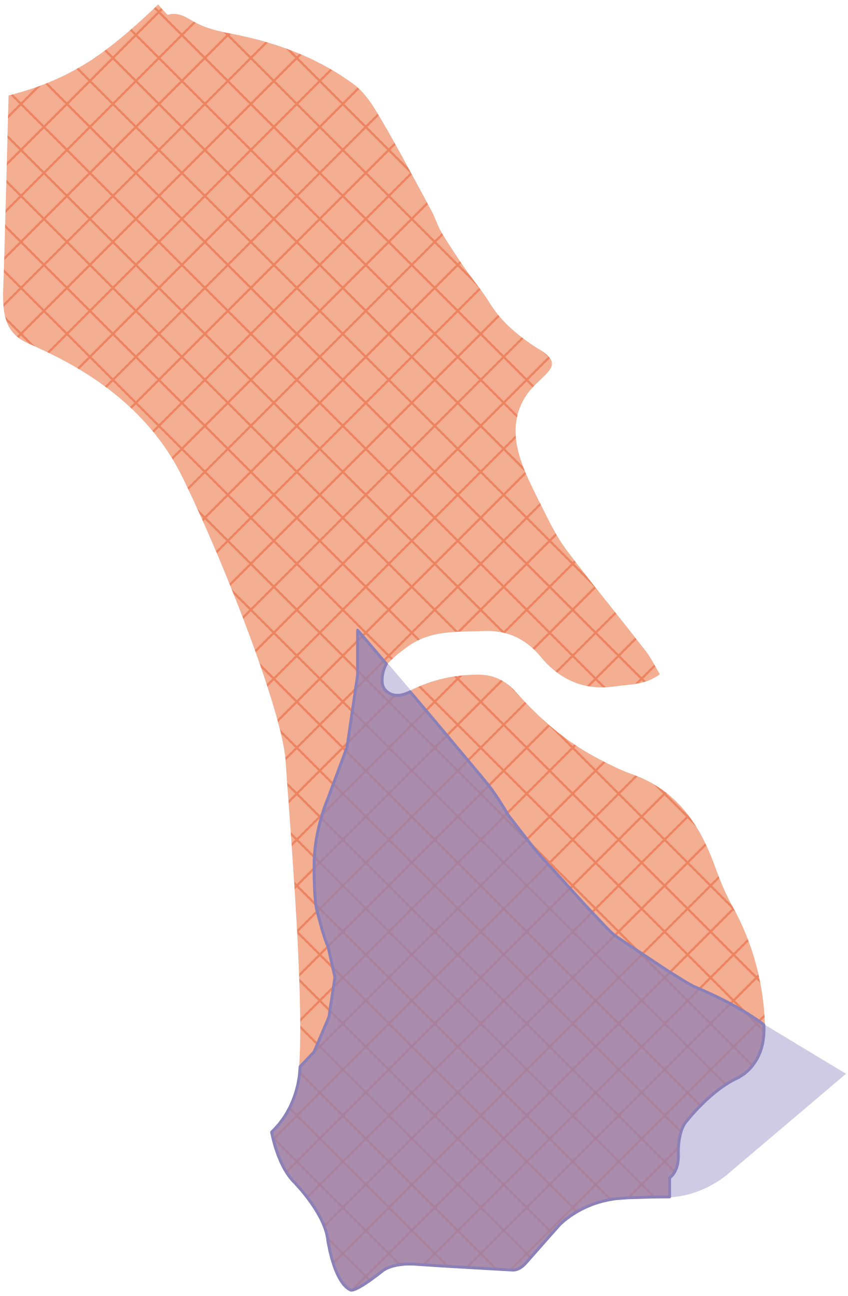
Radioactive Waste Management



Eastern England

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

Although rock cannot generally be seen at the surface in this subregion, except in man-made excavations such as quarries or road cuttings, numerous deep boreholes and geophysical investigations give us an understanding of the rocks present and their distribution.

There are clay-rich rock layers under the whole subregion in which we may be able to site a GDF. There are also layers of rock salt around Scunthorpe and granites and similar strong rocks around Boston and Grantham in which we may be able to site a facility. We would need to do more work to find out whether these rocks have suitable properties and thicknesses.

Even where individual clay-rich rock layers are found not to be thick enough to host a GDF they may contribute to the safety 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.

Some of the subregion, between Lincoln, Gainsborough and Market Rasen in particular, has known oil and gas resources. In these areas the 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.

Parts of this area, around Scunthorpe and Lincoln in particular, 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 oil or gas in these licence areas will be exploited. RWM will continue to monitor how this exploration programme progresses.

Introduction

This subregion comprises the southern part of the Eastern England region south of the River Humber, excluding the Lincolnshire Wolds and the western edge of the region as far south as Newark-on-Trent. It includes the northern, inshore half of the Wash.

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 depth range of interest in this subregion is occupied by a well-known sequence of sedimentary rocks including sandstones, limestones and mudstones. They overlie basement rocks about which relatively little is known, and which occur within the depth range of interest in the south of the subregion. Two Lower Strength Sedimentary Rock (LSSR) layers are present within the depth range of interest in this subregion (Figure 1b).

- The Lias Group is present below most of the subregion and occurs at the surface in a north-south trending band from Grantham to the Humber. Over 100m thickness of Lias Group is present within the depth range of interest in the east of the subregion as it tilted downward towards the coast. The mudstone dominated Lias Group mainly comprises mudstones and shales, but also contains frequent layers of sandstone or limestone. It is unlikely that individual mudstones are thick enough to act as a host rock, but the Lias Group provides an effective barrier to groundwater movement from depth towards the surface.
- Some 250 to 300m thickness of the Mercia Mudstone Group is present across the whole subregion. The thick mudstones within the Mercia Mudstone Group are known to act as a barrier to groundwater movement in other regions and have the potential to act as LSSR host rocks where they are sufficiently thick.

Further information on the characteristics of the Lias and Mercia Mudstone Groups at depth under this subregion would need to be obtained to determine whether they have the potential to host a GDF. 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 need to be considered during the siting process.

The few deep boreholes that have been drilled into the basement rocks underneath the sedimentary rocks in this area indicate granites and lavas of Ordovician age (approx. 445 to 485 million years old), the distribution of which has been interpreted based upon the results of geophysical surveys (seismic surveys, gravity and magnetic) (Figure 1c). At present there is little information on the nature of these basement rocks at these depths and new investigations would be required to establish their potential as Higher Strength Rock (HSR) hosts.

The youngest and shallowest evaporite cycle in the Zechstein Group, the Sneaton Halite Formation, is likely to occur at the bottom of the depth range of interest in the very north of this subregion (Figure 1d). Deep boreholes have shown that this formation contains rock salt (halite), potash, anhydrite and mudstone although there are not enough deep boreholes in this area to know whether the size and shape of the rock salt bodies would be suitable for an Evaporite host rock.

A summary of the geological attributes of the Eastern 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

Some major faults that affect the deeper basement rocks have been identified by extensive geophysical surveys across the subregion (Figure 2). These do not generally reach the surface but they have had an influence on the thickness of the potential LSSR layers within the sedimentary rocks deposited on top of the basement rocks in this area. 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]. There is no major folding in this subregion.

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. One principal aquifer is present within 400m of the surface in this subregion: the Sherwood Sandstone Group. It is widely used for public water supply, agriculture and industry to the west of the subregion, and is overlain by the Mercia Mudstone Group, a major barrier to groundwater movement. These units dip to the east with evidence of increasingly saline water in the Sherwood Sandstone as it becomes deeper. Two other rock types, which are principal aquifers in other regions, where they occur at shallow depths, are also present below this subregion but at depths too deep to be exploited as aquifers. The LSSR units in this subregion are likely to act as barriers to vertical flow between deep and shallow groundwater even where they are not thick enough to host a GDF. Samples of water collected from Carboniferous Limestone aquifer boreholes have shown saline water. The presence of older, more saline groundwater in these deeper rock units, compared to fresh groundwater present near the surface, provides evidence that there is hydraulic separation between deep and shallow rock units. Groundwater from depths greater than 400m is unlikely to be suitable as drinking water anywhere in the UK[2].

In some areas in the subregion, to the west of Lincoln in particular, deep exploration boreholes may influence the connectivity between shallow and deep groundwater which would need to be considered during the siting process (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

There are several small operational oil fields between Lincoln, Gainsborough and Market Rasen in particular (Figure 4a). In these areas the 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. These known resources would be taken into account in the siting of a GDF.

Petroleum Exploration and Development Licences[3] are currently held for the areas around Scunthorpe and Lincoln (see Figure 4a). It is not known whether oil or gas in these licence areas will be exploited but they would need to be considered during the siting process. There are deep (up to 1,000m in depth) coal deposits within the subregion for which there are no current licences.

Areas of historic iron ore mining are also shown in Figure 4b but are not relevant to the siting of a GDF as they 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.

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

Figure 1a The areas of the Eastern England subregion 3 where any of the 3 rock types of interest are present between 200 and 1,000 m below NGS datum.

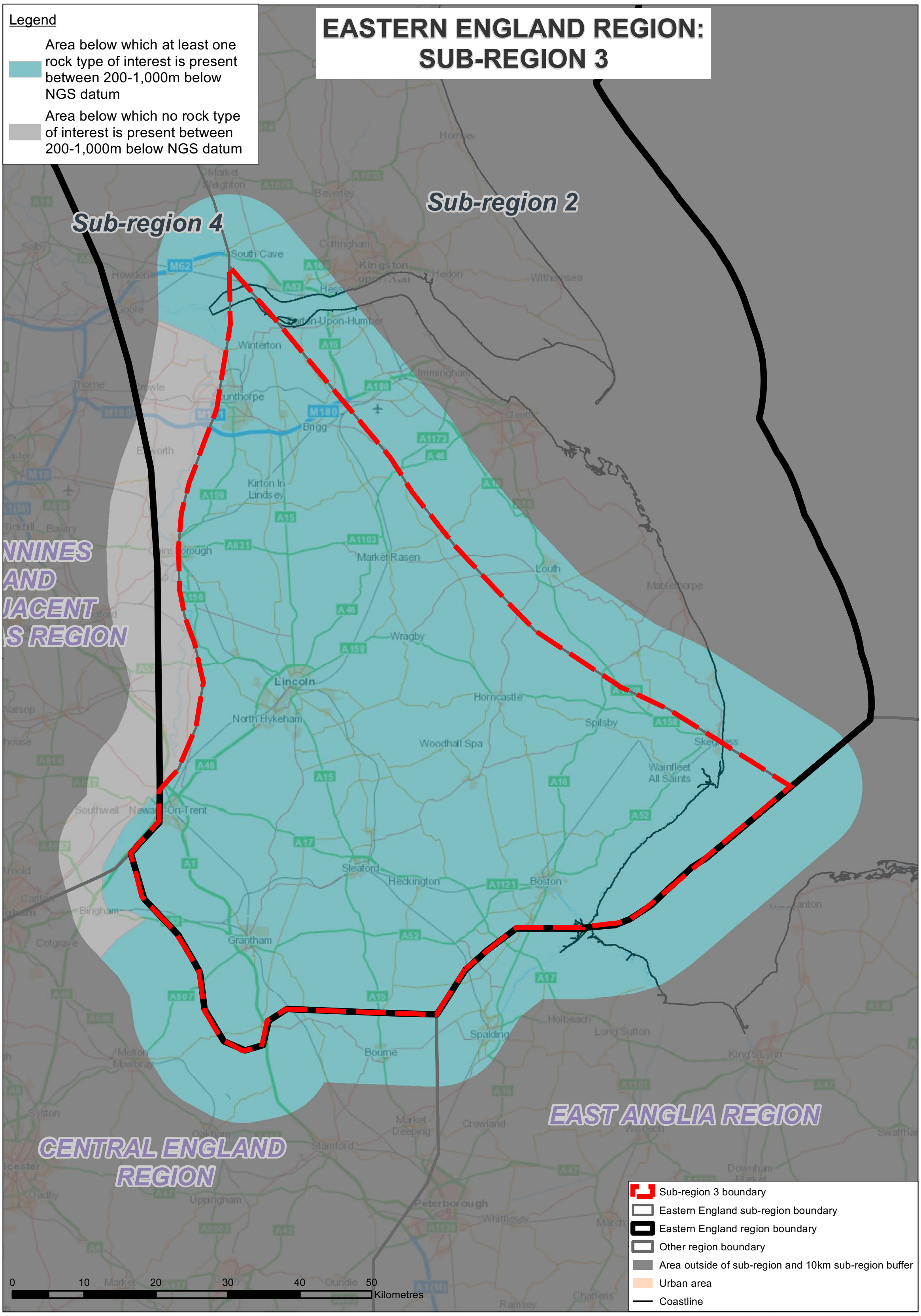


Figure 1b The areas of the Eastern England subregion 3 where Lower Strength Sedimentary Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

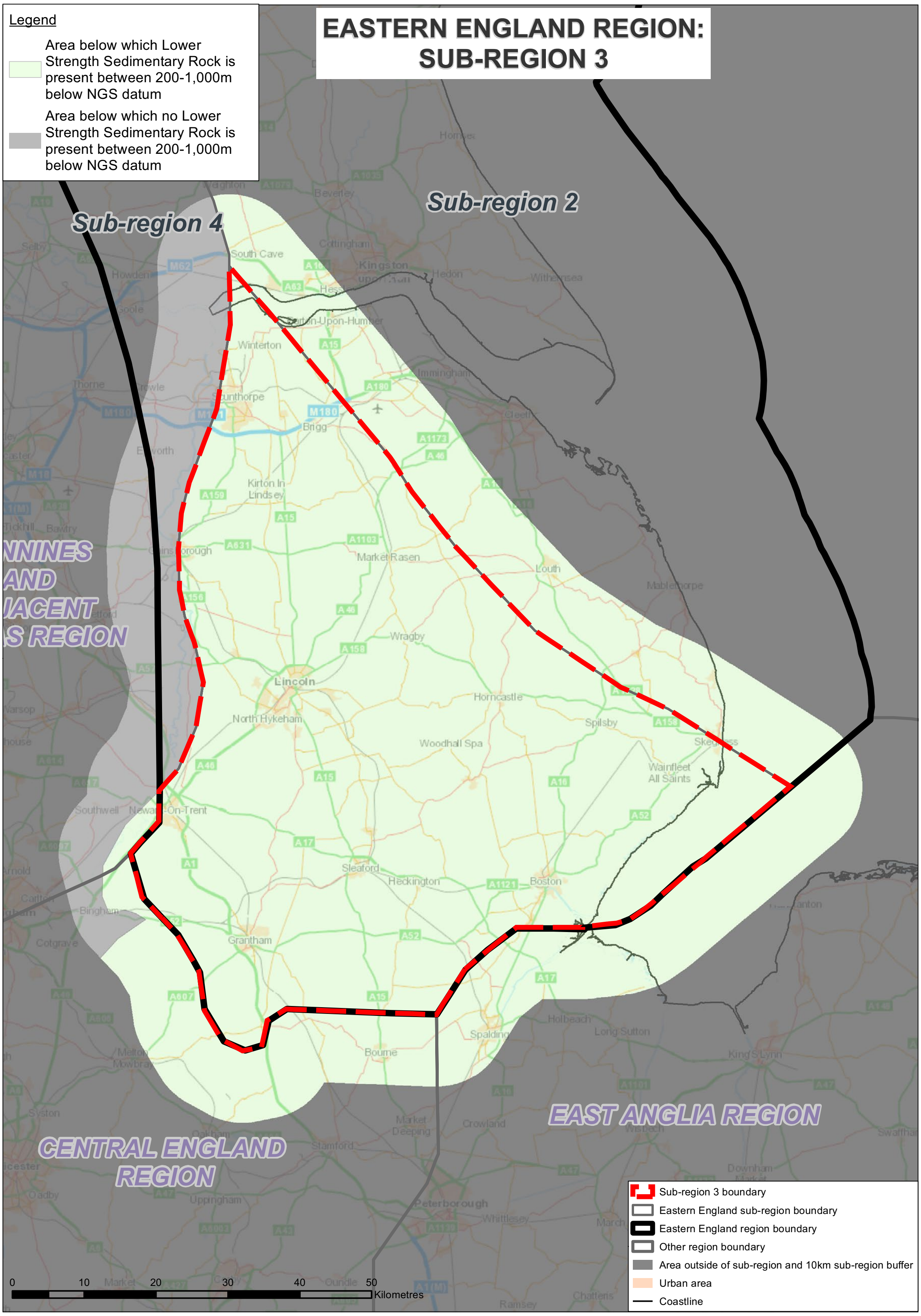


Figure 1c The areas of the Eastern England subregion 3 where Higher Strength Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

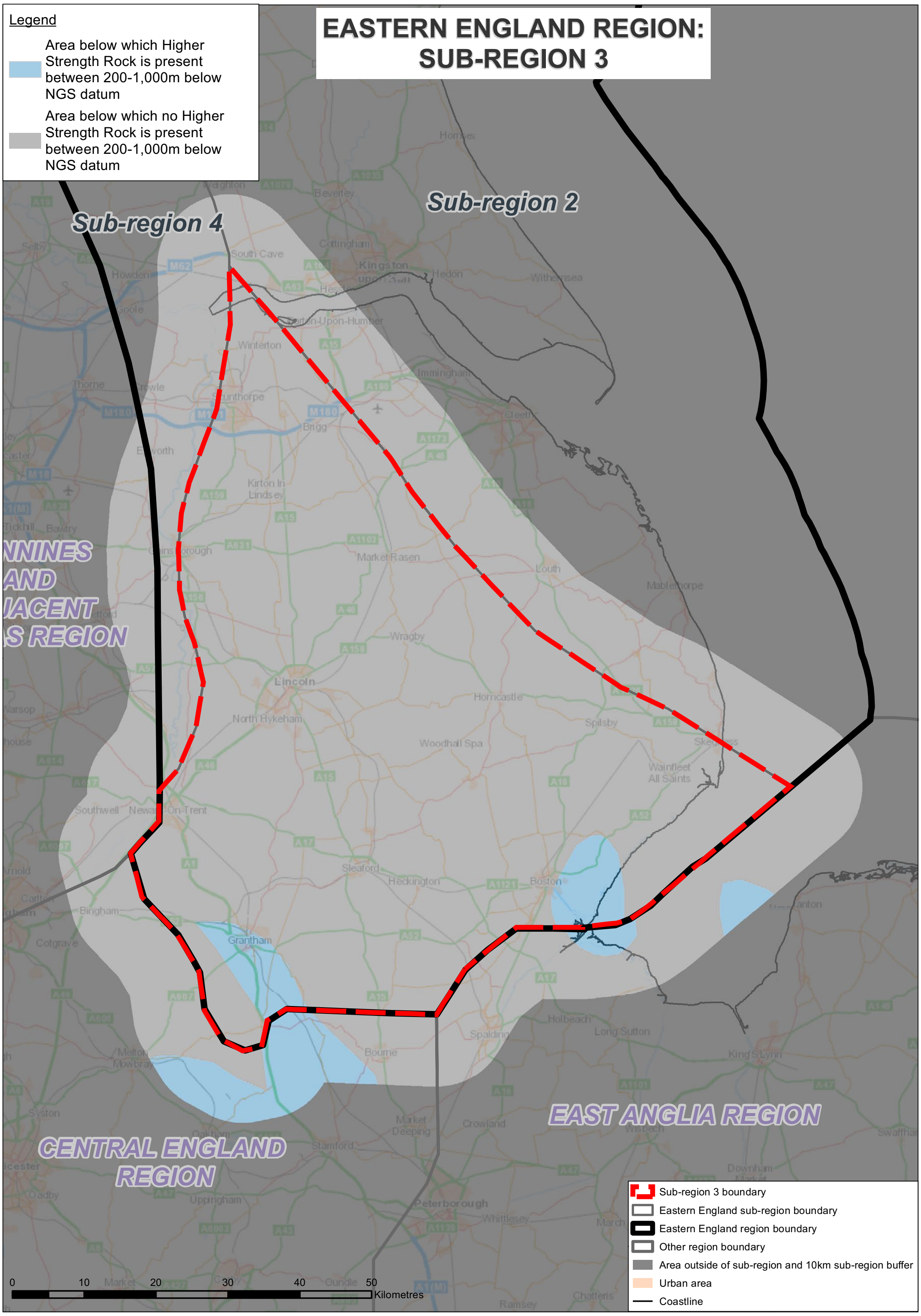


Figure 1d The areas of the Eastern England subregion 3 where Evaporite Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

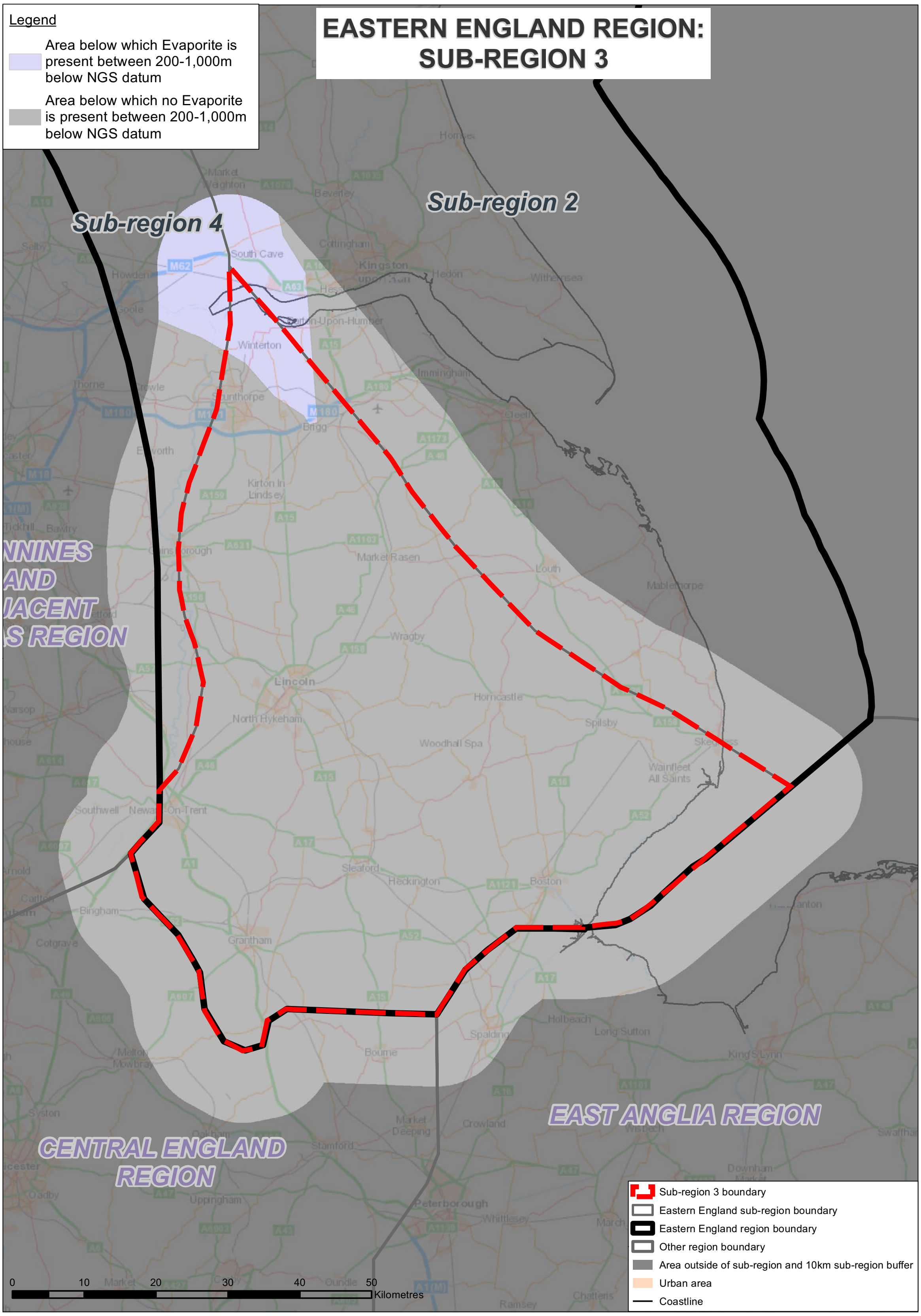


Figure 2 Location of major faults in the Eastern England subregion 3.

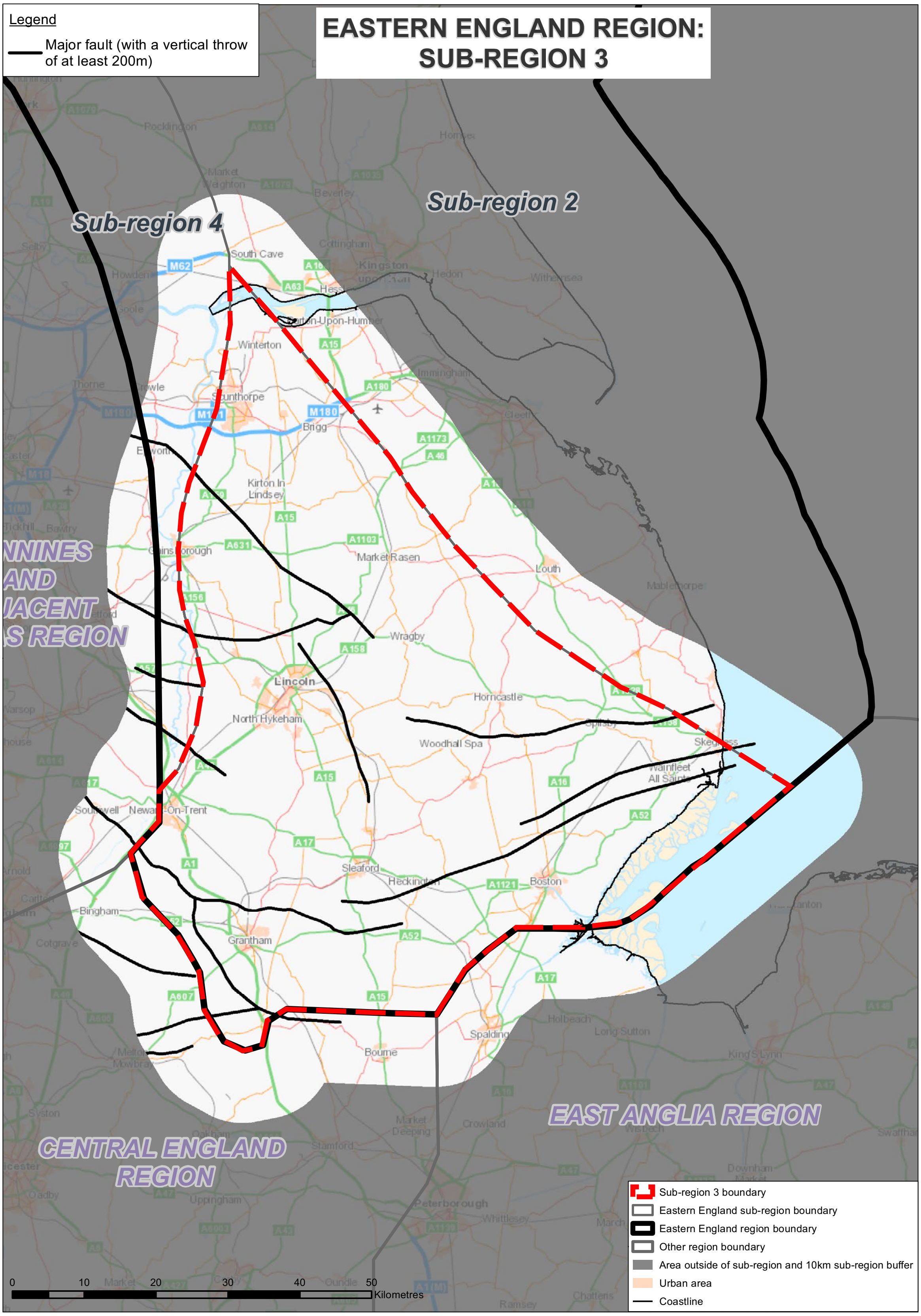


Figure 3 Areas in the Eastern England subregion 3 with concentrations of deep exploration boreholes.

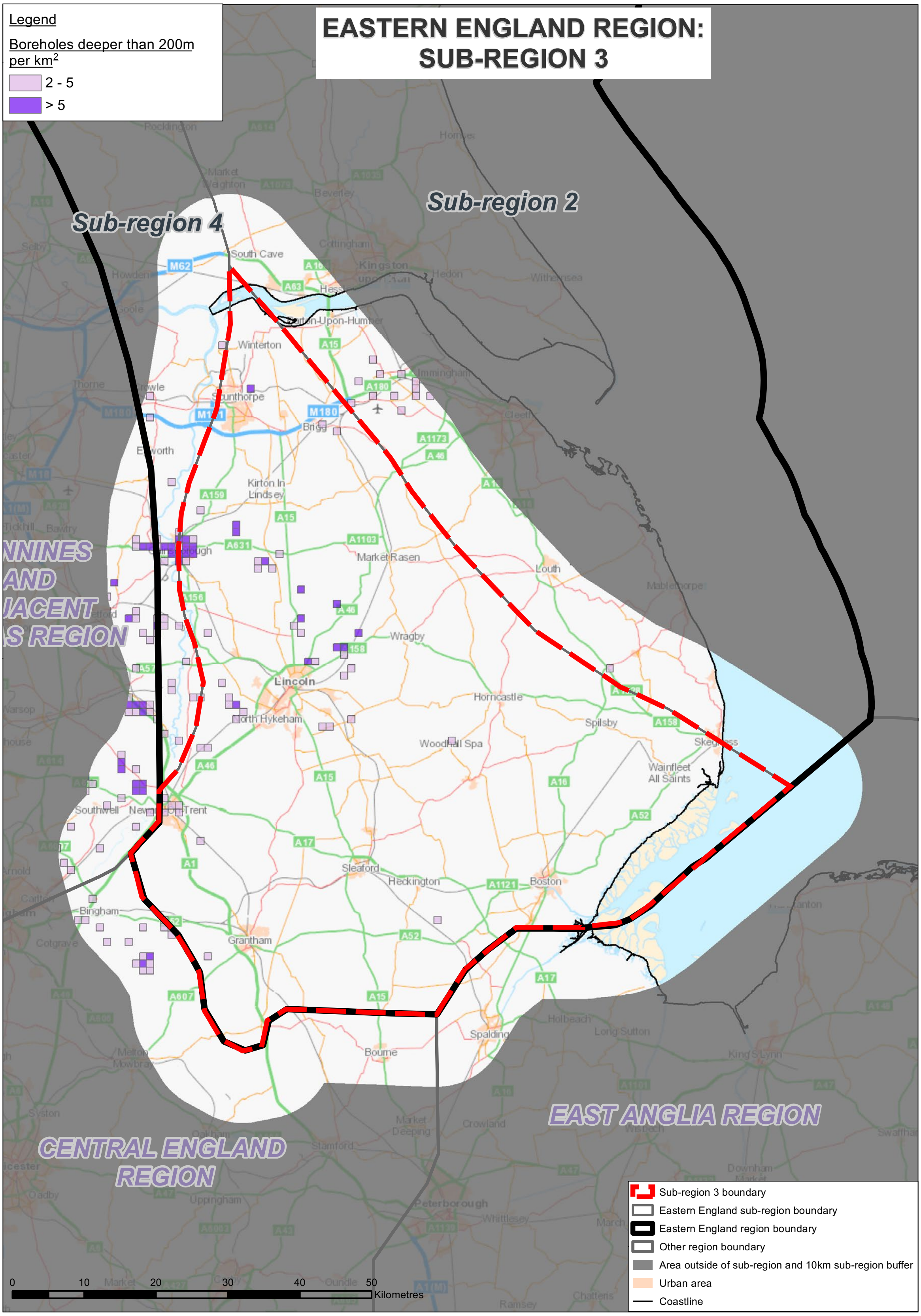


Figure 4a Areas of the Eastern England subregion 3 with oil and gas fields and Petroleum Exploration and Development Licences.

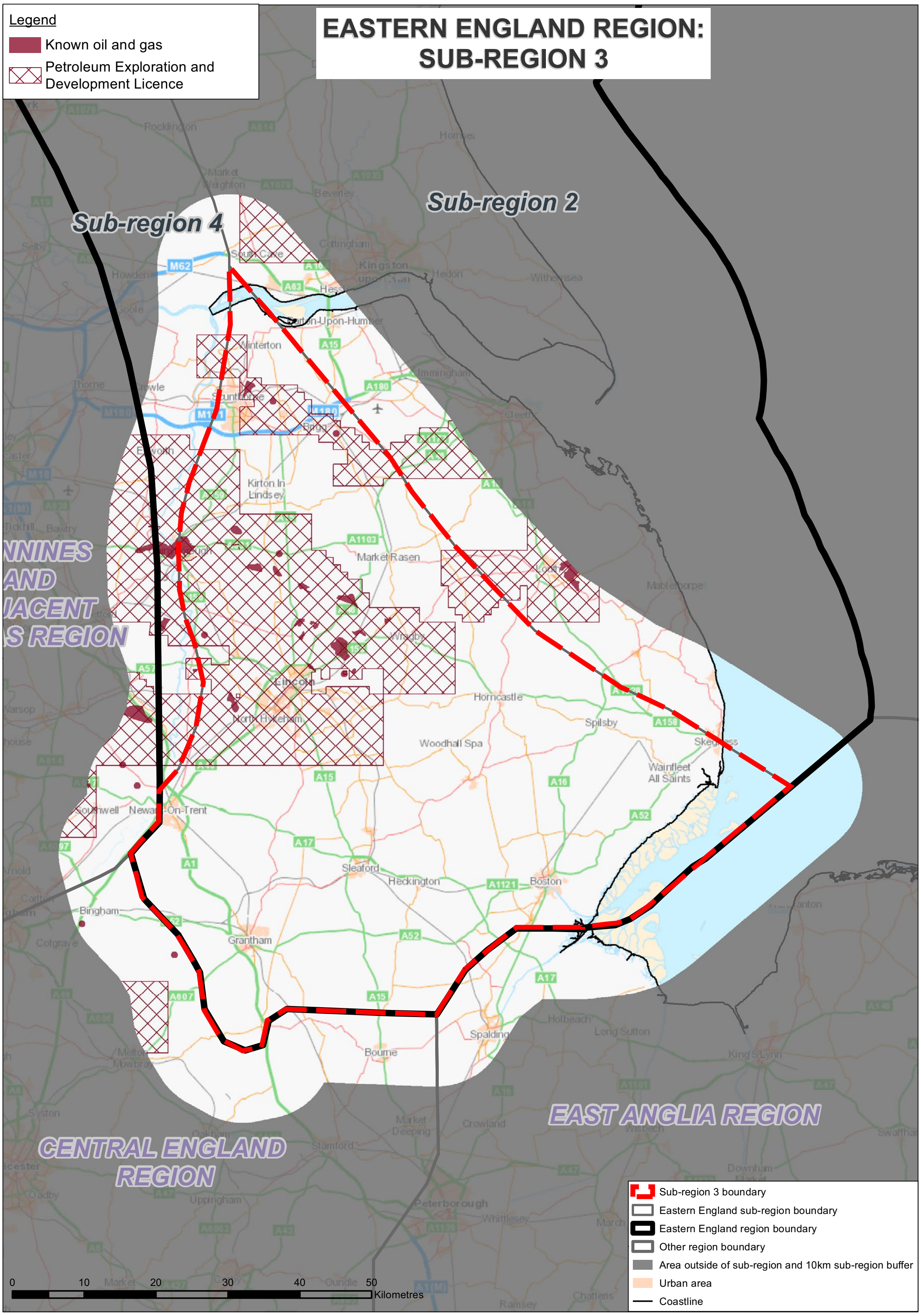
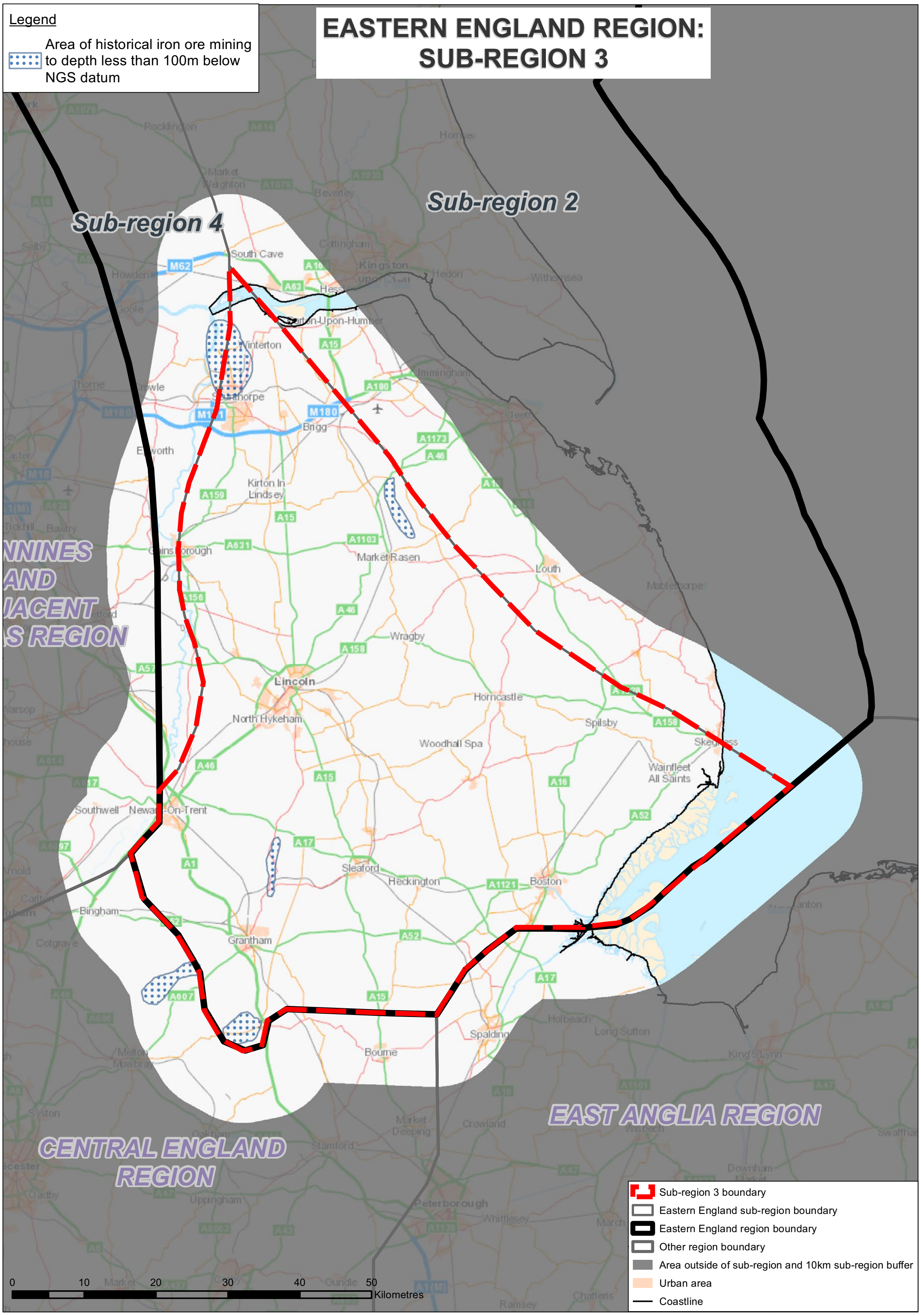


Figure 4b Areas of the Eastern England subregion3 with historical iron ore mines less than 100m deep.



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.

Dip
The angle, or slope of a plane, such as sedimentary layering, measured relative to the horizontal.

Evaporite cycle
An evaporite cycle is a sequence of rocks left behind after a body of salty water has evaporated Often this cycle is repeated numerous times within a sequence.

Granites
Pale-coloured, coarse crystalline igneous rock rich in silica, sodium, calcium and potassium

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

Lavas
A mass of flowing or solidified lava. After cooling and solidification, lava flows often form distinctive topographical features.

Potash
The collective term for potassium-bearing evaporite minerals. Potash is mined in the UK for use in fertilizer.

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.

Seismic survey
Geophysical method that produces an image of the subsurface by transmitting shock waves, or seismic energy, into the ground and measuring the pattern of energy that is reflected back to the surface. Widely used by the resource industries to provide information on the composition and structure of the underground geology.

Shales
A very fine-grained and strongly layered sedimentary rock in which the grains are not visible to the naked eye. Consists of clay grains and tiny fragments of other minerals such as quartz and mica.

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