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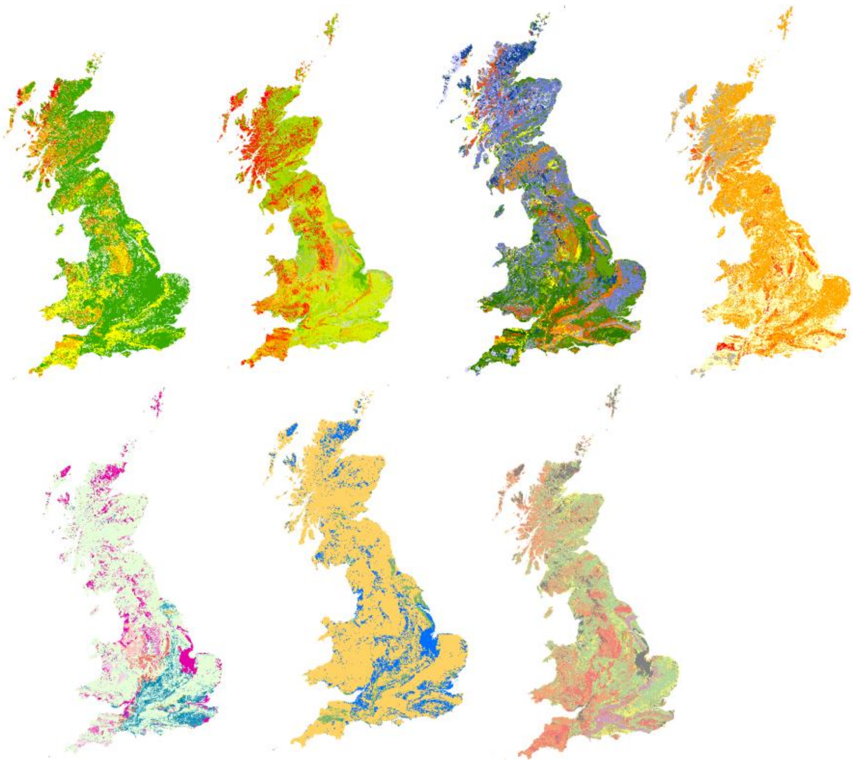
British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

User Guide for 'BGS Civils' - a suite of engineering properties datasets

Environmental Modelling Programme

Open Report OR/15/065



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BRITISH GEOLOGICAL SURVEY

ENVIRONMENTAL MODELLING PROGRAMME

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User Guide for BGS Civils - a suite of engineering properties
datasets

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The suite of Engineering Properties datasets.

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Foreword

This report is the user's guide for the national assessment of a suite of seven Engineering Properties datasets. These complimentary datasets provide information and advice on Excavatability, Strength, Discontinuities, Bulking of soils and rocks, Sulfate and sulfide potential, Corrosivity (ferrous) and Use for fill.

The purpose of this user guide is to provide the background, overview of the methodology developed by the British Geological Survey, and the potential applications and limitations of this GIS information.

Acknowledgements

A number of individuals in the Product Development, Engineering Geology and Climate and Landscape Change Directorates have contributed to the project and helped compile this report. This assistance has been received at all stages of the study. In addition to the collection and processing of data, many individuals have freely given their advice, and provided the local knowledge. We would particularly like to thank Marcus Dobbs, Peter Hobbs, Andy Tye and Paul Turner who provided expertise and input into the development of these datasets.

Contents

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1 Introduction

This document provides summary information for users of BGS Civils, a suite of seven engineering properties datasets. These comprise the following engineering geoproperty information:

- Excavatability
- Strength
- Discontinuities
- Bulking of soils and rocks
- Sulfate and sulfide potential
- Corrosivity (ferrous)
- Use for fill

Each dataset has an accompanying User Guide, which details the content and development of each engineering property dataset. These documents are summarised in this report.

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 files and how the data was created is described and advice is provided on using the dataset.

The information is primarily for the near surface, here defined as the top 2 m, but will have application to greater depths for many geological units where it occurs below this depth. This data 'product' has been driven by a perceived need and has been made possible by the increasing availability of ground investigation borehole and pit records, and the geotechnical data from the National Geotechnical Properties Database (Self et al. 2012). These provide the sources of data for the engineering properties, geological maps, reports and other documents, within the context of the spatial distribution of geological units across Great Britain. The need for this type of information was initially identified during work for the management of buried utilities, but equally, the information could prove useful to other industries such as civil engineering, the extractive industries, planning and development as well as answer more strategic legislative requirements such as the soil-framework directive.

The dictionaries, and terminology used are in accordance with standard engineering vocabulary as recommended in EuroCode7-2 (BSI 2007) and BS5930 standards (BSI 2003, BSI 2015).

The methods used to create the dataset have been critically assessed for fitness for purpose by experts in BGS.

2 About the Engineering Properties Datasets

2.1 BACKGROUND

The suite of engineering property datasets are developed for use within a GIS environment. They demonstrate the spatial distribution of geological unit properties, primarily, for the uppermost 2 m across Great Britain. Within this limited depth, weathering of material is to be expected and, therefore, the effects of weathering are considered. The classifications are ***indicative*** of the characteristics expected. This might cover most of the range of the characteristics or as minimum, typical and maximum expected values for each geological unit. Earlier national datasets for some of these properties at 1:1 000 000 are presented in Dearman et al. 2011a, 2011b, 2011c, (Dobbs et al. 2012).

2.2 EXCAVATABILITY

Excavations are dug for civil engineering purposes, cuttings, tunnels, borrow pits, quarries and mines. Other applications, generally of more limited depth, include ground investigation, foundations, utilities infrastructure, cellar construction and burial pits. A number of excavation methods have been devised to efficiently and cost-effectively remove material (digging, ripping or use of explosives). The selection of the method largely depends on the material characteristics, primarily 'strength' and mass characteristics, i.e. the spacing, number of and orientation of mechanical discontinuity sets. Materials that behave as engineering soil, that is, those described with a principal material type of clay, silt, sand, gravel or cobble, are diggable, and are more easily extracted than those described as rock (Pettifer and Fookes 1994). The classification is given in Appendix 1 (Lee et al. 2012a).

2.3 STRENGTH

Definitions of the engineering **strength** of **rocks (and fine soils)** are provided as minimum, maximum and typical strengths. This tri-fold classification allows for the wide range of variation encountered within some stratigraphic units. For example: the Mercia Mudstone Group where sandstones are included is classified as ***firm*** to ***strong*** because it has some mudstone beds that are firm due to weathering but also contains stronger sandstone and dolomitic beds. Because these locally weaker and stronger beds make up a small proportion of the deposit/formation, the most common 'strength' near surface is determined as ***stiff***. Additionally, this 'typical' classification takes into account its weathered state, water content, and other variations.

Definitions of the engineering strength of **coarse soils** are provided as minimum, maximum and typical densities. Again, this tri-fold classification allows for the wide range of variation encountered within some stratigraphic units. For example; the Kempton Park Gravel Formation is classified as ***loose*** to very ***dense*** because where it is at surface, it tends to be in a loose state, whereas, at depth it may become very dense. However, in the upper 2 m it is loose to dense and most commonly medium dense. The classification is given in Appendix 2 (Lee et al. 2012b, 2012c).

2.4 DISCONTINUITIES

Various terms have been used over the years to describe discontinuities and these often vary depending upon discontinuity type and the scale at which they are observed. Two of the more succinct and comparable 'engineering geology' definitions are provided below:

Discontinuities are breaks, fractures or planes of weakness in the rock mass. (BSI, 2015). Types of engineering discontinuities are joints, faults, bedding fractures, cleavage fractures and might include incipient fractures.

The general term for any mechanical discontinuity in a rock mass having zero or low tensile strength. It is the collective term for most types of joints, weak bedding planes, weak schistosity planes, weakness zones and faults (Ulusay & Hudson, 2007).

The 'Engineering Properties: Discontinuities' dataset defines discontinuities as a break in the continuity of a rock mass that has the potential to have zero or very low tensile strength. It can include all stratification planes (bedding, layering and lamination) (Figure 1), all foliation planes (fissility, cleavage, banding) (Figure 2) and includes all fractures (joints, faults, fissures) (Figure 3) as defined in British Standard BS5930 (BSI 2015) and International Society for Rock Mechanics (ISRM 2007). It does not include interfaces (other than stratification planes/depositional interfaces) and chemical-solution breaks (such as solution cavities). The classification is given in Appendix 3.

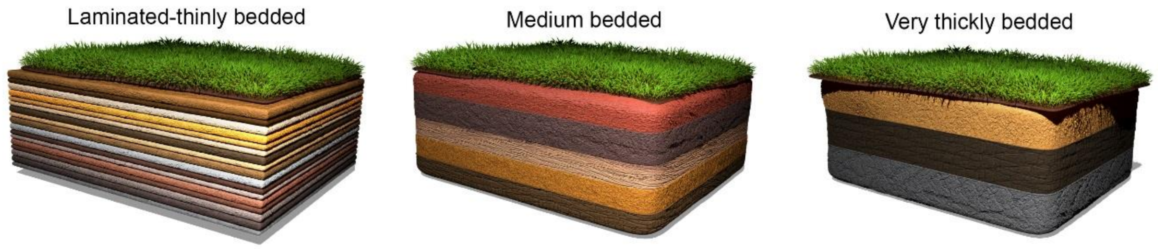

Figure 1: Examples of stratification

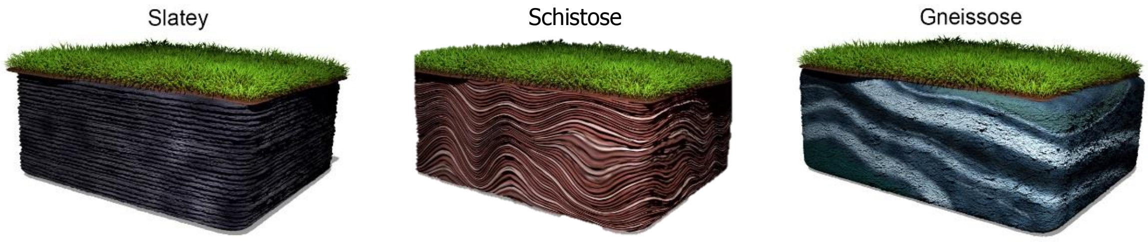

Figure 2: Examples of foliation

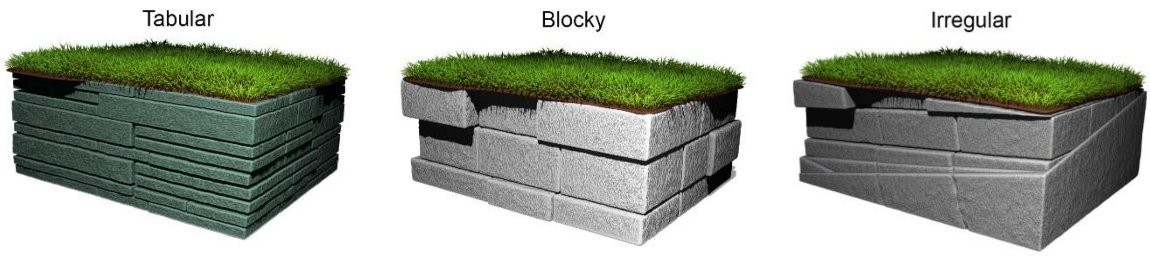

Figure 3: Examples of rock mass character

2.5 BULKING OF SOILS AND ROCKS

The excavation of rocks or soils is usually accompanied by an increase in volume. This change in volume is referred to as ‘bulking’ and the measure of the change is the ‘bulking factor’. The ‘bulking’ of excavated rocks and soils is an important consideration in civil engineering and extractive industry.

The bulking factor might be influenced by a number of different characteristics including lithological properties (specifically mineralogy, particle-size distribution, particle shape, porosity, density, and strength), alteration (weathering, hydrothermal alteration, and metamorphism) and the excavation method (digging, ripping or blasting).

The ‘Engineering Properties: Bulking of soils and rocks’ dataset is intended to provide information about the bulking factor of geological units as a desk-study tool for the planning and design for construction and resource extraction. The classification is given in Appendix 4.

2.6 SULFATE AND SULFIDE POTENTIAL

The presence of sulfur in rocks and soils is, in certain forms and in certain conditions, of importance to the engineered environment as it can give rise to aggressive ground conditions. Sulfate ions react with some types of cement and concrete weakening it (mostly in slightly acid to alkali conditions). Sources of sulfate ions are primarily from gypsum (calcium sulfate), which is an evaporite deposit found in certain geological units; and due to the oxidation usually of very fine grained iron sulfide (framboidal iron pyrites). The oxidation produces sulfuric acid which can react with calcium carbonate, commonly found in many grey clays and mudstone, to form gypsum (see

BRE 2005, Cripps & Edwards 1997, Czerewko & Cripps 2006, Taylor et al. 2013). If there is no calcium carbonate (or insufficient to buffer the sulfuric acid) then acid ground condition are formed such as in acid mine-waters. Also, where sulfide-rich mudstone is used as backfill beneath buildings the formation of gypsum increases the volume of the now weathered mudstone. The resulting ground heave can disrupt the floors of buildings (DCLA 2008).

Much of the research has been focussed on the damage caused to concrete associated with sulfate ions associated with calcium sulfate (gypsum) as this is the most likely sulfate present near surface. Other sulfate minerals such as magnesium sulfate (Epsom salts) and sodium sulfate (Glauber's salt) are more soluble and generally dissolve into the groundwater well below most engineering activities. However, these can occur at surface via natural springs.

This dataset provides a guide to the potential sulfate/sulfide geohazard for geological units found at surface for Great Britain. It can be used as an indicator of primary sulfate and the potential presence or likely formation of sulfate species due to oxidation. It should be considered as a part of desk study for civil engineering purposes to inform the intrusive ground investigation and construction in the ground (Entwisle et al. 2015). The classification is given in Appendix 5.

2.7 CORROSIVITY (FERROUS)

Ferrous (iron) structures and pipelines in the ground are susceptible to surface pitting and corrosion, weakening the asset and increasing the potential for failure. Such assets are more prone to failure where ground movement occurs due to the change in stress around the asset. The creation of the Corrosivity (ferrous) dataset was in response to the growing awareness of the cost of maintenance of iron structures in the ground such as infrastructure pipelines and building foundations. The cost of corrosion to the UK has been estimated at 4% of Gross National Product per year (Institute of Corrosion; http://www.icorr.org/). Some of this cost is due to the corrosion of ferrous underground assets, particularly in what are termed 'aggressive soils' conditions. Thus the new dataset identifies where the ground beneath the topsoil has potentially 'corrosive' or 'aggressive' characteristics and places them within the recognised scoring framework developed by the Cast Iron Pipe Research Association (CIPRA) now the Ductile Iron Pipe Research Association (DIPRA).

Scores for 5 properties are used to assess corrosive conditions:

i. Water content;
ii. Redox status;
iii. pH;
iv. Sulphates/Sulphides;
v. Electrical resistivity.

These factors have been combined to give a final corrosivity score for each geological unit. Each score gives an indication as to whether the ground conditions in the uppermost 2 m are likely to cause corrosion of underground ductile iron assets. The classification is given in Appendix 6 (Tye et al. 2011).

2.8 USE FOR ENGINEERED FILL

The 'use for engineered fill' of rocks and soils is an important consideration in civil engineering and extractive industry. The rapidly increasing cost of removal and disposal of material offsite, of unused material, means that a great deal of effort is now taken to identify how extracted materials are to be used on site. Engineered fill is used in earthworks, which includes infill, raising or levelling ground, embankments, foundation pads, road bases and landscaping. The earlier this process is carried out the greater the likelihood that it can be done efficiently.

The 'use as engineered fill' classification is based on the geological material, type of geological materials (e.g. Chalk), maximum particle size, presence of sulfate or readily oxidised sulfide, which might affect the use of the material and the presence of unsuitable materials (e.g. peat).

Much of the classification used to create this dataset is based on the 'Specification for Highway Works' Series 600 Earthworks (Highways Agency, 1991a, 1991b). More detailed specification tests will be required prior to use on site. The classification is given in Appendix 7 (Entwisle et al. 2012).

3 What the datasets show

The data are a synthesis of national databases and technical engineering data held by BGS, based primarily on DiGMapGB-50 V6 and the National Geotechnical Properties Database.

The primary source data for the Engineering Properties datasets / GIS are:

1. The DiGMapGB-Plus dataset (Lawley 2009) and DiGMapGB-50 digital geological map;
2. Ground investigation data from the National Geotechnical Properties Database and exploratory hole logs, from the National Geological Records Centre;
3. A series of 'look-up' dictionaries that provide the classification of the individual property of a material for the property in question. The assessment and categorisation is interpreted primarily in accordance with BS5930 (BSI, 2015), Eurocode 7 and other industry documents and references.

The data provides national coverage for England, Scotland and Wales primarily at a scale of 1:50,000.

The 'Engineering Properties' model provides data for the **uppermost 2 m** of all geological units distributed across Great Britain (including consideration of weathering).

3.1 WHO WOULD BENEFIT FROM THE DATASETS

3.1.1 General

It is envisaged that the suite of engineering properties is of interest to a wide range of organisations concerned with development including utility companies, local authorities, developers and civil engineering clients, consultants and contractors.

Properties of earth materials are important in all engineering projects and the classification of the properties provided by this suite of datasets could be used in all ground developments. The information presented in the Engineering Properties datasets (at a 1:50 000 scale) provides a generic assessment informing engineering geologists and ground engineers at the **desk study** stage of a project, allowing for more efficient tender preparation, planning and execution of subsequent ground investigations. Site specific assessments should be carried out for design purposes.

3.1.2 Corrosivity

The corrosivity dataset is aimed at asset managers responsible for underground iron and other assets. These include water pipelines, oil and gas pipelines, earthing rods, cabling, sewers and steel building foundations that are at risk from different types of corrosion. It can be used to identify the likely reason for failure, to inform maintenance scheduling and suitable materials to use for replacement or new build to help meet leakage reduction targets in a cost effective manner. In particular, the data might be used by water companies. In addition, the data might be useful at the desk study stage for selecting pipeline routes or to identify appropriate construction materials.

Some underground infrastructure is, or will be, constructed in areas where there is little information for instance renewable energy resources including wind, solar and wave in upland or coastal areas.

4 Technical information

4.1 DEFINITIONS

The description and classification of engineering strength depends on the type of deposit. In engineering geology, earth materials are split into two groups, 'soils' and 'rocks' as given below:

- ***Soil*** is an aggregate of mineral grains or organic material that can be separated by such gentle means as agitation in water. Their behaviour is determined by the particulate nature, specifically the particle size, particle shape, particle mineralogy, water content and material density. The mass properties are largely influenced by its material characteristics. The principal soil types are clay, silt (fine soils) sand, gravel (coarse soils) cobble and boulder (very coarse soils). Whether the soil is classified principally as fine or coarse is dependent upon the behaviour of the material as defined by simple hand tests that can be carried out in the field and not on particle size determinations. Discontinuities, such as fissure and shears affect the mass strength of some soils, primarily fine soils.
- ***Rock*** is an aggregation of minerals connected by strong and permanent forces. The behaviour of the rock material depends on the material characteristics. The behaviour of the rock mass depends on a combination of the material characteristics and the discontinuities (including spacing, roughness, persistence, filling, orientation and the number of sets).

4.2 HOW THE DATA WAS CREATED

The lithostratigraphy and lithology type and variability are implicitly classified in the BGS Lexicon (LEX) and Rock Classification Scheme (RCS) for each LEX-RCS code, and the individual property such as minimum/maximum and typical **strength** parameters/values have been determined for all LEX-RCS codes.

Data was collated and interpreted from a number of different sources currently held by BGS. The primary datasets used for the Engineering Properties dataset GIS are:

- Parent Material Map V6 dataset;
- BGS National Geotechnical Properties Database;
- BGS Lexicon of Named Rock Units;
- BGS Map Sheet Explanations;
- BGS Sheet Memoirs;
- BGS Geoscience Imagebase;
- BGS and Geological Society Regional Guides;
- BGS Urban Planning Reports (Smith and Ellison 1999);
- BGS Engineering Geology Formation Study Reports;
- Site Investigation Records and Borehole Scans held in BGS archives;
- BRITPITS (an abbreviation of British Pits, Cameron 2011).

The classifications for each LEX-RCS code and property are mostly based on those used by industry where available or from the literature. Bulking factor values were assessed using the characteristics from the literature (**Error! Reference source not found.**). These included values from the United States of America (Church et al., 1981, Hartman 1992), the UK (Horner 1988) and web resources such as the Engineering Tool Box, Durham University (1997) and Mal January's site (january.id.au). Spatial distribution of the source information is shown in Appendix 8.

5 Data format

5.1 FIELD DESCRIPTORS

The data fields that are common throughout all the dataset are described below. Full class descriptions as they appear in the dataset are provided in the Appendices.

General lithology (GEN_LITH)

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 geological materials from the BGS RCS system. In general, the aim is to provide the user with a simplified a lithological description as possible.

Lexicon Rock Classification Scheme (LEX_RCS)

This field is the standard DiGMapGB-50 code that describes the geological units found in Great Britain. It provides the starting point for the parent material characterisation. It comprises a Lithostratigraphic code (LEX) and 'Lithology' code (RCS).

Nominal Scale (Nom_Scale)

This field describes the notional x-y spatial scale of the data. Most geological map data in the dataset is 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 scales used are shown in Table 1 below.

Table 1. Nominal scales used in the 'datasets'

Field Value	Meaning
50	No superficial data is present for this sheet and bedrock data is available at 1:50,000 scale
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

Each dataset then has individual fields describing the specific engineering properties as in Table 2 below:

Table 2. The field relating to each property

Field name	**Description**
EXCAVATABILITY	
(STR_TYP_EX) (DEN_TYP_EX)	The mode of equipment required to excavate the typical deposit present (see Appendix 1 for full descriptors).
STRENGTH	
Strength_Minimum (STR_MIN)	The minimum strength or consistency expected for this unit. Where there is more than one lithology present (heterolithic units) the strength

	of the weakest lithology is given. This does take into consideration weathering and alteration.
Strength_Maximum (STR_MAX)	The maximum strength or consistency expected for this unit. Where there is more than one lithology present (heterolithic unit) the strength of the strongest lithology is given. In general, this will be unweathered material and found at depth. However, in some situations the maximum strength might be where weak rocks or soils are altered and includes calcrete, silcrete and ferricrete.
Strength_Typical (STR_TYP)	The typical strength expected of the rock or soil. This is a simplification but provides guidance as to the typical strength and can be taken in relation with the Minimum and Maximum values. For example in a mixed lithology of strong to very strong sandstone with subsidiary weak mudstone, the rock may exhibit predominantly strong characteristics and, therefore, its typical or dominant strength is strong.
Density_Minimum (DEN_MIN)	The minimum density expected for this unit, including rocks that are weathered or altered to coarse soil, generally near surface.
Density_Maximum (DEN_MAX)	The maximum density expected for this unit, including rocks that are weathered or altered to coarse soil, generally near surface.
Density_Typical (DEN_TYP)	The typical density expected of the soil. This is a simplification but provides guidance as to the typical density and can be taken in relation with the Minimum and Maximum values. For example for a soil that is moderately dense to very dense sand and gravel with subsidiary loose sand, the soil may exhibit predominantly moderately dense characteristics and, therefore its typical or dominant density is moderately dense (see Appendix 2 for full descriptors).
DISCONTINUITIES	
DISCO_S TEXT	This field describes the minimum and maximum spacing between **stratification** planes, the dividing planes that separate each layer in a rock or soil from layers below and above it.
DISCO_1 TEXT	This field is the code used for DISCO_S
DISCO_F TEXT	This field describes the typical foliation or range of **foliations** likely to be present within the formation. Includes the parallel orientation of platy minerals or mineral banding present in metamorphic rocks, layered structures formed by the separation and/or orientation of minerals in igneous rocks and strongly developed, very closely spaced, bedding fissility which is found in some un-metamorphosed argillaceous rocks (shales). (see Appendix 3 for full descriptors).
DISCO_2 TEXT	This field is the code used for DISCO_F
DISCO_RM TEXT	This field describes the overall shape of the blocks that form a **rock mass** at a metre to decimetre scale. (see Appendix 3 for full descriptors).
DISCO_3 TEXT	This field is the code used for DISCO_RM
DISCO_ADD TEXT	This field describes **other** types of discontinuities that may be present and that are not accounted for by the other three fields. (see Appendix 3 for full descriptors).

DISCO_4 TEXT	This field is the code used for DISCO_ADD
BULKING OF SOILS AND ROCKS	
Bulking factor class (BULK_CLASS)	This is the class or classes of the 'bulking factor' and is derived from the original DiGMapGB-50 LEX-RCS coding compared with the hierarchical classification of UK rocks from the BGS RCS system. It relates to lithology type, as described in Table 1 above.
Bulking factor values (BULK_FACTR)	This field contains the bulking factor (range or ranges) expected for each LEX-RCS code, as indicated by the bulking class or classes (**Error! Reference source not found.**). The range is separated by 'to', and where there are two bulking classes the ranges are separated by ','. They are described as primary and secondary factors. (See Appendix 4 for full descriptors).
SULFATE AND SULFIDE POTENTIAL	
Sulfide class (SUL_CLSS)	The primary and secondary sulfate classifications as used in the GIS are a short alpha-numeric code for GIS purposes.
Sulfide description (SUL_DESC)	This field describes the primary and secondary sulfate/sulfide classifications. Full descriptions are given in Appendix 5.
CORROSIVITY (FERROUS)	
Class	The primary classification as used in the GIS is a short alpha-numeric code for GIS purposes.
LEGEND	This field provides a brief explanation of the ground conditions
RECOMMENDA	This is a description of recommendations and factors to consider in designing or mitigating for potentially corrosive conditions.
BACKFILL	This is a description on suitability of material for backfill.
SCORE	The total score of all the contributing factors taken into account (pH, moisture conditions, resistivity, redox status and sulphate/sulphide). See Appendix 6 for full descriptions.
USE AS ENGINEERING FILL	
Use as engineering fill (FILL_CODE)	This is the code used by BGS to identify a type of 'use as engineering fill'. It is provided to enable identification of properties of a geological unit and for data management purposes.
Use as engineering fill (FILL_TYPE)	This is a description of the broad type of 'engineering fill' associated with the geological materials. The values are used are provided in Appendix 7.
Use as engineering fill (FILL_USES)	This is a description of the typical USE of the 'engineering fill' associated with the geological materials. It is a slightly more informative version of the FILL_TYPE field as it identifies key 'fill' characteristics that are important to test for, or ascertain, at an early stage of site investigation. For example it identifies fill types that may be 'partly' unsuitable. See the DETAIL section below for further description). See Appendix 7.
Use as engineering fill (DETAIL)	This is a description of the 'engineering fill' associated with the geological materials. It is a more descriptive and informative version of the FILL_USE and FILL_TYPE fields as it identifies key 'fill'

	characteristics that are important to test for, or ascertain, at an early stage of site investigation. It outlines the full range of subdivisions of fill-use in this dataset. See Appendix 7.
Use as engineering fill (OTHER_USES)	A description of known alternative uses of the geological materials, as defined in the BritPits database. (List is not exclusive)

5.2 SCALE

The ***Engineering Properties*** datasets are produced for use at 1:50000 scale providing 50 m ground resolution.

5.3 FORMAT

The data are released in ESRI shapefile formats. 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.

5.4 COVERAGE

Data is provided to indicate the strength of rocks and soils across Great Britain. The scale of map data available to create this dataset is shown in Appendix 9.

5.5 DATA HISTORY

The release dates of the datasets are in Table 3.

Table 3. The release dates of each engineering dataset

Dataset name	**Version release**	**Year of release**
Strength	Version 1: Derived from DiGMapGB-50 version 6.	2012
Excavatability	Version 1: Derived from DiGMapGB-50 version 6.	2012
Discontinuities	Version 1: Derived from DiGMapGB-50 version 6.	2015
Bulking of soils and rocks	Version 1: Derived from DiGMapGB-50 version 6.	2015
Sulfate and sulfide potential	Version 1: Derived from DiGMapGB-50 version 6.	2015
Corrosivity (ferrous)	Version 1: Derived from DiGMapGB-50 version 6.	2012
Use for engineering fill	Version 1: Derived from DiGMapGB-50 version 6.	2014

5.6 LIMITATIONS

- The Engineering Properties datasets have 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 spatial distribution of the data is limited by the distribution of the site investigation exploratory holes from which the geotechnical data have been extracted (shown in Appendix 3) and digital geological map data (DiGMapGB-50) (Appendix 8). 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.

- The presentation of the data are created as vector polygons and are available in a range of GIS formats, including ArcGIS (.shp), ArcInfo Coverages and MapInfo (.tab). Other formats might be available and might incur additional processing costs.
- The datasets are concerned with the properties of natural geological units and not those altered by man. It does NOT cover any man-made constructions, such as engineered fill or made ground.
- The data are based on, and limited to, an interpretation of the records in the possession of The British Geological Survey at the time the dataset was created.
- Engineering properties data are based on the mechanical and chemical properties rather than a physical property and are usually measured in the laboratory or occasionally in the field or described in the field. Earth materials are varied by their very nature, particularly in the top metre or so, where they are often affected by surface processes such as weathering. Thus, a geological unit is unlikely to have a homogenous characteristic. This is indicated in the datasets by providing the minimum, maximum and 'typical' values (or ranges of values) and descriptors for each units' characteristics.
- Site specific assessments should be carried out by suitably qualified and experienced professionals and using appropriate methods. The descriptions provided in these data are designed for DESK STUDY phases.
- Some of the engineering properties in the vicinity of faults or fault zones such as Discontinuities and Excavatability will be different from the mass of the unit. The effects of faults are not included in these assessments. An appropriate ground investigation should be used to assess the effect of faulting on the properties as required by the project.
- For engineered fill, the 'dataset' is for the lithology or lithologies as identified for each geological unit and does not include mechanical mixing of lithologies. This assessment can only be done on site and depends on the size of the site and the lithologies and quantities available on site. Such an assessment can only be made by inspection of the fill materials by a qualified professional.

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6.1 CONTACT INFORMATION

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Appendix 1 Excavatability classification terms and descriptions

The excavatability dataset uses the classification for the TYPICAL density and TYPICAL strength rating for the 0-2m depth range. These four excavatability 'ratings' correspond with the 'BS5930_term' which denotes the STRENGTH rating of the materials and the 'mode_of_excavation' denotes one of the four excavatability classes as shown below.

BS5930_term	MODE OF EXCAVATION
Extremely Strong	BLASTING
Very Strong	BLASTING
Strong	RIPPING
Medium Strong	RIPPING
Weak - Strong	RIPPING
Weak - Medium Strong	RIPPING
Weak	POWER TOOLS
Very Weak - Very Strong	POWER TOOLS
Very Weak - Strong	POWER TOOLS
Very Weak	POWER TOOLS
Extremely Weak	POWER TOOLS
Hard	POWER TOOLS
Very Stiff	POWER TOOLS
Stiff to Very Strong	POWER TOOLS
Stiff - Weak	POWER TOOLS
Stiff - Very Weak	POWER TOOLS
Stiff	HAND TOOLS
Firm - Stiff	HAND TOOLS
Firm	HAND TOOLS
Soft - Firm	HAND TOOLS
Soft	HAND TOOLS
Very Soft - Soft	HAND TOOLS
Very Soft	HAND TOOLS
Very Dense - Weak	HAND TOOLS
Very Dense	HAND TOOLS
Dense	HAND TOOLS
Medium Dense - Dense	HAND TOOLS
Medium Dense	HAND TOOLS
Loose - Medium Dense	HAND TOOLS
Loose	HAND TOOLS
Very Loose	HAND TOOLS
Variable	VARIABLE
Not Applicable	N/A

Appendix 2 Strength, consistency and density classification terms and descriptions

BS5930_term	Unconfined compressive strength or SPT N-values	BS5930_field_assessment
Extremely Strong	250+ MPa	May be chipped or not with geological hammer, rock may ring when hit, may be broken or not by sledge hammer
Very Strong	100 - 250 MPa	Requires many blows with a geological hammer to fracture
Strong	50 - 100 MPa	Requires more than one blow of a geological hammer to fracture
Medium Strong	25 - 50 MPa	Cannot be scraped or peeled with pocket knife, specimen can be fractured with one blow of a geological hammer.
Weak - Strong	5 - 100 MPa	Ranges from: Can be peeled with pocket knife with difficulty and shows shallow indentations with firm blows with point of geological hammer, to: requires more than one blow of a geological hammer to fracture.
Weak - Medium Strong	5 - 50 MPa	Ranges from: Can be peeled with pocket knife with difficulty and shows shallow indentations with firm blows with point of geological hammer. to: Cannot be scraped with pocket knife.
Weak	5 - 25 MPa	Can be peeled with pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer, Gravel sized lumps broken in half with heavy hand pressure.
Very Weak - Very Strong	1 - 250 MPa	Ranges from: Can be peeled by a pocket knife or crumbles under firm blows with point of geological hammer, to: requires many blows of a geological hammer to fracture.
Very Weak - Strong	1 - 100 MPa	Ranges from: Can be peeled by a pocket knife or crumbles under firm blows with point of geological hammer, to: requires more than one blow of a geological hammer to fracture.
Very Weak	1 - 5 MPa	Can be peeled by pocket knife. Crumbles under firm blows with geological hammer. Gravel-size lumps can be crushed between finger and thumb
Extremely Weak	0.6 - 1.MPa	Can be indented by thumbnail. Gravel sized lumps crush between finger and thumb.
Hard*	*0.6 - 1.25 MPa*	Can be scratched by thumbnail. Should only be used for transported materials such as tills, otherwise classed as extremely weak rock.
Very Stiff	*0.3 - 0.6 MPa*	Thumb nail will indent. Crumbles in rolling a 3 mm thick thread and cannot be remoulded into a lump
Stiff to Very Strong	*0.15 - 250 MPa*	Ranges from: Thumb nail will indent. Crumbles in rolling a 3 mm thick thread, but can be remoulded into a lump, to: requires many blows with a geological hammer to fracture.
Stiff - Weak	*0.15 - 25 MPa*	Ranges from: Thumb nail will indent, to: can be peeled with pocket knife with difficulty and shows shallow indentations with firm blow with point of geological hammer.
Stiff - Very Weak	*0.15 - 5 MPa*	Ranges from: Can be indented by thumb nail, to: can be peeled by pocket knife and crumbles under firm blows with geological hammer.
Stiff	*0.15 - 0.3 MPa*	Thumb nail will indent. Crumbles in rolling a 3 mm thick thread, but can be remoulded into a lump
Firm - Stiff	*0.08 - 0.3 MPa*	Ranges from: Thumb easily makes an impression and cannot be moulded by fingers and rolls in the hand a 3 mm thick thread without breaking or crumbling, to: can be slightly indented and crumbles when rolled to a 3 mm thick thread but can be remoulded into a lump.
Firm	*0.08 - 0.15 MPa*	Thumb makes impression (easily). Cannot be moulded by fingers, rolls in the hand to a 3 mm thick thread without breaking or crumbling.
Soft - Firm	*0.04 - 0.15 MPa*	Ranges from: Finger pushed in by 10mm and moulds with light finger pressure, to: thumb easily makes impression and rolls in the hand to a 3 mm thick thread without breaking or crumbling.
Soft	*0.04 - 0.08 MPa*	Finger pushed in by 10mm. Moulds by light finger pressure.

Very Soft - Soft	*<0.08 MPa*	Ranges from: Finger pushed in by 25mm and exudes between the fingers, **to:** finger pushed in by 10mm and moulds by light finger pressure
Very Soft	*<0.04 MPa*	Finger pushed in by 25mm and exudes between the fingers
Very Dense - Weak	50+ Blows to 25 MPa	Ranges from: Requires pick for excavation. 50 mm wooden peg hard to drive, to: can be peeled with pocket knife with difficulty and shallow indentations with firm blow with point of geological hammer.
Very Dense	50+ Blows	Requires pick for excavation. 50 mm wooden peg hard to drive in.
Dense	30 - 50 Blows	Requires pick for excavation. 50 mm wooden peg hard to drive in.
Medium Dense - Dense	10 - 50 Blows	Requires pick for excavation. 50 mm wooden peg hard to drive in.
Medium Dense	10 - 30 Blows	Requires pick for excavation. 50 mm wooden peg hard to drive in.
Loose - Medium Dense	4 - 30 Blows	Ranges from: Can be excavated with spade and 50 mm wooden peg easily driven in, to: requires pick for excavation and 50 mm wooden peg hard to drive in.
Loose	4 - 10 Blows	Can be excavated with spade. 50 mm wooden peg easily driven.
Very Loose	< 4 Blows	Can be excavated with spade. 50 mm wooden peg easily driven.
Variable		Highly variable currently cannot be predicted
Not Applicable		Value is not applicable as the classification is inappropriate for the LEX-RCS code (e.g strength and consistency for coarse soils or relative density for fine soils and rocks).

Italics – nominal uniaxial compressive strength but no longer used.

*Hard is no longer used and extremely weak with a rock description should be used (BSI 2015).

Appendix 3 Discontinuities classification terms and descriptions

Explanation of bedding descriptors (mostly sedimentary rocks)

Description	Definition (DISCO_1)	Code (DISCO_S)
Laminated	Stratification spacing <0.02 m	La
Thinly bedded/layered	Stratification spacing 0.02 – 0.20 m	Bn
Medium bedded/layered	Stratification spacing 0.20 – 0.60 m	Bm
Thickly bedded/layered	Stratification spacing 0.6 – 2.0 m	Bk
Very thickly bedded/layered	Stratification spacing >2.0 m	Bv
Not bedded	The unit has no bedding/layering, bedding/layering is not persistent, or bedding/layering is inconspicuous.	NB
Null	Application of stratification description is not possible or is inappropriate for this unit.	

Explanation of foliation descriptors (for suitable metamorphic rocks)

Description	Definition (DISCO_F)	Code (DISCO_2)
Bedding fissility/ Slaty cleavage	Strongly developed, very closely spaced (mm), highly fissile parallel planes along which the rock can be parted into thin plates indistinguishable from each other in terms of lithological characteristics. May not be persistent throughout unit.	Fs
Schistose Foliation	Strongly developed, closely spaced (mm-cm), highly fissile to poorly fissile, parallel and sub-parallel planes. All traces of bedding destroyed. May not be persistent throughout unit.	Sc
Gneissose Foliation	Well developed regular alternating bands (cm) of schistose material (highly to poorly fissile) and granofelsic material (unfoliated and unfissile). Foliation is more irregular and discontinuous than schistose foliation. All traces of bedding destroyed. May not be persistent throughout unit.	Gn
Not Foliated	The unit has no foliation, foliation is very rare or the foliation is non fissile and imparts no strength anisotropy to the unit.	NF
Null	Application of foliation description is not possible or is inappropriate for this unit.	

Explanation of rock mass descriptors

Description	Definition (DISCO_RM)	Code (DISCO_3)
Massive	There are less than three pervasive discontinuity sets and/or the discontinuity sets are widely spaced (>5m between discontinuities).	Ma
Blocky	The rock mass is made up of approximately equidimensional blocks.	Bl
Tabular	The rock mass is made up of blocks where one dimension is considerably shorter than other dimensions.	Ta
Irregular	The rock mass is made up of fragments which have a wide variation in size and shape. Includes shear and crush zones.	Ir
Not a Rock Mass	Rock mass description not applicable to artificial deposits, superficial deposits and very weak bedrock.	NR
Null	Application of rock mass description is not possible or is inappropriate for this unit.	

Explanation of additional discontinuity descriptors

Description	Definition (DISCO_ADD)	Code (DISCO_4)
Sheet jointing/ Exfoliation jointing	A pervasive, surface parallel, joint set may be present and extend up to 15 m below the surface.	Sj

Columnar jointing	Layers within the formation may have pervasive columnar jointing producing blocks where one dimension is considerably larger than other dimensions.	Cl
Sheared	Low angle fault planes with low residual shear strength may be present.	Sh
Fissured	Near surface joints associated with weathering extending from the surface downward may be present.	Fi
No additional discontinuities	No additional discontinuity types are known for this unit.	NS
Null	Application of additional discontinuity description is not possible or is inappropriate for this unit.	

Appendix 4 Bulking of soils & rocks classification descriptions

Bulking class and nominal bulking factor range with typical lithology characteristics.

Class	Typical class lithology	Bulking factor (%)
1	Sand and/or gravel, very soft to soft clay or silt.	5 to 20
2	Firm (and stiffer) clay and silt, mudstones that break-up easily during excavation, peat.	20 to 40
3	Weaker rocks that are likely to break into a wide variety of particle sizes, sand to cobble or even boulder.	40 to 55
4	Medium strong rocks (and stronger) that are likely to break into a variety of blocks sizes and block shapes.	50 to 65
5	Strong (and stronger) rocks that form generally blocky material when excavated.	>65
6	Not applicable, relates to non-geological deposits e.g. water bodies.	N/A

Bulking factors from literature

Rock class	Lithology	Inital bulk density Mg/m^3	Bulking factor %	Reference
Igneous rock	Andesite	2.94	67	Church (1981)
	Tuff	2.40	50	Church (1981)
	Basalt	2.94	64	Church (1981)
	Basalt	2.4 to 3.1	75 to 80	Engineering tool box
	Basalt	2.95	64	Durham University
	Diabase	3.00	67	Church (1981)
	Diorite	3.1	67	Church (1981)
	Felsite	2.5	67	Church (1981)
	Gabbro	3.1	67	Church (1981)
	Granite	2.675	50 to 86	Hartman (1992)
	Granite and porphyry	2.72	75	Hartman (1992)
	Granite	2.6 to 2.8	75 to 80	Engineering tool box
	Granite	2.41	72	Durham University
	Rhyolite	2.40	67	Church (1981)
	Igneous		50 to 80	Horner, 1988
Metamorphic rocks	Gneiss	2.70	67	Church (1981)
	Gneiss	2.69	75	Hartman (1992)
	Gneiss	2.69	75 to 80	Engineering tool box
	Marble	2.68	67	Church (1981)
	Marble	2.72	68 to 75	Hartman (1992)
	Quartzite	2.68	67	Church (1981)
	Schist	2.69	67	Church (1981)
	Slate	2.67	77	Church (1981)
	Slate	2.72 to 2.88	29 to 30	Hartman (1992)
	Slate	2.6 o 3.3	85 to 90	Engineering tool box
	Metamorphic		30 to 65	Horner, 1988
Sedimentary rock	Breccia	2.4	33	Church (1981)
	Conglomerate	2.21	33	Church (1981)
	Sandstone	2.31 to 2.45	39 to 50	Hartman (1992)
	Sandstone	2.42	61	Church (1981)
	Sandstone	2.1 to 2.4	75 to 80	Engineering tool box
	Sandstone	2.5	60	Durham University
	Sandstone	2.65	61	Durham University
	Shale	2.64	50	Church (1981)
	Shale	2.35	50	Durham University
	Siltstone	2.42	61	Church (1981)
	Limestone	2.60	63	Church (1981)

	Limestone (blasted)	2.5	68 to 75	Hartman (1992)
	Limestone	2.7 to 2.8	75 to 80	Engineering tool box
	Limestone	2.6	63	Durham University
	Dolomite	2.8	50 to 60	Engineering tool box
	Dolomite	2.88	67	Church (1981)
	Chalk	1.85	50	Durham University
	Chalk	2.2	30 to 45	January.id.au
	Chalk	2.41	33	Church (1981)
	Chalk		30 to 40	Horner, 1988
	Sedimentary		40 to 75	Horner, 1988
Soil	Clay	1.75	33	Hartman (1992)
	Clay	1.778	34	Hartman (1992)
	Clay	1.75 to 1.78	30 to 40	Engineering tool box
	Clay dry	1.362	25	Hartman (1992)
	Clay damp	1.99	40	Church (1981)
	Clay	1.8 to 2.6	20 to 40	Engineering tool box
	Clay	1.6 to 2.1	20 to 40	Engineering tool box
	Clay (low PI)	1.65	30	Durham University
	Clay (high PI)	2.1	40	Durham University
	Clay and gravel dry	1.602	41	Hartman (1992)
	Clay and gravel wet	1.826	41	Hartman (1992)
	Clay with gravel	1.8	35	Durham University
	Clay and silt (fine)		20 to 40	Horner, 1988
	Silt (loam) dry	1.80	35	Church (1981)
	Silt (loam) damp	2	40	Church (1981)
	Mud	1.28 to 1.76	21	Hartman (1992)
	Mud	1.76 to 2.08	20 to 21	Hartman (1992)
	Mud	1.745	0	Church (1981)
	Loess, dry	1.911	35	Church (1981)
	Loess, moist	1.99	40	Church (1981)
	Silt (loam)		15 to 25	Engineering tool box
	Sand dry	1.30	10 to 16	Hartman (1992)
	Sand moist	2.018	15	Hartman (1992)
	Sand	2.00	5	Durham University
	Sand, wet	2.0	20 to 30	Engineering tool box
	Sand, dry	1.8	20 to 30	Engineering tool box
	Uniform sand	1.6 to 2.1	10 to 15	
	Well-graded sand	1.7 to 2.2	10 to 15	
	Sand and gravel dry	1.97	14	Hartman (1992)
	Sand and gravel, wet	2.31	15	Hartman (1992)
	Sand and gravel	1.95	15	Durham University
	Sand or gravel (coarse)		10 to 15	Horner, 1988
	Gravel	1.7 to 2.3	10 to 15	Engineering tool box
	Gravel Dry	1.79	15	Church (1981)
	Gravel, dry	1.46 to 1.92	12	Hartman (1992)
	Gravel wet	2.01	5	Church (1981)
	Gravel wet	2.31	10	Hartman (1992)
	Gravel	2.1	5	Durham University
	Peat/topsoil	1.1 to 1.4	25 to 45	Horner, 1988

Appendix 5 Sulfate/sulfide potential classification descriptions

Primary classification of sulfate/sulfide as used in the GIS

Primary Class	Description
0	Sulfate/sulfide not generally present.
1	Primary calcium sulfate present.
2	Iron sulfide and calcium carbonate present. The iron sulfide will or might oxidise to form sulfuric acid and react with calcium carbonate to form secondary gypsum.
3	Units that contain sulfides that might oxidise to form acid ground conditions.
4	Mixed, contains beds with iron pyrites and calcium carbonate and beds with iron pyrites and little or no calcium carbonate.
5	Contains beds of anhydrite or gypsum, and sulfides that might oxidise and react with calcium carbonate.
6	Unknown, lithologies not known
7	Areas of mapped water – not applicable

Secondary classification of sulfate/sulfide as used in the GIS

SUL_CLSS	SUL_DESC
0A	Sulfate or sulfide that will oxidise are not normally present.
1A	Major sulfate bed. The sulfate might be leached from the near-surface zone, the thickness depends on local conditions.
1B	Sulfate common throughout as beds, nodules and veins. The sulfate might be leached from the near-surface zone, the thickness depends on local conditions.
1C	Sulfate beds, nodules and veins are present at certain levels. The sulfate might be leached from the near-surface zone; the thickness depends on local conditions.
1D	Sulfate beds, veins and nodules are present locally at certain levels. The sulfate might be leached from the near-surface zone; the thickness depends on local conditions.
1E	Minor sulfate: in beds present locally at certain levels or as dispersed nodules. The sulfate might be leached in the near surface zone; the thickness depends on local conditions.
2A	Sulfide oxidises in weathering zone or when disturbed and reacts with calcium carbonate to form secondary gypsum.
2B	Sulfide likely to oxidise in weathering zone or when disturbed and reacts with calcium carbonate to form secondary gypsum.
2C	Sulfide might be present and oxidise in weathering zone or when disturbed and react with calcium carbonate to form secondary gypsum.
2D	Sulfide and calcium carbonate might be present, unlikely to form secondary gypsum unless reworked.
2E	Sulfide and calcium carbonate might be present, unlikely to form secondary gypsum.
3A	Sulfide likely to oxidise in weathering zone or when disturbed to form acidic conditions.
3B	Sulfide likely to oxidise when disturbed to form acidic conditions.
3C	Sulfide present locally and might oxidise when disturbed to form acidic conditions.
3D	Sulfide might be present in some beds that will only oxidise when disturbed to form acidic conditions.
3E	Sulfide might be locally present in some beds and might oxidize when disturbed to produce acidic conditions.
4A	Mixed lithologies, with beds containing sulfide, sometimes with calcium carbonate. Sulfide oxidises when weathered.
4B	Mixed lithologies, with beds containing sulfide, sometimes with calcium carbonate. Sulfate might oxidize under some conditions (e.g. reworking).
4C	Mixed lithologies, sulfide beds occasionally present sometimes with calcium carbonate. Sulfide might oxidize under some conditions (e.g. reworking).
5A	Minor sulfate and sulfide and calcium carbonate beds present locally. Sulfate might be leached in the near surface zone, depth depends on zone local conditions. Sulfide might oxidise.
5B	Contains minor beds of sulfate and sulfides that might oxidise under unusual conditions such as mining operations or reworking.
6	Sulfate/sulfide content unknown (geology unknown)
7	No hazard (water body)

Appendix 6 Corrosivity classification descriptions

Corrosion Property	Value	Score
pH (a)	< 4.5	3
	4.5-8.5	0
	>8.5	3
Moisture conditions (b)	Sand	0
	Sand > loam	0
	Sand > loam >clay	1
	Loam	1
	Loam > sand	1
	All	1
	Loam > clay	1
	Clay + loam	1
	Clay > loam	1
	Clay	2
	Peat	2
Resistivity, Ohm.m (c)	<7	10
	7 – 10	8
	10 – 12	5
	12 – 15	2
	15 – 20	1
	>20	0
Redox status (d)	Well oxidised soils e.g. coarse and highly permeable soils	0
	Soils prone to seasonal waterlogging e.g. clay soils	4
	Very wet or waterlogged soils e.g. peat and salt marsh soils	5
Suphates/sulphides (e)	Primary	3.5
	Secondary	3.5
	Not present or unlikely	0

Classification descriptions

CLASS	SCORE	LEGEND	RECOMMENDA	BACKFILL	Typical Material Description
1	<9	Ground conditions beneath topsoil are unlikely to cause corrosion to iron	Special protection probably not required, unless the ground is clay or peat or likely to contain saline water (estuarine or marine) if so see class 3.	Do not use peat or salty materials for backfill. Only use clay materials if they do not contain sulphide or sulphate crystals or are of low pH	Most rocks e.g. sandstone, limestone, chalk, igneous and metamorphic rocks, boulders, cobbles, gravel, sand and silt
2	9 - 11	Ground conditions beneath topsoil may cause corrosion to iron	Special protection probably required if materials at site are clay, peat or likely to contain saline water (estuarine or marine). If so see class 3 Do not use peat or salty materials for backfill. Only use clay materials if they do not contain sulphide or sulphate crystals or are of low pH	Do not use peat or salty materials for backfill. Only use clay materials if they do not contain sulphide or sulphate crystals or are of low pH	Mostly 'clays' and mudstones with relatively low clay size content and do not contain iron sulphide or calcium sulphate.
3	>11	Ground conditions beneath topsoil are likely to cause	Special protection probably required if materials at site are clay, mudstone, peat or likely to contain saline water (estuarine or	Do not use peat or salty materials for backfill. Only use clay materials if they do not contain sulphide or sulphate	A variety of material types depending on the lithostratigraphical classification

		corrosion to iron	marine). If so, further ground investigation is required to assess whether the hazard exists. Do not use peat or salty materials for backfill. Only use clay materials if they do not contain sulphide or sulphate crystals or are of low pH	crystals or are of low pH	The following indicate corrosivity hazard: i) Grey to black clay, brown near surface. May be mudstone at depth. May contain white or translucent 'soft' crystals (gypsum) at a few metres depth. ii) Red clay or mudstone, may contain white or translucent 'soft' crystals (gypsum) at a few metres depth iii) Peat. iv) Contains saline water

Score = a + b + c + d + e

Appendix 7 Use for engineered fill classification descriptions

Explanation of the 'fill type' descriptor

Fill Code(s)	Fill type	Meaning
0,0A	Mixed 'soil' fill	Mixed coarse and fine engineering 'soils'
1,1A,1B,1C,1D	Coarse 'granular' soil fill	Coarse-grained engineering soils
2A,2B,2C,2D,2E,2F,2G	Fine 'cohesive' fill	Fine-grained engineering soils
3,3A,3B,3C	Chalk fill	Chalk materials
6,6A,6B,6C,6D	Rock fill	Generic 'rock' materials
7A,7B,7C	Mixed rock and 'soil' fill	Mixed 'rock' and engineering 'soil' materials
8	Unsuitable for fill	Unsuitable for fill (contains unsuitable materials, i.e. Peat)
9	Unknown	Rock/Soil type is unknown, suitability is not yet known, or site is located in a body of water

Description of the engineering fill materials

FILL_USES	DETAIL
	Both fine and coarse beds, generally soil, 'cohesive' and 'coarse' fill
Mixed 'soil' fill (partly unsuitable)	Both fine and coarse beds, 'cohesive' and 'coarse' fill, may be partly unsuitable for engineered fill
Coarse 'granular' soil fill	Coarse 'granular' fill (sand, gravel, possible cobbles)
	Well-graded sand and gravel 'granular' fill
	Uniform-graded sand or gravel 'granular' fill
	Well-graded coarse soil, 'granular' fill containing cobbles
Coarse 'granular' soil fill (partly unsuitable)	Generally coarse, may be partly unsuitable material
Fine 'cohesive' fill	Generally suitable for 'cohesive' engineering fill
Fine 'cohesive', dry fill	Generally 'dry cohesive' fill
Gravel clay	Mostly gravelly clay 'stony cohesive' fill, may contain sand and gravel beds or silt and clay beds
Fine soil (silty)	Silty 'cohesive' fill
Fine soil (sulphide/sulphate)	Fine 'cohesive' fill that may contain sulphide or sulphate
Fine soil (specialist clay)	Contains specialist clays commonly of very high or extremely high plasticity clay
Fine soil ('wet')	'Cohesive' material that may be 'too wet' (in its typical natural state) for engineered fill.
Chalk fill	Chalk
	Chalk with flint
	Northern Province Chalk
	Chalk and calcareous mudstone
Rock fill	Rock fill but may have higher grade fill uses
	Rock fill that has been used for crushed rock aggregate
	Rock fill that has been used for higher value uses than rock fill or aggregate
	Rock fill with mixed lithology, which may have different uses
Rock fill (sulphide or sulphate)	Rock fill sometimes with mixed lithologies that may contain sulphide or sulphate

Mixed rock and soil	Mixed materials uses: Rock fill and/or coarse 'granular' fill (coarse rock sandstone, breccias, conglomerate or sand, gravel)
	Mixed rock fill and ‘cohesive’ or coarse 'granular' fill
Mixed rock and soil (sulphide/sulphate)	Mixed rock fill and ‘cohesive’ fill sometimes coarse 'granular' fill, ‘cohesive’ fill may contain sulphide or sulphate
Unsuitable for fill	Generally unsuitable may have special uses identified during the project or require special processing
Unknown	Unknown material or suitability

Use of the unit as identified from BRITPITS (OTHER_USE)

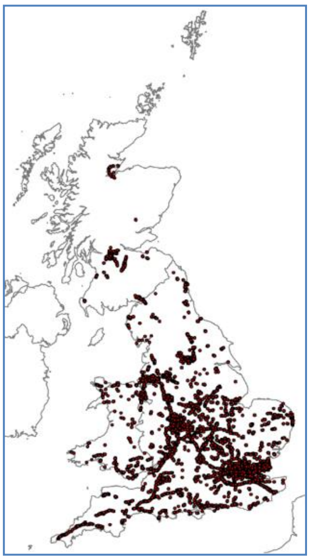
The possible alternative or recorded use of the geological materials as in BRITPITS, which is the BGS database for extracted minerals in the UK (Cameron, 2011). There are multiple entries where the units are used for different purposes. This may be for the same lithology or for different lithologies found at the quarry/pit (at different depths or parts of the excavation). Note that this does not mean that the entire unit is used for that purpose, in many cases, only part of the unit might be used. The following descriptive terms are used:

- Used as general aggregate (but may have high value uses);
- Rocks for aggregate use requiring crushing prior to use (crushed rock aggregate);
- Aggregate with high value uses (railway ballast, road aggregate, armour rock);
- Building sand, concrete sand, asphalting sand;
- Silica sand, glass sand, foundry and moulding sand, cleaning sand;
- Building stone, slate, decorative stone;
- Clay for bricks, tiles, pipes;
- Clay for ceramics, pottery (whiteware);
- Clay for paper making, fillers, fullers earth;
- Coal;
- Gypsum, calcium carbonate (limestone, chalk), fluorspar, cement (calcium carbonate, clay or mudstone);
- Peat products;
- Unknown product but quarried ground (unspecified use in Britpits).

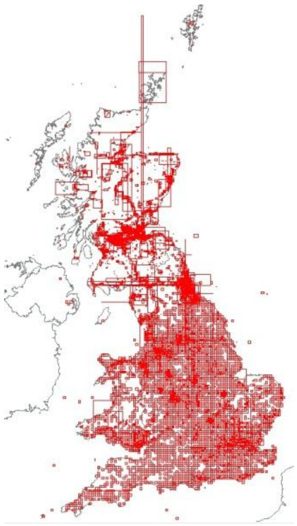
Appendix 8 Distribution of source data

Data held in the (a) National Geotechnical Properties Database boreholes and pits, (b) Site Investigation Records, (c) Geoscience Imagebase, (d) sheet memoirs, (e) borehole scans

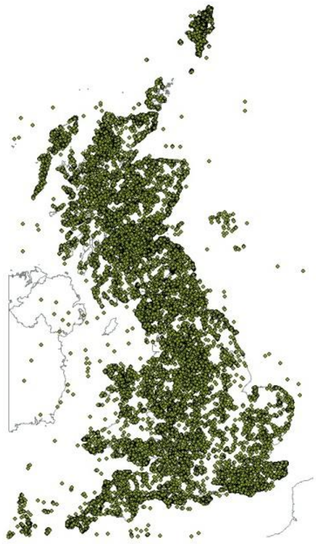
(a)



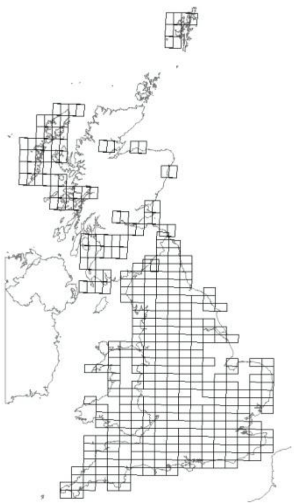
(b)



(c)

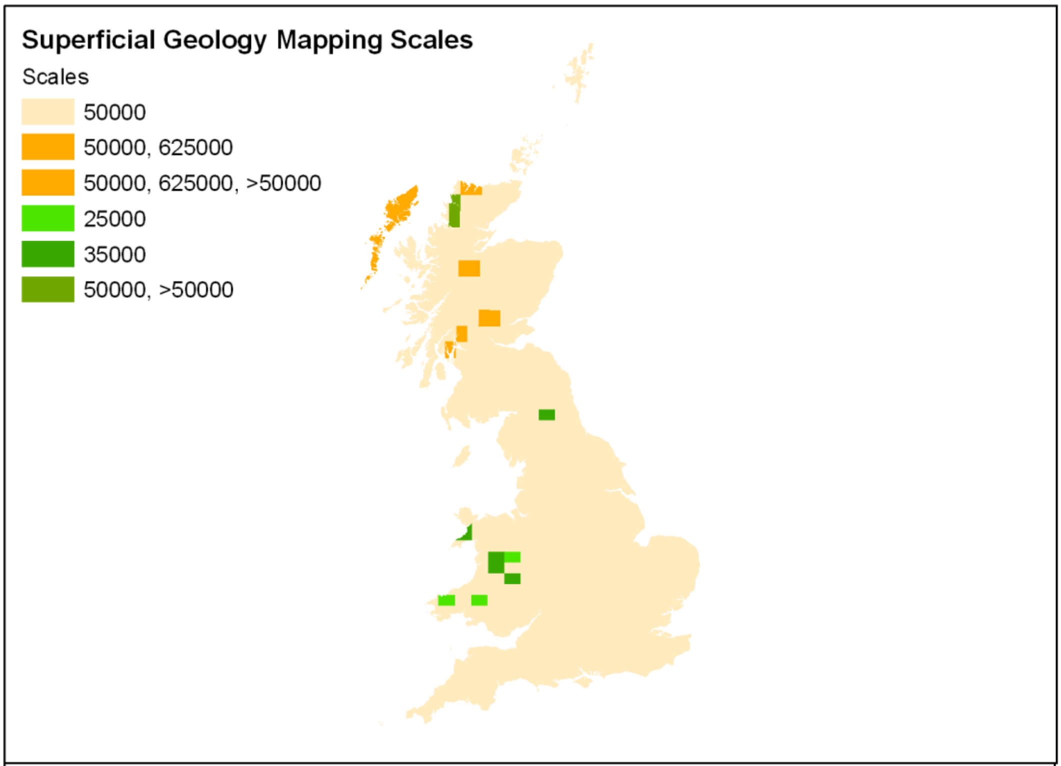


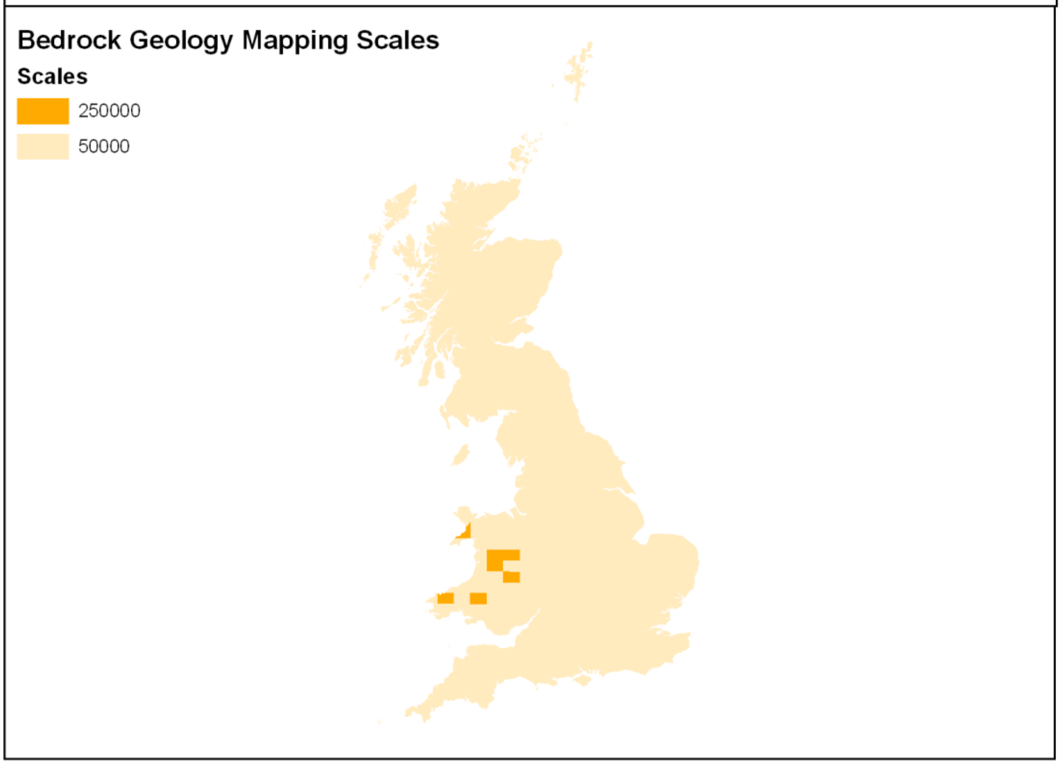
(d)



(e)

Appendix 9 Mapping Scales





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