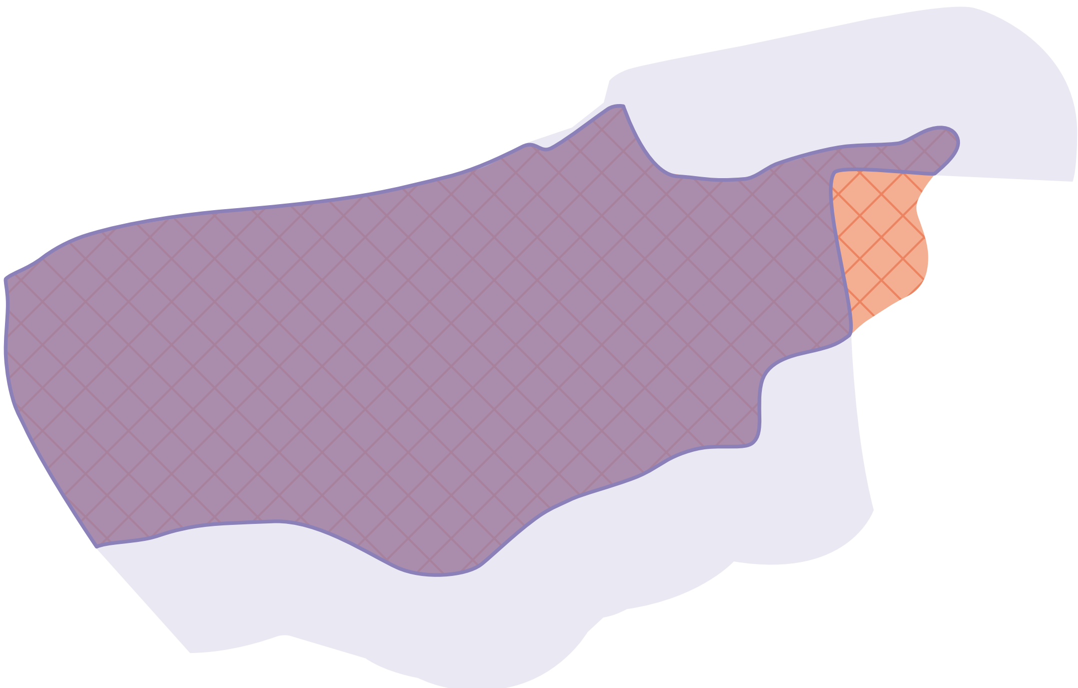
Radioactive Waste Management



# Wealden District

## SUBREGION 1

# 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.

Rock can be seen at the surface in some parts of the subregion including the extensive sea cliffs, inland cliffs around Tunbridge Wells and in man-made excavations such as quarries or road cuttings. Combined with numerous deep boreholes and geophysical investigations, this gives us an understanding of the rocks present and their distribution.

There are clay-rich rock layers under the whole of the subregion in which we may be able to site a GDF. There are also slates and similar strong rocks, between Maidstone, Rye and Hythe and extending under the English Channel, 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 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 known oil and gas resources in the north and centre of the subregion, in particular to the south of Guildford, east of Redhill and north of Chichester and Worthing. 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 the west of this 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 oil or gas in these licence areas will be exploited. RWM will continue to monitor how this exploration programme progresses.

Parts of this area, in the Thames Estuary north of Sheerness and between Canterbury and Hythe, 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.

Parts of the subregion which have been mined for gypsum, in the Brightling and Robertsbridge areas of east Sussex, 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 comprises the majority of the Wealden District region excluding only the Kent Coalfield. It includes the adjacent inshore area which extends to 20km from the coast.

## Rock type

Figures 1a to 1c 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 geology of this subregion comprises a well-known and predictable sequence of younger sedimentary rocks throughout the depth range of interest. This sequence contains the following Lower Strength Sedimentary Rock (LSSR) layers with the potential to host a GDF (in increasing depth order):

- The Gault Clay Formation is present in the depth range of interest towards the margins of the subregion, in north Kent and Surrey, Sussex and immediately adjacent parts of Hampshire. In this subregion it typically consists of 40 to 90m of soft mudstones and silty mudstones reaching a maximum thickness of 110 to 120m near Guildford.
- The Wealden Group includes 3 thick mudstone units, comprising the Wadhurst Clay Formation (27 to 78m thick in boreholes in the subregion), the Grinstead Clay Member (9 to 27m thick in boreholes in the subregion), and the Weald Clay Formation (121 to 454m thick in boreholes in the subregion), each separated by thick units composed largely of sandstone. The Weald Clay Formation occurs within the depth range of interest in the western part of the subregion and does not occur off the coast in this subregion. It is dominated by shales and mudstones, but also includes numerous beds and lenses of sandstone and siltstone, pebble beds, shelly limestones and clay ironstones.
- The Kimmeridge Clay Formation is 200 to 500m thick within the depth range of interest over much of the subregion. It drops below the depth range of interest in the extreme west and thins to 13m in a borehole beneath the North Downs. It is thickest under the centre of the Weald Basin in the Ashdown Forest area and also occurs off the coast.
- The Oxford Clay Formation occurs in the lower half of the depth range of interest around the edges of the Weald Basin, but in the centre of the basin is below the depth range of interest. Where it is within the depth range of interest it is likely to comprise between 50 to 100m of mudstones with minor siltstones and silty limestones.
- The mudstone dominated Lias Group occurs at the bottom of the depth range of interest in the east and south of this subregion. Boreholes have indicated predominantly mudstones and shales between 167 to 480m thick in this subregion. However, this layer also contains frequent layers of higher permeability sandstone and limestone. As a result, it is unlikely that individual mudstones are thick enough to act as a host rock, but the Lias Group provides an effective barrier to movement of groundwater from depth towards the surface. Further investigations would therefore be needed to determine whether the Lias Group is suitable to host a GDF in any given location.

- The Mercia Mudstone Group in the western part of the subregion includes mudstones and siltstones up to 106m thick, though these lie well below the depth range of interest. The Group locally rises into the depth range of interest towards the east, but thins substantially and sandstones, breccias and conglomerates become common constituents. Further investigations would be needed to determine whether the Mercia Mudstone Group was suitable to host a GDF in any given location.

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.

Potential Higher Strength Rocks (HSRs) within the older sedimentary and basement rocks occur between Maidstone, Folkestone and Hastings and extending into the inshore. Mudstones and siltstones of Silurian age (approx. 420 to 445 million years ago) were encountered in boreholes at Bobbing near Sittingbourne and Cliffe near Rochester. These sedimentary rocks occur to the north of the Variscan Front and are therefore expected to be relatively weakly metamorphosed and less likely to be suitable as host rocks as a result. However, a borehole at Brightling, located 12.5km east of Heathfield, encountered Devonian mudrocks (approx. 360 to 420 million years old). The BGS considers that since these mudrocks are located to the south of the Variscan Front, they are likely to have been folded and metamorphosed and may be slaty. However, there is little information on the nature of these rocks and further information would be required to evaluate their potential as HSR hosts.

A summary of the geological attributes of the Wealden District 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

The sedimentary rocks are affected by local faulting across much of this subregion. 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].

Whilst the overall structure of the Weald is that of a large-scale anticline, the angle of dip of strata is generally of the order of a few degrees except where sedimentary layers are tilted steeply by local faulting e.g. The Hogsback.

[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. Several principal aquifers are present within 400m of the surface around the margins of this subregion including the Chalk Group and the Upper and Lower Greensand and Portland Stone Formations. The Chalk Group is vitally important to public water supplies as it is the most important groundwater source in the subregion and is consequently relatively well understood. Studies have shown that the main groundwater flow is concentrated near the top of the Chalk Group, in the zone of water table fluctuation, with little flow deeper than 50m below the water table. Some parts of the shallow Chalk aquifer have developed as karst, where concentrated flow of mildly acidic groundwater has enlarged fractures by dissolution to form a network of major fissures, resulting in fast movement of groundwater near the surface. The thick layers of LSSR described in the section above are likely to act as barriers to vertical flow between the various more permeable shallow units described here and the groundwater at depth, even where they are not thick enough to host a GDF. Groundwater from depths greater than 400m is unlikely to be suitable as drinking water anywhere in the UK[2].

There are some areas, such as around Battle, where 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.

## Resources

There are 8 gas fields in the north and centre of the subregion and 7 oil fields (Figure 4a). Currently all 7 oil fields are producing, but only 1 field actively produces gas, at Albury near Guildford. 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 west of the subregion (see Figure 4a) which also extend into the extreme southern ends of London and Thames Valley subregions 2 and 3. There are also Coal Authority Licence Areas, off the coast to the north of Sheerness which also extend into the southern end of the London and Thames Valley subregion 2 and at the eastern edge of the region between Canterbury and Hythe associated with the Kent Coalfield (Figure 4b). 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.

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

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

Gypsum is mined in the area just north of Battle, at depths below 100m in the Brightling and Robertsbridge areas of east Sussex (Figure 4c). Until 1990, gypsum was also worked underground from a mine at Mountfield in the same area. The maximum depth of working is around 300m below NGS datum. 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.

Parts of the subregion contain mudstones or shales that have been identified as having potential for shale oil and/or shale gas. As yet there has been no drilling or testing to prove any resources, but this would also need to be taken into account in the siting of a GDF.

Depleted hydrocarbon fields have been considered for underground gas storage within the subregion, but so far none have progressed to the planning application stage.

A significant part of the subregion to the south of Tunbridge Wells was mined for iron ore historically (Figure 4c) but is 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 Wealden District subregion 1 where any of the 3 Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

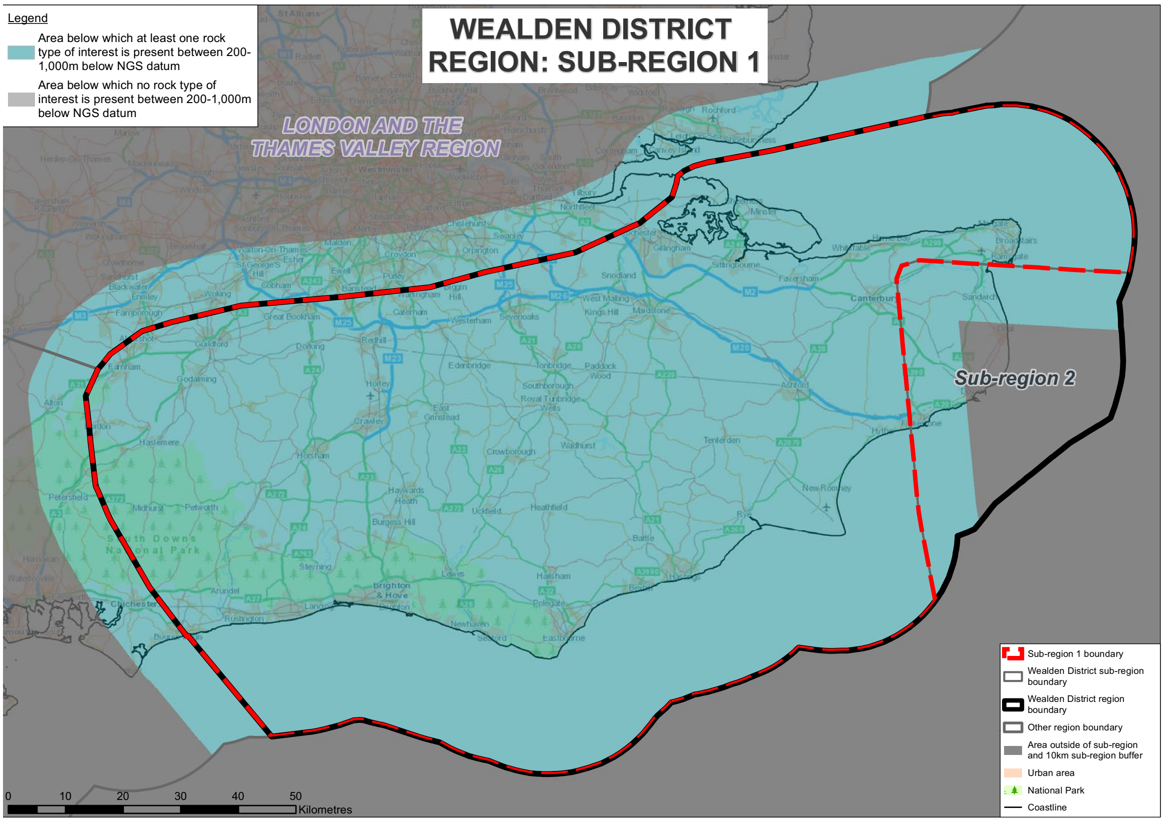



**Figure 1b** The areas of Wealden District subregion 1 where Lower Strength Sedimentary Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

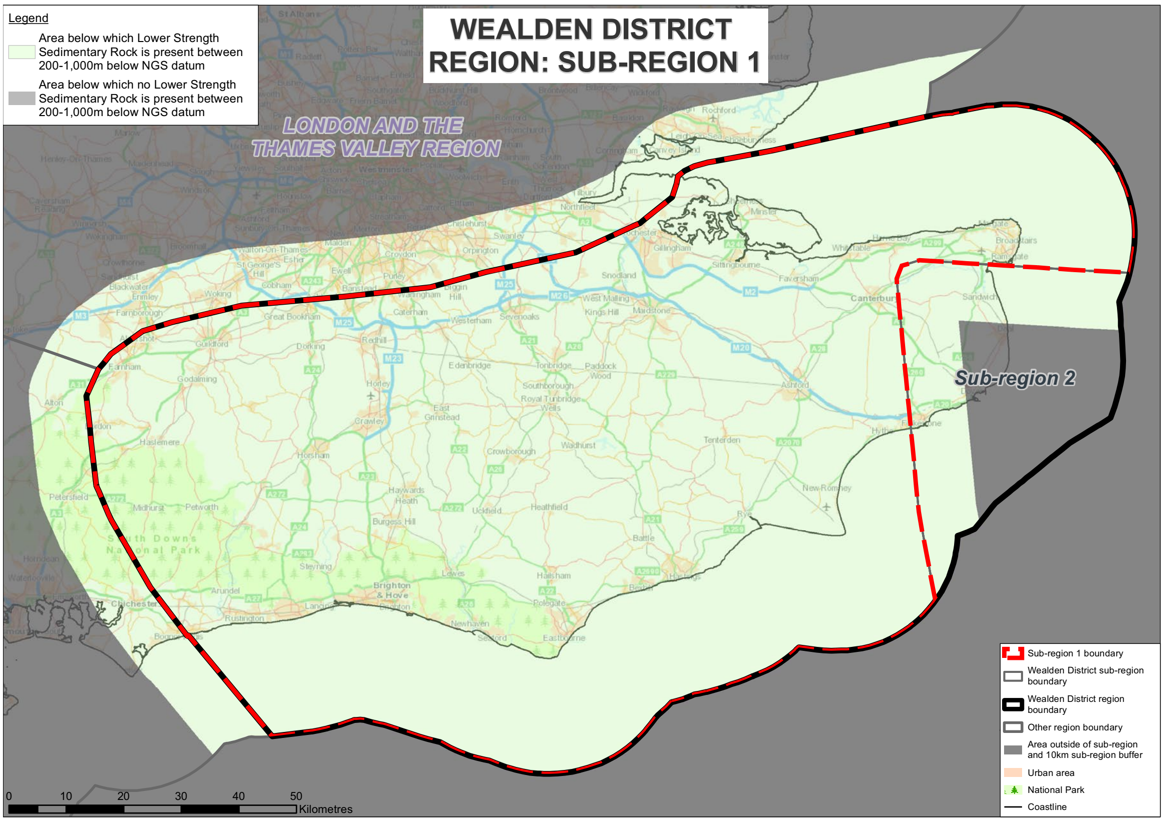


**Figure 1c** The areas of Wealden District subregion 1 where Higher Strength Rock Types of Interest are present between 200 and 1,000 m below NGS datum.

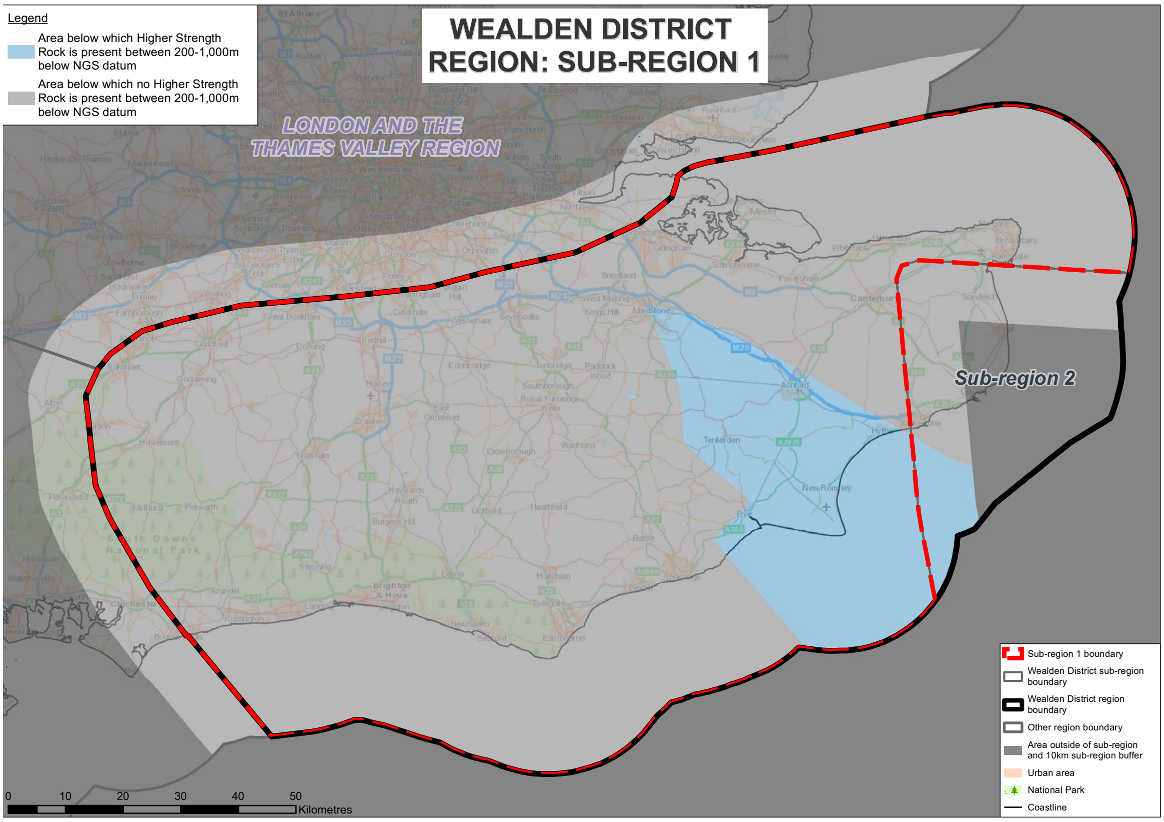



**Figure 2** Location of major faults and folds in Wealden District subregion 1.

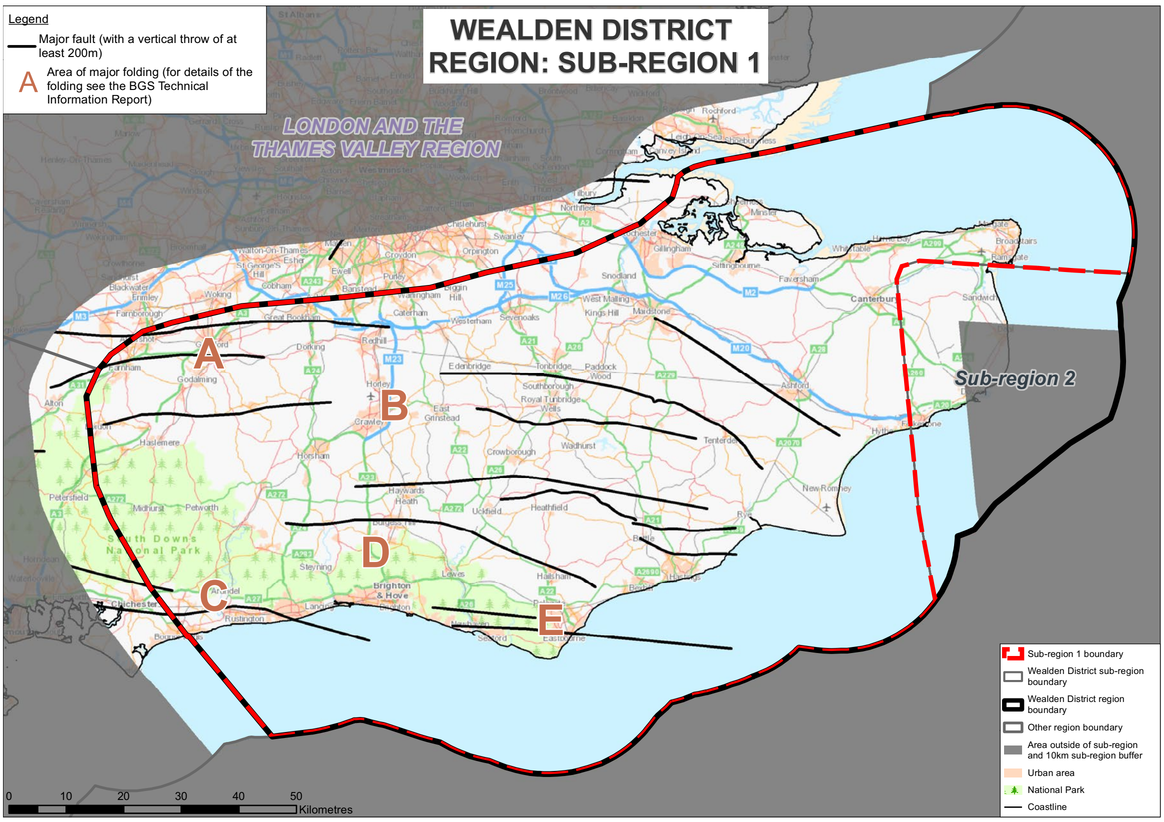


**Figure 3** Location of intensely drilled areas in Wealden District subregion 1.

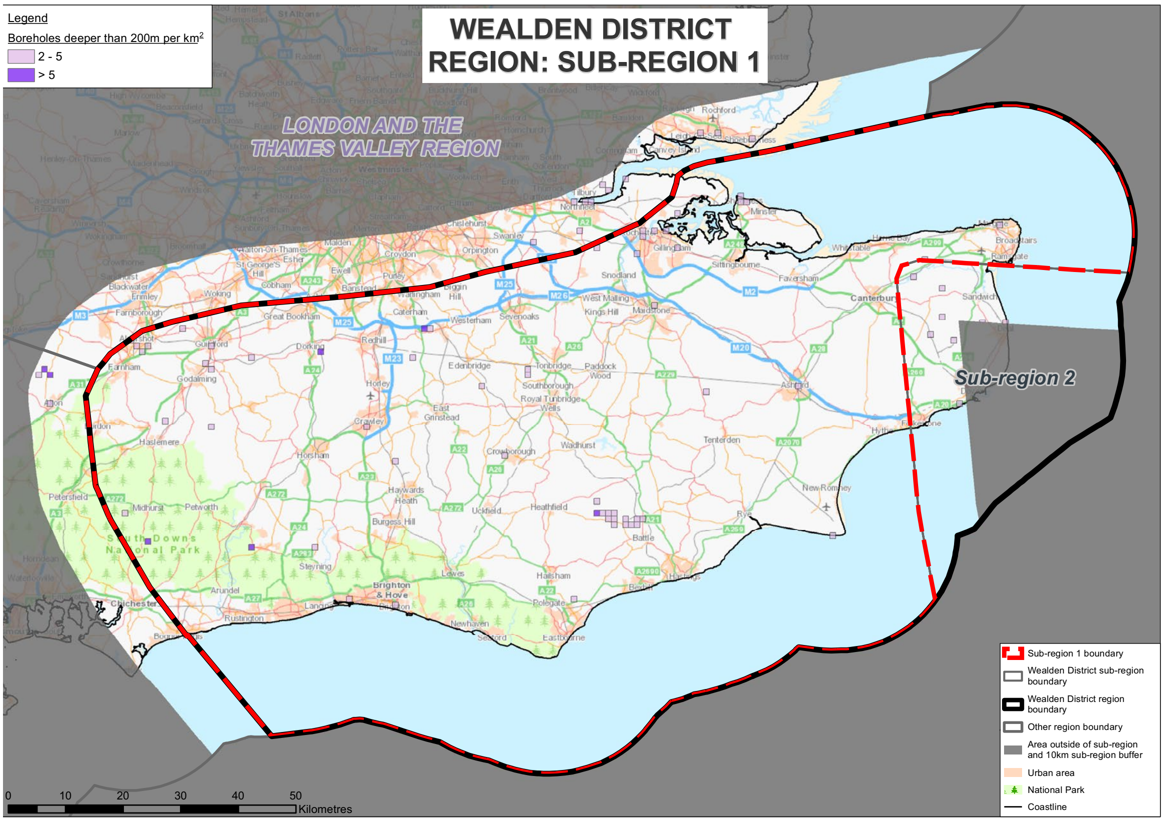



**Figure 4a** Areas of Wealden District subregion 1 with oil and gas fields and Petroleum Exploration and Development Licences.

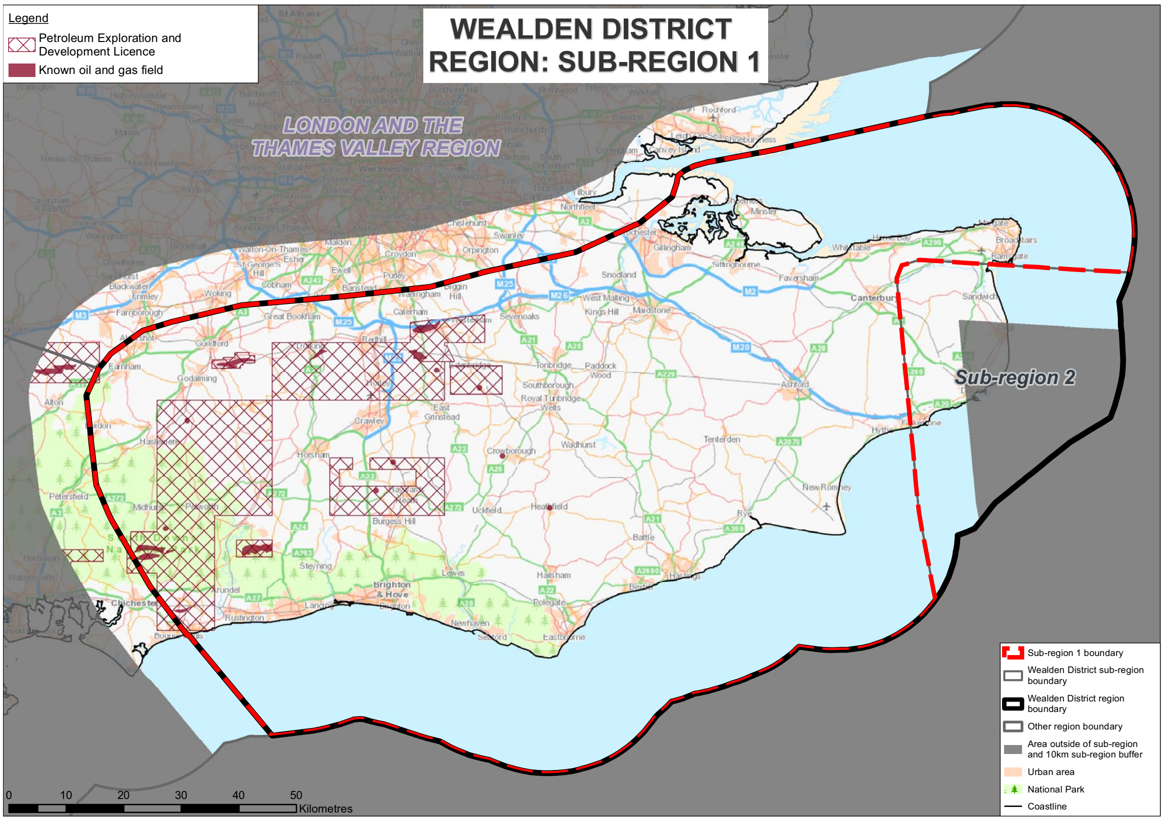


**Figure 4b** Areas of Wealden District subregion 1 with Coal Authority Licence Areas.

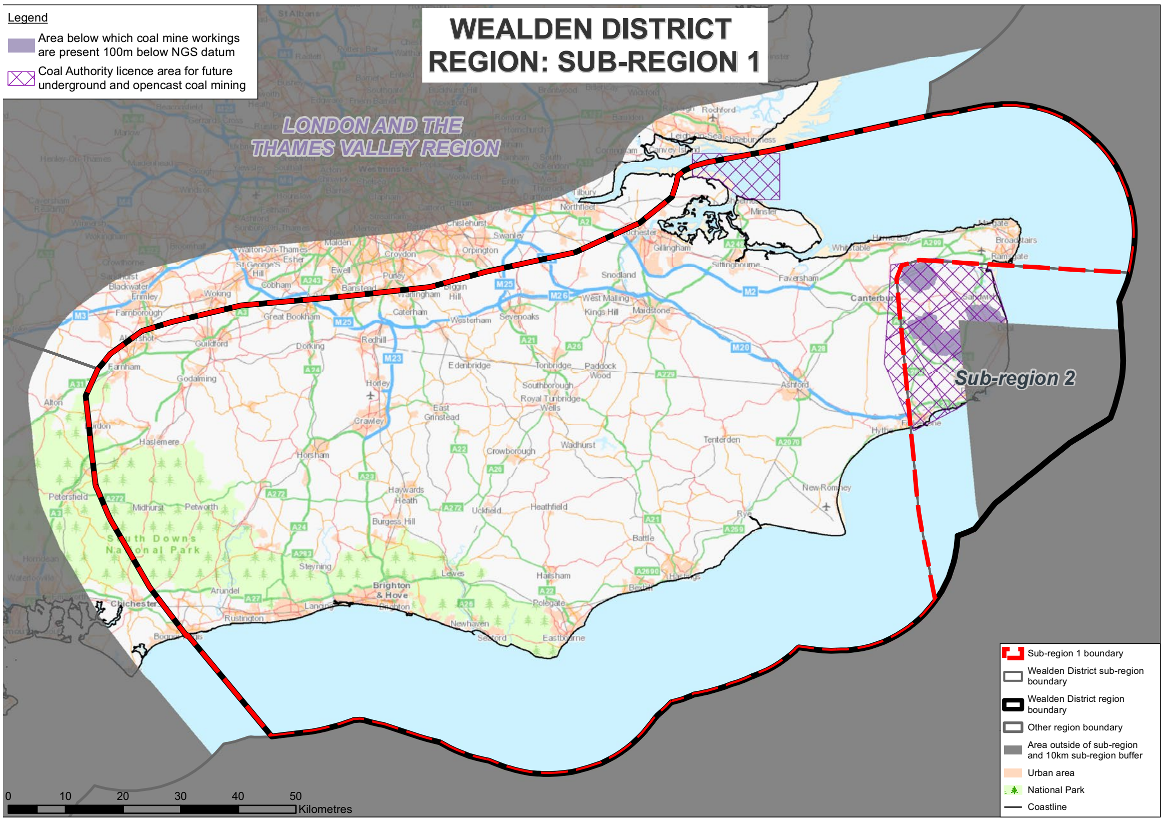
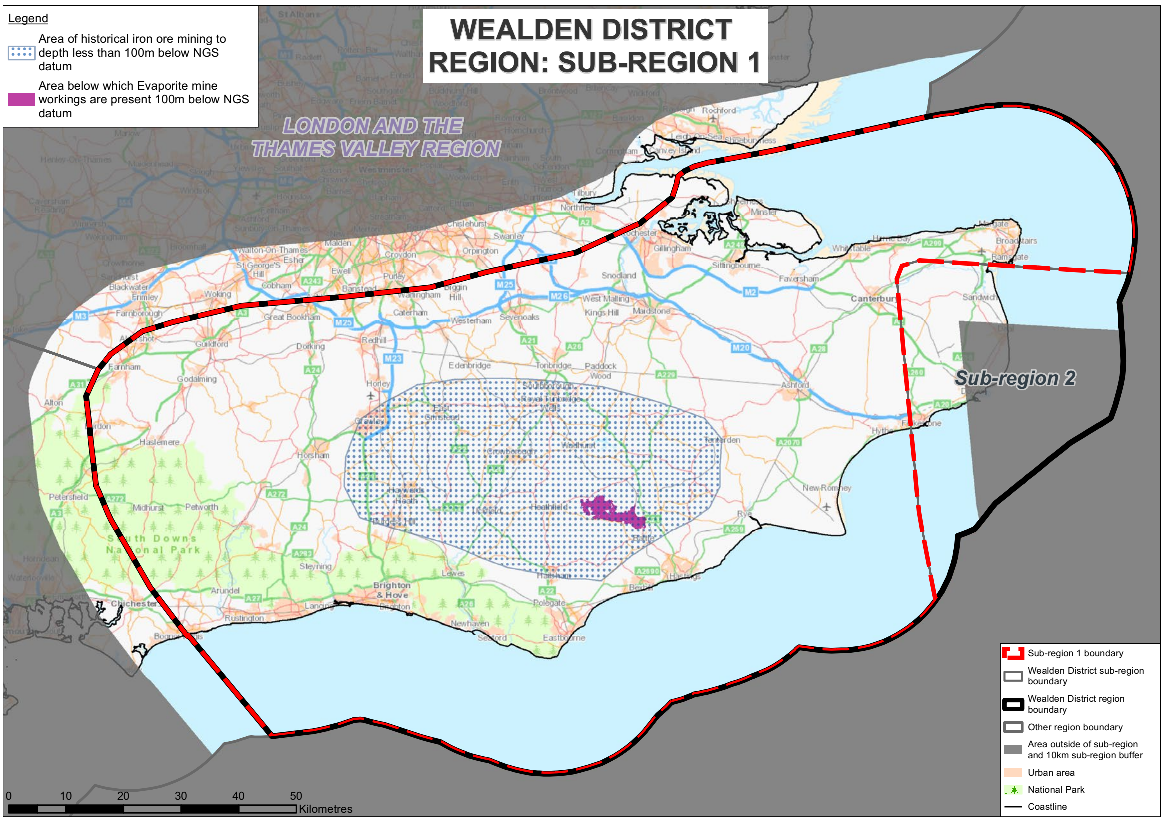



**Figure 4c** Areas of Wealden District subregion 1 with historical iron ore mines less than 100m deep and evaporite mines present below 100m.



# 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.

### Breccia
A type of sedimentary rock made up of large angular clasts. The space in between the fragments is filled with a smaller 'matrix' material which cements the larger clasts together.

### 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.

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

### 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.

### Hydrocarbon
A compound of hydrogen and carbon. Hydrocarbons are the chief components of oil and natural gas.

### 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.

### Metamorphosed
A rock that has undergone change due to the action of temperature and pressure.

### 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.

### 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.

### 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.

### Shale gas
Gas that is naturally generated and trapped within shales that contain a high amount of organic material. Shale gas can be extracted for use as a fuel in heating or power generation by a technique known as hydraulic fracturing or ‘fracking’.

### Shale oil
Oil that is naturally generated and trapped within shales that contain a high amount of organic material . Shale oil can be extracted by a technique known as hyrdaulic fracturing or ‘fracking’ and used as a fuel in heating or power generation, or refined into petroleum products.

### Slaty
Distinctive way in which slate rocks split into very fine sheets.

### Hydrocarbon
A compound of hydrogen and carbon. Hydrocarbons are the chief components of oil and natural gas.

### Variscan
An episode of mountain-building during the Carboniferous period that led to deformation of the basement rocks of much of the southern UK.

**Radioactive Waste Management**

Building 587
Curie Avenue
Harwell Oxford
Didcot OX11 0RH

T 03000 660100
www.gov.uk/rwm