



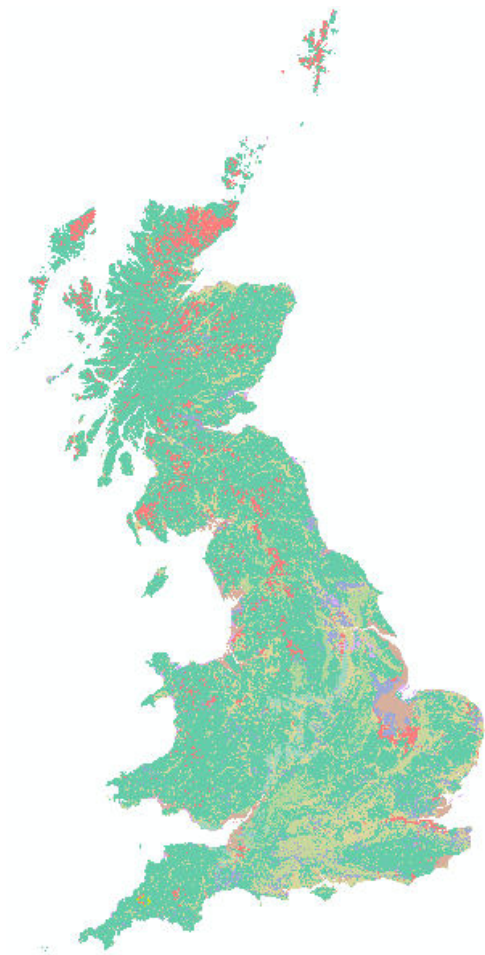
**British
Geological Survey**

NATURAL ENVIRONMENT RESEARCH COUNCIL

User Guide BGS Civils: foundations conditions (version 1)

Environmental Modelling Programme

Open Report OR/15/018



BRITISH GEOLOGICAL SURVEY

ENVIRONMENTAL MODELLING PROGRAMME

OPEN REPORT OR/15/018

User Guide BGS Civils: foundations conditions (version 1)

The National Grid and other Ordnance Survey data © Crown Copyright and database rights 2016. Ordnance Survey Licence No. 100021290 EUL.

Keywords

Engineering characteristics, Foundation conditions, National dataset, User Guide, GIS.

National Grid Reference

SW corner 0,0
NE corner 999999,999999
1:50 000 (primarily) scale,

Front cover

Excerpt from the Suitability for foundations dataset, south west England

Bibliographical reference

ENTWISLE, D C, Dobbs, M, Lawley, R. S, Lee, K. A.. 2016. User Guide BGS Civils: foundations conditions (version 1). *British Geological Survey Open Report*, OR/15/018. 24pp.

Copyright in materials derived from the British Geological Survey's work is owned by the Natural Environment Research Council (NERC) and/or the authority that commissioned the work. You may not copy or adapt this publication without first obtaining permission. Contact the BGS Intellectual Property Rights Section, British Geological Survey, Keyworth, e-mail ipr@bgs.ac.uk. You may quote extracts of a reasonable length without prior permission, provided a full acknowledgement is given of the source of the extract.

Maps and diagrams in this book use topography based on Ordnance Survey mapping.

D C Entwisle, M Dobbs, R S Lawley, K A Lee

Contributor/editor

P R N Hobbs

BRITISH GEOLOGICAL SURVEY

The full range of our publications is available from BGS shops at Nottingham, Edinburgh, London and Cardiff (Welsh publications only) see contact details below or shop online at www.geologyshop.com

The London Information Office also maintains a reference collection of BGS publications, including maps, for consultation.

We publish an annual catalogue of our maps and other publications; this catalogue is available online or from any of the BGS shops.

The British Geological Survey carries out the geological survey of Great Britain and Northern Ireland (the latter as an agency service for the government of Northern Ireland), and of the surrounding continental shelf, as well as basic research projects. It also undertakes programmes of technical aid in geology in developing countries.

The British Geological Survey is a component body of the Natural Environment Research Council.

British Geological Survey offices

BGS Central Enquiries Desk

Tel 0115 936 3143 Fax 0115 936 3276
email enquiries@bgs.ac.uk

Environmental Science Centre, Keyworth, Nottingham, NG12 5GG

Tel 0115 936 3241 Fax 0115 936 3488
email sales@bgs.ac.uk

Murchison House, West Mains Road, Edinburgh, EH9 3LA

Tel 0131 667 1000 Fax 0131 668 2683
email scotsales@bgs.ac.uk

Natural History Museum, Cromwell Road, London, SW7 5BD

Tel 020 758 4090 Fax 020 7584 8270
Tel 020 7942 5344/45 email bgs london@bgs.ac.uk

Columbus House, Greenmeadow Springs, Tongwynlais, Cardiff, CF15 7NE

Tel 029 2052 1962 Fax 029 2052 1963

Maclea Building, Crowmarsh Gifford, Wallingford, OX10 8BB

Tel 01491 838800 Fax 01491 692345

Geological Survey of Northern Ireland, Colby House, Stranmillis Court, Belfast, BT9 5BF

Tel 028 9038 8462 Fax 028 9038 8461
www.bgs.ac.uk/gsni/

Parent Body

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon, SN2 1EU

Tel 01793 411500 Fax 01793 411501
www.nerc.ac.uk

Website www.bgs.ac.uk

Shop online at www.geologyshop.com

Foreword

This report is the user guide for the BGS Civils foundation conditions dataset for use as a planning or desk study tool within a Geographical Information System (GIS) environment.

Acknowledgements

A number of individuals in the Environmental Modelling and Engineering Geology Programmes have contributed to the development. This assistance has been received at all stages of the study. In addition to the analysis of available information and data, individuals have freely given their advice to improve this product.

Contents

Foreword.....	i
Acknowledgements.....	i
Contents.....	ii
Summary.....	iii
1 Introduction.....	1
1.1 Background.....	1
2 Who would benefit from the product?	2
3 What the dataset shows	2
3.1 Foundation and geological considerations	2
4 Classification.....	3
4.1 Primary classification	3
4.2 Secondary classifications.....	7
5 How the dataset was created	8
6 Technical information.....	9
6.1 Scale.....	9
6.2 Coverage	9
6.3 Data history.....	9
6.4 Limitations.....	9
Contact information.....	10
Appendix 1 Engineering Properties: Field Properties.....	11
Appendix 2 Distribution of data	12
Appendix 3 Mapping Scales	13
Appendix 4. Foundation class with described condition, hazard and notes as in the GIS... 14	14
References	17

TABLES

Table 1: Foundation class and general ground conditions for foundations.....	4
Table 2: Classification of natural hazards that might affect foundations.....	5
Table 3: Additional notes for each foundation class	6
Table 4: Explanation of the nominal scales of geological map data.....	7

Summary

This report describes the national scope BGS Civils: foundation conditions dataset.

This document outlines the background to why the dataset was created, its potential uses and gives a brief description of the content. Technical information regarding the GIS and how the data was created is described and advice is provided on using the dataset. The methods used to create the dataset have been critically assessed and its fitness for purpose determined by specialists in BGS.

1 Introduction

This document provides information for users of the ‘BGS Civils: foundation conditions data product.

The ‘foundation’ must carry and transmit the load of the construction safely into the ground. The ground (rock and soil) is, therefore, an important consideration for the design and construction of foundations for buildings and other structures.

The main considerations are:

- Strength or bearing capacity.
- Settlement (compressibility) and differential settlement.
- Volume change of the ground due to climatic conditions.
- Subsidence or collapse due to natural voids beneath the foundation.

Other considerations include:

- Weathering and alteration.
- Aggressive ground conditions produced by soluble sulfate, oxidation of sulfide, low pH or high chloride content.
- Foundation excavation protection.

The ‘BGS Civils: foundation conditions dataset only considers the conditions of the ground and does not consider hazards such as harmful gases (radon, methane or carbon dioxide) or local hydrogeological conditions (information about these hazards can be derived elsewhere: www.bgs.ac.uk).

The dataset is intended to provide information for the foundations, and the conditions of soils and rocks that are likely to be encountered.

1.1 BACKGROUND

The properties and behaviour of rocks and soils are fundamental to the planning design and construction of buildings and infrastructure. The assessment of the geology for planners and civil engineers were included in a series of BGS Technical Reports (A geological background for planning and development) funded by the Department of the Environment during the 1980’s and 1990’s (reviewed in Smith and Ellison 1999). Many of these characteristics were also included in a number of British Geological Survey 1:50 000 geological sheet brief explanations and the 1:1 000 000 scale engineering geology maps of the United Kingdom (Dearman et al. 2011, Dobbs et al. 2012).

In 2010, the British Geological Survey initiated a development programme to produce thematic products that identified and assessed various engineering characteristics of the geology at surface in Great Britain. These products at the publication of this user-guide include strength, excavatability, corrosivity (ferrous), fill, discontinuities, bulking factor, and sulfate/sulfide potential.

2 Who would benefit from the product?

The foundation conditions product is of interest to a wide range of organisations concerned with development or management of assets including utility companies, local authorities, developers and engineering consultants and contractors.

The information presented in the foundation conditions dataset (primarily using the 1:50 000 scale geological data) is intended to provide a generic assessment to inform planning and the desk study stage of ground investigations, thereby allowing for more efficient planning and practices.

3 What the dataset shows

3.1 FOUNDATION AND GEOLOGICAL CONSIDERATIONS

The foundation conditions dataset forms part of a BGS Civils suite of GIS maps for a range of engineering parameters. The purpose of this dataset is to provide general guidance on the foundation conditions of rocks and soils present within geological units, as defined on DiGMapGB and the geology at surface (DiGMapGB-PlusV6). The GIS model displays the spatial variation of foundation conditions as three fields - foundation conditions, foundation hazards and additional foundation notes.

The classification system used to develop the dataset is in line with the British Standard on foundations (BSI 1986, 2015) and Eurocode EN 1997-1 (BSI 2004+A1:2013). The Standards provide guidance on multiple factors that need to be considered for the design and construction of foundations as well as foundation types and the situations in which they are generally used. Additional details (not in the standard) are provided within the foundation conditions dataset such as the possible occurrence of sulfate and sulfide, which might produce aggressive ground conditions.

The factors considered as part of the foundation conditions dataset are:

3.1.1 Strength or bearing capacity

The stress imparted by the foundation must not result in the ground failing.

3.1.2 Differential settlement and ground movement.

Differential settlement causes strains across a structure, which, unless designed correctly, could result in damage the buildings foundations. Settlement might occur as a result of differential movement, or where the ground responds differently to the loads imparted across the foundations. . Differential movement can have a number of causes including:

- Where foundations are sited on clays prone to volume change (due to changes in water content particularly where associated with growth or removal of certain tree species.).
- Frost heave near surface in silts and fine sand.
- The strains caused by landslides;
- Collapse due to dissolution in certain rocks;
- The contrast in material characteristics between bedrock and infilled dissolution features;
- Constructions on active or activated landslides;
- In deposits where there are rapid changes in contrasting material types for instance in some alluvium that contain soft clay or silt, or peat lenses or beds of varying thickness;

Note - Ground movement caused by human activity including undermining or ground is not included in this assessment.

3.1.3 Subsidence due to dissolution.

Rainfall and ground water movement can dissolve a number of rock types over time to form surface or underground cavities or more general subsidence. Underground cavities might be empty or infilled with younger material of different strength or compressibility.

3.1.4 Weathering and alteration

Physical and chemical changes generally reduce strength or completely alter the material and might provide variable foundation conditions across a site or a construction.

3.1.5 Aggressive ground conditions

The presence of soluble sulfate minerals and excessive acid or alkalinity might create aggressive ground conditions. Sulfate ions attack modern cement and concrete resulting in loss of strength. Excessive acid or alkalinity of the groundwater can also have a detrimental effect on buried concrete and steel structures. The oxidation of sulfide minerals can produce acid ground conditions or, in combination with calcium carbonate, which provides a store of moderately soluble sulfate (i.e. gypsum) and sulfate ions dissolved into groundwater.

3.1.6 Foundation excavations protection

Clay, some mudstones and silts are prone to deterioration on wetting and drying and need protection after excavation at foundation level and prior to construction of the foundations. Some lithologies require frost protection if exposed during very cold weather conditions.

3.1.7 Collapsible ground

Some silt deposits have an open fabric and might be prone to rapid collapse when loaded and saturated with water.

3.1.8 Soakaways

Soakaways are used to dispose of water from buildings and paved areas remote from public sewer or water courses, or to reduce water in public sewers particularly during times of high rainfall. The increased requirement of sustainable urban drainage systems (SUDS) has resulted in more use of these systems. Soakaways might not be suitable where they can cause an increased chance of ground collapse above and within soluble rocks (gypsum, limestone and chalk) or where the water might activate or reactivate landslides. In very low permeability rocks they are generally impractical. Further information about the use of SUDS is available from www.bgs.ac.uk/suds.

4 Classification

The dataset is provided in four primary fields: Class, Condition, Hazard and additional Notes. Each of these attribute fields are described below.

4.1 PRIMARY CLASSIFICATION

4.1.1 CLASS

This is a re-classification of the standard BGS rock description (shown on geology maps) into classes of 'engineering foundation' characteristics. The alphanumeric code is used to provide a handy, short reference code when using the digital maps.

4.1.2 CONDITION

The 'condition' attribute provides a general comment/ overview relevant to the foundation class derived for each geological and lithological description of a rock or soil. The foundation class and condition fields are described below in Table 1.

Table 1: Foundation class and general ground conditions for foundations

CLASS	CONDITION
9	Generally unsuitable for most foundation types (water)
A0	Generally unsuitable for most foundation types
A1C	Generally very poor foundation conditions OR poor to moderate conditions (where ground is no longer tidal)
A1S	Variable foundation conditions from poor (in dynamic environment) to good (in stable environment)
A2	Generally unsuitable foundation conditions (unless assessed as stable or stabilised by engineering works)
A3	Difficult foundation conditions (due to the presence of boulders)
C1	Generally good foundation conditions
C1U	Generally good foundation conditions
C2	Generally good foundation conditions
C2U	Generally good foundation conditions
C3	Good to poor foundation conditions
C3L	Generally good foundation conditions
C3P	Generally good foundation conditions
C4	Good to poor foundation conditions
DD1	Foundation conditions unknown because lithologies are unknown
DD2	Good to very poor foundation conditions
K0	Good to poor foundation conditions
K0C1U	Generally good foundation conditions BUT might be locally moderate or poor
K1	Generally good foundation conditions BUT might be locally moderate or poor where dissolution occurs
K1C	Generally good foundation conditions BUT might be locally moderate or poor
K1CS	Generally good foundation conditions BUT might be locally moderate or poor where dissolution occurs
K1S	Generally good foundation conditions BUT might be locally moderate or poor where dissolution occurs
K2	Generally good foundation conditions BUT may be locally variable or poor
L	Generally good foundation conditions BUT might be locally poor
M1	Generally good foundation conditions BUT might be locally poor
M2	Generally good foundation conditions
M2U	Generally good foundation conditions
M3	Generally good foundation conditions
R1	Generally good foundation conditions
RC1	Generally good foundation conditions
RC2	Generally good foundation conditions
RCS	Generally good foundation conditions
RCSL	Generally good foundation conditions
RCSU	Generally good foundation conditions
RCSV	Generally good foundation conditions
RCU	Generally good foundation conditions
RD	Foundation conditions unknown because lithologies are unknown
S1	Generally good foundation conditions BUT might be locally poor
S2	Generally good foundation conditions

4.1.3 HAZARD

The 'hazard' field contains a short description of various inherent characteristics of the ground that might adversely affect construction or foundation design. This includes the propensity for volume change, karstic conditions, possibility of aggressive ground conditions and exposure to dynamic environments. The foundation class and hazard fields are described below in Table 2.

Table 2: Classification of natural hazards that might affect foundations

CLASS	HAZARD
9	Water. Changes in water levels possible. Poor foundation conditions beneath water
A0	Likely highly compressible ground. Possible large and differential settlement and aggressive acidic conditions. Excavations might to be unstable
A1C	Highly compressible ground. Possible differential settlement. Salt and sulfide might be present. Excavation might be unstable
A1S	Possible dynamic environment. Deposition and erosion might occur. Silt and some sand might be frost susceptible. Shells, if present, might crush under load. Excavations might be unstable
A2	Possible unstable ground (assess for stability). Excavations likely to be unstable
A3	If boulders are present they can obstruct foundations and there is potential for differential settlement
C1	Probable volume change (shrink/swell) hazard
C1U	Probable shrink/swell hazard. Sulfate/sulfide might be present
C2	Possible shrink/swell hazard
C2U	Possible shrink/swell hazard. Sulfate/sulfide might be present
C3	Possible variable compressibility. Local low bearing-capacity and differential settlement. Flooding of alluvium should be considered
C3L	Possible variable ground conditions (clay and mudstone)
C3P	Low potential for collapse when loaded and saturated
C4	Might contain shear surfaces. Excavation might be unstable
DD1	Hazards not known
DD2	Hazards not known. Possible highly variable ground conditions. Might contain chemical and physical hazards
K0	Dissolution of gypsum at or near foundation level. Collapse breccia, and differential settlement might occur. Sulfate might be present
K0C1U	Possible dissolution of gypsum at or near foundation level. Collapse breccia, and differential settlement might occur. Sulfate might be present
K1	Voids or infilled voids in limestone might result in differential settlement
K1C	Voids or infilled voids in limestone might result in differential settlement
K1CS	Voids or infilled voids in limestone might result in differential settlement. Sand, if present, might be frost susceptible
K1S	Voids or infilled voids in limestone might result in differential settlement. Sandstone might weather to sand and might be frost susceptible
K2	Voids or infilled voids in limestone might result in differential settlement. Weathered chalk (silt) might be frost susceptible
L	Coal present at foundation level requires remedial measures. Assess emissions of dangerous gasses. Might be mined out and backfilled
M1	Possible highly compressible ground and variable bearing capacity. Possible differential settlement. Sand and silt might be frost susceptible
M2	Sand or silt might be frost susceptible
M2U	Possible shrink/swell hazard. Sulfate/sulfide hazard. Sand and silt might be frost susceptible
M3	Possible variable ground conditions due to lithological variability. Boulders at or just below foundation level might result in differential settlement
R1	Possible variable ground conditions near surface due to weathering
RC1	Possible variable ground conditions near surface due to weathering
RC2	Possible variable foundation conditions at interface between granite and altered granite
RCS	Possible variable ground conditions near surface due to weathering. Sand, if present, might be frost susceptible
RCSL	Possible variable ground conditions near surface due to weathering. Sand, if present, might be frost susceptible. Possible near surface coal mining

RCSV	Possible variable ground conditions near surface due to weathering. Fine-grained Head deposits, if present, might contain shear surfaces affecting stability in pits and trenches
RCU	Sulfate/sulfide might be present
RD	Hazards not known
S1	Excavations might be unstable. Sand and silt might be frost susceptible
S2	Possible variable ground conditions due to sand/sandstone lithological variability. Sand might be frost susceptible. Excavations might be unstable

4.1.4 NOTES

The ‘notes’ attribute provides additional relevant information about inherent characteristics of the ground as they relate to foundations; such as actions recommended to be taken before construction, or further implications for design and constraints. The foundation class and notes fields are described below in Table 2.

Table 3: Additional notes for each foundation class

CLASS	NOTES
9	Assess water levels, ground conditions and practical foundation type
A0	Peat at surface is usually removed if shallow. Assess for potential differential settlement between buildings and services. Identify if water table is near surface
A1C	Tidal ground generally unsuitable. If non-tidal, assess ground conditions (including salinity and effects on construction and infrastructure)
A1S	Construction of buildings generally only suitable if the deposit is stable (not eroding or accreting)
A2	Assess slope stability and the effects of loading the ground or effects of changes to drainage. Foundation level may need protection in open excavation. Soakaways should not be used
A3	Assess for presence of boulders and remove where required.
C1	Assess if shrink/swell hazard is likely. Foundation type and depth might be influenced by planting or removal of nearby trees. Foundation level might need protection in open excavation
C1U	Assess if shrink/swell hazard is likely. Foundation type and depth might be influenced by planting or removal of nearby trees. Foundation level might need protection in open excavation. Sulfide/sulfate might be present
C2	Assess if shrink/swell hazard is likely. Clay at foundation level might require protection in open excavation
C2U	Assess if shrink/swell hazard is likely. Assess sulfate/sulfide content. Clay at foundation level might require protection in open excavation
C3	Assess the variable compressibility of the ground and areas of lower bearing capacity. Foundation level might need protection in open excavation. Identify if water table is near surface
C3L	Foundation levels might need protection in open excavation. Presence of coal or lignite might require remedial measures
C3P	Assessment for collapse potential might be required
C4	Foundation level might need protection in open excavation
DD1	Assess the lithology(ies) and engineering characteristics. Sand/silt at foundation level might be frost susceptible. Foundation level might need protection if clay is present
DD2	Assess the variability and character of the ground. Assess for possible contaminated ground and aggressive ground conditions. Decontamination might be required. Open excavations might need protection if clay is present
K0	Assess the effect of gypsum dissolution and infilling of voids. Assess sulfate/sulfide content. Foundation level might need protection in open excavation
K0C1U	Assess the effect of gypsum dissolution and infilling of voids. Assess sulfate/sulfide content. Foundation level might need protection in open excavation
K1	Assess the presence of dissolution features and possible variable ground conditions. Soakaways should not be constructed near buildings
K1C	Assess the presence of dissolution features and possible variable ground conditions. Soakaways should not be constructed near buildings. Fine soils and rocks might need protection at foundation level in open excavation
K1CS	Assess the presence of dissolution features (limestone) and possible variable ground conditions. Soakaways should not be constructed in limestone near buildings. Foundations might need protection in open excavation

K1S	Assess the presence of dissolution features (limestone) and possible variable ground conditions. Soakaways should not be constructed in limestone near buildings
K2	Assess the presence of dissolution features and possible variable ground conditions. Soakaways should not be constructed near buildings
L	Identify if coal or evidence of mining is present. If so, remedial measures might be required
M1	Identify possible presence of variable ground conditions. Clay at foundation level might require protection in open excavation
M2	Clay at foundation level might require protection in open excavation
M2U	Assess if shrink/swell hazard is likely. Assess sulfate/sulfide concentrations. Sand/silt at foundation level might be frost susceptible. Foundation levels might need protection in open excavation
M3	Assess variability of ground conditions. Clay at foundation level might require protection. Assess for presence of boulders at or just below foundation level
R1	Assess the nature and depth of weathering and methods of excavation
RC1	Foundation level in clay or mudstone might need protection in open excavation
RC2	Identify if altered granite (sand and clay) is present
RCS	Assess nature and depth of weathered material. Clay (weathered mudstone) at foundation level might need protection in open excavation
RCSL	Assess nature and depth of weathered material. Clay (weathered mudstone) at foundation level might need protection in open excavation. Coal or presence of mining might require remedial measures
RCSU	Assess nature and depth of weathered material. Assess sulfate/sulfide concentrations
RCSV	Assess nature and depth of weathered material including clay, sand and gravel. Clay (weathered mudstone/slate) at foundation level might need protection in open excavation
RCU	Assess nature and depth of weathered material. Clay (weathered mudstone) at foundation level might need protection in open excavation. Assess sulfate/sulfide concentrations
RD	Assess the lithology and ground behaviour to identify suitable foundations
S1	Assess lithological and density variation. Clay at foundation level might need protection in open excavation
S2	Assess the distribution of sand/sandstone at foundation level

4.2 SECONDARY CLASSIFICATIONS

The additional data fields included in this dataset are described below. These are provided as metadata for individual objects within the dataset. Field descriptions as they appear in the dataset are shown in Appendix 1.

4.2.1 Nominal Scale (NOM_SCALE)

This field describes the notional x-y spatial scale of the data. Most geological map data in the dataset is captured and presented at a scale of 1:50 000. The field identifies a combination of scales used to create the map from the bedrock and superficial map sources. The available scales are shown in Table 4.

Table 4: Explanation of the nominal scales of geological map data

Field Value Superficial_bedrock scales (k)	Meaning
0_50	No superficial data is present for this sheet and bedrock data is available at 1:50 000 scale
0_250	No superficial data is present for this sheet and bedrock data is available at 1:250 000 scale
625_50	Superficial data is present for this sheet at a scale of 1:625 000 and bedrock data is available at a scale of 1:50 000
50_50	Superficial data is present for this sheet at a scale of 1:50 000 and bedrock data is available at a scale of 1:50 000
35_50	Superficial data is present for this sheet at a scale of 1:35 000 and bedrock data is available at a scale of 1:50 000
35_250	Superficial data is present for this sheet at a scale of 1:35 000 and bedrock data is available at a scale of 1:250 000

4.2.2 UID

This is a unique object identifier based on DNF notation and ArcGIS indexing using a field calculation based on the following pseudo code: “bgsn:DPF_V6_” & FID.

4.2.3 VERSION

This is a layer identifier based on BGS standard practice using a field calculation based on the following pseudo code: “BGSCivils_Foundations_V6”.

5 How the dataset was created

The foundation conditions dataset is based on British Standard on foundations (BSI, 1986, 2015), interpreted for each lithology unit. The interpretation uses data from a number of different sources currently held by BGS. The primary datasets used for the foundation conditions dataset are:

- Parent Material Map V6 dataset
- BGS National Geotechnical Properties Database
- BGS Lexicon of Named Rock Units
- BGS Map Sheet Memoirs and Explanations
- BGS and Geological Society Regional Guides
- BGS Urban Planning Reports
- BGS Engineering Geology Formation Study Reports
- BGS 1:1 M Scale Engineering Geology Maps of the UK (including the extended key)
- Site Investigation Records and Borehole images held in BGS archives.

The BGS Civils datasets follow a standard workflow to create each dataset:

- Step 1: Identify characteristic, measurements and observations from archive records and literature.
- Step 2: Categorise the observations into primary and then secondary classes of similar behaviours. Where possible using published standards of classification such as BS 5930, Eurocode 7 or other similar international or national standard.
- Step 3: Assess the range of lithostratigraphic variation of geological materials across Great Britain, in terms of the categories and classes identified in step 2 to create a ‘lookup’ dataset of expected attributes (material characteristics and behaviours) per lithostratigraphic unit.
- Step 4: Join the spatial (map) components of the DiGMapPlusV6 datasets with the ‘lookup’ dataset to create a new .shp file of foundation conditions.
- Step 5: Import the foundation conditions and design of the colour scheme to produce a layer (.lyr) file and assess the result.
- Step 6. Critically assess the resulting GIS files and make alterations.
- Step 7. Finalise GIS files.

Categorisation of the data, and assessment of the foundation conditions of rocks and soils within the UK, has been made by expert judgement in order to create ‘look up tables’ of lithostratigraphic rock type and associated engineering properties. Assignments of characteristics and descriptors has been made at the ‘formation’ level of lithostratigraphic classification.

Spatial data-creation and discontinuity attribution has been completed using ESRI ARCGIS software.

6 Technical information

6.1 SCALE

The 'BGS Civils: foundation conditions' dataset is produced for use at 1:50 000 scale providing 50 m ground resolution.

The data are released in ESRI shapefile formats (.shp). Other formats such as MapInfo TAB are available on request. The standard data supplied to customers has polygons or areas in a single layer or theme.

6.2 COVERAGE

Data is provided to indicate the likely foundation conditions of rocks and soils across Great Britain. The scales of map data available to create this dataset are shown in Appendix 3.

6.3 DATA HISTORY

Version 1 (released 2016): Derived from DiGMapGB-50 version 6.

6.4 LIMITATIONS

- The 'BGS Civils: foundation conditions' product has been developed for **desk study purposes only** and under no circumstances should it be used for foundation design.
- The 'BGS Civils: foundation conditions' product has been developed to provide general guidance on the foundation conditions of soils and rocks within geological units up to 20 m below ground level, as defined on DiGMapGB-50.
- The 'BGS Civils: foundation conditions' product has been developed at 1:50 000 scale and must not be used at larger scales. All spatial searches against the data should be done with a minimum 50 m buffer
- The 'BGS Civils: foundation conditions' product has been developed at a formational scale, as such it does not detail intra-formational variation.
- The spatial distribution of the data is limited by the distribution of the site investigation exploratory holes from which the geotechnical data have been extracted and the distribution of available information from sheet memoirs and sheet explanations, reports, and digital geological map data (DiGMapGB-50) (Appendix 2 and Appendix 3). Although the National Geotechnical Properties Database is the 'first port of call' for data it has limited coverage so other descriptive data from exploratory borehole logs or from site investigation reports has been used.
- Local conditions might vary and this dataset should not replace detailed site investigations. Further detail of the geology might be available on more detailed 1:10 000 scale geological maps.
- The spatial distribution of the data is limited by the spatial accuracy and resolution of the digital geological map data (DiGMapGB-50) (Appendix 3). Spatial mismatches of foundation conditions related to mismatches in lithostratigraphical or rock classification type (i.e. variation in Lex-RCS across map-sheet boundaries) are unavoidable and require resolution by reference to higher resolution map information. Further detail of the geology might be available on more detailed 1:10 000 scale geological maps.
- 'BGS Civils: foundation conditions' product is created as vector polygons and are available in a range of GIS formats, including ArcGIS (.shp), ArcInfo Coverages and

MapInfo (.tab). More specialised formats might be available but might incur additional processing costs.

- The 'BGS Civils: foundation conditions' product is concerned with the properties of NATURAL geological deposits and conditions only. It does NOT cover any man-made constructions or materials. It also does NOT cover undermining. This hazard is addressed in the BGS Mining Hazard dataset.
- 'BGS Civils: foundation conditions' product is based on, and limited to, an interpretation of the records in the possession of The British Geological Survey at the time the product was created.
- An indication of the foundation conditions does not necessarily mean that the ground properties are consistent throughout the outcrop. Such an assessment can only be made by inspection of the area by a qualified professional.

The engineering codes, general foundation conditions, natural geological hazards and additional notes are summarised in Appendix 4.

Contact information

For all data and licensing enquiries please contact:

Central Enquiries
British Geological Survey
Kingsley Dunham Centre
Keyworth
Nottingham
NG12 5GG
Direct tel: +44(0)115 936 3143
Fax: +44(0)115 9363150
Email: mail to enquiries@bgs.ac.uk

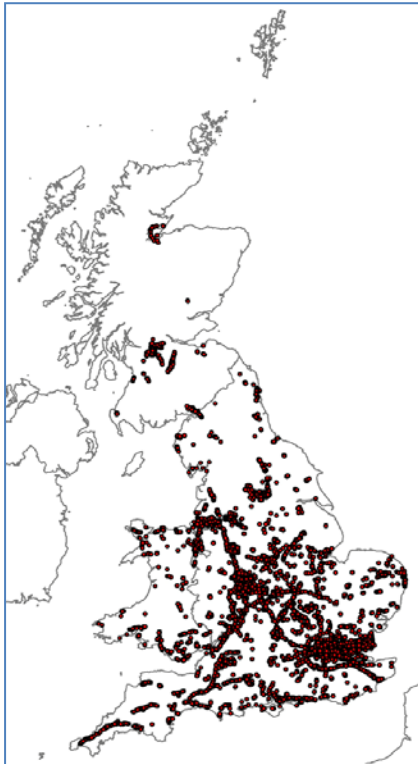
Appendix 1 Engineering Properties: Field Properties

Field name	Field description	Description
GEN_PMLITH	Generalised lithology description	This is a simplified geological description of the parent material and is derived from the original DiGMapGB-50 LEX-RCS coding compared with the hierarchical classification of UK rocks from the BGS RCS system. In general the aim is to provide the user with as simplified a lithological description as possible.
CLASS	Classification of the geology in relation to the foundation conditions	This field contains the code for the characteristics of the geology that might affect planning and foundation design and construction.
CONDITION	Description of the likely foundation conditions	A general descriptive comment on the likely ground conditions, primarily for spread formations.
HAZARD	The possible geological, physical and chemical hazards	The geological, physical and chemical hazards that might occur. The geological hazards are mostly from the GeoSure layers.
NOTES	Additional notes on the conditions, hazards and construction constraints	Comments on the foundations, local conditions and some possible construction constraints
NOM_SCALE	Nominal Scale	This field describes the notional x-y spatial scale of the data. Most geological map data in the dataset is captured and presented at a scale of 1:50,000. The field identifies a combination of scales used to create the map from the bedrock and superficial map sources.
UID	Unique identifier	Map metadata (identifies each spatial object uniquely)
VERSION	Version of the dataset	Map metadata (identifies dataset uniquely)

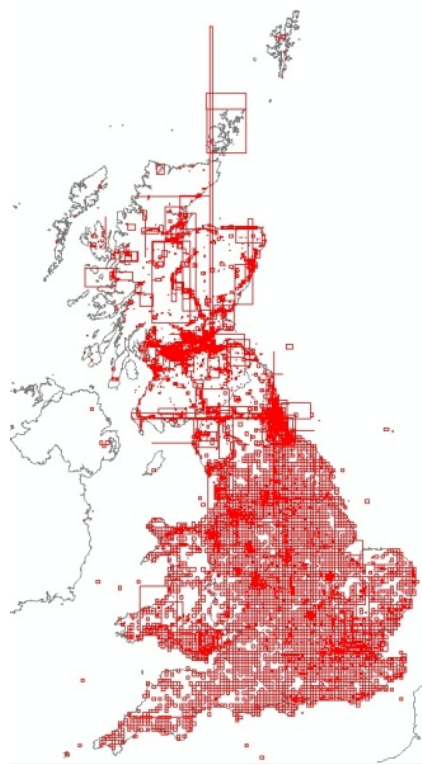
Appendix 2 Distribution of data

Distribution of data held in the (a) National Geotechnical Properties Database, (b) Site Investigation Records, (c) sheet memoirs, (d) borehole scans

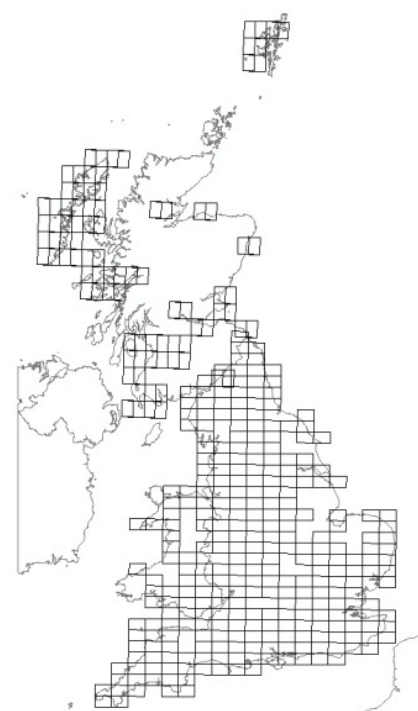
(a)



(b)



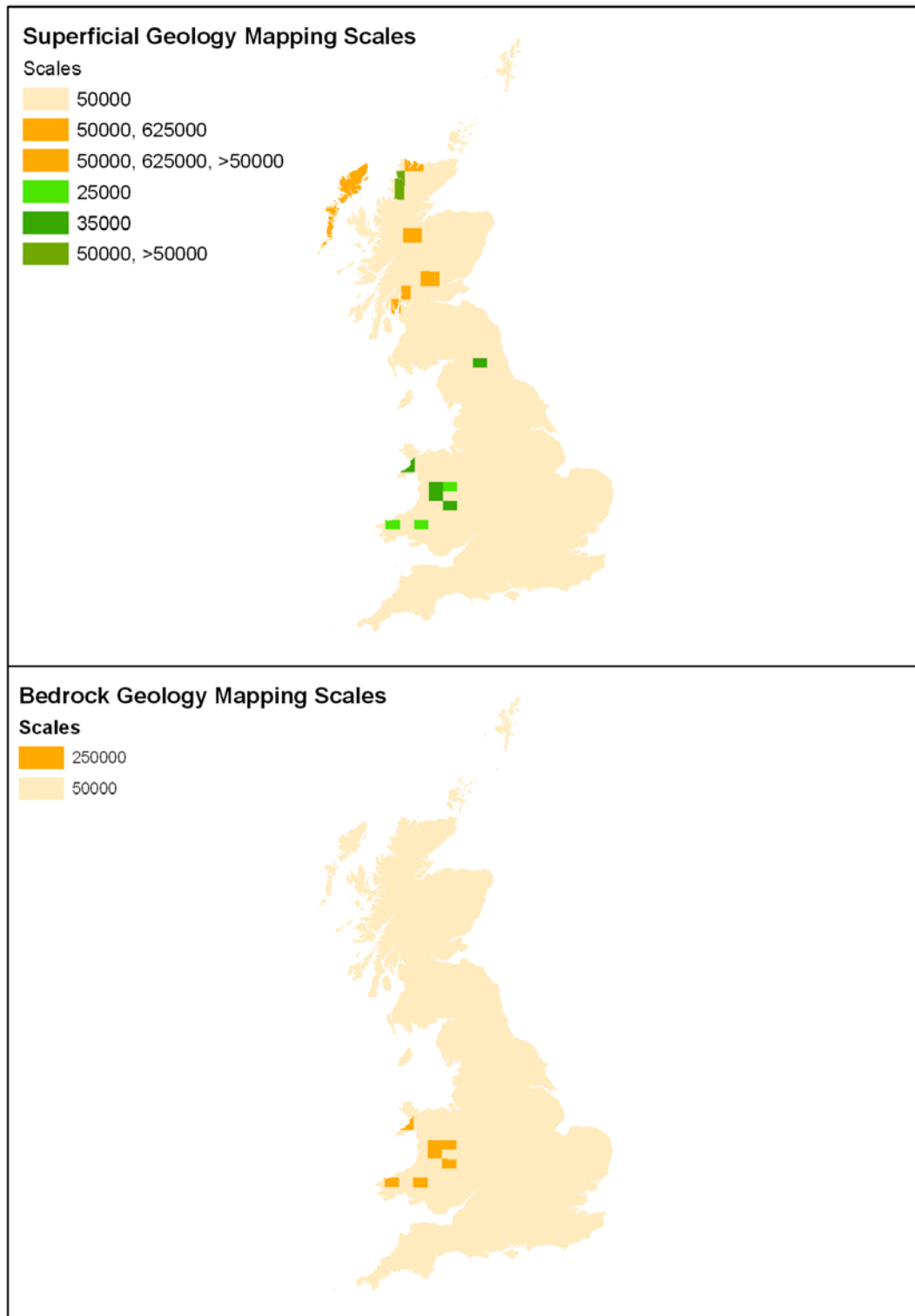
(c)



(d)



Appendix 3 Mapping Scales



Appendix 4. Foundation class with described condition, hazard and notes as in the GIS

CLASS	CONDITION	HAZARD	NOTES
9	Generally unsuitable for most foundation types	Water. Changes in water levels possible. Poor foundation conditions beneath water	Assess water levels, ground conditions and practical foundation type
A0	Generally unsuitable for most foundation types	Likely highly compressible ground. Possible large and differential settlement and aggressive acidic conditions. Excavations might to be unstable	Peat at surface is usually removed if shallow. Assess for potential differential settlement between buildings and services. Identify if water table is near surface
A1C	Generally very poor foundation conditions OR poor to moderate conditions (where ground is no longer tidal)	Highly compressible ground. Possible differential settlement. Salt and sulfide might be present. Excavation might be unstable	Tidal ground generally unsuitable. If non-tidal, assess ground conditions (including salinity and effects on construction and infrastructure)
A1S	Variable foundation conditions from poor (in dynamic environment) to good (in stable environment)	Possible dynamic environment. Deposition and erosion might occur. Silt and some sand might be frost susceptible. Shells, if present, might crush under load. Excavations might be unstable	Construction of buildings generally only suitable if the deposit is stable (not eroding or accreting)
A2	Generally unsuitable foundation conditions (unless assessed as stable or stabilised by engineering works)	Possible unstable ground (assess for stability). Excavations likely to be unstable	Assess slope stability and the effects of loading the ground or effects of changes to drainage. Foundation level may need protection in open excavation. Soakaways should not be used
A3	Difficult foundation conditions (due to the presence of boulders)	If boulders are present they can obstruct foundations and there is potential for differential settlement	Assess for presence of boulders and remove where required.
C1	Generally good foundation conditions	Probable volume change (shrink/swell) hazard	Assess if shrink/swell hazard is likely. Foundation type and depth might be influenced by planting or removal of nearby trees. Foundation level might need protection in open excavation
C1U	Generally good foundation conditions	Probable shrink/swell hazard. Sulfate/sulfide might be present	Assess if shrink/swell hazard is likely. Foundation type and depth might be influenced by planting or removal of nearby trees. Foundation level might need protection in open excavation. Sulfide/sulfate might be present
C2	Generally good foundation conditions	Possible shrink/swell hazard	Assess if shrink/swell hazard is likely. Clay at foundation level might require protection in open excavation
C2U	Generally good foundation conditions	Possible shrink/swell hazard. Sulfate/sulfide might be present	Assess if shrink/swell hazard is likely. Assess sulfate/sulfide content. Clay at foundation level might require protection in open excavation
C3	Good to poor foundation conditions	Possible variable compressibility. Local low bearing-capacity and differential settlement. Flooding of alluvium should be considered	Assess the variable compressibility of the ground and areas of lower bearing capacity. Foundation level might need protection in open excavation. Identify if water table is near surface
C3L	Generally good foundation conditions	Possible variable ground conditions (clay and mudstone)	Foundation levels might need protection in open excavation. Presence of coal or lignite might require remedial measures
C3P	Generally good foundation conditions	Low potential for collapse when loaded and saturated	Assessment for collapse potential might be required
C4	Good to poor foundation conditions	Might contain shear surfaces. Excavation might be unstable	Foundation level might need protection in open excavation
DD1	Foundation conditions unknown because lithologies are unknown	Hazards not known	Assess the lithology(ies) and engineering characteristics. Sand/silt at foundation level might be frost susceptible. Foundation level might need protection if clay is present

DD2	Good to very poor foundation conditions	Hazards not known. Possible highly variable ground conditions. Might contain chemical and physical hazards	Assess the variability and character of the ground. Assess for possible contaminated ground and aggressive ground conditions. Decontamination might be required. Open excavations might need protection if clay is present
K0	Good to poor foundation conditions	Dissolution of gypsum at or near foundation level. Collapse breccia, and differential settlement might occur. Sulfate might be present	Assess the effect of gypsum dissolution and infilling of voids. Assess sulfate/sulfide content. Foundation level might need protection in open excavation
K0C1U	Generally good foundation conditions BUT might be locally moderate or poor	Possible dissolution of gypsum at or near foundation level. Collapse breccia, and differential settlement might occur. Sulfate might be present	Assess the effect of gypsum dissolution and infilling of voids. Assess sulfate/sulfide content. Foundation level might need protection in open excavation
K1	Generally good foundation conditions BUT might be locally moderate or poor where dissolution occurs	Voids or infilled voids in limestone might result in differential settlement	Assess the presence of dissolution features and possible variable ground conditions. Soakaways should not be constructed near buildings
K1C	Generally good foundation conditions BUT might be locally moderate or poor	Voids or infilled voids in limestone might result in differential settlement	Assess the presence of dissolution features and possible variable ground conditions. Soakaways should not be constructed near buildings. Fine soils and rocks might need protection at foundation level in open excavation
K1CS	Generally good foundation conditions BUT might be locally moderate or poor where dissolution occurs	Voids or infilled voids in limestone might result in differential settlement. Sand, if present, might be frost susceptible	Assess the presence of dissolution features (limestone) and possible variable ground conditions. Soakaways should not be constructed in limestone near buildings. Foundations might need protection in open excavation
K1S	Generally good foundation conditions BUT might be locally moderate or poor where dissolution occurs	Voids or infilled voids in limestone might result in differential settlement. Sandstone might weather to sand and might be frost susceptible	Assess the presence of dissolution features (limestone) and possible variable ground conditions. Soakaways should not be constructed in limestone near buildings
K2	Generally good foundation conditions BUT may be locally variable or poor	Voids or infilled voids in limestone might result in differential settlement. Weathered chalk (silt) might be frost susceptible	Assess the presence of dissolution features and possible variable ground conditions. Soakaways should not be constructed near buildings
L	Generally good foundation conditions BUT might be locally poor	Coal present at foundation level requires remedial measures. Assess emissions of dangerous gasses. Might be mined out and backfilled	Identify if coal or evidence of mining is present. If so, remedial measures might be required
M1	Generally good foundation conditions BUT might be locally poor	Possible highly compressible ground and variable bearing capacity. Possible differential settlement. Sand and silt might be frost susceptible	Identify possible presence of variable ground conditions. Clay at foundation level might require protection in open excavation
M2	Generally good foundation conditions	Sand or silt might be frost susceptible	Clay at foundation level might require protection in open excavation
M2U	Generally good foundation conditions	Possible shrink/swell hazard. Sulfate/sulfide hazard. Sand and silt might be frost susceptible	Assess if shrink/swell hazard is likely. Assess sulfate/sulfide concentrations. Sand/silt at foundation level might be frost susceptible. Foundation levels might need protection in open excavation
M3	Generally good foundation conditions	Possible variable ground conditions due to lithological variability. Boulders at or just below foundation level might result in differential settlement	Assess variability of ground conditions. Clay at foundation level might require protection. Assess for presence of boulders at or just below foundation level
R1	Generally good foundation conditions	Possible variable ground conditions near surface due to weathering	Assess the nature and depth of weathering and methods of excavation
RC1	Generally good foundation conditions	Possible variable ground conditions near surface due to weathering	Foundation level in clay or mudstone might need protection in open excavation
RC2	Generally good foundation conditions	Possible variable foundation conditions at interface between granite and altered granite	Identify if altered granite (sand and clay) is present
RCS	Generally good foundation conditions	Possible variable ground conditions near surface due to weathering. Sand, if present, might be frost susceptible	Assess nature and depth of weathered material. Clay (weathered mudstone) at foundation level might need protection in open excavation

RCSL	Generally good foundation conditions	Possible variable ground conditions near surface due to weathering. Sand, if present, might be frost susceptible. Possible near surface coal mining	Assess nature and depth of weathered material. Clay (weathered mudstone) at foundation level might need protection in open excavation. Coal or presence of mining might require remedial measures
RCSU	Generally good foundation conditions	Sulfate/sulfide might be present	Assess nature and depth of weathered material. Assess sulfate/sulfide concentrations
RCSV	Generally good foundation conditions	Possible variable ground conditions near surface due to weathering. Fine-grained Head deposits, if present, might contain shear surfaces affecting stability in pits and trenches	Assess nature and depth of weathered material including clay, sand and gravel. Clay (weathered mudstone/slate) at foundation level might need protection in open excavation
RCU	Generally good foundation conditions	Sulfate/sulfide might be present	Assess nature and depth of weathered material. Clay (weathered mudstone) at foundation level might need protection in open excavation. Assess sulfate/sulfide concentrations
RD	Foundation conditions unknown because lithologies are unknown	Hazards not known	Assess the lithology and ground behaviour to identify suitable foundations
S1	Generally good foundation conditions BUT might be locally poor	Excavations might be unstable. Sand and silt might be frost susceptible	Assess lithological and density variation. Clay at foundation level might need protection in open excavation
S2	Generally good foundation conditions	Possible variable ground conditions due to sand/sandstone lithological variability. Sand might be frost susceptible. Excavations might be unstable	Assess the distribution of sand/sandstone at foundation level

References

British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: <http://geolib.bgs.ac.uk>.

BSI. 1986. BS8004: Code of practice for foundations. British Standards Institution, London.

BSI. 2003. BS EN ISO 14689-1 – Geotechnical investigation and testing — Identification and classification of rock — Part 1: Identification and description. British Standards Institution, London.

BSI. 2004 + A1: 2013. Eurocode 7. Geotechnical design. General rules. Amendment 2 British Standards Institution, London.

BSI. 2015. Code of practice for foundations. British Standards Institution, London.

DEARMAN, W R, DOBBS, M, CULSHAW, M G, NORTHMORE, K J, ENTWISLE, D C AND REEVES H J. 2011a. *Engineering geology (superficial) map of the United Kingdom, 1: 1 000 000*. British Geological Survey, Keyworth, Nottingham, UK. <http://nora.nerc.ac.uk/19267/>

DEARMAN, W R, DOBBS, M, CULSHAW, M G, NORTHMORE, K J, ENTWISLE, D C AND REEVES H J. 2011b. *Engineering geology (bedrock) map of the United Kingdom, 1: 1 000 000*. British Geological Survey, Keyworth, Nottingham, UK. <http://nora.nerc.ac.uk/19266/>

DEARMAN, W R, DOBBS, M, CULSHAW, M G, NORTHMORE, K J, ENTWISLE, D C AND REEVES H J. 2011c. *Extended key for the Engineering geology (superficial and bedrock editions) map of the United Kingdom, 1: 1 000 000*. British Geological Survey, Keyworth, Nottingham, UK. <http://nora.nerc.ac.uk/19268/>

DOBBS, M, CULSHAW, M G, NORTHMORE, K J, REEVES H J AND ENTWISLE, D C. 2012. Methodology for creating national engineering geological maps of the UK. *Quarterly Journal of Engineering Geology and Hydrogeology*, **45**, 335-347. <http://nora.nerc.ac.uk/19265/>

ENGINEERING TOOL BOX. Soil or rock expansion – swell- after mining. http://www.engineeringtoolbox.com/soil-rock-bulking-factor-d_1557.html

ENTWISLE, D C, LEE K A. LAWLEY R A. 2014. DigMapPlus Engineering properties: Suitability for Foundations. Methodology report. British Geological Survey internal report IR/14/059. British geological Survey, Keyworth, Nottingham, UK. 24pp.

SMITH, A AND ELLISON, R A. 1999. Applied geological maps for planning and development: a review of examples from England and Wales. *Quarterly Journal of Engineering Geology*, **32**, S1 – 44.