

INFORMATICS PROGRAMME

# User Guide: BGS Superficial Deposit Thickness Model (SDTM)

Open report OR/25/087



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# User Guide: BGS Superficial Deposit Thickness Model (SDTM)

British Geological Survey

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*British Geological Survey offices*

**Nicker Hill, Keyworth,  
Nottingham NG12 5GG**

Tel 0115 936 3100

**BGS Central Enquiries Desk**

Tel 0115 936 3143

email [enquiries@bgs.ac.uk](mailto:enquiries@bgs.ac.uk)

**BGS Sales**

Tel 0115 936 3241

email [sales@bgs.ac.uk](mailto:sales@bgs.ac.uk)

**The Lyell Centre, Research Avenue South,  
Edinburgh EH14 4AP**

Tel 0131 667 1000

email [scotsales@bgs.ac.uk](mailto:scotsales@bgs.ac.uk)

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

Tel 020 7589 4090

Tel 020 7942 5344/45

email [bgs\\_london\\_staff@bgs.ac.uk](mailto:bgs_london_staff@bgs.ac.uk)

**Cardiff University, Main Building, Park Place,  
Cardiff CF10 3AT**

Tel 029 2167 4280

**Geological Survey of Northern Ireland, 7th Floor,  
Adelaide House, 39-49 Adelaide Street, Belfast, BT2 8FD**

Tel 0289 038 8462

[www2.bgs.ac.uk/gsni/](http://www2.bgs.ac.uk/gsni/)

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

Tel 01793 411500

Fax 01793 411501

[www.nerc.ac.uk](http://www.nerc.ac.uk)

**UK Research and Innovation, Polaris House,  
Swindon SN2 1FL**

Tel 01793 444000

[www.ukri.org](http://www.ukri.org)

Website:

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# Foreword

The British Geological Survey (BGS) is a world-leading geological survey, focusing on public-good science for government, and research to understand earth and environmental processes.

We are the UK's premier provider of objective and authoritative geoscientific data, information and knowledge to help society to:

- use its natural resources responsibly
- manage environmental change
- be resilient to environmental hazards

We provide expert services and impartial advice in all areas of geoscience. As a public sector organisation, we are responsible for advising the UK Government on all aspects of geoscience as well as providing impartial geological advice to industry, academia and the public. Our client base is drawn from the public and private sectors both in the UK and internationally.

The BGS is a component body of the Natural Environment Research Council (NERC), part of UK Research and Innovation (UKRI).

## DATA PRODUCTS

The BGS produces a wide range of data products that align to government policy and stakeholder needs. These include baseline geological data, engineering properties and geohazards datasets. These products are developed using in-house scientific and digital expertise and are based on the outputs of our research programmes and substantial national data holdings.

Our products are supported by stakeholder focus groups, identification of gaps in current knowledge and policy assessments. They help to improve understanding and communication of the impact of geo-environmental properties and hazards in Great Britain, thereby improving society's resilience and enabling people, businesses, and the government to make better-informed decisions.

# Acknowledgements

This report is the published product of a study by the British Geological Survey (BGS) to produce a digital dataset depicting superficial sediment thickness for Great Britain.

Several individuals from the BGS have contributed to the project and this assistance has been received at all stages of the study. In addition to the collection of data, many individuals have freely given their advice and provided expert knowledge. Of the many individuals who have contributed to this project we would particularly like to thank Russell Lawley, Tim Kearsley, Katie Whitbread and Jonathon Lee.

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# Summary

The Superficial Deposit Thickness Model (SDTM) is a dataset designed to demonstrate the regional variation in thickness of superficial deposits that lie on top of bedrock, across Great Britain. These deposits are unconsolidated sediments and may include river channel and floodplain deposits, beach sands, talus gravels and glacial drift and large areas of peat. Superficial deposits are of importance for geologists, civil engineers, hydrogeologists and environmental scientists as they are often unconsolidated and, together with other processes, form pathways for groundwater to travel along. Their thickness over much of the country relates to the glacial history of the UK over the Quaternary period.

The dataset combines borehole data records and mapped superficial and artificial geology (at 1:50 000 scale). The different components of the SDTM provide the user with rasterised surfaces of potential superficial sediment thickness distribution across Great Britain as well as information on the distribution of the input data sources.

The SDTM has been created as part of ongoing scientific research into the 3-D distribution of these superficial deposits across Great Britain.

The intended scale of use of this dataset is 1:100,000 with a vertical modelled precision of +/-5m elevation. The dataset is intended for use at national, regional and local scales but not site scales where specific ground investigation works should be undertaken to determine superficial thickness and / or rockhead elevation.

The information provided in this User Guide is intended to provide a quick start guide to using and understanding this BGS data product.

**Users should not use the SDTM datasets without first reading this User Guide in full, in particular [section 5](#) on data limitations.**

# 1 Introduction

The SDTM dataset presents the modelled regional variation in thickness of superficial and unconsolidated deposits across Great Britain (GB). These include sediments of fluvial, glacial, marine or anthropogenic origin that were generally formed during the Quaternary geological period (the past 2.588 Ma). The thickness of these deposits represents the depth down to the top of bedrock, known as geological rockhead. The variation in thickness across GB partly reflects the different processes involved in the development and preservation of these sediments. The distribution of these deposits is not uniform: sometimes they are developed in thin veneers, sometimes they form large irregular masses and sometimes they infill entire valleys. This variation in thickness is a function of the pre-Quaternary topography of the bedrock surface, the availability of accommodation space within the landscape and the interaction of this accommodation space with the wide range of processes which have created the superficial deposits.

The transition between superficial sediments and geological rockhead and associated bedrock units is an important zone for geologists, civil engineers, hydrogeologists and environmental scientists because it is where most physical and chemical properties of the deposits significantly change. Strength, lithology, conductivity, porosity, and permeability are most strongly affected by this transition, so an understanding of the depth of this transition zone beneath the ground surface is vital (in addition to the processes that both formed and deformed the surface).

The study of the distribution of superficial sediment thickness across GB is an active area of scientific research and we are constantly updating and improving the accuracy of the modelled thickness surfaces that we provide.

The SDTM (V8) product consists of the following components:

1. ODM (Observation Driven Model): gridded model of sediment thickness across GB created by using a Natural Neighbour interpolation algorithm to create a continuous surface grid of thickness values based on borehole records.
2. TAM (Terrain Adjusted Model): gridded model of sediment thickness across GB derived using a method which combines borehole records, the mapped extent of quaternary age geological units and superficial deposits as well as surface elevation data. This differs to the Observation Driven Model (ODM) which is calculated using only Natural Neighbour interpolation based on borehole records.
3. RHEM (Rockhead Elevation model): gridded model of the elevation of rockhead (the transition between superficial sediments and bedrock material) relative to Ordnance Datum. Derived from interpolation of borehole records that identify the elevation of rockhead, the mapped extent of Quaternary age superficial deposits, and surface elevation data for areas of bedrock-at-surface. RHEM is an interpolated elevation surface representing the top of bedrock across Great Britain (note this differs from TAM and ODM which provide an interpolation of superficial thickness).
4. DataDist (Data Distance): a gridded surface defining the distance of any location relative to the nearest source of thickness information; either the location of a borehole, or the mapped boundary of a superficial deposit. This is provided as a pseudo-uncertainty surface relative to the ODM, TAM and RHEM components of the SDTM. The further a cell location is from a source of thickness data, the more uncertain any values provided by ODM, TAM and RHEM models are likely to be.

The following sections outline how these datasets can be used (section 2), how they were created (section 3), associated technical information (section 4), limitations that must be considered (section 5) and a number of frequently asked questions (section 6).

## 2 Case study: potential application of SDTM for identifying sediment thickness

The thickness of superficial deposits is highly variable across GB. In areas away from where rock is exposed at the surface, there is a 'blanket' of complex, superficial geological deposits obscuring the buried bedrock. At the transition zone between superficial sediments and bedrock material (known as geological rockhead), there can be strong contrast in the physical and chemical properties of the geological materials present. The SDTM is important as it can be used to provide a guide to the thickness of these superficial sediments, albeit at a relatively coarse scale, as part of any desk-based study. This information can then be used to inform and guide planning and implementation for various ground engineering schemes. The information provided by SDTM can then be used to assist in the direction of further analyses and potentially more localised site-specific surveys. The overview of potential sediment thickness values made possible by analysing and interrogating the SDTM product is particularly important where projects are data limited, and it is of use to geologists, civil engineers, hydrogeologists and environmental scientists.

The SDTM product allows for the rapid assessment of regional thickness variations in superficial materials. As the SDTM layers are provided as raster data, they can be spatially queried within any compatible software or spatial data analysis framework (Fig. 1). Where ODM and TAM can provide information on potential sediment thickness values (e.g. Fig. 1a), the RHEM provides information on the elevation of the base of the superficial materials (or top of bedrock), relative to Ordnance Datum; additionally the DataDist layer can be used to assess how far a predicted value is from the nearest borehole (DataDist provides the distance of any location relative to the nearest source of thickness information – see Fig. 1b). Interrogating these layers in this way then allows a user to build up a conceptual understanding of the sediment distribution, as well as a notion of the uncertainty associated with it, in a specified area of interest.

At all stages of analysis with the SDTM product, users must be aware that predicted thickness values provided by the ODM and TAM layers in areas of sparse observations (which are represented as larger values on the DataDist surface – greater distances of locations from observations) should be treated with caution as these predictions are further from available observation data and are therefore likely to be less accurate than those closer to observation data (and therefore, smaller DataDist values). The values provided by the SDTM product are intended only as a regional guide and local sediment thickness investigations will likely result in the identification of thickness values that differ to the values provided. These differences will be due to geological processes and sediment distributions that were not possible to capture considering the input data that were available, and the modelling process employed to develop the current version of the SDTM product. Please refer to section 5 for more information on the limitations of SDTM.

Either the TAM or ODM thickness model can be used to identify potential sediment thickness at a location. The main difference between the models is that the TAM is developed in conjunction with terrain data in order to provide additional context for sediment thickness distribution in relation to the current land surface. Whilst the ODM model does not consider the terrain data and simply shows thickness variation within the borehole. Each approach has associated advantages and limitations (see section 5). Using terrain data, as in the TAM, can introduce artefacts into the model, especially where borehole data is sparse, and so care and judgement should be exercised when using the TAM model in areas of few boreholes. Users who need to determine the elevation of the base of the superficial material (rather than the thickness/depth) should use the RHEM. The ODM model is prone to having a *bullseye* dominated appearance because of the relatively sparse input borehole data used to constrain the interpolation method that is used (see Section 3). The ODM 'borehole-only' is unable to make predictions of superficial thickness in areas with too few boreholes. In these areas, which are mostly rural or remote, ODM provides a 'minimum of thickness' of superficial cover (1m). A discussion about the limitations of the models is provided in section 5.

As a general rule, users who are seeking information about proven depths (i.e. 'is there a borehole near my location that has proved rockhead and if so at what depth?') should use the ODM data set in conjunction with the DataDist information to determine the proximity of known thickness data and values. Users seeking more generic information (i.e. "what ranges of thickness could I expect in the 1- 2 km around my location"), can use the TAM (or the ODM) version to look at the range of values the models provide, as well as using the DataDist data to assess the uncertainty of those values.

Further details of how the TAM and ODM models are derived, and any assumptions made of the data are provided in [section 5](#), particularly [figures 11 and 12](#).

**Users should not use the SDTM datasets without first reading this User Guide in full, in particular [section 5](#) on data limitations**

## 3 Methodology

This section provides information on the source data used and the procedures taken to develop the ODM, TAM, RHEM and DataDist gridded dataset components of the SDTM product. Of these four component datasets, TAM and ODM describe sediment thickness variation, RHEM describes the elevation of rockhead and DataDist details 'proximity' of the modelled data to the original source information.

### 3.1 SOURCE DATA OVERVIEW

There are three primary sources of data used to create the ODM, TAM and RHEM models and which feed into the DataDist dataset: borehole records (BGS Single Onshore Borehole Index (SOBI)), geological map data, and terrain elevation data.

#### 3.1.1 Borehole data

Borehole data are used for all components of SDTM: ODM, TAM and DataDist and were derived from BGS SOBI holdings (<https://www.bgs.ac.uk/products/onshore/sobi.html>) available to the modelling team. The purpose of the SDTM modelling is to utilise as many borehole records as possible. However, the following criteria were used to preclude boreholes from the SDTM modelling process (on the grounds of quality or applicability):

- Inclined boreholes (i.e. where they had not been drilled vertically down, but at an angle)
- Subsurface bores or boreholes associated with quarrying, infilled mine shafts and temporary sections
- Boreholes with unreadable or unclear analogue records
- Boreholes with ambiguous location details
- Boreholes deemed to have an inaccurate/spurious interpretation of superficial content
- Boreholes starting within bedrock as defined by their location to BGS digital geological records (BGS Geology 50k – see [section 3.1.2](#))

Following initial quality analysis of the borehole data available, the qualifying boreholes were then subjected to a series of further tests to determine general thickness trends (including minimum, maximum, mean, mode, standard deviation), to determine outlying or spurious data points. Data falling outside expected ranges were then submitted for additional manual checks and, where appropriate, their interpretations were either corrected, or the borehole record is discarded.

#### 3.1.2 Geological map data

BGS Geological records are used as an input for all components of SDTM: ODM, TAM and DataDist . These data are acquired from the BGS Geology 50k V8 dataset suite:

[https://www.bgs.ac.uk/products/digitalmaps/digmapgb\\_50.html](https://www.bgs.ac.uk/products/digitalmaps/digmapgb_50.html)

These data provide a 1:50 000 scale digital geological map of Great Britain, containing information on the spatial extent of geological units including bedrock geology, superficial deposits and artificial ground. All superficial and artificial areas available in the BGS Geology 50k dataset (stored as polygons) were considered in the formation of SDTM. This information is rasterised from its vector form in BGS Geology 50k and is used to form a baseline 1 m minimum-thickness model of sediments where superficial or artificial units are mapped across GB.

### 3.1.3 Terrain elevation data

Terrain elevation data are used as part of the TAM methodology and were sought from the [OS Terrain® 50](#) digital terrain model (DTM) product. This is a photogrammetry-derived raster grid of terrain elevation released by Ordnance Survey in July 2024. All borehole record data and geological map data were compared against this DTM to assess elevations of borehole locations and points of rockhead contact, relative to sea-level. Limitations associated with the terrain elevation data are discussed in section 5.

## 3.2 SUPERFICIAL THICKNESS INPUT DATA PREPARATION

The interpolation methods underpinning both the ODM, TAM and RHEM datasets require the identification of the interface between bedrock and superficial deposits. This interface represents the topography of the pre-Quaternary landscape approximately 2.588 million years ago. It is called the geological 'rockhead'. The subsequent deposition of the Quaternary superficial deposits has largely buried this topography. However, it can be identified from geological mapping, where it is defined as the outer margins of superficial deposits; and it can also be seen in boreholes that drill through superficial deposits and into the underlying bedrock. Geologists identify rockhead by comparing the nature of the materials either side of the boundary. With the younger materials being generally un lithified and less consolidated than materials typically associated with bedrock.

The nature of the boundary can be complex. Identification of the interface can be complicated where there is insufficient lithological contrast between the superficial and bedrock materials. This is particularly the case where pre-Quaternary weathering has degraded lithified bedrock into unconsolidated (but in situ) materials. These areas can result in a degree of uncertainty in positioning of the precise point of transition from bedrock to superficial. This is also evident from data taken from a geological map, where limits of precision used for mapping purposes, mean that it is rarely possible to precisely define a boundary representing an exact rockhead (where superficial materials are exactly 0 m thick). To resolve this, all rockhead boundaries extracted from the geological maps are assumed to represent a minimum thickness of 1 m. Which is the minimum thickness that can be portrayed on a map due to the limitations of the scale at which most surveys are made.

Using borehole records geological rockhead is identified by considering the descriptions of the materials recorded in the logs by drillers and geologists. In boreholes, the depth to the point of rockhead can vary considerably; for vertically drilled boreholes, the depth to rockhead equals the 'thickness' of the superficial deposits. This model precludes use of non-vertical (deviating boreholes), because of the difficulties in determining a true vertical depth from their records. It is important to note that some boreholes are drilled to terminate within bedrock, some terminate where they meet bedrock (often as a result of the bedrock being too strong to drill further), and others terminate whilst still being within superficial sediment, never reaching bedrock. Whilst the first two scenarios provide an opportunity to identify a definitive rockhead and thickness value, the latter provides only a minimum thickness of drilled materials – the full thickness not having been proved (see Figure 1).

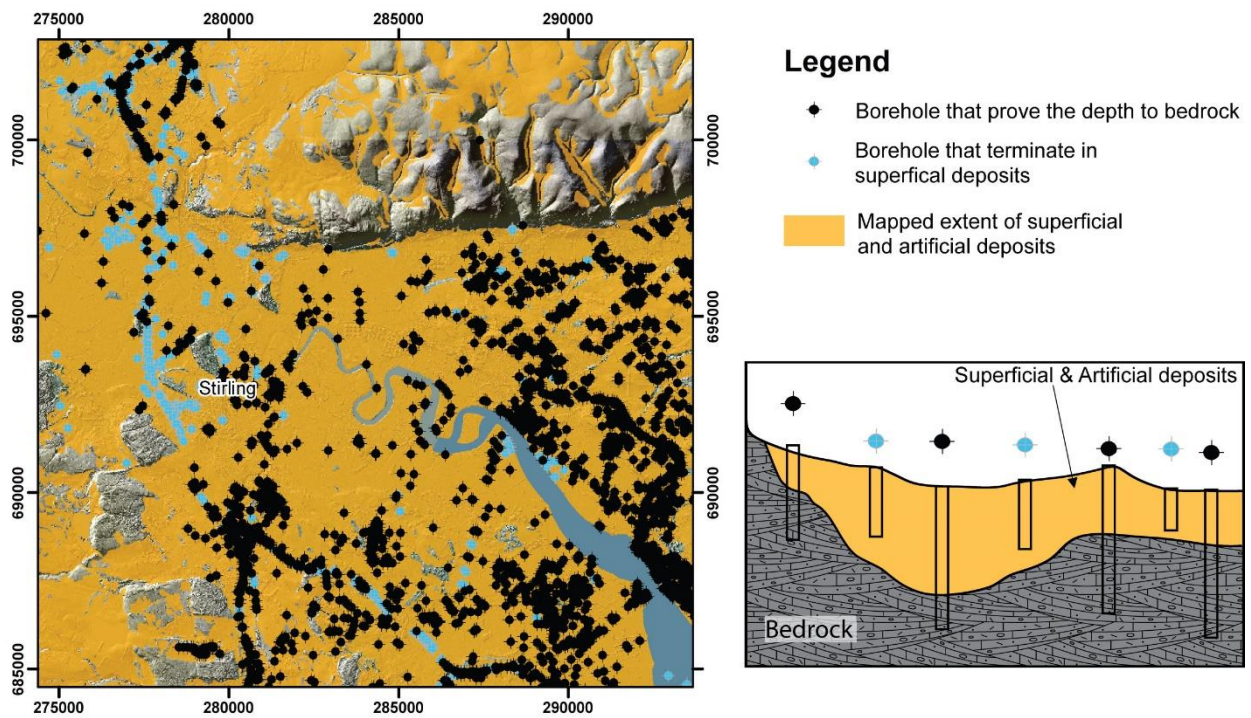


Figure 1 - Map extract showing the location of boreholes and the limit of the mapped superficial deposits known as rockhead, and a schematic cross section through superficial deposits and bedrock, showing how thickness of the superficial deposits can vary. The grey scale DTM displayed in the plan image is an extract from the OS Terrain® 50 DTM product. Contains OS Terrain® 50 DTM data © Crown copyright and database rights 2026

As can be seen in Figure 1, the distribution of boreholes is not uniform and exhibits clusters of boreholes in certain locations and this is true across Great Britain. This is a result of borehole data being more concentrated in urban areas and along linear networks. This occurs to a similar extent for the mapped superficial and artificial deposits which vary in their distribution across Great Britain in relation to the different landscape processes responsible for their deposition (e.g. historical glacier activity) as well as the history of artificial landscape development.

### 3.3 ODM CONSTRUCTION

The ODM surface (Figure 2) is calculated by directly interpolating the thickness values from boreholes and mapped superficial deposit boundaries using a natural-neighbour interpolation algorithm. The interpolation is limited to the mapped extent of known superficial deposits by nulling any area of interpolation that tried to extend where bedrock is present at surface. See Appendix 1 for more information on the interpolation and gridding procedure used, **note that this interpolation does not exactly honour observed thicknesses at borehole locations**. See figures 3 and 4 for a diagrammatic example.

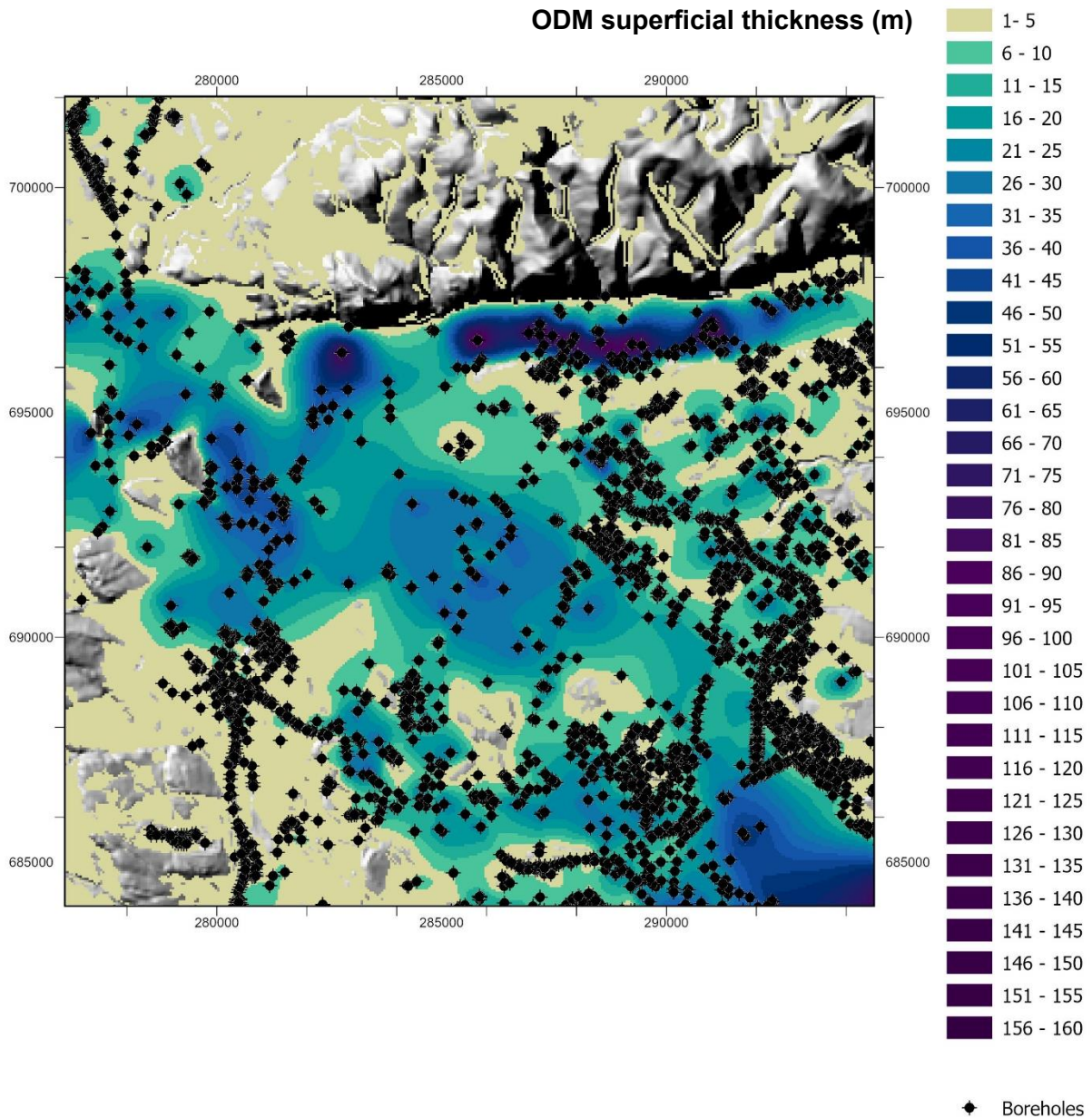


Figure 2 - Map extract from the ODM, showing direct modelling of thickness from borehole-to-borehole, within the known areas of superficial deposits. The grey scale DTM displayed in the image is an extract from the OS Terrain@ 50 DTM product. Contains OS Terrain@ 50 DTM data © Crown copyright and database rights 2026.

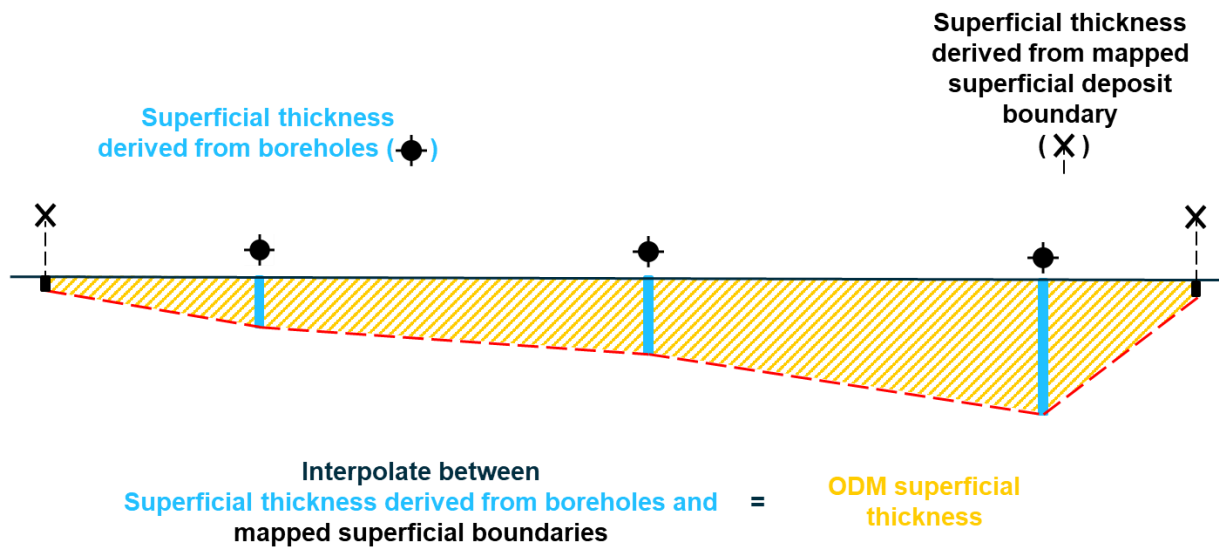


Figure 3 - Superficial thicknesses derived from boreholes (blue) and mapped superficial deposit margins (black crosses) are interpolated between with a Natural neighbour algorithm to create a thickness surface (red). Note that this is a simplified diagram for explanation purposes and that the Natural neighbour algorithm does not always exactly honour observed values. See Appendix 1 for more details on the interpolation algorithm.

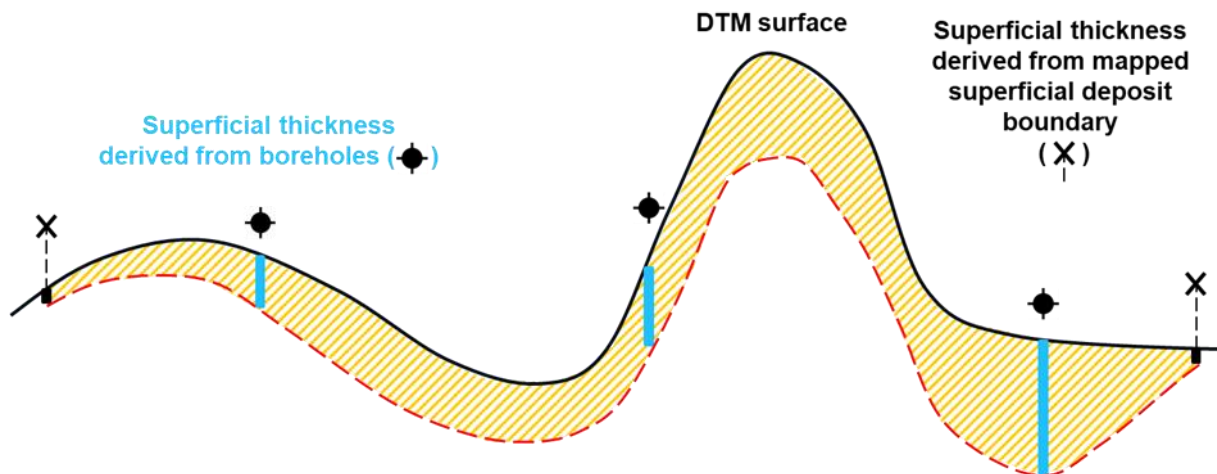


Figure 4 – The resultant thickness surface fitted to the surface topography

### 3.4 TAM CONSTRUCTION

The TAM (Figure 5) uses the same sources of superficial thickness information as the ODM, but rather than directly interpolating a thickness model, each point is compared against the OS Terrain® 50 digital terrain model (DTM), and its thickness subtracted from the calculated elevation. The resultant set of new elevation values provides a proxy measure of rockhead elevation (representing height, in metres relative to Ordnance Datum) for each point.

These calculated rockhead elevations are then interpolated, using the same Natural Neighbour interpolation, to create a rockhead elevation surface. **Note that this interpolation does not exactly honour observed elevations at borehole locations**, see Appendix 1 for more details. This is then compared to the DTM (minus 1m to represent the minimum 1 m thickness BGS applies to its superficial mapping requirements) and where the DTM (minus 1 m) surface is at a lower elevation than the interpolated rockhead elevation surface the DTM elevation value replaces the interpolated rockhead elevation value creating a Rockhead Elevation model (RHEM). This is because it is impossible for rockhead to be at a higher elevation than the ground surface. To calculate the final sediment thickness (known as an isochore map), the resultant RHEM is subtracted from the DTM. Notice how the TAM contains topographic features e.g. the river channel which are absent in the ODM. See Appendix 1 for further information on the gridding procedure. See figures 6,7 and 8 for a diagrammatic example.

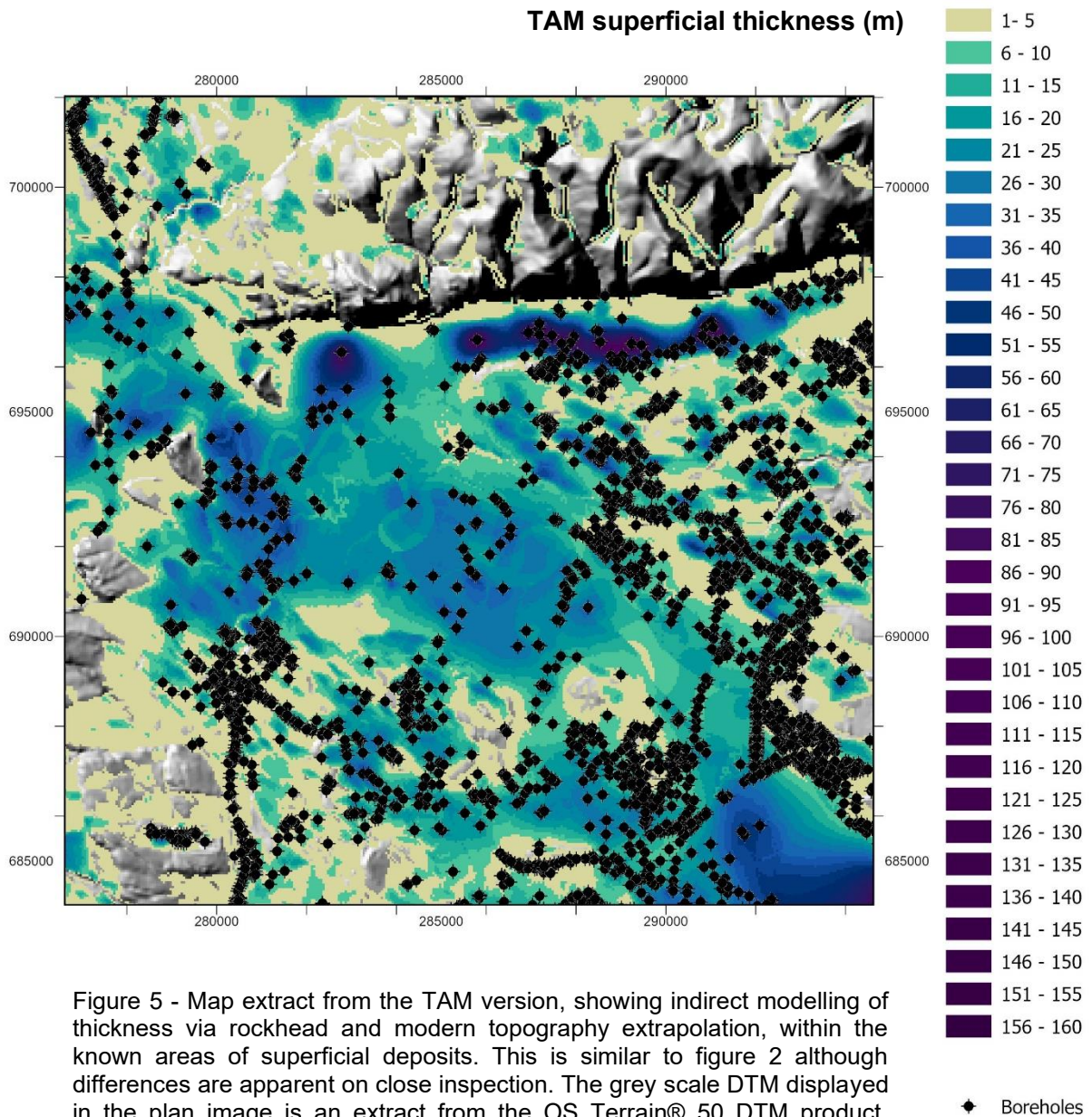


Figure 5 - Map extract from the TAM version, showing indirect modelling of thickness via rockhead and modern topography extrapolation, within the known areas of superficial deposits. This is similar to figure 2 although differences are apparent on close inspection. The grey scale DTM displayed in the plan image is an extract from the OS Terrain® 50 DTM product. Contains OS Terrain® 50 DTM data © Crown copyright and database rights 2026.

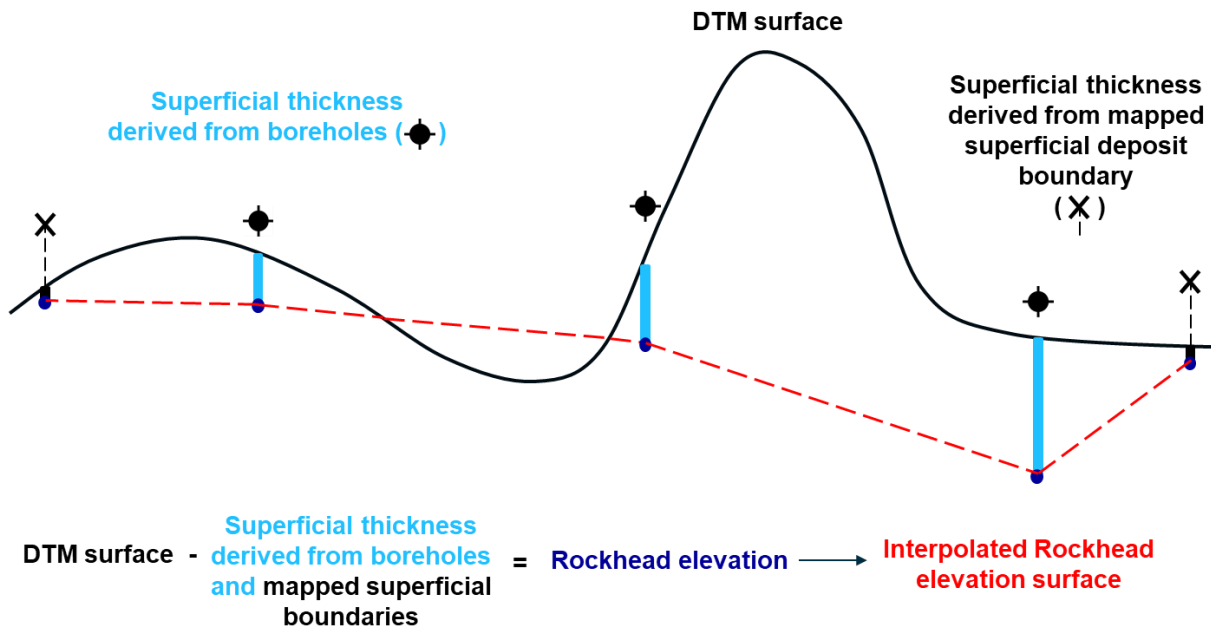


Figure 6 - Superficial thicknesses derived from boreholes (blue) and mapped superficial deposit margins (black crosses) are subtracted from the DTM surface to calculate a rockhead elevation (navy points). Rockhead elevation values are interpolated between with a Natural Neighbour algorithm to create a rockhead elevation surface (red). Note that this is a simplified diagram for explanation purposes and the Natural neighbour algorithm does not always exactly honour observed values. See Appendix 1 for more details on the interpolation algorithm.

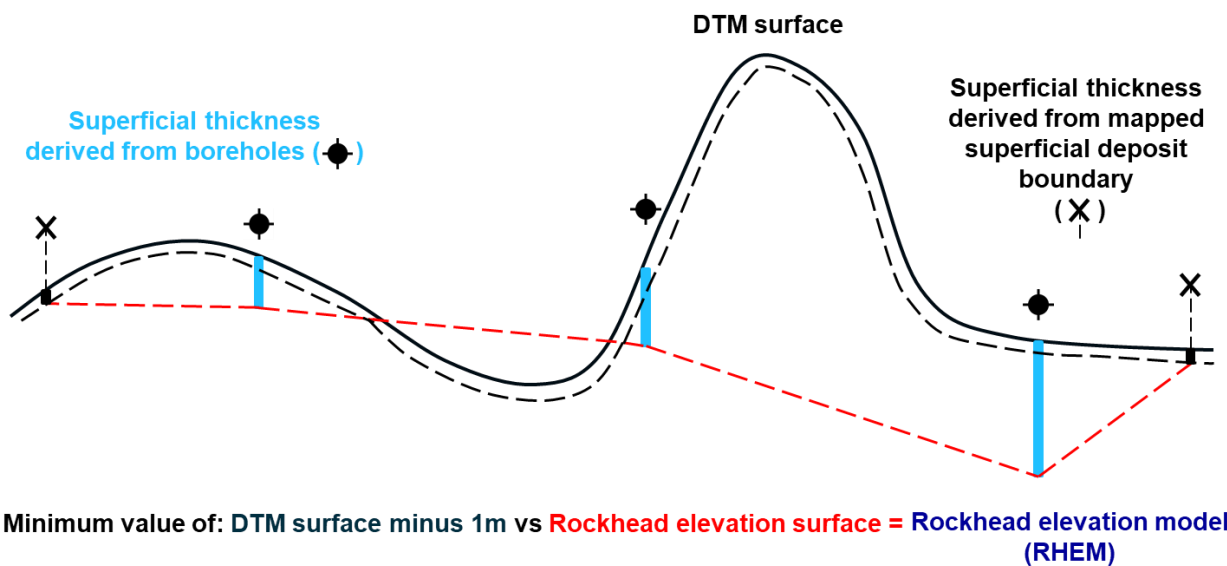


Figure 7 - The interpolated rockhead elevation surface (red) is compared to the DTM (minus 1m to represent the minimum 1 m thickness BGS applies to its superficial mapping requirements) (black dashed) and where the DTM (minus 1 m) surface is at a lower elevation than the interpolated RHEM the DTM elevation value replaces the interpolated rockhead elevation value to create a Rockhead elevation model (RHEM) (see navy line in figure 8). This is because it is impossible for rockhead to be at a higher elevation than the ground surface.

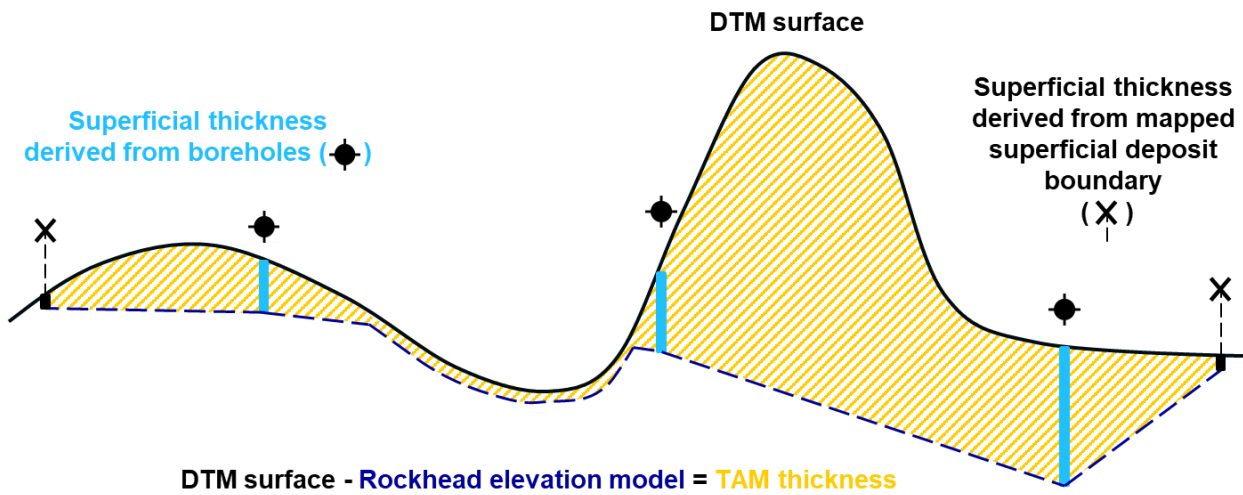


Figure 8 - The Rockhead elevation model (navy) is subtracted from the DTM surface (black) to calculate a TAM superficial thickness (yellow fill).

**See section 5.2 for further diagrams comparing ODM and TAM modelled thickness in the context of data limitations.**

### 3.5 RHEM CONSTRUCTION

RHEM (Rockhead Elevation model) provides an interpolated elevation of rockhead (the transition between superficial sediments and bedrock material) relative to Ordnance Datum. It is created by subtracting the interpolated TAM superficial thickness from the OS Terrain® 50 digital terrain model, represented by the navy line in figure 8. As such, RHEM is derived from the same interpolation of borehole records that prove depth to rockhead, the mapped extent of Quaternary age superficial deposits, and surface elevation data as TAM. RHEM is limited to the extent of the BGS mapped superficial deposit extents. Areas located beyond these mapped superficial extents are considered to have a rockhead elevation within 1 m of the surface. See section 3.4 and figures 6-8 for a diagrammatic explanation of how RHEM is derived.

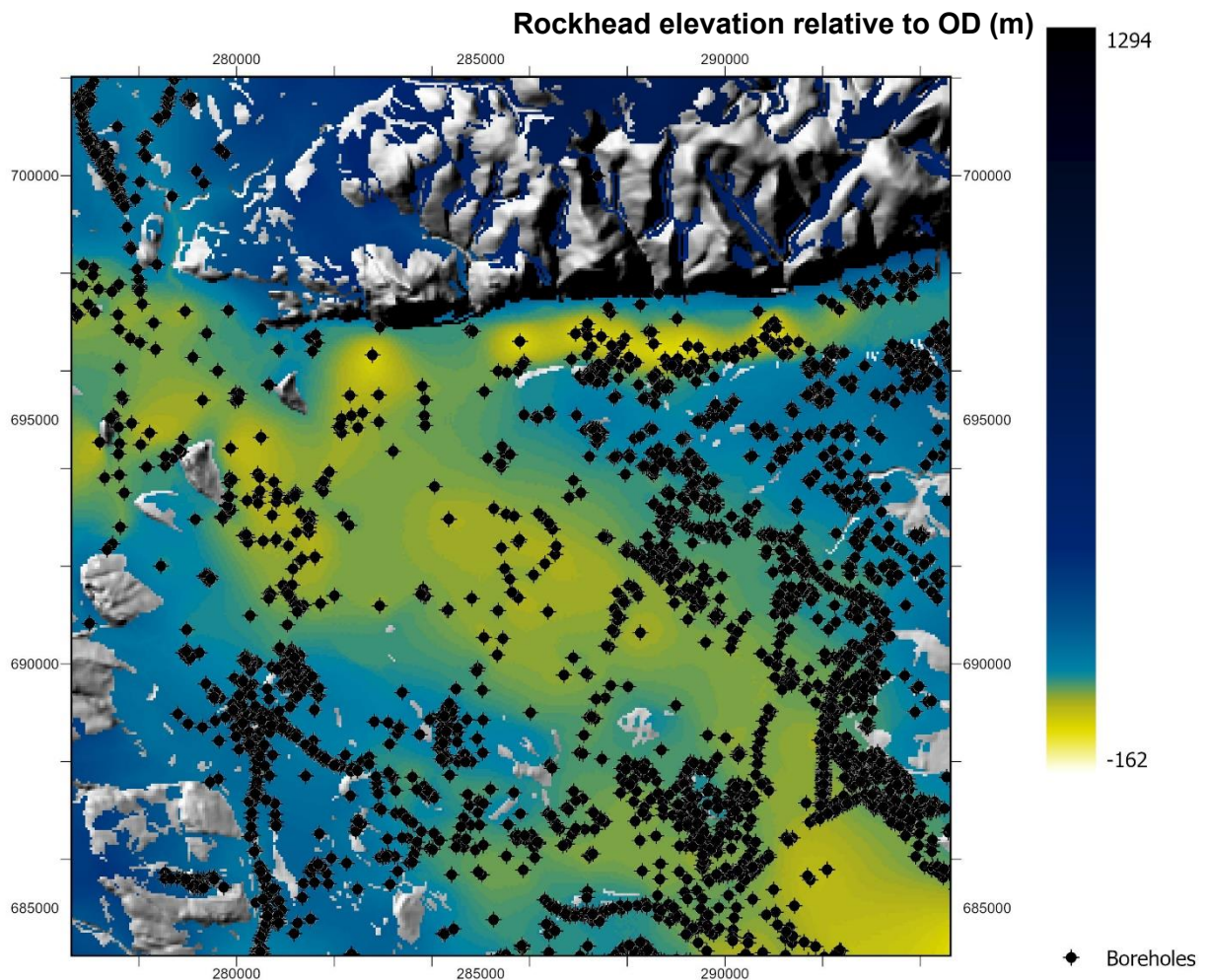


Figure 9 - Map extract from the RHEM version, showing a proxy measure of rockhead elevation in areas where superficial materials are present (representing height, in metres relative to Ordnance Datum). The grey scale DTM displayed in the plan image is an extract from the OS Terrain® 50 DTM product. Contains OS Terrain® 50 DTM data © Crown copyright and database rights 2026.

### 3.6 DATADIST CONSTRUCTION

This dataset provides the distance of any location relative to the nearest source of thickness information, either the location of a borehole, or the mapped boundary of a superficial deposit. The DataDist dataset *does not* provide thickness values - only the distance of each cell/location from the nearest known data source. An example of the DataDist dataset is presented in Figure 10. This methodology is based on the assumption that the closer a location is to a known thickness data observation point, the more accurate the model results are likely to be for that location in the ODM, TAM and RHEM datasets. By contrast, the further a location is from source data, the more uncertain any predictions are likely to be for the equivalent location in the ODM, TAM and RHEM datasets. Therefore, the DataDist dataset can be used by users to interrogate the ODM, TAM and RHEM dataset to determine areas of potentially higher or lower uncertainty.

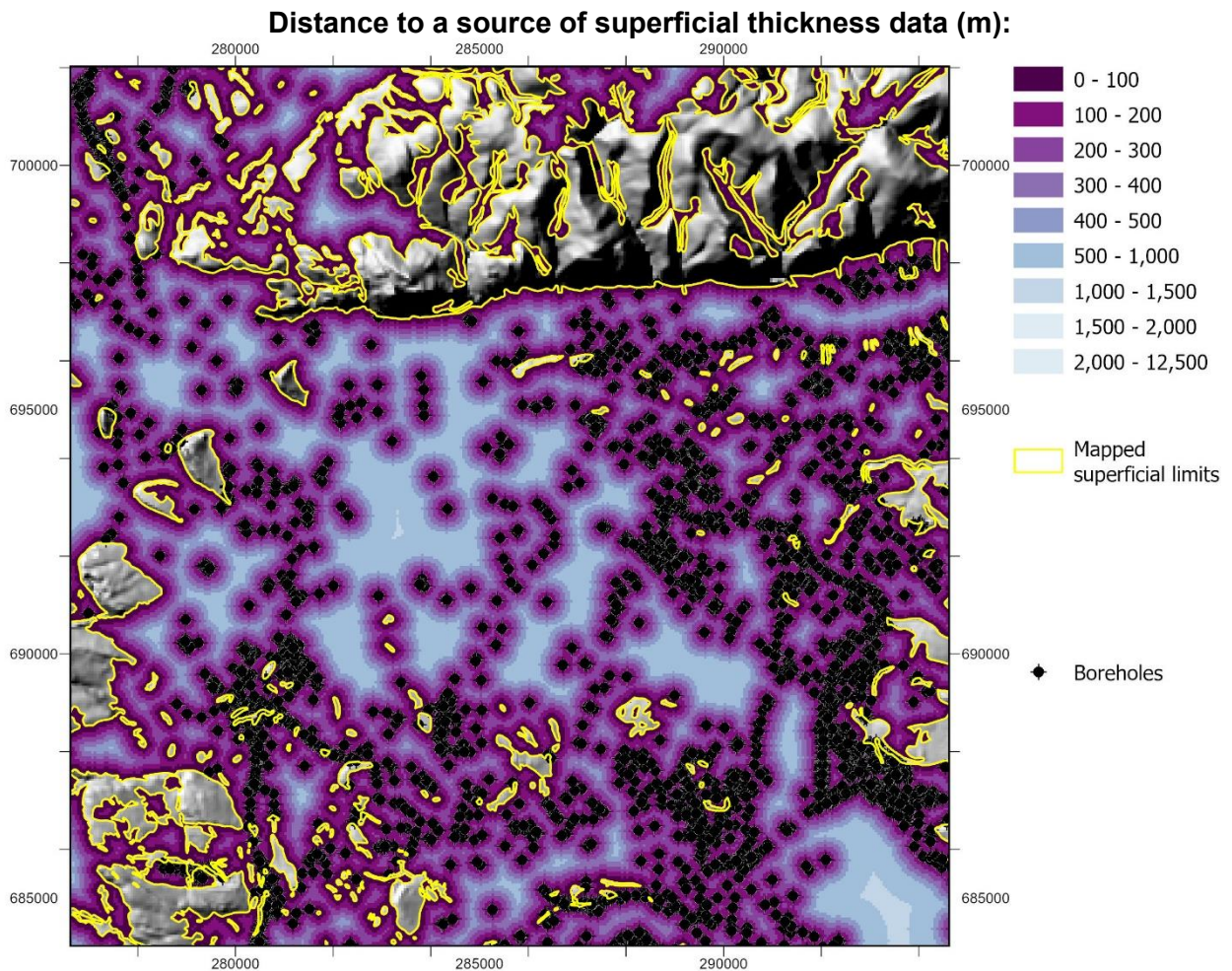


Figure 10 - The DataDist grid, showing how far (in metres) any cell in the model is from either a borehole or mapped limit of superficial deposits. The grey scale DTM displayed on this figure is an extract from the OS Terrain® 50 DTM product. Contains OS Terrain® 50 DTM data © Crown copyright and database rights 2026.

# 4 Technical Information

The following sections provide all technical information relating to the SDTM dataset.

## 4.1 SCALE

The SDTM dataset is provided at a *pseudo*-1:100 000 scale with a 50 m cell size (see Dixon and Uddameri, 2015) associated with all raster components. These data should not be resampled to finer scales than provided. Such a process if implemented would not provide additional accuracy to the model. Users requiring finer levels of detail should contact BGS for advice about creating higher resolution models from our source datasets. The SDTM product is intended for use at 1:100 000 scale. The SDTM provides a regional estimated value of superficial thickness, and as such, is not designed to assess superficial thickness at a specific point.

The scale of dataset is at a *pseudo*-1:100 000 scale, due to a range of input datasets, of a range of spatial scales and resolution being used to develop this map product. For the dataset to be at a true 1:100 000 scale, all input data components would need to conform to a 1:100 000 (or finer) scale, therefore *pseudo*-1:100 000 is used to make this distinction.

Given the scale at which these data are provided, they can be used for regional scale studies and only coarse high-level preliminary desk studies for indication purposes. They should not be used for site-specific studies as the scale of these data is not suitable for such applications. Modifying the SDTM dataset to finer resolutions will not improve the data and should therefore not be carried out.

## 4.2 COVERAGE

The SDTM covers Great Britain. Users should note that the accuracy of the SDTM product varies across Great Britain due to the density of boreholes which are used to constrain the dataset (see Section 5.4).

## 4.3 ATTRIBUTE DESCRIPTION

All components of the SDTM product are provided as raster grids containing the following attributes:

### 4.3.1 Value

An integer value representing:

- ODM – interpolated thickness of superficial deposits in metres (m)
- TAM – interpolated thickness of superficial deposits in metres (m)
- RHEM – interpolated elevation of rockhead in metres (m), relative to Ordnance Datum
- DataDist – distance to a source of thickness information; either the location of a borehole, or the mapped boundary of a superficial deposit, in metres (m)

### 4.3.2 Count

A count of the number cells with that Value

### 4.3.3 UsageInfo

A text attribute providing the user with information on appropriate use of the data and sources of further information.

ODM, TAM and RHEM contain the following text attribution:

*BGS SDTM is provided at a pseudo-1:100000 scale and a vertical accuracy of +/-5m. This data should not be used without first reading the accompanying User Guide which provides details on model limitations, associated uncertainty and appropriate data use.*

DataDist contains the following text attribution:

*BGS SDTM DataDist shows the distance to the nearest source of thickness information. Locations further from sources of thickness info have greater uncertainty. DataDist should be used to judge if SDTM data is appropriate for use in your area of interest.*

#### 4.3.4 Dataset

The name of the SDTM component dataset.

#### 4.3.5 Product

The name of the BGS product (BGS SDTM).

#### 4.3.6 Version

The product version (Version 8)

### 4.4 DATA FORMAT

The data is supplied as signed integer GeoTiffs (.tif) although other formats can be supplied on request. .lyrx files are also supplied with embedded symbologies.

The no data value for all SDTM rasters is -999

Areas shown in the model to have a NULL value (often displayed as white or transparent in GIS) are where no superficial deposits are known to exist. All values of thickness, elevation and distance in the model are expressed in metres.

### 4.5 DATA HISTORY

In line with BGS naming conventions relating to the use of the BGS Geology 50k data product, this model is known as the Superficial Deposits Thickness Model \_V8, and its component files are titled: TAM\_V8, ODM\_V8, RHEM\_V8 and DataDist\_V8. The 'V8' suffix refers to the version of the BGS Geology 50k data that the model is based on (version 8).

Since 2001 there have been four versions of the SDTM as follows:

1. SDTM (v1)
2. SDTM (v2)
3. SDTM (v2.1)
4. SDTM (v5)
5. SDTM (v8) [current]

We do not publish information relating to how the dataset changes from version to version. This is because new boreholes are continually being added to our collections every year, borehole logs are continually being reviewed and reinterpreted and our geological maps are continuously updated, making tracking of every data change in a mathematical model like the SDTM unviable. We do, however, monitor overall changes between versions in order to help identify data trends and unusual data features. The SDTM aims to include the best available data and interpretation at the time of compilation. As we gather new and additional data it is sometimes necessary to discard older information, and thus we expect the datasets and the subsequently re-gridded models to evolve and change through time. The V8 update has introduced a more comprehensive borehole selection criteria resulting in fewer borehole interpretations being utilised in the modelling workflow compared to V5. Having identified and excluded low confidence, inappropriate and conflicting boreholes which may have previously been included in the models, the borehole selection underpinning V8 is considered to be more robust and results in a higher confidence model. V8 also provides the RHEM dataset (see section 3.5) which was not available in V5.

Naming conventions for the ODM and TAM datasets have changed between V5 and V8. The Observation Driven Model (ODM) was previously known as the Basic Superficial Deposit Thickness Model (BSTM) and the Terrain Adjusted Model (TAM) was previously known as the Advanced Superficial Thickness Model (ASTM). These name changes better describe the

characteristics of the two datasets and removes confusion relating to the terms 'Basic' and 'Advanced'.

#### 4.6 DISPLAYING THE DATA

We recommend the ODM, TAM and RHEM are shown classified into 5 m intervals as the vertical accuracy of the surfaces is likely to be on average  $\pm 5$  m. Suggested symbologies are supplied as .lyrx, .qlr and .qml files.

# 5 Limitations

Users should be aware of the following limitations associated with the SDTM data product and its associated components of ODM, TAM, RHEM and DataDist.

## 5.1 DATA CONTENT

All components of the SDTM dataset are highly dependent on the quality and availability of observational data records. For this reason, the dataset is limited in quality according to the availability of these data at the time of its development. For the different datasets within the SDTM product, these datasets include:

- ODM: borehole records, mapped superficial deposit extents
- TAM: borehole records, terrain data (OS Terrain® 50), mapped superficial deposit extents
- RHEM: borehole records, terrain data (OS Terrain® 50), mapped superficial deposit extents
- DataDist: borehole records

The mathematical model (Natural Neighbour) underlying the ODM, TAM and RHEM datasets is limited by the spatial distribution of boreholes which are generally clustered in urban centres and along major transport routes. Consequently, rural areas – and in particular upland regions – of modelled superficial sediment thickness across GB are subject to low borehole data density and interpolation in these areas is calculated over longer distances, which increases model uncertainty. The DataDist dataset has been provided to enable users to consider the distance of a given location to the nearest observation. Where the distance to an observation is greater, predicted model values are likely to be more uncertain.

## 5.2 DATA ARTEFACTS

Any artefacts within the ODM will be exhibited as spurious predicted model values and will relate to the density of borehole observations, or the spatial complexity of the mapped deposits.

The TAM and RHEM will be subject to similar artefacts from borehole and mapping density. However, it also considers surface topography (elevation) and therefore inherits artefacts related to the elevation dataset (DTM) that is used (OS Terrain® 50).

In addition to topographic artefacts that may translate into the TAM, the underlying methodology used to create TAM results in the following types of artefact which are present within the TAM dataset: *DTM-clutter*, *Through-hill-modelling*, *Through-valley-modelling*:

- DTM clutter: The DTM used in the SDTM is derived from the OS Terrain® 50 DTM. This data set is derived largely from photogrammetry methods and for much of the UK represents the bare ground surface. However, there may be some artefacts entrained within the dataset as a result of how it is made (for more details on these please see Ordnance Survey, 2022: <https://www.ordnancesurvey.co.uk/documents/product-support/support/os-terrain-50-overview-v1.5.pdf> ).
- Through hill modelling: Through-hill modelling is an artefact caused by the method of integration that combines the distribution of geological deposits, the interpolation method, and the varying resolution of these datasets. It is only found in the TAM and RHEM datasets and is a result of the use of an over-simplified superficial coverage model in areas of high relief (mountainous terrain). Relatively thin deposits such as of peat, can completely mantle areas of high relief, which results in the model extrapolating data “through the terrain”, rather than “over it”. This results in the model providing values which imply that hills or other raised features consist wholly of superficial sediments, rather than

being bedrock covered by a thin, but persistent veneer of superficial material. This results in the TAM containing unrealistically high thickness values in areas of high relief terrain and the RHEM containing unrealistically low elevation (Fig.7). Users interrogating the TAM/RHEM must be aware of this limitation.

- Through-valley-modelling: Section 3.4 and figure 7 highlight that during the construction of the TAM the rockhead elevation model (RHEM) is compared to the DTM and where the DTM surface is at a lower elevation than the interpolated RHEM the DTM elevation value replaces the interpolated RHEM value. This is because it is impossible for rockhead to be at a higher elevation than the ground surface. This can result in valley bottoms having a no modelled superficial thickness and being assigned the minimum superficial thickness value of 1 m applied to all mapped superficial deposits. In reality, valley bottoms often have significant thicknesses of superficial deposits. This results in TAM containing unrealistically low thickness values and RHEM containing unrealistically elevated rockhead elevation values. Users interrogating the TAM/RHEM must be aware of this limitation.

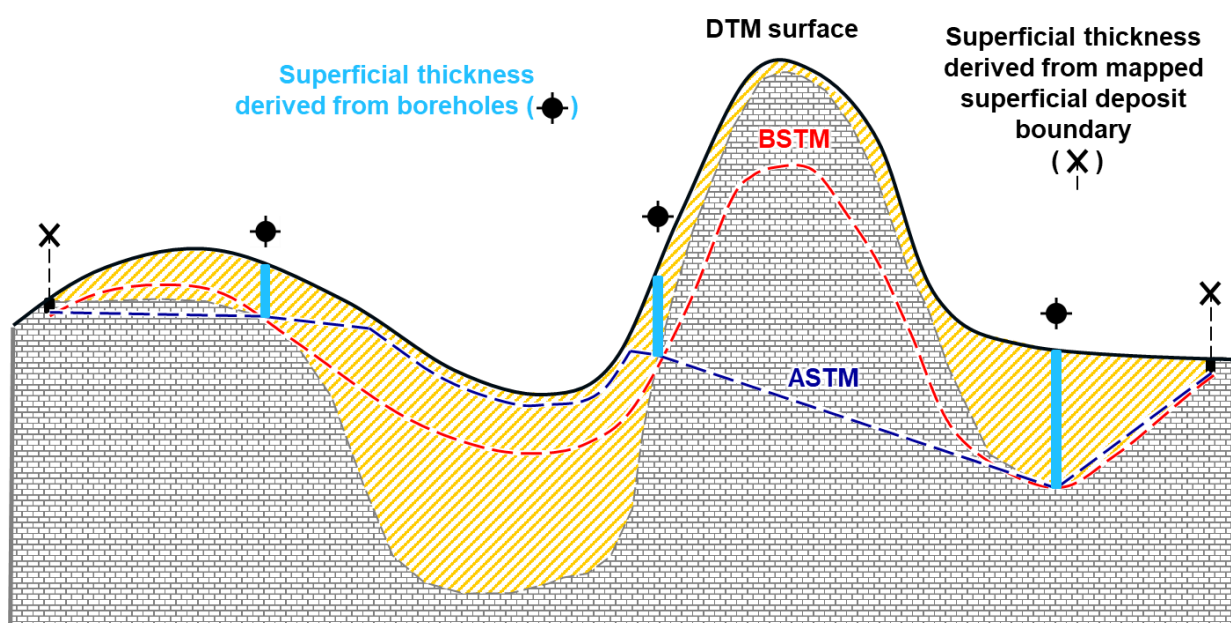


Figure 11 - Continuing the diagrammatic example from figures 5-9, this example shows an example configuration of bedrock (grey fill) and overlying superficial deposits (yellow fill). Considering the available superficial thickness information available from boreholes (blue) and mapped superficial deposit margins (black crosses) the resultant ODM (red) and TAM (navy) thickness surfaces are shown and labelled. Note that this is a simplified diagram for explanation purposes and the Natural neighbour algorithm does not always exactly honour observed values. See Appendix 1 for more details on the interpolation algorithm.

As described above the ‘through-hill-modelling’ affect is seen when considering the TAM thickness. Boreholes either side of a topographic feature have been interpolated between resulting a significant thickness of modelled superficial thickness throughout the topographic feature. In this case, the topographic feature is a bedrock feature mantled in superficial deposits therefore ‘through-hill modelling’ results in TAM overestimating the superficial thickness and ODM provides a more realistic view of superficial thickness.

Similarly, this example highlights the implications of ‘through-valley modelling’ in the TAM (navy) where the modelled thickness is taken to be 1m below the DTM surface (see figure 7 for explanation) when in reality superficial thickness is much deeper in the valley bottom. Here again ODM provides a better view of superficial thickness but is still limited by a lack of observational data in the valley bottom proving this localised increase in superficial thickness.

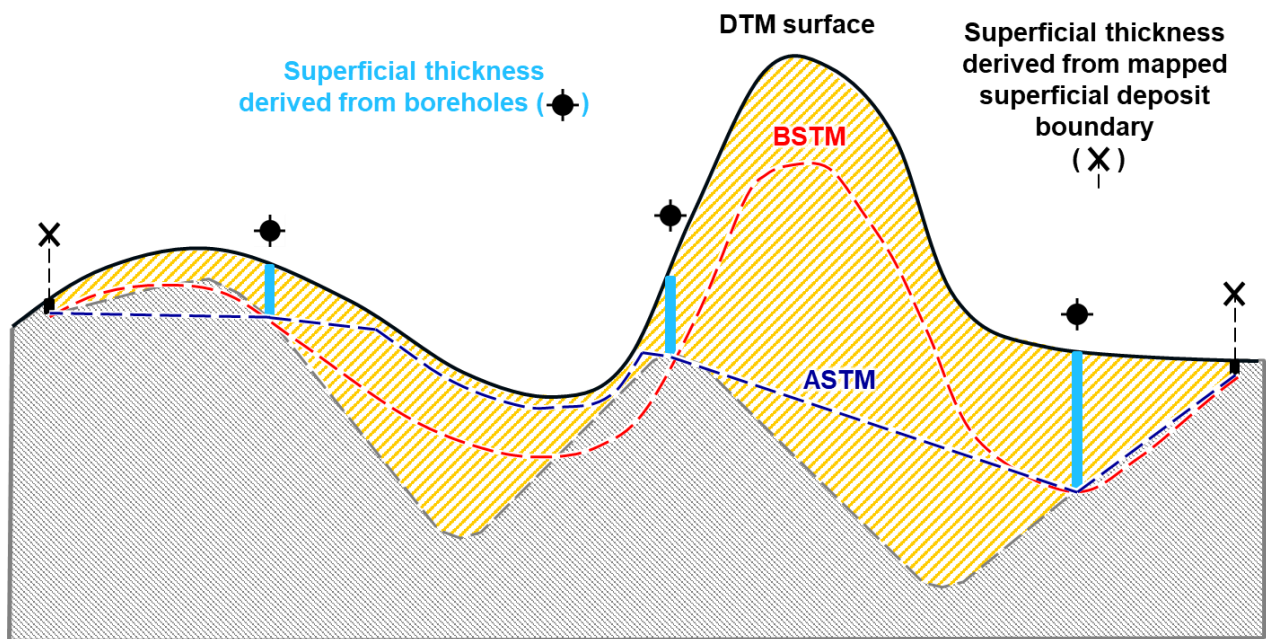


Figure 12 - Continuing the diagrammatic example above, this example shows an alternative configuration of bedrock (grey fill) and overlying superficial deposits (yellow fill). Considering the available superficial thickness information available from boreholes (blue) and mapped superficial deposit margins (black crosses) the resultant ODM (red) and TAM (navy) thickness surfaces are shown and labelled. This example demonstrates the ability of the TAM better model superficial thickness in terrains where the topography is controlled by superficial deposits rather than the bedrock surface. The example shows a topographic feature (hill) with no observational data proving thickness. The TAM model considers the entire feature to consist of superficial deposits whilst the ODM mantles the feature in superficial deposits.

**This demonstrates the importance of considering the context in which the SDTM layers are used. TAM can better predict superficial thicknesses in sediment-controlled topographies but requires careful interpretation of the wider landscape to determine when its use is appropriate. If users are not able to make this interpretation BGS recommends the use of ODM.**

Note that these artefacts affect only the TAM and RHEM versions of the model and must be considered by the user. The DataDist layer should be consulted alongside TAM and RHEM to determine proximity to a borehole observation of superficial thickness and judge the confidence in modelled thickness at any given location. The ODM version is dominated by borehole data rather than terrain data, so users should consider switching to using the ODM model if they suspect their area of interest is affected by terrain issues.

### 5.3 SCALE

The SDTM dataset is provided at a *pseudo*-1:100 000 scale with a 50 m cell size associated with all raster components. Any values within the dataset represent a predicted value for 50 m<sup>2</sup> areas. Consequently, the values provided should not be considered for areas smaller than 50 m<sup>2</sup>. For this reason, field observations at a specific point in the landscape will not likely correspond to the values provided within the SDTM product. The SDTM product must not be used at finer scales than 1:100 000.

Given the 1:100 000 scale at which SDTM is provided as well as consideration of the density of input borehole data illustrated by the DataDist dataset, users should also be aware that this provides limits on how the dataset can be used. For example, features such as buried valleys (old channel features that have been infilled by superficial sediments) may not appear within the SDTM dataset as boreholes may not be available that cover these features, or the features are only possible to resolve at scales finer than 1:100 000.

The intended scale of use of this dataset is 1:100,000 with a vertical modelled precision of +/-5m elevation. The dataset is intended for use at national, regional and local scales but not site scales where specific ground investigation works should be undertaken to determine superficial thickness and / or rockhead elevation.

### 5.4 ACCURACY

The average vertical accuracy of this the SDTM is likely to be  $\pm 5$  m. However, the average vertical error is not consistent across the country, and it is likely to be more accurate in urban areas compared to mountainous areas due to differences in observation density. Using the DataDist layer, areas more distant from observations can be identified.

Any areas further away from observations will be more uncertain and users should consider whether the view of superficial thickness offered by SDTM is appropriate for their use case.

The Natural Neighbour interpolation that underpins the ODM, TAM and RHEM datasets does not honour observation points but rather provides a smooth transition between observations: the intention being to provide a potential surface of superficial sediment thickness values based on observations, rather than a direct observation dataset. Given these sources of uncertainty and the relatively coarse scale of the product, the SDTM dataset is intended to only provide a cursory analysis of potential sediment thickness patterns.

Users should also note that observed superficial thicknesses upon which the SDTM models have been built are relative to the ground surface at the time the observation was taken, i.e. when a borehole was drilled. Therefore, where the ground surface has changed significantly since a borehole was drilled such as areas of mining/quarrying/dam construction and major infrastructure such as flyovers thickness values presented by SDTM outputs may not apply to the present-day ground surface. Where users are aware of significant changes to the ground surface elevation the SDTM is not recommended for use.

The scale of this dataset can often mask natural features that may influence the elevation of the bedrock surface or the superficial deposit thickness, where penetrating boreholes are not available. For example, buried channels, so-called drift-filled hollows and various types of solution feature.

In areas with no borehole coverage (e.g. rural and remote regions) superficial thickness information is derived from the mapped superficial deposits which are considered to have a minimum superficial thickness of 1m. In the ODM these areas are easy to identify as they are the regions dominated by a modelled superficial thickness of 1m. In the TAM the inclusion of terrain data can mask this effect making these areas harder to identify. The DataDist layer should be consulted alongside TAM and ODM to determine proximity to a borehole observation of superficial thickness and judge the confidence in modelled thickness at any given location.

## 5.5 DISCLAIMER

The use of any information provided by the British Geological Survey ('BGS') is at your own risk. Neither BGS nor the Natural Environment Research Council (NERC) or UK Research and Innovation (UKRI) gives any warranty, condition or representation as to the quality, accuracy or completeness of the information or its suitability for any use or purpose. All implied conditions relating to the quality or suitability of the information, and all liabilities arising from the supply of the information (including any liability arising in negligence) are excluded to the fullest extent permitted by law. No advice or information given by BGS, NERC, UKRI or their respective employees or authorised agents shall create a warranty, condition or representation as to the quality, accuracy or completeness of the information or its suitability for any use or purpose.

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## 6 Frequently asked questions

The questions and answers below have been provided to address any potential issues relating to how the product can be used or how it can be interpreted. If you have any additional questions, please contact [enquiries@bgs.ac.uk](mailto:enquiries@bgs.ac.uk)

Q: What do the SDTM datasets show?

A: The SDTM dataset models shows the variation in thickness of all superficial deposits including man-made deposits. Man-made deposits include features such as railway embankments, spoil heaps and landfill.

Q: SDTM consists of 4 separate components, what is the ODM?

A: The ODM component of the SDTM dataset is the Observation Driven Model and provides a predicted continuous grid of thickness variation across GB. The values are predicted using a mathematical model which considers borehole observations collected in the field and mapped superficial deposit boundaries.

Q: SDTM consists of 4 separate components, what is the TAM?

A: The TAM component of the SDTM is the Terrain Adjusted Model and provides a predicted continuous grid of thickness variation across GB, whilst also accounting for changes in topography as well as mapped extents of geological units based on our field surveys. The predicted values across the grid have been calculated using a surface elevation model (OS Terrain® 50 Digital Terrain Model) to extrapolate thickness values to areas where there are sparse borehole records and therefore few observations of superficial sediment thickness.

Q: SDTM consists of 4 separate components, what is the RHEM?

A: The RHEM component of the SDTM is the Rockhead Elevation Model and provides a gridded model of the elevation of rockhead (the transition between superficial sediments and bedrock material) relative to Ordnance Datum across GB. Derived using a method which combines borehole records, the mapped extent of quaternary-age superficial deposits as well as surface elevation data.

Q: SDTM consists of 4 separate components, what is the DataDist?

A: The DataDist component of the SDTM displays how far any particular point on the grid is from a point of known thickness (e.g. a borehole or a mapped superficial deposit margin point). This layer is useful as, the closer a location is to a known data point the more accurate the model is for that location. Users should interrogate this layer to determine more likely accurate areas of the ODM, TAM and RHEM models.

Q: What data formats can these data be provided as?

A: The SDTM product and its component datasets are all provided in raster (or grid) format as opposed to vector. These are typically available as GeoTiff files although formats can be provided upon request.

Q: What are superficial deposits?

A: Superficial deposits correspond to geology that was formed during the current geological time period called the Quaternary. This period spans the past 2.588 Ma of geological time up to and including the present day. Superficial deposits are largely (but not exclusively) unconsolidated and cover much of the bedrock of Britain. Natural superficial deposits have historically been referred to on BGS maps as drift deposits

Q: What map scale is SDTM provided at?

A: The SDTM dataset is provided at a *pseudo*-1:100 000 scale with grids consisting of pixels which represent a 50 m<sup>2</sup> land area. Consequently, the values provided should not be considered for areas smaller than 50 m<sup>2</sup>. Any values within the dataset represent a predicted value for 50 m<sup>2</sup> areas. For this reason, field observations at a specific point in the landscape will not likely correspond to the values provided within the SDTM product. The ODM, TAM, RHEM and DataDist

components of the SDTM dataset are not designed for use at viewing scales finer than 1:100 000, and all spatial searches against the data should be implemented with a minimum 50 m buffer.

Q: How accurate is this dataset?

A: The average vertical accuracy of this the SDTM is likely to be  $\pm 5$  m. However, the average vertical error is not consistent across the country, and it is likely to be more accurate in urban areas compared to mountainous areas due to differences in observation density. Using the DataDist layer, areas more distant from observations can be identified. Users must not consider this dataset at scales finer than 1:100 000.

Q: Are the dataset values real world observations or predictions?

A: The ODM, TAM and RHEM components of the SDTM dataset provide predicted values based on real world observations. These predictions are required to create continuous surfaces of values. Due to the application of these methods, it should not be expected that a value within the dataset directly corresponds to a point observation e.g. a borehole record. The DataDist component of SDTM provides the distance of all locations across the grid to the closest borehole record.

Q: How often will this dataset be updated?

A: This dataset is under on-going revision as more observations become available. As an active project, future releases are expected although no future release dates are currently available.

Q: Can I use this dataset as part of a commercial application?

A: Please refer to the licencing terms supplied alongside the dataset. For further queries regarding the licencing terms of our products, please contact [digitaldata@bgs.ac.uk](mailto:digitaldata@bgs.ac.uk).

# Glossary

Jargon	Explanation
<i>Anthropogenic</i>	Some phenomena relating to human influence e.g. anthropogenic environmental change is that caused by or resulting from the influence of people or their activities either directly or indirectly.
<i>ArcGISPro</i>	Proprietary geographic information system (GIS) software for working with spatial information, maintained by the Environmental Systems Research Institute (ESRI).
<i>Bedrock</i>	The main mass of rocks forming the earth, laid down prior to 2.6 million years ago. Bedrock is present everywhere, whether exposed at the surface in rocky outcrops or concealed beneath superficial deposits, artificial ground or water. Formerly called <i>solid</i> .
<i>Bullseye</i>	Anomalously high or low values seen as peaks or dips relative to surrounding locations within an interpolated surface dataset. In the context of SDTM, these can be caused or linked to anomalous borehole interpretations.
<i>Buried channels</i>	Buried channels or valleys are ancient river or subglacial (beneath a glacier) drainage networks that are now abandoned and have become either partly or completely buried by more recently deposited sediments. Buried channels often exhibit little or no surface expression within the modern landscape.
<i>Conductivity</i>	The degree to which a specified material conducts electricity.
<i>Extrapolate</i>	The process of constructing new data points outside a discrete set of known data points. It is similar to the process of interpolation, which constructs new points between known points, but the results of extrapolations are often less meaningful, and are subject to greater uncertainty.
<i>Fluvial</i>	Sedimentary deposits consisting of material transported by, suspended in, and laid down by a river or stream.
<i>Geological units</i>	A volume of rock of similar origin and relative age range that is defined by being easily mapped over distances.
<i>GeoTiff</i>	A specialized raster file format commonly used in Geographic Information Systems (GIS). It embeds geographic metadata into TIFF images, enabling accurate mapping and geospatial analysis.
<i>Hermitian smoothing</i>	Hermitian smoothing is a technique of analysing a square matrix of values (such as a raster grid) and applying a numerical filter to modify values that do not fit a measurable trend within the data. The effect is to smooth out extraneous values without unduly altering the values so that the trend is lost.
<i>Interpolation</i>	A mathematical technique to estimate a trend in data between known points.
<i>Isochore map</i>	A map of contours that link together points of equal thickness relative to a specific geological unit.
<i>Lithology</i>	The physical characteristics of a rock or sediment, including colour, composition, and texture

<i>Modelled</i>	Refers to the process required to create values based on the application of some algorithm or technique to a set of input data.
<i>Natural Neighbour</i>	A method of spatial data interpolation that predicts values using weights derived by considering the relationship between the Voronoi neighbourhoods of observations and the equivalent Voronoi neighbourhoods when considering a point location at which to interpolate (see Sibson, 1981).
<i>OS Terrain® 50</i>	A Digital Terrain Model (DTM) developed by Ordnance Survey provided at a 50 m resolution covering GB. Version July 2024.
<i>Porosity</i>	The ratio of the volume of the interstices to the total volume of rock expressed as a fraction. Effective porosity includes only the interconnected pore spaces available for groundwater transmission; measurements of porosity in the laboratory usually exclude any void spaces caused by cracks or joints (secondary porosity).
<i>Quaternary domains</i>	A set of domains across GB defined partly on the occurrence of recurring geomorphological features and assemblages of superficial deposits, and partly on genetic linkages to the surface processes that formed them (see Booth, et al., 2012).
<i>Quaternary superficial deposits</i>	All unconsolidated material deposited in the last 2.588 million years.
<i>Raster</i>	Data provided as a grid of numerical values. Raster data can be thought of as being similar to a digital photograph. A raster dataset is a grid of cells (or pixels) whereby each cell stores a single value.
<i>Resolution</i>	Resolution expresses the size of the smallest object in a spatial data set that can be described. It refers to the amount of detail that can be discerned. It is also known as granularity.
<i>Rockhead</i>	The point of contact between Bedrock and Superficial units. The 'ground level' before the superficial deposits were laid down.
<i>Scale</i>	The relation between the dimensions of features on a map and the geographic objects they represent on the earth, commonly expressed as a fraction or a ratio. A map scale of 1/100 000 or 1:100 000 means that one unit of measure on the map equals 100,000 on the earth.
<i>Spatial data</i>	Data describing anything with spatial extent, i.e. size, shape or position. These will be relative to some defined coordinate system.
<i>Superficial</i>	The youngest geological deposits predominantly formed during the most recent period of geological time, the Quaternary. They date from about 2.588 million years ago to the present.
<i>Topographic</i>	The physical features of a land mass. A topographic map's principal purpose is to portray and identify these features, which might include the cultural landscape, but normally refer to the terrain and its relief.
<i>Voronoi neighbourhood</i>	An area in Euclidian space around a point observation constructed in relation to neighbouring points – each node of the neighbourhood extent will be equidistant between the observation in question and the nearest two neighbours.

# 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](mailto:libuser@bgs.ac.uk) for details). The library catalogue is available at: <https://envirolib.apps.nerc.ac.uk/olibcgj>.

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# 7 Appendix

## 7.1 Interpolation and gridding procedure

For the interpolation procedure used as part of the ODM, TAM and RHEM methodologies, Natural Neighbourhood interpolation (Sibson, 1981) is used. This method was chosen as it weights the predictions that ultimately make the output dataset considering the *Voronoi neighbourhood* of the input point observations (see Fig. 13a), which in this application, are the thickness observations.

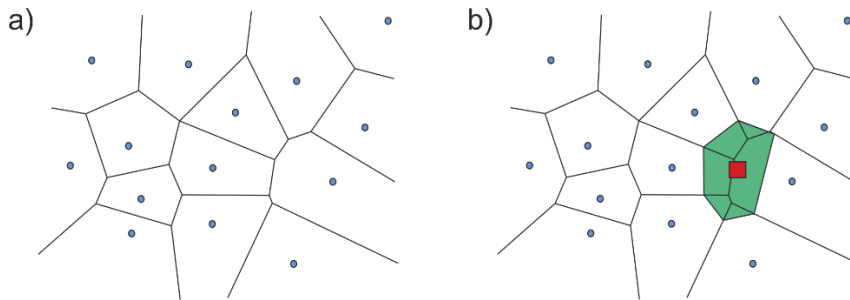


Figure 13 - Schematic of Voronoi polygon areas around observation points (a) and with the Voronoi neighbourhood of the prediction location in relation to observations (b).

When constructing Voronoi neighbourhoods, each point used to define the perimeter of the area is equidistant to the nearest observations. Firstly, the algorithm creates a Voronoi neighbourhood for the observations (Fig. 13a). Secondly, for a given location where a prediction is to be made, an additional Voronoi neighbourhood is constructed around the prediction location (Fig. 13b). The weighting then applied to individual observation data within the interpolation is calculated according to the proportional relationship between the prediction location Voronoi neighbourhood area and any intersecting observation Voronoi areas. In this way, this interpolation approach ensures that predicted values remain within the value range of the nearest observation data but do not exactly honour observed values. For the development of SDTM, the interpolation is implemented using [ArcGISPro®](#).

The target grid of the interpolation is to a pixel size of 50 x 50 m with an origin based on the British National Grid (EPSG code: 27700).

The following additional steps were then taken to modify the predicted thickness surfaces for both the ODM and TAM models:

- where the mapped geology (BGS Geology 50k) datasets presented an absence of superficial sediment, equivalent locations on the interpolated grids were set to null values.
- grids were assigned with a minimum thickness value of 1 m where no bore data were present, but superficial sediment is known to occur in line with the mapped geology dataset

The gridding procedure is an iterative process in relation to the quality of the borehole thickness information that is available. The first iteration of the interpolation procedure considered only borehole records which terminated at bedrock and therefore an absolute sediment thickness could be assumed. The second iteration is carried out using boreholes not terminating in bedrock (i.e. where there is no absolute superficial sediment thickness measurement available) in locations only where the first interpolation underestimated thickness values, assessed by comparison. This provides a *minimum thickness* model and is useful in areas of low borehole density.

Throughout the process, the interpolated surfaces models were checked for outliers and where required, the initial source borehole data were re-assessed to check for errors.