British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

GeoReports

Karl Collett
Green Inc Solutions Ltd
30 Doune Way
Harleston
Norfolk
IP20 9QB

Geological Assessment:

This report contains a geological description of the specified site or area. It is based on currently available 1:10 000 scale geological maps, unless otherwise stated, together with other relevant local information such as borehole records. The report includes extracts from digitised 1:50 000 scale geological maps (DigMapGB-50).

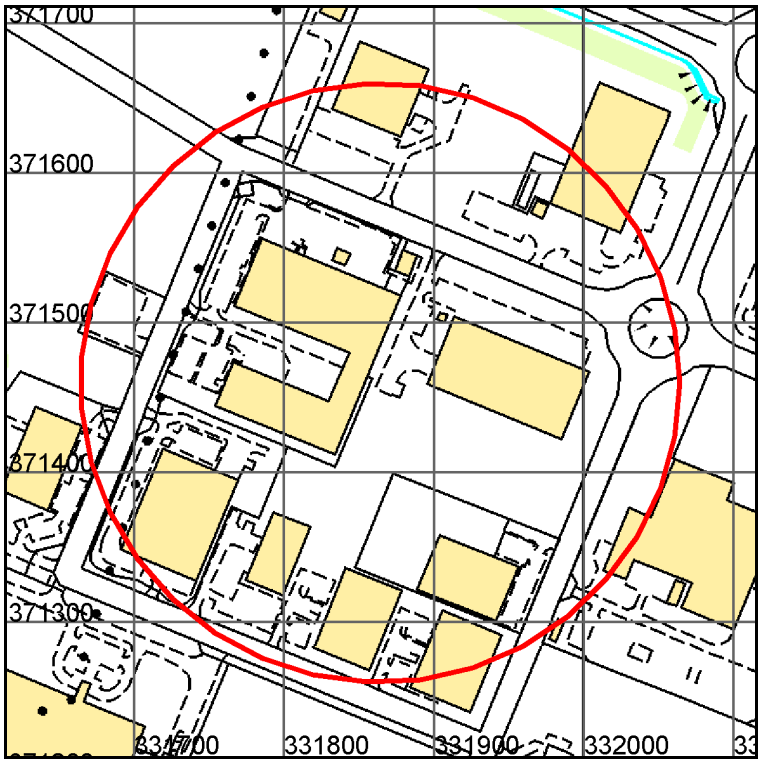
The report contains the following modules:
Geological Map Extracts
Geological Assessment (area)
Geological Cross Section
Geologists Assessment of Geohazard Potential
Natural Ground Stability
Hydrogeology (non abstraction)
Geoscience Data List

Report Id: ***GR_201775/1***

Client reference: Farmers Boy (Deeside) Ltd

Location and extent of site

This report describes a site located at National Grid Reference 331864, 371460. Note that for sites of irregular shape, this point may lie outside the site boundary. Where the client has submitted a site plan the assessment will be based on the area given.



Scale: 1:5 000 (1cm = 50 m)

Search area indicated in red

Geological map extracts

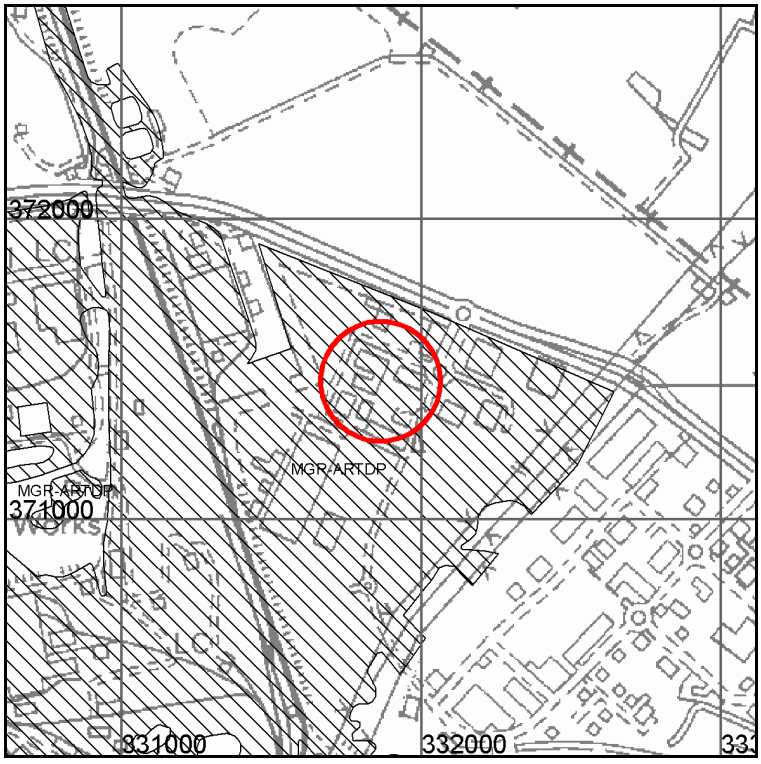
This part of the report contains extracts of geological maps taken from the 1:50,000 scale BGS Digital Geological Map of Great Britain (DiGMapGB-50). The geological information in DiGMapGB is separated into four themes: artificial ground, landslide deposits, superficial deposits and bedrock, shown here in separate maps. The fifth 'combined geology' map superimposes all four of these themes, to show the geological formations that occur at the surface, just beneath the soil.

More information about DiGMapGB-50 and how the various geological units are classified can be found on the BGS website (www.bgs.ac.uk). The maps are labelled with two-part computer codes that indicate the name of the geological unit and its composition. Descriptions of the units listed in the map keys may be available in the BGS Lexicon of Named Rock Units, which is also on the BGS website (http://www.bgs.ac.uk/lexicon/). If available, these descriptions can be found by searching against the first part of the computer code used on the maps. Please treat this labelling with caution in areas of complex geology, where some of the labels may overlap occurrences of several geological formations. If in doubt, please contact BGS Enquiries for clarification.

In the map keys the geological units are listed in order of their age, as defined in the BGS Lexicon, with the youngest first. However, where units are of the same defined age they are listed alphabetically and this may differ from the true geological sequence.

Artificial ground

This is ground at or near the surface that has been modified by man. It includes ground that has been deposited (Made Ground), landscaped, disturbed, excavated (Worked Ground) or some combination of these.



Scale: 1:25 000 (1cm = 250 m)

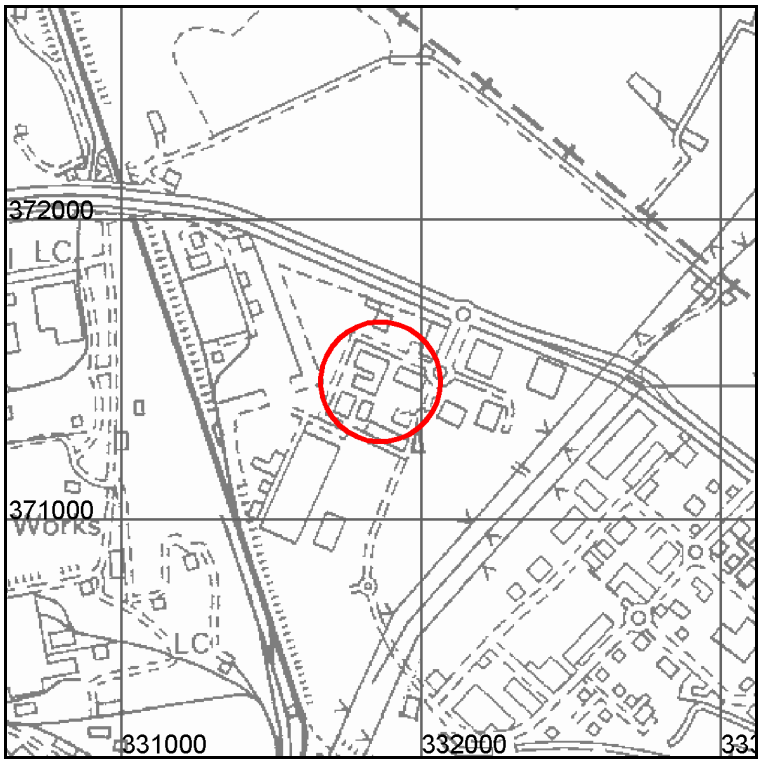
Search area indicated in red

Key to Artificial ground:

Map colour	Computer Code	Name of geological unit	Composition
▨	MGR-ARTDP	MADE GROUND (UNDIVIDED)	ARTIFICIAL DEPOSIT

Landslide deposits

These are deposits formed by localised mass-movement of soils and rocks on slopes under the action of gravity. Landslides may occur within the bedrock, superficial deposits or artificial ground; and the landslide deposits may themselves be artificially modified.



Scale: 1:25 000 (1cm = 250 m)

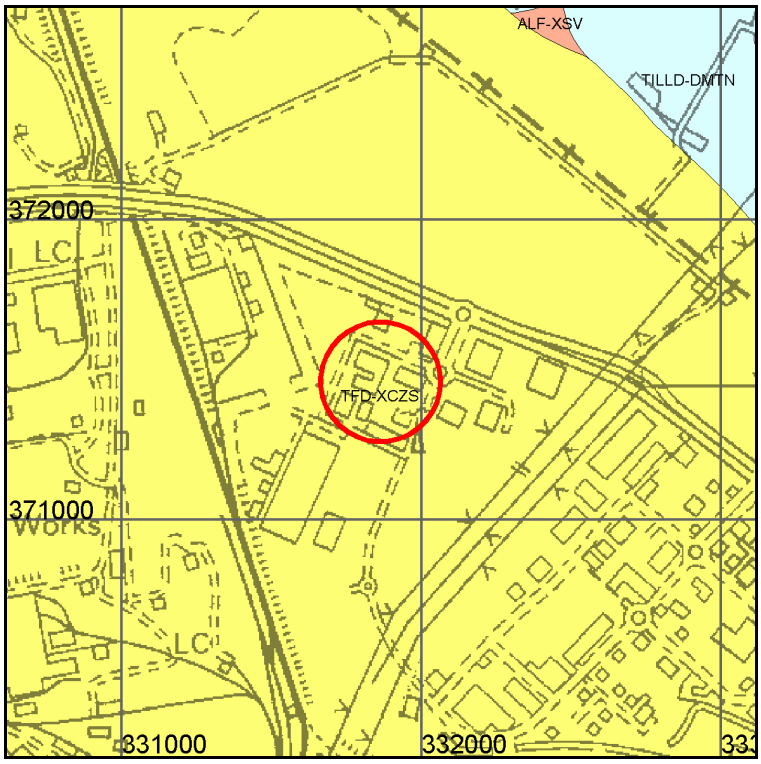
Search area indicated in red

Key to Landslide deposits:

No deposits found in the search area

Superficial deposits

These are relatively young geological deposits formerly known as 'Drift', which lie on the bedrock in many areas. They include deposits such as unconsolidated sands and gravels formed by rivers and clayey tills formed by glacial action. They may be overlain by landslide deposits or by artificial deposits, or both.



Scale: 1:25 000 (1cm = 250 m)

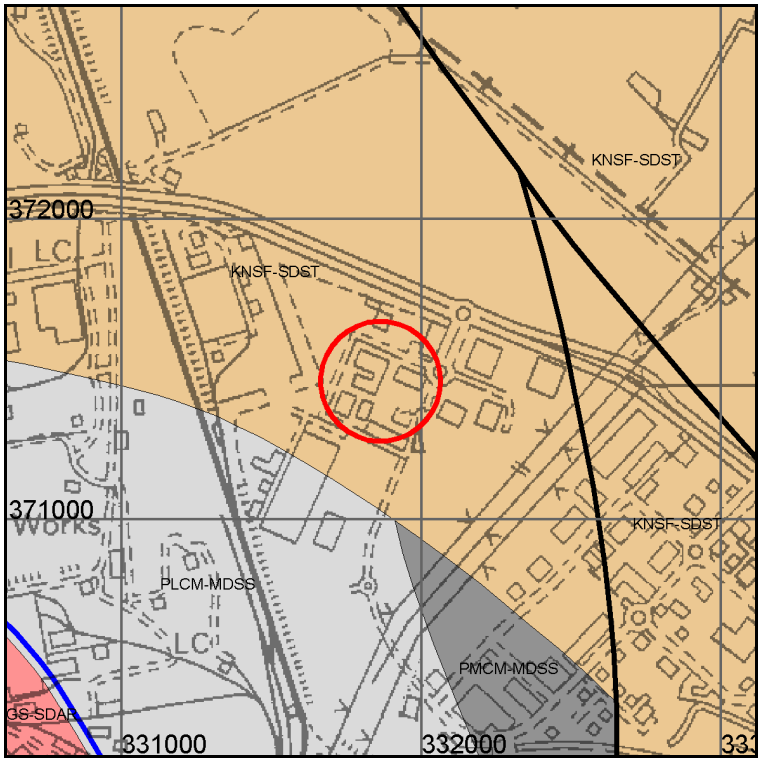
Search area indicated in red

Key to Superficial deposits:

Map colour	Computer Code	Name of geological unit	Composition
	TFD-XCZS	TIDAL FLAT DEPOSITS	CLAY, SILT AND SAND
	GFDUD-XSV	GLACIOFLUVIAL DEPOSITS, DEVENSIAN	SAND AND GRAVEL
	TILLD-DMTN	TILL, DEVENSIAN	DIAMICTON
	ALF-XSV	ALLUVIAL FAN DEPOSITS	SAND AND GRAVEL

Bedrock

Bedrock forms the ground underlying the whole of an area, commonly overlain by superficial deposits, landslide deposits or artificial deposits, in any combination. The bedrock formations were formerly known as the 'Solid Geology'.



Search area indicated in red

Fault

Coal, ironstone or other mineral vein

Note: Faults are shown for illustration and to aid interpretation of the map. Because these maps are generalised from more detailed versions not all such features are shown and their absence on the map face does not necessarily mean that none are present. Coals, ironstone beds and mineral veins occur only in certain rock types and regions of the UK; if present here, they will be described under 'bedrock' below.

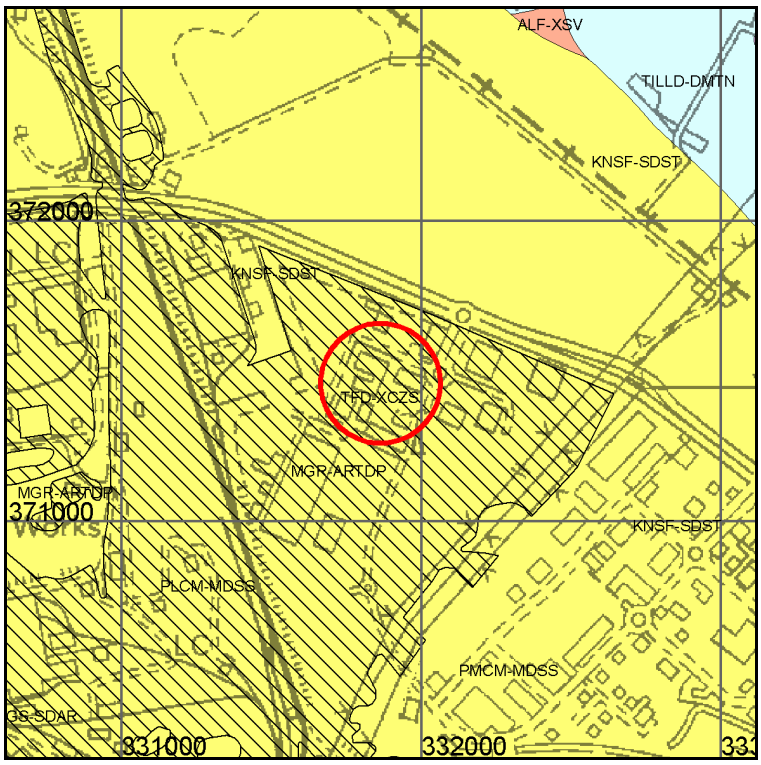
Scale: 1:25 000 (1cm = 250 m)

Key to Bedrock geology:

Map colour	Computer Code	Name of geological unit	Rock type
	KNSF-SDST	KINNERTON SANDSTONE FORMATION	SANDSTONE
	PMCM-MDSS	PENNINE MIDDLE COAL MEASURES FORMATION	MUDSTONE, SILTSTONE AND SANDSTONE
	PLCM-MDSS	PENNINE LOWER COAL MEASURES FORMATION	MUDSTONE, SILTSTONE AND SANDSTONE
	GS-SDAR	GWESPYR SANDSTONE	SANDSTONE AND [SUBEQUAL/SUBORDINATE] ARGILLACEOUS ROCKS, INTERBEDDED

Combined 'Surface Geology' Map

This map shows all the geological themes from the previous four maps overlaid in order of age.



Scale: 1:25 000 (1cm = 250 m)

Search area indicated in red

Please see the Keys to the Artificial, Landslide, Superficial and Bedrock geology maps.

Geological Assessment

This module contains a geological description of the specified site or area. It is based on currently available 1:10 000 scale geological maps unless otherwise stated, together with other relevant local information such as borehole records.

Setting:

The site lies within low ground (c. 5 m AOD) and at its closest point the course of the tidal River Dee is c. 2 km to the south west. The site was formerly a marshland area subject to tidal inundation; it is now part of an extensive reclaimed area, in part used for farming but in the site vicinity used for light industrial purposes. The ground hereabouts is largely flat lying; in undeveloped areas the natural drainage is via small meandering streams and creeks which drain north westwards towards the Dee estuary. As this is a 'reclaimed' area, it is likely that the ground water levels hereabouts are monitored and determined by a local drainage board (see note under Superficial Deposits relating to 'reclaimed' ground and flood suseptibility).

Artificial ground:

Historical OS maps dating from 1900 to 1938 show that the land was formerly used for rough grazing. The current BGS map shows that the site is entirely underlain by Made Ground presumably associated with the light industrial development. Whilst BGS has no records to indicate the thickness or composition of deposits comprising Artificial Ground at this site, it should be borne in mind that such deposits may well be highly variable in character and potentially, locally compressible if consisting of constructional fill (e.g. crushed brick, wood etc). See note under Superficial Deposits on 'reclaimed' ground.

Superficial deposits:

The site is entirely underlain by Tidal Flat Deposits (TFD) of Holocene, Quaternary age. These generally comprise silt, silty clay, clay and sand with possible thin layers of gravel; however, beneath the site TFD comprise mostly sand (see Detail below).

Any Made Ground underlying the site may in part replace or reduce the thickness of these superficial deposits. BGS holds records for a number of boreholes near to but not within the site; many of these records are held on an in confidence basis so specific information cannot be provided (but see Detail below).

The region was affected by glaciation during the Quaternary; two significant ice sheets (the 'Irish Sea' ice and the 'Welsh' ice-sheet) affected the post-Triassic landscape and carved out deep westward trending valleys. During the glacial period, sea level was considerably lower than present-day. As the climate ameliorated and the ice melted, glacial erosive processes gave way to sedimentation and infilling of these over deepened valleys. Thus the basal part of this infill often comprises sand and gravel (glaciofluvially derived) and stiff clay (glacial till).

During the last 10 000 years or so (the Holocene), as sea level rose significantly, rivers hereabouts draining westwards were progressively 'ponded back'. This resulted in an infill of interdigitating fluvial land-derived material and marine-derived (estuarine) material. Importantly for this site, the last phase of this infill complex comprised TFD sediments deposited whilst the ground was subject to regular tidal inundation.

The site now lies within ground classified as 'reclaimed' – in the sense that tidal inundation is prevented by embankments (flood protection measures) and the ground has been/is drained by a network of drainage channels and possibly pumping. However, it should be noted that the site surface lies at a few metres above sea level and would be prone to marine or brackish water flooding if not for the local flood protection measures. Despite such measures, during periods of exceptional wet weather combined with adverse high tides and onshore winds, many such reclaimed areas of the UK mainland have experienced flooding. It would be appropriate to check the flood susceptibility of the site with the Environment Agency.

Detail:
Based on a review of mostly confidential borehole information, the site appears to be underlain primarily by fine- to medium-grained, silty sand which locally is at least 26 metres thick and may well be in excess of 30 metres. At least 26 m of this is interpreted as TFD sediments as organic pockets within the sand sequence have been recorded around this depth. As noted above, the basal infill of former overdeepened valleys may well include sand (generally coarse-grained) and gravel, and a clay layer – possibly glacially-derived. Based on the available borehole data near the site, it is not certain whether such deposits are glacial and include till or whether they are the basal lithologies associated with fluvial and marine processes.

It is worth noting that a BGS Technical Report (WA/88/2) entitled 'Deeside (North Wales) thematic geological mapping' published in 1988 includes a number of maps one of which (Map 2 Superficial (Unconsolidated) Deposits) shows rockhead contours (base of superficial deposits) near to and west of the site, at around 40 to 50 m below the present-day surface. The inference from these contours is that rockhead beneath the site is between -30 and -40 m OD.

It was noted above that TFD usually includes silt, silty clay and clay although beneath this site the lithologies are dominated by sand. Despite whatever local drainage policy prevails it is likely that the water table will be encountered within 2 metres from surface so 'running sand' conditions should be anticipated in any excavation near to, or deeper than, this. It should also be borne in mind that if saturated silts and silty clay are present, these are also very prone to 'running' conditions in open excavations. These same deposits also exhibit a thixotropic property i.e. a tendency to weaken or change from a gel to a sol when vibrated or shaken but to increase in strength when steady pressure is applied.

Rockhead depth:
The depth to rockhead (base of superficial deposits) is not known with any degree of certainty; however, based on a number of confidential boreholes in the vicinity and a BGS Technical Report (WA/88/2), the inference is that rockhead beneath the site is between -30 and -40 m OD. Also see note on weathered bedrock surface below.

Bedrock:
The bedrock underlying the site is the Kinnerton Sandstone Formation (Sherwood Sandstone Group) of Permian to Triassic age. This comprises dominantly fine- to medium-grained, friable sandstones, red brown and yellow in colour with dune cross bedding and rare planar laminations. The sandstones are predominantly well-sorted with well-rounded grains. Occasional thin beds of red mudstone or pebble-rich conglomerate are also present. The Kinnerton Sandstone Formation is likely to be about 100 to 150 m thick in this locality. The Kinnerton Sandstone Formation is a major aquifer in this district.

Weathered bedrock surface: BGS Technical Report (WA/88/2, p 40) notes that the Kinnerton Sandstone Formation '…..is generally highly to moderately weathered ……in the 2 to 3 m below rockhead, becoming slightly weathered below that depth.'

The Kinnerton Sandstone Formation sits unconformably on sandstone, siltstone and mudstone of the Pennine Coal Measures Group of Upper Carboniferous Age (Westphalian). Strata of the Pennine Coal Measures Group generally dip towards the east northeast beneath the overlying younger Permo-Triassic sequence. These Coal Measures strata are by definition coal-bearing and may have been mined at depth beneath the site.

Faults are present 1500 m to the north and 700 m to the east of the site. These displace both the Coal Measures and the Permo-Triassic cover sequence. To the easternmost fault is orientated north to south and this is intersected by the northernmost fault which is aligned north west to south east.

Faults are planes of movement along which adjacent blocks of rock strata have moved relative to each other. They commonly consist of zones, perhaps up to several tens of metres wide, containing several to many fractures. The portrayal of such faults as a single line on the geological map is therefore a generalisation. Other minor faults or fractures, which are not recorded on the BGS maps, may be present underlying the site.

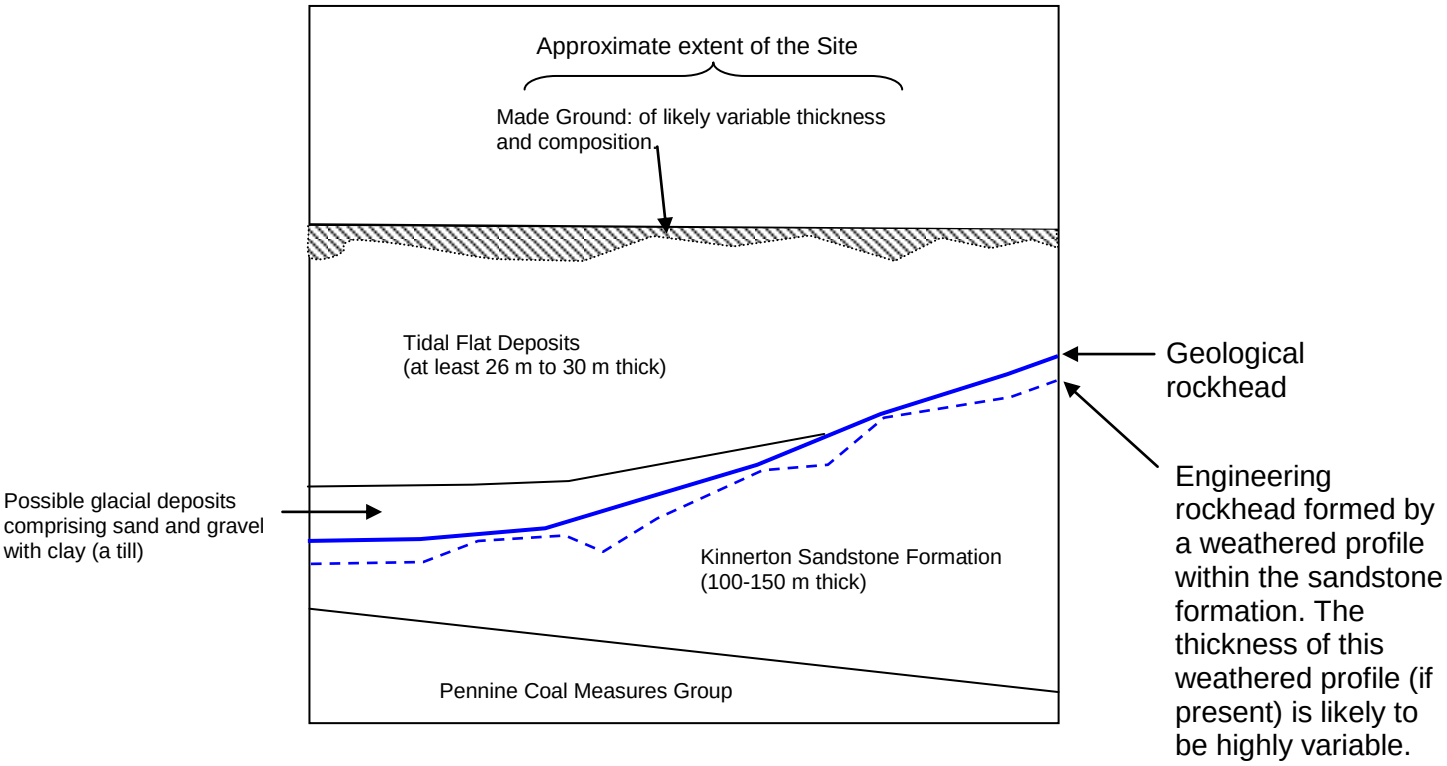
Geological faults in this area are of ancient origin, are today mainly inactive, and are thought to present no threat to property in terms of natural tectonic activity. Faults are, however, generally planes of weakness that may form the focus for mining induced subsidence and severe subsidence effects may commonly be concentrated along them. Differential subsidence may occur along a fault line where different mining depths or techniques have been employed on either side.

We are unable to say whether a particular property has been affected by a fault, or is likely to be so affected in the future, as this largely depends on the conditions of mining, about which the Coal Authority (address below) will be able to supply information. If mining has long ceased, and there are no indications of severe subsidence damage, future ground movement is unlikely.

Schematic geological cross-section of the Site

Not to scale

South west	North east



This sketch represents an interpretation of the geometrical relationships of the main rock units described in the text. It is not to scale.

The solid blue line indicates ‘rockhead’, that is the base of superficial deposits. This is the ‘geological rockhead’, as distinct from the ‘engineering rockhead’, which is the base of ‘engineering soil’ (in the sense of BS5930:1999) indicated by the broken blue line.

Geologists Assessment of Geohazard Potential

This module lists some of the principal geological hazards that may affect the specified site. It is a geologist's interpretation of data available at the time of compilation; additional information may be available in BGS files. The assessment is designed to act as a checklist and should not be used in place of a detailed site investigation.

Note that the assessment given here may differ from that in some types of report that are automatically generated from digital datasets (such as GeoSure).

Geohazard	May be significant within site area (Yes/No)?	Comments
Shrink-Swell Clay Hazard	N	Whilst the site is underlain by Tidal Flat Deposits (TFD) which may comprise a high percentage of clay which can be susceptible to shrink swell behaviour in response to changes in water content – in this instance, based on nearby borehole information, TFD sediments beneath the site are dominated by sand.
Landslide Hazard (unstable ground)	N	Potential for hazard is not significant and is at a level such as to cause problems only in exceptional circumstances.
Ground Dissolution Hazard	N	Potential for hazard to be active either zero or insignificant.
Compressible Ground Hazard	Y	Significant potential for hazard to become active that requires site-specific advice on the level of hazard related to building type and environment. The site is located on Tidal Flat Deposits which may contain compressible layers of saturated silt, silty clay and organic-rich material – but see note on Shrink-Swell above.
Collapsible Ground Hazard	N	Potential for hazard to be active either zero or insignificant.
Running Sand Hazard	Y	Significant potential for hazard to become active that requires site-specific advice on the level of hazard related to building type and environment. The site is located on Tidal Flat Deposits which in this instance, based on nearby borehole information are dominated by sand. It is likely that the water table will be encountered within 2 m from surface and thus running sand conditions in excavations should be anticipated. Tidal Flat Deposits may include silt and silty clay sequence(s) which are also very prone to 'running' conditions in open excavations. Saturated silt and silty clay sediments also exhibit a thixotropic property i.e. a tendency to weaken or change from a gel to a sol when vibrated or shaken but to increase in strength when steady pressure is applied.
Mining Hazard	Y	Coal mining has been undertaken throughout the district and may be present at depth beneath the site.
Flooding Hazard	Y	The site lies within a former tidally flooded area: despite the local flood protection measures it may be subject to flooding during exceptionally wet weather combined with high tides and onshore winds. Advice should be sought from the Environment Agency.
Natural land gas	N	Unlikely to encounter gas from bedrock and coal mining; unlikely to encounter gas from peat
Level of Radon Protective Measures		None

General explanation of hazards (not site specific)

Natural geohazards that might be present at the site; Shrink-swell clay, Landslide, Ground dissolution, Compressible ground, Collapsible ground and Running sands, are described in the Natural Ground Stability module of the report.

Mining

The voids created by underground mining activity may pose a potential hazard to both life and assets, and the associated risk of ground movement can reduce property values. Further, spoil from mineral workings can present a pollution hazard.

Flooding

Flooding due to natural causes can occur following run-off of surface water or overflow from a river or stream, or because of rising groundwater levels, or (in coastal areas) because of inundation by the sea, or through a combination of these factors.
For further information on flood-risk, the likely frequency of its recurrence in relation any proposed development of the site, and the status of any flood prevention measures in place, you are advised to contact the local office of the Environment Agency.
www.environment-agency.gov.uk/homeandleisure/floods/

Natural Land Gas

The table indicates whether or not there is any potential susceptibility of the site to surface or near-surface emissions of methane or carbon dioxide or both, from natural sources or from mining. Where methane and carbon dioxide emissions do occur at the surface most appear to be derived from abandoned shallow coal mines although a number of recorded incidences originate from peat and other natural deposits of organic materials, such as in buried ponds or river channels. It should be noted that the exact extent of potential sources of natural land gas, particularly that of peat and other organic deposits, can be difficult to predict.

An indication of potential for gas emissions does not necessarily indicate that there is a problem. That would depend on (1) the quantity of gases in the source rocks or superficial deposits, (2) whether they have been released and (3) whether there are pathways for transmission and locations for accumulation.

The relatively small number of gas emission incidents from coal mining and natural sources recorded in most areas of the UK suggests that the hazard is relatively minor and of local significance compared with, for example, the extensive problems associated with mining-related subsidence or gas problems associated with landfill sites. However, in some parts of the coal fields, such as in parts of Northumberland, a relatively high number of gas emission sites have been identified, so the gas hazard is correspondingly greater. Whereas specific problems with methane and carbon dioxide from natural sources and mining can cause severe and, sometimes, expensive or dangerous problems, most gas emissions from natural sources and mining can usually be dealt with readily if they do arise.

A Residential Property or Non-Residential Property, Commercial or Development Site (maximum of 25 hectares) coal mining search from the Coal Authority (www.ppsearches.co.uk/coal_mining_searches.htm) will indicate whether any shafts or adits, which may act as pathways for gas, are located within 20 m of the boundary of the property or site. Where the Coal Authority is aware that a property or site being the subject of a search has been affected by mine gas, this information will be included in the Coal Mining Search Report.

If the site is potentially susceptible to surface or near-surface emissions of methane and/or carbon dioxide from natural sources or mining, (1) caution should be exercised in planning on the basis that hazards from natural methane and carbon dioxide impose a constraint on development by virtue of public health or safety implications; (2) developers need to be aware that potential problems may be associated with gas emissions; (3) employers at some places of work may have responsibilities under the Health and Safety at Work Act (1974) to monitor gas levels; and (4) there may be a need to consult an appropriate specialist or to seek further information through desk studies and/or site investigations.

The information in this report should not be used in place of a site investigation. The existence of gas emissions at specific sites can be established only by detailed site investigation. The level of risk from methane or carbon dioxide in a particular building or underground cavity can be established only by monitoring the spaces in which it may accumulate.

Radon

Radon is a naturally-occurring radioactive gas. It diffuses from the ground and occurs in greater concentrations in some areas, depending on the local geology. It can accumulate in buildings, unless measures are taken to prevent this, and can then cause ill-health.

The above table indicates the level of Radon Protective Measures required at the site during the construction of new buildings or extensions to existing buildings. This determination complies with information set out in *BR211 Radon: Guidance on protective measures for new dwellings (2007 edition)*, which also provides guidance on what to do if the result indicates that protective measures are required (please see BRE Website for more details: www.bre.co.uk/radon). This assessment is based on the Radon Potential Dataset produced jointly by the BGS and the Health Protection Agency (for more information please see the BGS website at www.bgs.ac.uk/radon).

The following ground stability information is automatically generated from selected datasets and as such is limited. It may therefore vary from the information provided above which is a geologists interpretation of a wider array of geological information.

Natural Ground Stability

The following provides an indication of potential significant NATURAL ground instability generated automatically from BGS's GeoSure dataset, which is based on 1:50 000 scale digital data. Its scope and accuracy is limited by the methods used. It may therefore differ from a geologist's interpretation of a wider array of geological information.

This is not a site-specific assessment and only indicates the potential for a geohazard to occur within the site boundary and a surrounding 50 m buffer zone.

It is intended for use by suitably-qualified professionals involved in conveyancing or development of low-rise domestic properties. If in doubt users should consult a suitably-qualified professional about the search results in this report before making any major decisions based upon it.

Definitions to help you understand this report:

- **Natural Ground Instability** refers to the upward, lateral or downward movement of the ground that can be caused by a range of natural geological hazards. Such movements associated with particular hazards may be gradual and of millimetre or centimetre scale, whilst others may be sudden and of metre or tens of metres scale.
- **Significant** natural ground instability has the potential to cause subsidence damage to some weaker buildings and structures. It should be noted, however, that many buildings, particularly more modern ones, are built to such a standard that they can remain unaffected in areas of very significant ground movement.
- Where significant natural ground instability is indicated, its **level** of significance is expressed on a scale of C to E ('low' to 'high'), relating to its potential to cause subsidence damage in low-rise buildings.

Contents of the report:

- **Search Results:** Answers a series of questions about any natural ground movement hazards found in the area. It assesses how significant they are and what the related geohazards are.
- **Maps:** Shows areas of where any natural geological hazards indicated may occur, and their significance in terms of a range of indicative implications.
- **Explanation of hazard information:** Provides further explanation of the geological hazards that have been identified in the search (if any).

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Limitations:

- This search is concerned with potential ground instability related to NATURAL geological conditions only. This includes swelling clays, landslides, ground dissolution, collapsible ground, running sand and compressible ground. The search does NOT cover any man-made hazards, such as contaminated land or mining. Searches of coal mining should be carried out via The Coal Authority Mine Reports Service: www.coalminingreports.co.uk.
- This ground stability and natural geological hazards search uses the BGS GeoSure database, which is based on 1:50 000 digital geological maps. GeoSure is generated automatically by interpretation of the records in the possession of BGS as of the release date of the data. The answer given should therefore only be treated as indicative for the search area.
- More specific and detailed information is available through the 'Geologists Assessment of Geohazards Potential' module which can be purchased as part of GeoReports. This assessment could result in a modified assessment of ground instability potential.
- An indication of natural ground instability does not necessarily mean that a building will be affected by subsidence. Such an assessment can be made only by inspection of the building itself by a suitabley-qualified professional. This will take into account a variety of other contributing factors, such as building type and build quality, and nearby vegetation (in particular, the proximity and type of trees).

Search Results:

Question 1	Answer
Which natural geological hazards could be contributing to ground instability in the area? **NOTE: The hazard levels are described as A (least) to E (greatest), or as 'No Hazard'. Levels A and B are not considered significant and are not shown on the maps.**	Clays that can swell when wet and shrink when dry, causing the ground to rise and fall ('Swelling Clays Hazard') (LEVEL B) Rocks that can dissolve and develop underground cavities that may lead to surface collapses and hollows ('Ground Dissolution Hazard') (LEVEL No hazard) Material that collapses when a load is placed on it or when it becomes saturated ('Collapsible Ground Hazard') (LEVEL No hazard) Sand that can wash away or flow into holes or fissures due to presence of water ('Running Sand Hazard') (LEVEL B) Weak or unstable rocks that could slip downhill on steep slopes (greater than about 5 degrees) or into excavations ('Landslide Hazard') (LEVEL B) Very soft ground that might compress and progressively sink under the weight of a building ('Compressible Ground Hazard') (LEVEL B)

Question 2	Answer
What action should be taken?	If natural ground instability has been indicated, then this means there is potential in your area for some properties to suffer subsidence damage. However, it does not necessarily mean that your property will be affected, and in order to find out if this is the case or not, you should obtain further advice from a qualified expert, such as a building surveyor. Show them this report and ask them to evaluate the property and its surroundings for any signs of existing subsidence damage as well as advice on the likelihood for subsidence to occur in the future. The notes at the end of this report may be useful in this regard. Note that the type of building and its surroundings (e.g. the presence of trees) are also very important when considering subsidence risk. Many types of properties, particularly newer ones, are well constructed and unlikely to be affected by subsidence, even in areas of very significant ground movements.

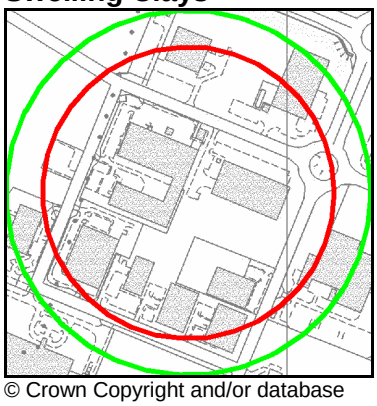
Question 3	Answer
Where could the natural geological hazards occur in the area?	See the maps that follow.

Maps of natural geological hazards

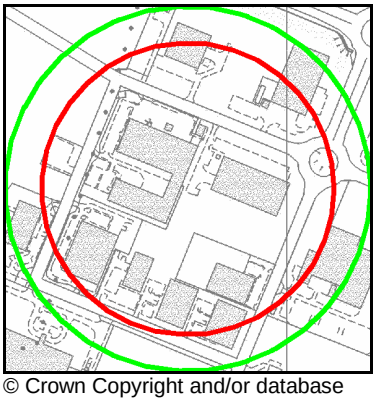
The following maps show where significant natural ground instability could occur in relation to each of the hazards. The indicative implications are shown in colour and described in the key. Please note, a hazard is reported as significant for the property only if it crosses the designated search area.

The unshaded (white) areas on the map (levels A, B or 'No hazard') represent areas where the conditions that cause natural ground movements are considered to be absent or unlikely to be significant.

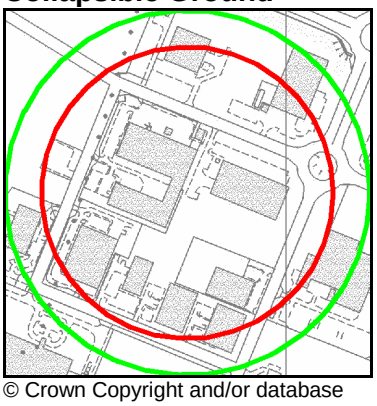
Swelling Clays



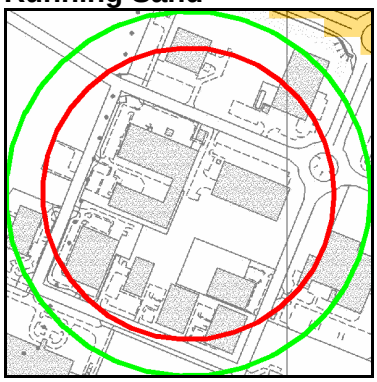
Ground Dissolution



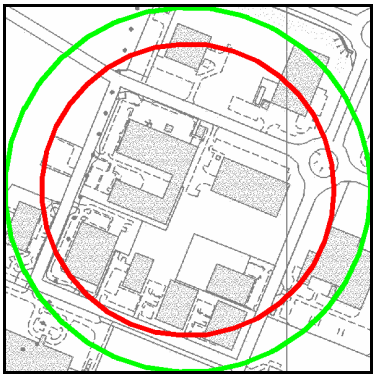
Collapsible Ground



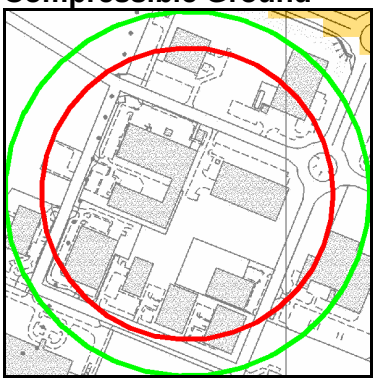
Running Sand



Landslide



Compressible Ground



Search area indicated in red
50 m buffer indicated in green

Key to natural geological hazards:

Map colour	Level	Significance
	C	Potential for hazard to become active is at a level where it should be considered in decisions about construction, building maintenance and land use.
	D	Significant potential for hazard to become active that requires site-specific advice on the level of hazard related to building type and environment.
	E	Significant potential for hazard to become active that requires site-specific advice on level of hazard related to building type and environment and a management plan to minimise future problems.

Explanation of hazards

Shrinking and Swelling Clays Hazard

A shrinking and swelling clay changes volume significantly according to how much water it contains. All clay deposits change volume as their water content varies, typically swelling in winter and shrinking in summer, but some do so to a greater extent than others. Most foundations are designed and built to withstand seasonal changes. However, in some circumstances, buildings constructed on clay that is particularly prone to swelling and shrinking behaviour may experience problems. Contributory circumstances could include drought, leaking service pipes or tree roots drying-out the ground. Shrinkage may remove support from the foundations of a building, whereas clay expansion may lead to uplift (heave) or lateral stress on part or all of a structure; all such movements may cause cracking and distortion.

Landslide Hazard

A landslide is a relatively rapid outward and downward movement of a mass of rock or soil on a slope due to the force of gravity. A slope is under stress due to the force of gravity but will not move if its strength is greater than this stress. If the balance is altered so that the stress exceeds the strength, then movement will occur. The stability of a slope can be reduced by removing ground at the base of the slope, increasing the water content of the materials forming the slope or by placing material on the slope, especially at the top. Property damage by landslide can occur through the removal of supporting ground from under the property or by the movement of material onto the property.

The assessment of landslide hazard refers to the stability of the present land surface. It does not encompass a consideration of the stability of excavations.

Ground Dissolution Hazard

Some rocks are soluble in water and can be progressively removed by the flow of water through the ground. This process tends to create cavities, potentially leading to the collapse of overlying materials and possibly subsidence at the surface.

Compressible Ground Hazard

Many ground materials contain water-filled pores (the spaces between solid particles). Ground is compressible if a building (or other load) can cause the water in the pore space to be squeezed out causing the ground to decrease in thickness. If ground is extremely compressible the building may sink. If the ground is not uniformly compressible, different parts of the building may sink by different amounts, possibly causing tilting, cracking or distortion.

Collapsible Ground Hazard

Collapsible ground comprises certain fine-grained materials with large pore spaces (the spaces between solid particles). It can collapse when it becomes saturated by water and a building (or other structure) places too great a load on it. If the material below a building collapses it may cause the building to sink. If the collapsible ground is variable in thickness or distribution, different parts of the building may sink by different amounts, possibly causing tilting, cracking or distortion.

This hazard is likely to be encountered only in parts of southern England.

Running Sand Hazard

Running sand conditions occur when loosely-packed sand, saturated with water, flows into an excavation, borehole or other type of void. The pressure of the water filling the spaces between the sand grains reduces the contact between the grains and they are carried along by the flow. This can lead to subsidence of the surrounding ground.

If sand below a building runs it may remove support and the building may sink. Different parts of the building may sink by different amounts, possibly causing tilting, cracking or distortion.

Hydrogeology (non abstraction)

This module is intended for clients assessing a site for development, including the installation of a closed loop ground heat pump system, and contains hydrogeological information such as aquifer descriptions, groundwater levels, direction of groundwater flow, groundwater quality and groundwater vulnerability. It does not contain detailed information on yields or borehole design and is therefore not suitable for customers proposing to drill a water borehole, or establish an open-loop ground heat pump system.

Hydrogeology

In lowland areas of the UK with little topographic variation, groundwater is likely to be found at shallow depths of only a few metres. Water table fluctuations will be small as they will be constrained by the ground surface and the base level of the local perennial streams and rivers.

In upland areas, precipitation is usually high and the dominantly metamorphic and igneous rocks often have relatively shallow groundwater levels. This is due to preferential groundwater storage in near-surface weathered and fractured zones with limited drainage into the underlying unweathered lower permeability rock. Exceptions can occur where higher permeability rocks, such as sandstone or limestone, allow faster throughflow of groundwater towards the nearest stream or other discharge point.

Perched water tables occur where a less permeable horizon (e.g. a clay layer) in an otherwise permeable sequence retains a body of groundwater above the level of the regional water table. They usually occur at shallow depths in alluvial and glacial sediments and can be difficult to identify or to delimit.

An aquifer becomes confined when it is overlain by a less permeable horizon that restricts the upward movement of groundwater. When this less permeable horizon is penetrated (e.g. by drilling), the groundwater level rises above where struck to a level controlled by the hydrostatic pressure. If this is above ground level, overflowing artesian conditions will be encountered. Confined conditions should be anticipated, where possible, in order to plan for the problems they can generate.

In this area both the water levels and water quality in all the underlying strata may be affected by the proximity of the site to the coast, causing water levels to vary diurnally with the tides and water quality to be brackish.

Geological unit	Groundwater potential	Water level and strikes	Quality	*Environment Agency Groundwater vulnerability classification
Made Ground	May contain some groundwater if contains permeable horizons.	Some water may be perched above low permeability material. If permeable, shallow water could drain into underlying tidal flat deposits.	Not known, but may reflect nature of infill material	Not classified
Tidal flat deposits	Generally permeable deposits with intergranular flow and storage.	Water level likely to be about 1-2 m below ground surface, water may rise slightly above where first struck.	May be brackish	Minor Aquifer with high soil leaching potential
Glacial deposits (possibly present)	Sand and gravel will be permeable with intergranular flow and storage. Till likely to be of low permeability.	Water level likely to lie about 1-2 m below ground surface.	May be brackish	Minor Aquifer (sand and gravel). Low permeability superficial deposits, however some groundwater flow may still occur and this should be taken into consideration when assessing persistent pollutants (Till).
Kinnerton Sandstone Formation	Important aquifer, capable of yielding large amounts of water with groundwater storage and flow via both intergranular spaces and fractures.	Water probably confined by low permeability horizons within superficial deposits and would rise above where struck to lie between 5 and 10 m above OD (i.e could be artesian).	Naturally of calcium-bicarbonate type with chloride generally less than 100 mg/l, but may be slightly brackish with elevated sodium and chloride concentrations due to saline intrusion or mixing with more saline water at depth. Iron content generally less than 0.3 mg/l, but locally may exceed 5 mg/l.	Major Aquifer

Geological unit	Groundwater potential	Water level and strikes	Quality	*Environment Agency Groundwater vulnerability classification
Coal Measures	Multi-layered aquifer with individual sandstone horizons acting as independent aquifers separated by low permeability mudstone horizons. Groundwater storage and movement occurs within secondary fractures.	Water levels within sandstones may rise above where first struck. Different sandstone horizons are likely to have different water levels.	At depth, water quality can be poor with a high total dissolved solids content, chloride, sulphate, iron and manganese concentrations.	Minor Aquifer

*Individual sites will always require more detailed assessments to determine the specific impact on groundwater resources. The maps represent conditions only at the ground surface. Where the soil and/or underlying formations have been disturbed or removed the vulnerability class may have been changed and site specific data will be required.

The regional direction of groundwater flow in the Kinnerton Sandstone Formation is likely to be north-eastwards towards an area where water levels are depressed due to abstraction, but this may differ on the local scale.

Argillaceous strata predominate in the Coal Measures Group, acting as aquitards or aquicludes, isolating the occasional thicker sandstone horizons that, under natural conditions, effectively act as separate aquifers. However, some water may also be encountered in the upper weathered zone. Coal Measures sandstones are generally fine-grained, very well cemented, extremely hard and dense and in consequence possess little primary porosity or intergranular permeability. Groundwater storage and movement occurs predominantly within and through fractures in the sandstones. Water may rise above the level at which it is struck. The volume of water encountered is dependent on the number, size and degree of interconnection of fractures encountered in a productive horizon. In the vicinity of old coal workings, large volumes may be encountered if disused, flooded mine levels are intercepted.

Sandstone outcrop areas are often small, limiting the amount of recharge that can infiltrate to individual sandstone units. Extensive faulting has frequently split previously continuous sandstone horizons into disconnected isolated fault-bounded blocks, to which little or no direct recharge can occur. Where mining of coal seams has taken place, this will have largely disrupted natural hydrogeological conditions in the Coal Measures by the creation of open shafts, roadways and galleries, as well as collapsed disused workings. The physical disturbance and removal of material may cause subsidence and associated fracturing of the overlying strata, which can either increase the permeability of an existing aquifer horizon or even, in extreme cases, create a permeable horizon out of poorly permeable strata. Subsidence and associated fracturing can also create hydraulic continuity between layers that were previously isolated and, in some places, between aquifer horizons and flooded disused workings. In this area, the formation occurs at depth below thick superficial deposits and the sandstones are not marked on the published maps.

Faults generally increase fracturing in the bedrock, which normally improves groundwater potential, however if the throw is greater than the sandstone thickness, the resultant displacement can prevent hydraulic continuity between the water-bearing horizons, resulting in compartmentalisation of the aquifer.

BGS holds no information regarding the likely rest water level in the Coal Measures below this site, but it is assumed that levels will rise to lie near the ground surface. The natural level may have been affected by colliery dewatering.

The natural quality of shallow groundwater in the Coal Measures Group is typically hard and dominated by calcium and bicarbonate ions. Water from deep mines is often of poor quality with a high total hardness, sulphate, chloride and iron concentrations. The Environment Agency, Wales Region, may hold some water quality information for this area.
Mining activities tend to lower water tables compared with natural conditions, particularly where the shafts are actively dewatered by pumping. Rising groundwater levels following mine closures in areas that have previously been dewatered, can dissolve chemicals such as sulphide in worked coal seams, leading to widespread ground and surface water pollution. The Coal Authority or the Environment Agency should be able to supply information on past and current dewatering activities in this area.

Geoscience Data Listing

List of available geological data

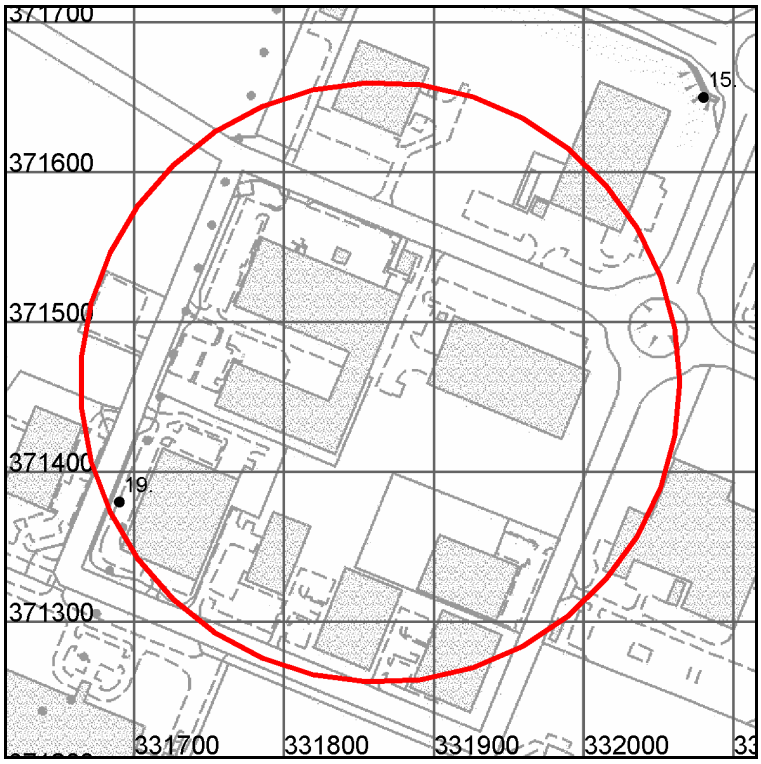
This section lists the principal data sets held in the National Geoscience Records Centre that are relevant to your enquiry and explains how to obtain copies of the records. Users with access to computing facilities can make their own index searches using the BGS Internet; go to 'Online shops' at www,bgs.ac.uk This will give access to the BGS Bookshop, Publications catalogue, GeoRecords (borehole browser) and GeoReports.

For current pricing see internet pages above or do not hesitate to contact us using the list found at the back of this report.

Note that this report contains selective datasets and is not a definitive listing of all data held in BGS.

Search area based on full extent of map

Borehole location map



Scale: 1:5 000 (1cm = 50 m)

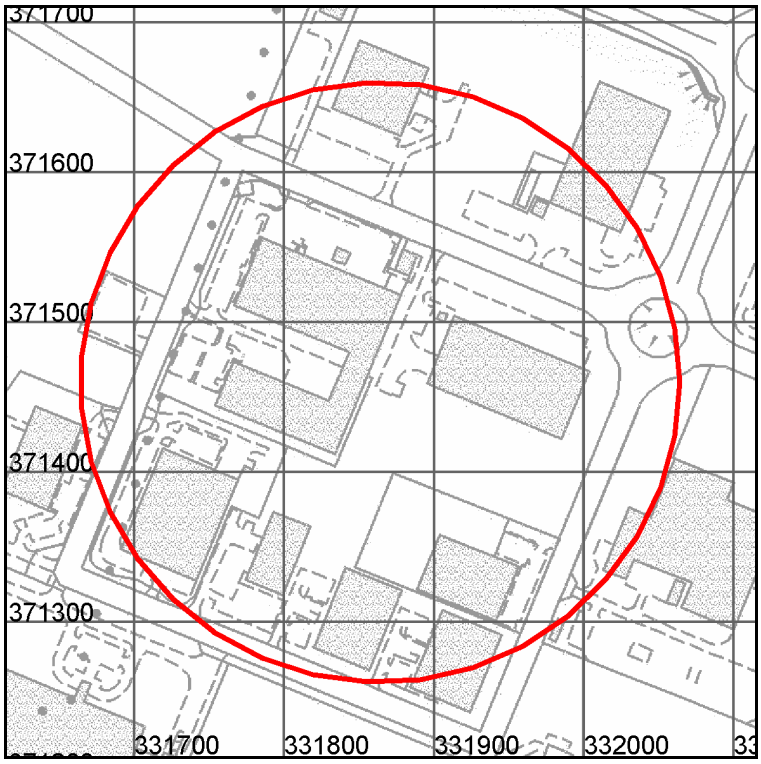
Borehole records

Number of records in search area: 2

In the following table a blank Length field indicates that the borehole is confidential or that no depth has been recorded digitally.
Enquiry staff may be able to provide you with contact details for the originator if you wish to seek release of confidential information.

Borehole registered no	Grid reference	Borehole name	Length (m)
SJ37SW15	SJ 32080 71650	SHOTTON S.I. 2	-1
SJ37SW19	SJ 31690 71380	SHOTTON S.I. 6	-1

Water Well location map



Scale: 1:5 000 (1cm = 50 m)

Water Well records

Number of records in search area: 0

All of these records are registered in the main Borehole Records collections (see Borehole Records Table and map above), but please note that some may be duplicate or part duplicate copies. This map shows records of water wells and boreholes in the National Well Record Archive held at Wallingford (WL) or Murchison House (MH). Each record has a Well Registration number which should be quoted when applying for copies.

Additional index information may be held for the Water Well Records as shown below, indicating the information that can be found on the well record itself. If fields are blank, then the well record has not been examined and its contents are unknown. A 'Yes' or a 'No' indicates that the well record has been examined and the information indicated is, or is not, present. This information should help you when requesting copies of records.

Water Well records

BGS holds no water well records for the selected area

KEY:
Aquifer = The principal aquifer recorded in the borehole
G = Geological Information present on the log
C = Borehole construction information present on the log
W = Water level or yield information present on the log
Ch = Water chemistry information present on the log

Boreholes with water level readings

Number of records in search area: 0

BGS holds no boreholes with water level readings for the selected area

Locations with aquifer properties

Number of records in search area: 0

BGS holds no locations with aquifer properties for the selected area

Site investigation reports
Number of records in search area: 22

Additional laboratory and test data may be available in these reports, subject to any copyright and confidentiality conditions. The grid references used are based on an un-refined rectangle and therefore may not be applicable to a specific site. Borehole records in these reports will be individually referenced within the borehole records collection, described above.

Number	Site investigation title
3795	SITE INVESTIGATION FOR THE MORECAMBE BAY TERMINAL WITHIN SITES AT SHOTTON HESKETH AND BARROW
5861	A550 IMPROVEMENTS STAGES 1 AND 2 DEESIDE PARK JUNCTION TO LEDSHAM ROAD
6587	RECLAMATION OF LAND NORTH OF SHOTWICK ROAD DEESIDE
7084	DAINES - DEESIDE 400KV OVERHEAD LINE TOWER ZO 173A
7103	PROPOSED ENGINE PLANT DEESIDE
7301	INNER MARSH FARM DEESIDE
7304	SHOTTON PAPER COMPANY CONNAHS QUAY CLWYD
10119	DEESIDE PARK 132KV SUBSTATION TERMINAL TOWER
13219	RECLAIMATION OF LAND NORTH OF SHOTWICK
13223	DEESIDE ROAD LINK-STAGE 3 B SHOTWICK ROAD IMPROVEMENT
15547	LINK 56, DEESIDE INDUSTRIAL PARK
15582	RAF SEALAND
26035	NK INTERNATIONAL SITE
26705	DEESIDE INDUSTRIAL PARK SHOTTON CLYWD NORTH WALES
29943	DEESIDE INDUSTRIAL PARK SHOTTON
30442	TOYOTA ENGINE PLANT
32547	DEESIDE INDUSTRIAL PARK SITE 2
32880	BESPOKE FACTORY DEVELOPMENT DEESIDE INDUSTRIAL PARK
34415	PROPOSED DEVELOPMENT AT FIRST AVENUE DEESIDE INDUSTRIAL ESTATE
35230	BURTON AND PUDDINGTON SOUTH WIRRAL
38048	PROPOSED FOUL SEWER IMPROVEMENT PARKWAY, DEESIDE IND PARK
51485	DEE COASTAL PATH PHASE 2B

National Grid geological maps (1:10 000 and 1:10 560 scale)
Number of records in search area: 1

Map	Type	Survey
SJ37SW	C	1991

County Series geological maps (1:10 560 scale)
Number of records in search area: 5

Map	Type	Published
Cheshire30SE		1911
Cheshire30SE	C	0
Flintshire10FS	C	0
Flintshire10NE		1911
Flintshire10NE	C	0

New Series medium scale geological maps (1:50 000 and 1:63 360 scale)
Number of records in search area: 4

Sheet number	Sheet name	Type	Published
108	Flint	C	1999
108	Flint	S	1924
108	Flint	S	1999
108	Flint	D	1924

Old Series one inch geological maps (1:63360 scale)
Number of records in search area: 0
BGS holds no old series one inch geological maps for the selected area

Hydrogeological maps (various scales)
Number of records in search area: 1

Map	Scale
Clwyd and Cheshire Basin	1:100,000

Geological Memoirs
Number of records in search area: 2

Geological memoir	Date
Flint	2002
Flint, Hawarden and Caergwrle	1924

Technical reports
Technical reports may be available for this area. Please see http://geolib.bgs.ac.uk

Waste sites
Number of records in search area: 0

Listing of some 3500 waste sites for England and Wales identified by BGS as part of a survey carried out on behalf of the Department of the Environment in 1973. Later information may be available from the Local authority.
BGS holds no records of waste sites for the selected area

Mining plans
Number of records in search area: 2

This listing includes plans of various types, principally relating to mining activity including abandonment plans. The coverage is not comprehensive; however that for Scotland is most complete.

Record Type	Plan No.	Title
KP	1765	FLINTSHIRE MINING SECTIONS
KP	18191	WESTPHALIAN A & B OF THE COALFIELDS OF ENGLAND & WALES (INCLUDING CANONBIE)

Contact Details

Keyworth (KW) Office
British Geological Survey
Kingsley Dunham Centre
Keyworth
Nottingham
NG12 5GG
Tel: 0115 9363143
Fax: 0115 9363276
Email: enquiries@bgs.ac.uk

Wallingford (WL) Office
British Geological Survey
Maclean Building
Wallingford
Oxford
OX10 8BB
Tel: 01491 838800
Fax: 01491 692345
Email: hydroenq@bgs.ac.uk

Murchison House (MH) Office
British Geological Survey
Murchison House
West Mains Road
Edinburgh
EH9 3LA
Tel: 0131 650 0282
Fax: 0131 650 0252
Email: enquiry@bgs.ac.uk

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- Geological observations and interpretations are made according to the prevailing understanding of the subject at the time. The quality of such observations and interpretations may be affected by the availability of new data, by subsequent advances in knowledge, improved methods of interpretation, and better access to sampling locations.
- Raw data may have been transcribed from analogue to digital format, or may have been acquired by means of automated measuring techniques. Although such processes are subjected to quality control to ensure reliability where possible, some raw data may have been processed without human intervention and may in consequence contain undetected errors.
- Detail, which is clearly defined and accurately depicted on large-scale maps, may be lost when small-scale maps are derived from them.
- Although samples and records are maintained with all reasonable care, there may be some deterioration in the long term.
- The most appropriate techniques for copying original records are used, but there may be some loss of detail and dimensional distortion when such records are copied.
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- Note that for some sites, the latest available records may be quite historical in nature, and while every effort is made to place the analysis in a modern geological context, it is possible in some cases that the detailed geology at a site may differ from that described.

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