4 Mineral resources

4.1 Introduction

The earliest records of exploitation of a geological resource in Doncaster, other than water supply, refer to peat cutting, which has continued from mediaeval times and was until recently carried out on a large scale by mechanised means. In contrast, the sand and gravel industry has expanded enormously since the Second World War. However, the most important industry based on a geological resource is coal mining. This began in the first decade of the 20th century with the sinking of several deep shafts, forming part of the extension of the Yorkshire Coalfield eastward into its ‘concealed’ region. This industry, more than any other, has been responsible for the large increase in population in the district, mainly concentrated in Doncaster and adjacent areas, during the present century, and it has enabled other industries to develop in these areas. More recently there has been some exploration for deep hydrocarbon sources in the district, and although the results are extremely modest by comparison with other regions in and around Britain, the gas find which produced a spectacular ‘blow out’ on Hatfield Moors late in 1981 has now been tapped for industrial use.

4.2 Resources and reserves

Mineral resources are natural concentrations of minerals or bodies of rock that are, or may become, of potential interest for the economic extraction of a mineral product. They exhibit physical and/or chemical properties that make them suitable for specific uses and are present in sufficient quantity to be of economic interest. Areas that are of potential economic interest as sources of minerals change with time as markets expand or contract, product specifications change, recovery technology improves or more cost-effective sources become available.

That part of a mineral resource, which has been fully evaluated and is commercially viable to extract is called a mineral reserve. In the context of land-use planning, the term mineral reserve should strictly be further limited to those minerals for which valid planning permission for extraction has been granted (i.e. permitted reserves). Without a valid planning consent no mineral working can take place and consequently the economic value of the mineral resource cannot be released.

Currently active, ceased and recently disused mines and quarries from the BGS BritPits Database are shown on (Figure 10).

4.3 Sand and gravel

Sand and gravel resources occur in a variety of geological environments. In the Doncaster area these resources occur mainly within superficial deposits, resulting from glaciofluvial, glaciolacustrine, fluvial and aeolian processes. Additional sand and gravel resources occur within the bedrock.

Sand and gravel are defined on the basis of particle size rather than composition. In current commercial practice, following the introduction of new European standards from 1 January 2004, the term ‘gravel’ (or more correctly coarse aggregate) is used for general and concrete applications to define particles between 4 and 80 mm, and the term ‘sand’ for material that is finer than 4 mm, but coarser than 0.063 mm. For use in asphalt 2 mm is now the break point between coarse and fine aggregate. Most commercial sand and gravel is composed of particles that are rich in silica (quartz, quartzite and flint).

4.3.1 River sand and gravel (Terrace and sub-alluvial deposits)

Resources occur in both raised river terrace sequences flanking the modern floodplains and in floodplain terrace deposits underlying present day alluvium. This sequence of deposits is best developed along the River Don with a succession of deposits formed, representing accumulations of sand and gravel in response to falling sea level in Pleistocene times.

Extensive terrace deposits occur around Bentley at up to 12 m above OD. These deposits consist of sand, thin beds of fine gravel in which most of the pebbles are of Carboniferous rocks, and thin clay beds. Coal particles are present in the sand fraction. The deposits pass laterally into glaciolacustrine silt and clay deposits. East of Doncaster, fluvial deposits of sand and gravel form extensive flattish spreads, commonly referred to as Older River Gravels. These deposits consist of beds, lenses and layers of both pebble-free sand and well-sorted fine to medium gravel with a sand matrix. Variations in composition of the gravel fraction show that the more northerly deposits around Dunsville were derived from the west, presumably via the Don, with the predominant composition of the pebbles being Carboniferous sandstone. In areas rich in Carboniferous-derived materials, coal detritus, usually in the form of coarse sand-sized particles can comprise up to 1 per cent of the deposit.

The Older River Gravels are worked for sand and gravel at several sites in the Doncaster district, primarily in the Finningley area and to the northeast of Doncaster for example, at Dunsville Quarry. At both Finningley and Austerfield Quarries, Older River Gravels, the original focus of extraction, have now been depleted. Current extraction at Finningley is from adjacent glaciofluvial deposits while extraction at Austerfield is now from the underlying Sherwood Sandstone Group.

Sub-alluvial gravels are encountered beneath the alluvium of the major valleys throughout the area. The extent of alluvium has been modified in places by land management practices, including the construction of drainage channels and the deposition of Warp (silt and clay) during periods of artificially controlled flooding. The deposits are compositionally similar to the river terrace deposits. They were mainly laid down during periods of deep downcutting during the late Devensian cold phase when sea-levels fell to at least –100 m OD. The subsequent rise in sea level enabled silting up of these river channels producing thick overlying alluvial deposits. The deposits rest on an irregular channelled surface and are thus of very variable thickness. These deposits are always saturated and require wet working.

4.3.2 Glaciofluvial deposits

The sequence of glaciofluvial deposits is complex with units commonly exhibiting intricate relationships. Bodies of sand and gravel may occur as sheet-like layers or ridges on top of the sheet of till (boulder clay) or as elongate, irregular lenses within the till sequence. Areas of wholly concealed, and thus unknown, bodies of sand and gravel may occur under spreads of till and other drift deposits.

Glaciofluvial deposits occur in the east of the county, where they form elongate ridges and mounds capping the Doncaster and Rossington ridges and adjacent hills. These deposits have been described in detail in BGS Mineral Assessment Reports Nos. 37 and 92. The deposits comprise beds, lenses and layers of both pebble-free sand, and gravel with a sand matrix. They are fairly well sorted, though a few cobbles and small boulders are present. The deposits rest mainly on Sherwood Sandstone and transgress locally over clay, till and glacial channel deposits.

4.3.3 Glaciolacustrine deposits

During the Devensian glaciation, ice occupying the present coastal zone farther east blocked the eastward-draining valleys including the Humber Gap between Brough and Winterton and thus impounded ‘Lake Humber’ in the southern part of the Vale of York. Glaciolacustrine deposits associated with this glacial lake occupy a wide irregular channel incised into Older River Gravels (see River sand and gravel) and Sherwood Sandstone, running from Doncaster Racecourse northeastwards towards Hatfield Woodhouse. They are present in the West Moor depression, in other low-lying localities towards the east (where they pass under the peat on Hatfield Moors) and under the alluvium of the River Don in the northwest. These deposits are predominantly bedded fine-grained sands and laminated clays up to 5 m in thickness. The sand fraction is predominantly fine-grained quartz; up to 35 per cent of medium-grained sand has been recorded but coarse-grained sand nowhere accounts for more than 1 per cent of these deposits.

4.3.4 Blown sand

Blown sand deposits occur in the east of the area and are largely concealed beneath peat and alluvium. The most extensive blown sand deposits crop out on the flanks of Thorne Moor, Hatfield Moor and south of Finningley. Extensive

deposits of sand, that rest in turn on glaciolacustrine silt and clay, also extend under the peat and alluvium of Thorne Moor and adjacent areas. This concealed sand varies from 0 to 3 m in thickness, with appreciable variations across short distances due to its undulating top. Blown sand is not worked in the area. These deposits are believed to be largely of late Quaternary age resulting from aeolian reworking of fluvial and glaciofluvial sands, particularly those associated with the Vale of York superficial deposits.

4.3.5 Bedrock Sand and Gravel

The sandstones and conglomerates of the Sherwood Sandstone Group, in particular the Nottingham Castle Sandstone Formation, have been worked mainly as a minor component in the floor of sites working overlying superficial sand and gravel deposits. This material is mainly friable, loosely consolidated and easily worked. It is largely composed of a fine "clayey" sand with generally <2 per cent gravel and is generally more suitable for building sand and asphalting than the 'sharper' alluvial sands which are used for concreting. Where more gravel is present or conglomeratic horizons occur, the clasts are mainly rounded and sub-rounded quartz and quartzite pebbles with subordinate Carboniferous sandstone fragments. The Sherwood Sandstone Group is currently worked at Austerfield Quarry. The sand, which is dry screened, is predominantly used for mortar sand and asphalt sand and to a lesser extent for fill and pipe bedding sand.

4.4 Crushed rock aggregates

A variety of hard rocks are suitable for use as aggregates when crushed. Their suitability for different applications depends on their physical characteristics, such as resistance to impact and abrasion and crushing strength. Higher quality aggregates are required for coating with bitumen for road surfacing, or for mixing with cement to produce concrete. For applications with less demanding specifications, such as constructional fill and drainage media, lower quality materials are acceptable. The only significant source of crushed rock aggregate in Doncaster is dolostone.

4.4.1 Dolostones

Dolostones and subordinate limestones of the Zechstein Group occupy a broad outcrop of easterly dipping strata to the west of Doncaster (Figure 3). These strata, commonly referred to as the Magnesian Limestone, have highly variable lithological and rock properties. They are frequently too weak and friable to make high quality aggregate. Nevertheless, they are extensively quarried for low-grade applications, such as sub-base roadstone and fill, but some of the rocks are sufficiently strong and durable to be used as concreting aggregate or coated roadstone.

4.4.2 Sandstone

Most sandstone is too weak and porous to make good quality aggregate for roadstone and concrete, but may be suitable for fill or for the production of sand for reconstituted stone products.

Sandstones form substantial parts of the Upper Carboniferous sequence in Doncaster where they are interbedded with mudstones and coals. Where thick beds of sandstone are developed they have been widely extracted for building stone, although there is little current quarrying activity. There is no production of aggregate materials due, in part, to more readily available local supplies of crushed dolostone and natural sand and gravel.

4.5 Industrial dolostone

Dolostone is an important economic mineral because of its physical and chemical properties. It has a wide variety of applications but its primary use is in the construction industry. Dolostone is also important in certain industrial applications where its chemical properties are important. The principal uses of industrial dolostone are as a flux in steelmaking, for refractory use and in glassmaking. For these applications, dolostone is required to be of high chemical purity. Dolostone for industrial purposes accounts for a relatively small and decreasing proportion of total dolostone output in Britain.

Dolostones with sufficiently low levels of impurities to be used in steelmaking and glassmaking are relatively scarce in Britain. The Permian, Cadeby Formation in the Cadeby, Sprotborough and Warmsworth area is, however, of higher purity and is extracted for glassmaking at Warmsworth and Cadeby quarries. The quality of the stone is variable and selective quarrying of specific horizons and subsequent blending is required to ensure that the stone meets the low iron requirements for glassmaking. Ground dolostone is also used for filler applications.

4.6 Brick clay, including fireclay

'Brick clay' is used in the manufacture of bricks, roof tiles, clay pipes and decorative pottery. These clays may sometimes be used in cement manufacture, as a source of constructional fill and for lining and sealing landfill sites. The suitability of a clay for the manufacture of bricks depends largely on its behaviour during shaping, drying and firing. This determines the properties of the fired brick, such as strength and frost resistance and, importantly, its architectural appearance.

Most facing bricks, engineering bricks and related clay-based building products are manufactured in large automated factories. These represent a high capital investment and are increasingly dependent, therefore, on raw materials with predictable and consistent firing characteristics in order to achieve high yields of saleable products. Blending different clays to achieve improved durability and to provide a range of fired colours and textures is an increasingly common feature of the brick industry. Continuity of supply of consistent raw materials is of paramount importance.

The major brick clay resources in Doncaster occur within the mudstones of the Pennine Coal Measures Group which are interbedded with siltstones, sandstones, coal seams and seatearths. The mudstones are dark grey, with variable carbon content. They are typically up to 5 m thick, but much thicker (20 to 30 m) in places.

Fireclays typically occur beneath coal seams and resources are confined to coal-bearing strata. Although originally valued as a refractory raw material, fireclay is now used by the brick industry for its combination of good technical properties allied to its cream-buff-firing characteristics. Not all fireclays are suitable for buff brick production because of the presence of impurities. The close association of fireclay and coal means that opencast coal sites are one of the few viable sources. Resources of fireclay are thus coincident with opencast coal resources and consequently the future supply of fireclay is largely dependent on the future of the opencast coal industry.

4.7 Building stones

The Pennine Coal Measures Group has been a prolific source of building sandstones, and the many sandstones that occur in the succession have all been used for local building purposes, mostly to the west of Doncaster around Barnsley, Mexborough, Sheffield and Rotherham.

The pale coloured dolostones of the Cadeby Formation have been extensively quarried for local building along much of their outcrop, most notably around Brodsworth, Doncaster and Conisborough. Building stone is largely produced as a by-product of aggregates and dolostone production but good quality stone extracted by traditional quarry methods is intermittently available.

4.8 Coal

Doncaster lies predominantly within the East Pennine Coalfield. The coal-bearing strata of the Pennine Coal Measures Group (Upper Carboniferous) generally dip to the east or south. Coal seams crop out at the surface in the west and become concealed to the east beneath younger rocks, down to depths of 1200 m below OD (Figure 10). Coal seams are numerous and many are developed at a regional scale. They vary laterally in both thickness and composition, chiefly by variation in the number of dirt partings present within the seams. Nine major coal seams are recognised in the Pennine Coal Measures Group of the Doncaster area. The seams are mainly bituminous and the calorific value and rank of the coals broadly increases eastwards. Sulphur is an impurity associated with all Yorkshire coals, with the most easterly parts of the coalfield recorded as moderately high in sulphur.

Although UK domestic production of coal has declined in recent years, South Yorkshire remains an important coal-mining region in the UK with five opencast coal sites and two deep coal mines in recent operation. In the last five years, from 1999 to 2004, total coal production in South Yorkshire decreased from 3.5 Mt to 2.8 Mt. There is no current opencast coal production in Doncaster. Production from the last underground coal mine in Doncaster, Rossington ceased in 2006.

4.9 Peat

Peat is an unconsolidated deposit of compressed plant remains formed in a water-saturated environment such as a bog or fen. Bogs occur in areas where inputs of water (almost exclusively from precipitation) have a low nutrient content and where rainfall is sufficient and drainage low enough to maintain the ground surface in a waterlogged condition. The vegetation is characterised by acid-tolerant plant communities of which the moss genus Sphagnum is dominant. The two main types of bog are raised bogs, characteristic of flat underlying topography and found on plains and broad valley floors; and blanket bogs, which occur mainly in upland areas where conditions are suitably cool and wet, both of which occur in Doncaster.

Many lowland raised bogs have been designated as sites of international and national conservation importance. Peat in England is dug almost entirely (98 per cent) for horticultural purposes, either as a growing medium, or as a soil improver.

In Doncaster, extensive peat deposits occur in the east of the county on Hatfield Moors and Thorne Moors. These deposits have been exploited for many years and the industry based on these resources is currently one of the largest in Great Britain. The peat is extracted by both a mechanised block cutting method and a surface milling technique, the latter accounting for an increasing proportion of the output. The peat is used for a variety of horticultural applications. The upper part of the deposit produces a light brown, open-textured peat which is of premium quality. A darker, more compact material from lower levels is of less value. These deposits occur within designated conservation areas (SSSI, SPA and SAC). Natural England now own both Thorne and Hatfield moors and Peat extraction has now largely ceased with extraction only occurring as part of the restoration process. Natural England managed restoration programmes are now in place to return the land to its original raised bog status.

4.10 Hydrocarbons

4.10.1 Conventional oil and gas

Doncaster lies towards the northwestern end of two major Carboniferous basins: the Gainsborough Trough and Edale Gulf. Within these areas source rocks were deposited which have since produced significant quantities of oil and gas, forming a series of important oil and gas fields to the southeast that make up the East Midlands Oil Province. Permian and Triassic strata crop out over the eastern half of the county providing, in addition to Carboniferous sequences, potential reservoir rocks for hydrocarbons generated from the Carboniferous rocks.

Several exploration wells were drilled in the county between 1940 and 1983 (Figure 11). All were dry, plugged and abandoned with the exception of two wells. Trumfleet 1 proved a major gas discovery but was only developed in 1998. To the southeast, Hatfield 1 followed as a gas discovery in 1981 and proved to be the discovery well for the series of wells that confirmed the two related Hatfield West and Hatfield Moors gas fields, which were developed in the mid 1980s. Trumfleet was still producing in late 2005, whilst the role of the Hatfield gasfields had changed to that of gas storage facilities, gas being injected into the reservoir during periods of low demand and then pumped out during peak demand.

The pattern of exploration to date thus indicates that the hydrocarbon potential of the county is perhaps relatively poor, due to the previous exploration and the level of coal mining activity. As seen in the Hatfield fields, depleted oil and gas fields could be increasingly used for gas storage. The majority of the exploration licences held in the county relate to the extraction of methane (see below).

4.10.2 Abandoned Mine Methane (AMM), Coal Mine Methane (CMM) and Coal Bed Methane (CBM) Potential

Pennine Coal Measures forming crop out or are below the Permian cover in much of the area. These Coal Measures have a generally simple eastward dip with local folding. They continue eastwards beneath the Permian cover rocks in the east of the county, being continuous with the concealed Eastern England Coalfield.

The Pennine Coal Measures in the county have been very heavily worked, with thicker seams almost totally worked out. The coal across the county is a high volatile bituminous coal with a seam gas content of between 4.1 and 6.1 cubic metres methane per tonne. In the USA, most CBM production is from coals containing 7 or more cubic metres methane per tonne. The lower gas content of the coal in the county, combined with the fact that the coalfield has been heavily worked suggests that CBM development from virgin coal seams in South Yorkshire is probably not economic at present. However, the gas seam content in the South Yorkshire region is 6.1 cubic metres methane per tonne and is therefore perhaps only just marginal. Future CBM potential and prospectivity will be dependent on areas of undisturbed coal, which in the county will probably be limited to the east.

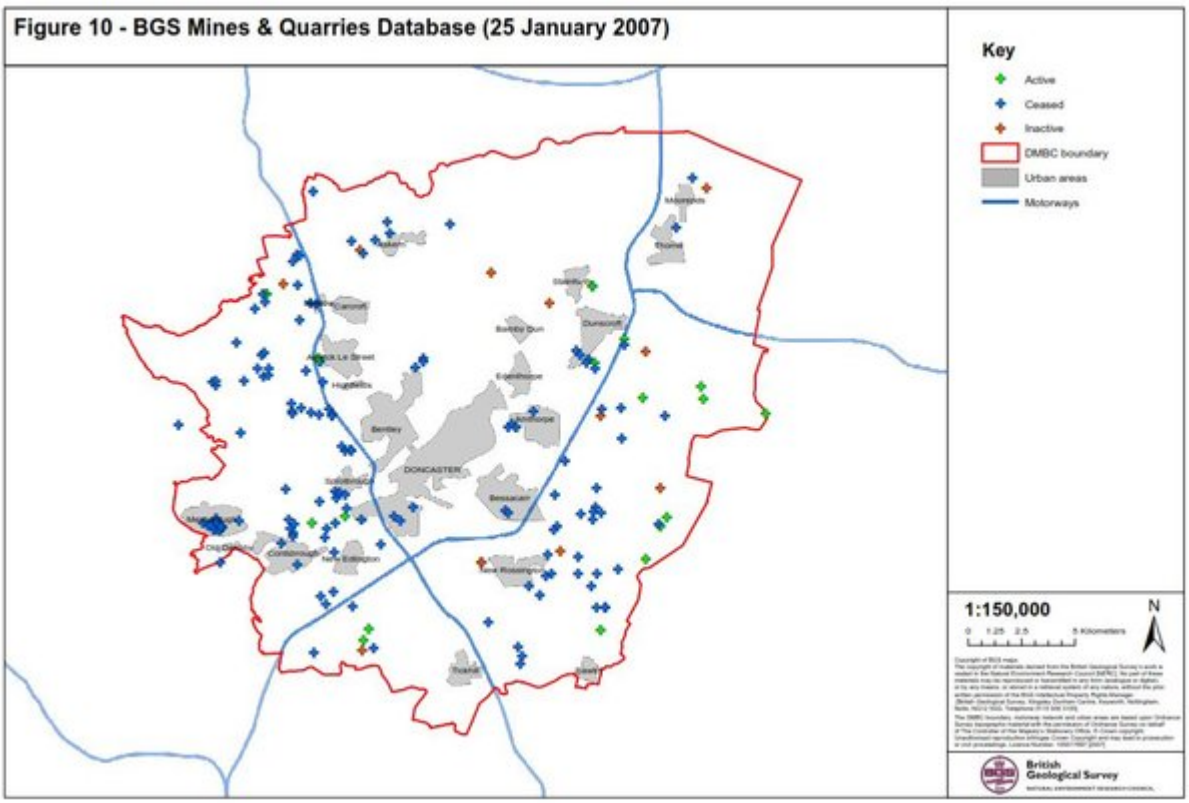
Initially AMM and CMM potential in the county appears good, given the intense coal mining in the area. During 2005 Alkane Energy held one licence (PEDL 37), Stratagas one (PEDL92) and Octagon three (PEDLs 60, 11, 43) that covered some part of the area. These permit the extraction of gas from abandoned coal mines with schemes at Wheldale (near Castleford) and at Monk Bretton (near Barnsley) and at Shirebrook and Markham in the North Derbyshire, although all are outside Doncaster. Investigations for CMM are currently taking place at Cadeby; results of this are not yet available. The gas produced is commonly used on site for power generation or supplied direct to local consumers. However, the potential for water entering and flooding areas of the mines, that are often interconnected, could impact greatly on any prospects identified in the county. Water is currently pumped from the Barnsley area to protect Maltby Colliery.

Prospects for AMM in the county are thus thought to be good if the mines are not flooded. The schemes operated by Alkane Energy have, however, seen rapid declines in the volumes of gas extracted and concerns in 2003 over the classification and tax regimes of the resource have led to doubts over the economic viability of this resource. Coal Mine Methane is recovered from existing operating mines.

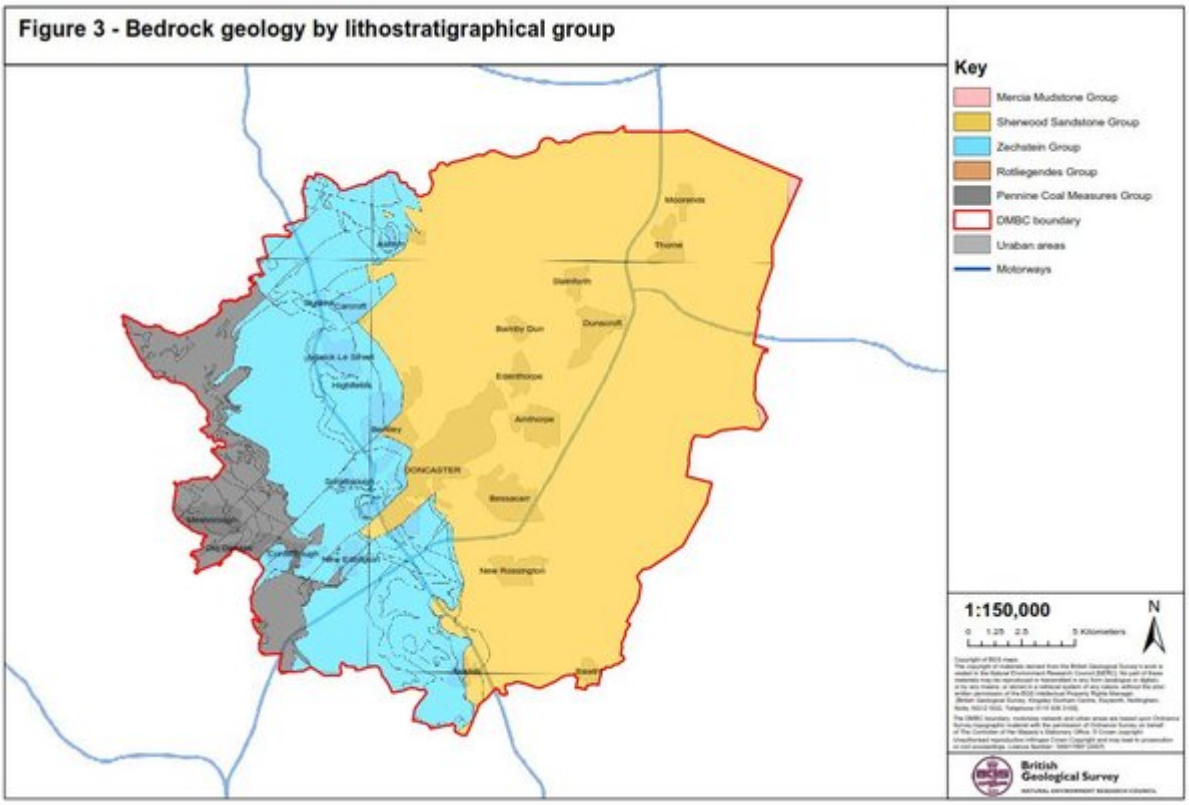
A potential future area for development in coalfield areas is Underground Coal Gasification. This is very much an unproven, new technology, which is under review and test in a number of countries. Again, the level of mining across the county and the depth of the coals might rule against this being a realistic potential resource in Doncaster.

4.10.3 Licensing

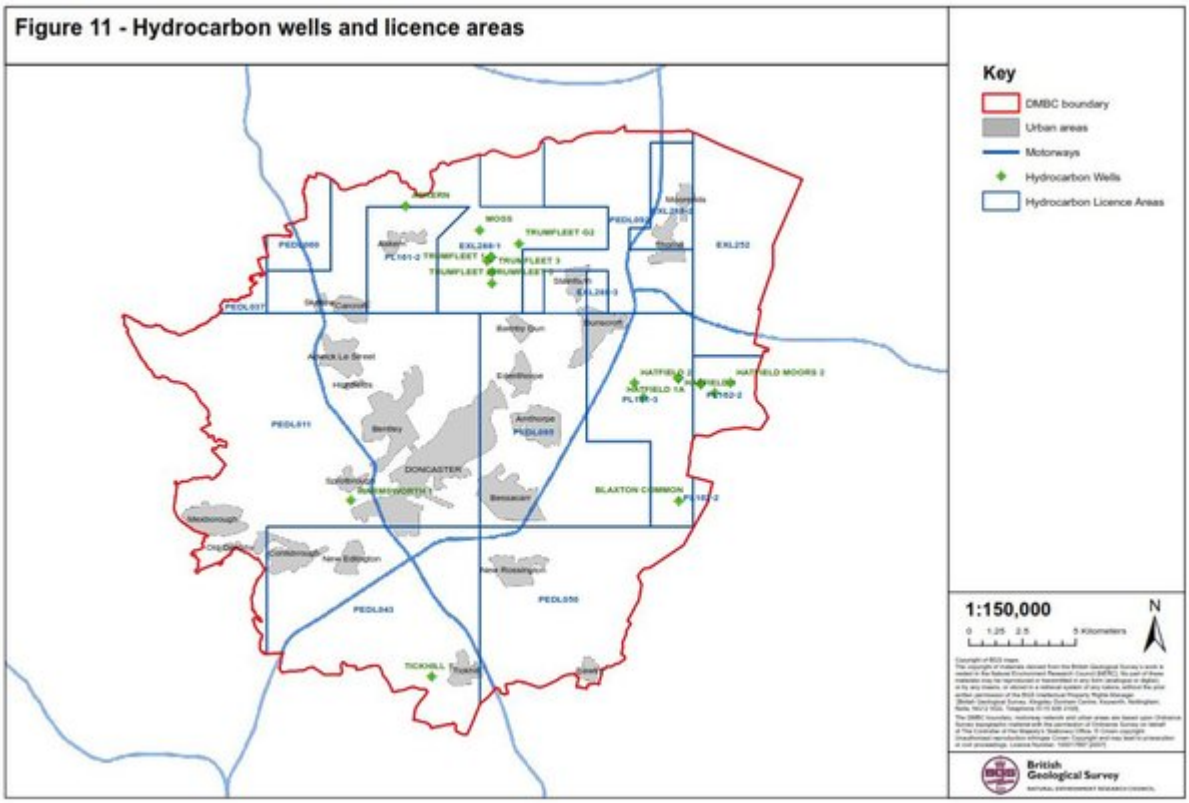
The Department of Trade and Industry grants licences for exclusive rights to explore and exploit oil and gas onshore within Great Britain. The rights granted by landward licences do not include rights of access, and the licensees must obtain any consent under current legislation, including planning permission. Licensees wishing to enter or drill through coal seams for coalbed methane and abandoned mine methane must also seek the permission of the Coal Authority.



(Figure 10) BGS Mines & Quarries Database (25 January 2007).



(Figure 3) Bedrock geology by lithostratigraphical group (Figure 4) Bedrock geology by lithostratigraphical formation (Figure 5) Superficial geology by lithostratigraphical group (Figure 6) Superficial deposits by lithogenetic class.



(Figure 11) Hydrocarbon wells and licence areas.