3D geological modelling for infrastructure projects in the context of a national geological model

Holger Kessler

Geologist, Team Leader Modelling Systems

including work by

Dave Entwisle, Helen Burke, Rachel Dearden, Luz Ramos, John Lee, Cath Cripps, Leanne Hughes, Ben Wood, Jon Ford, Ricky Terrington, Don Aldiss

and our external partners

The British Geological Survey

- UK national Geological Survey Founded in 1835
- UK custodian of geoscientific information
- 646 staff (510 multi-disciplinary scientists)
- Part of NERC not-for-profit Public Sector Research Establishment
- Funded by Government & external income through commissioned research
- Offices at Keyworth, Wallingford, Edinburgh & Cardiff

Maps to models in Great Britain

The mission has remained constant:
To understand & explain the Geology

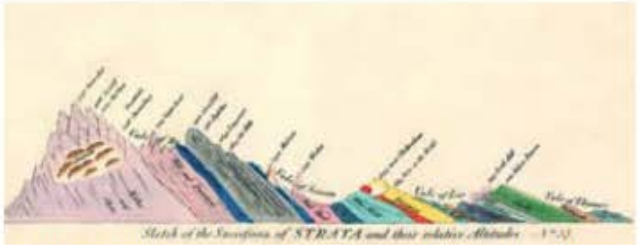
1815

1874

1939

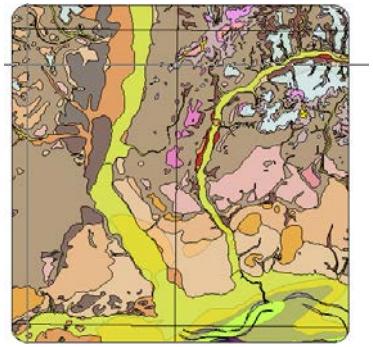
2007

William Smith

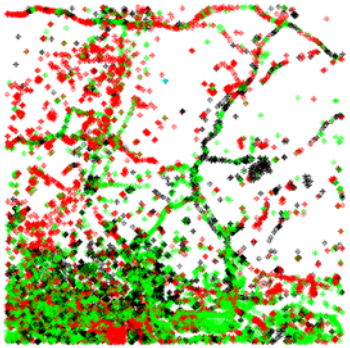


2012

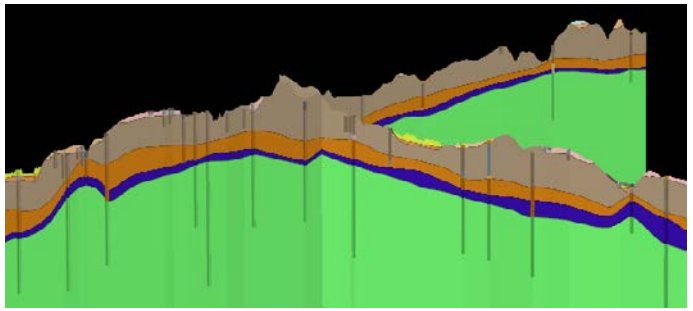
Building a geological model (aka 3D mapping)



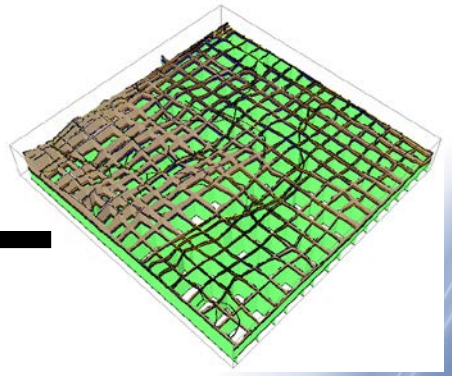
Map and DTM



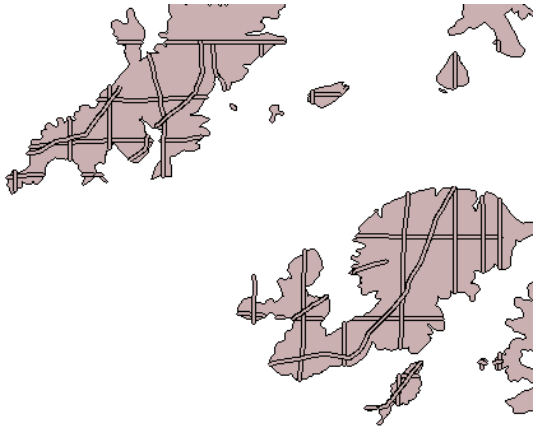
Boreholes



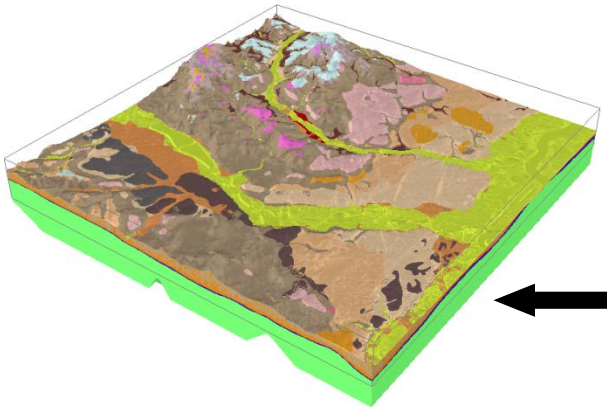
Cross-sections



Fence diagram



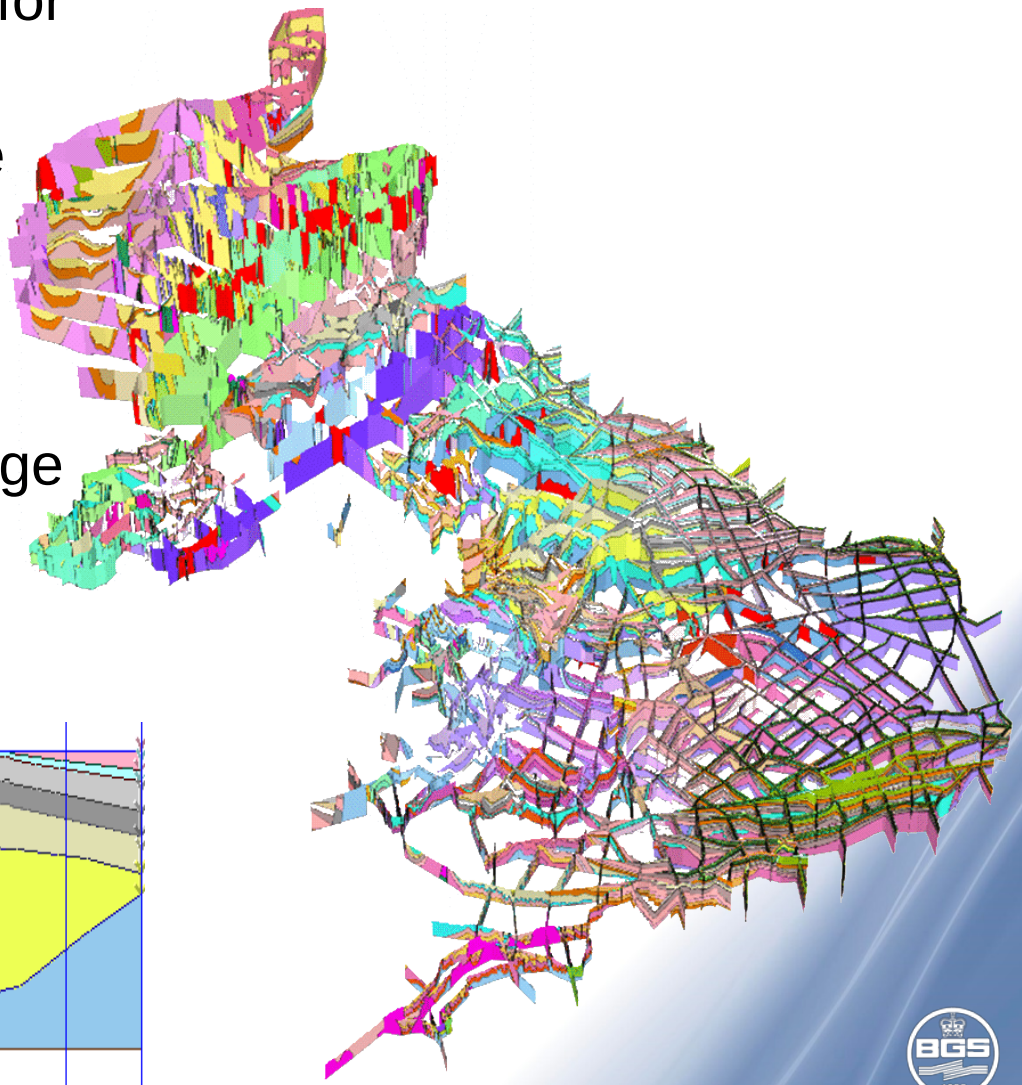
Unit distribution

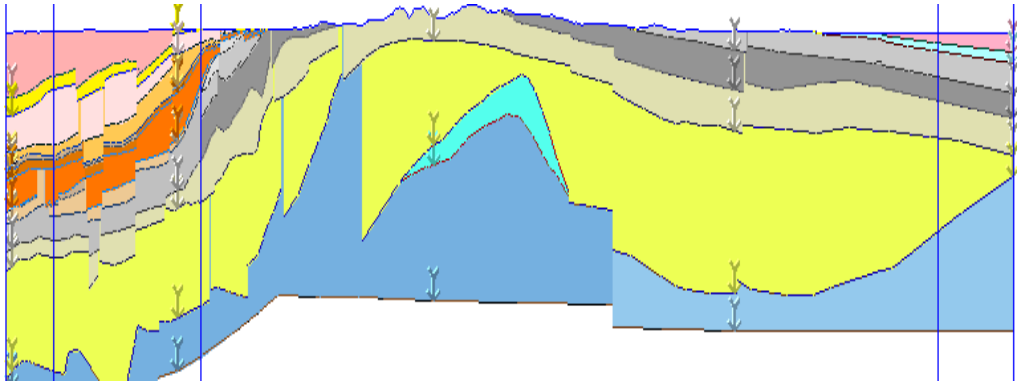


Geological Block model

UK3D - National Bedrock Model

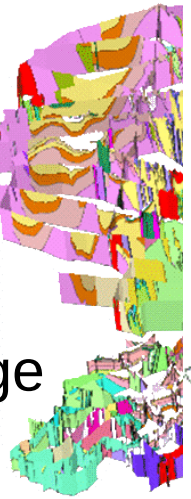
- An impartial reference-frame for the UK subsurface
- Successor to 1:625,000 scale map
- Synthesises a wealth of data and interpretation
- Captures geologists' knowledge in a consistent framework
- Peer-reviewed, open dataset

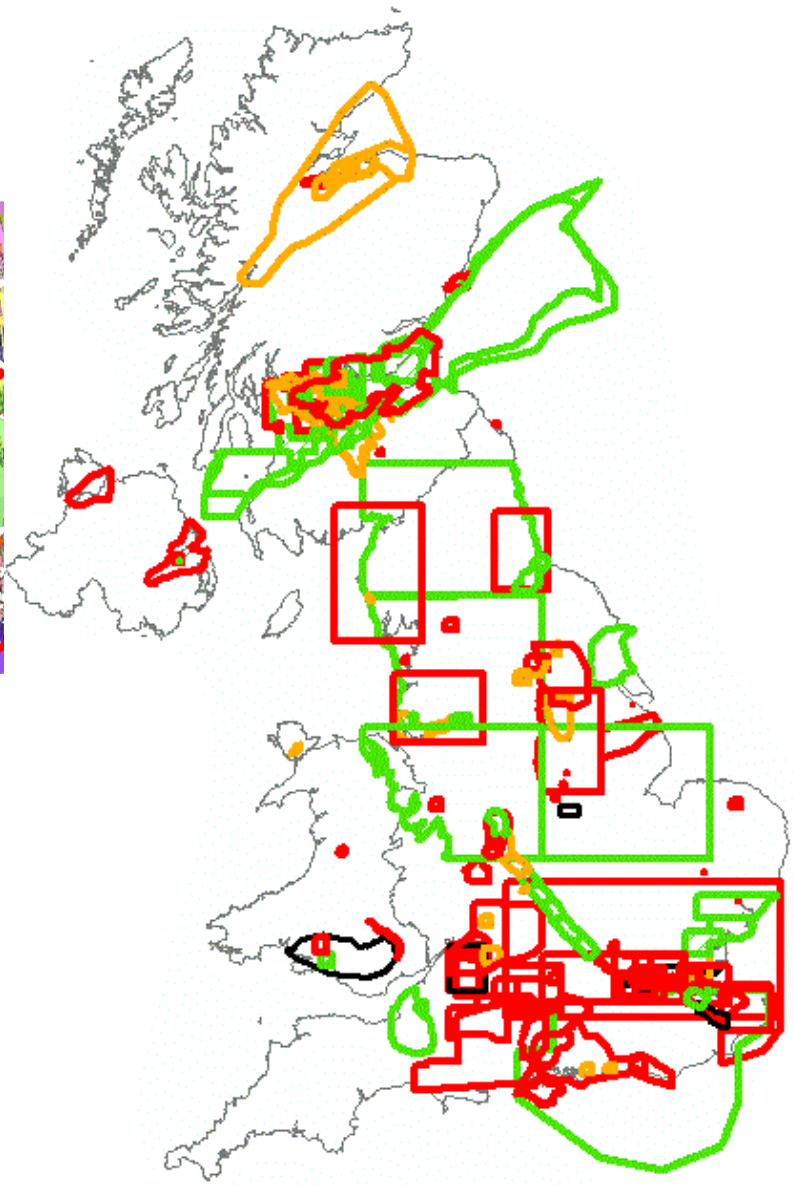


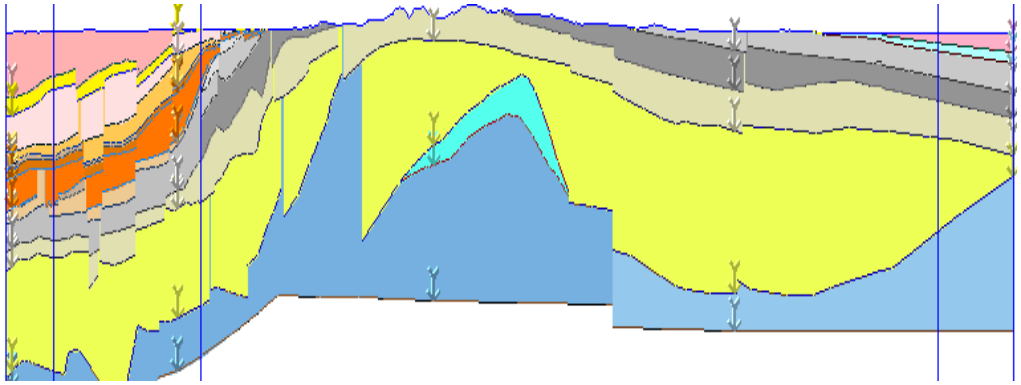


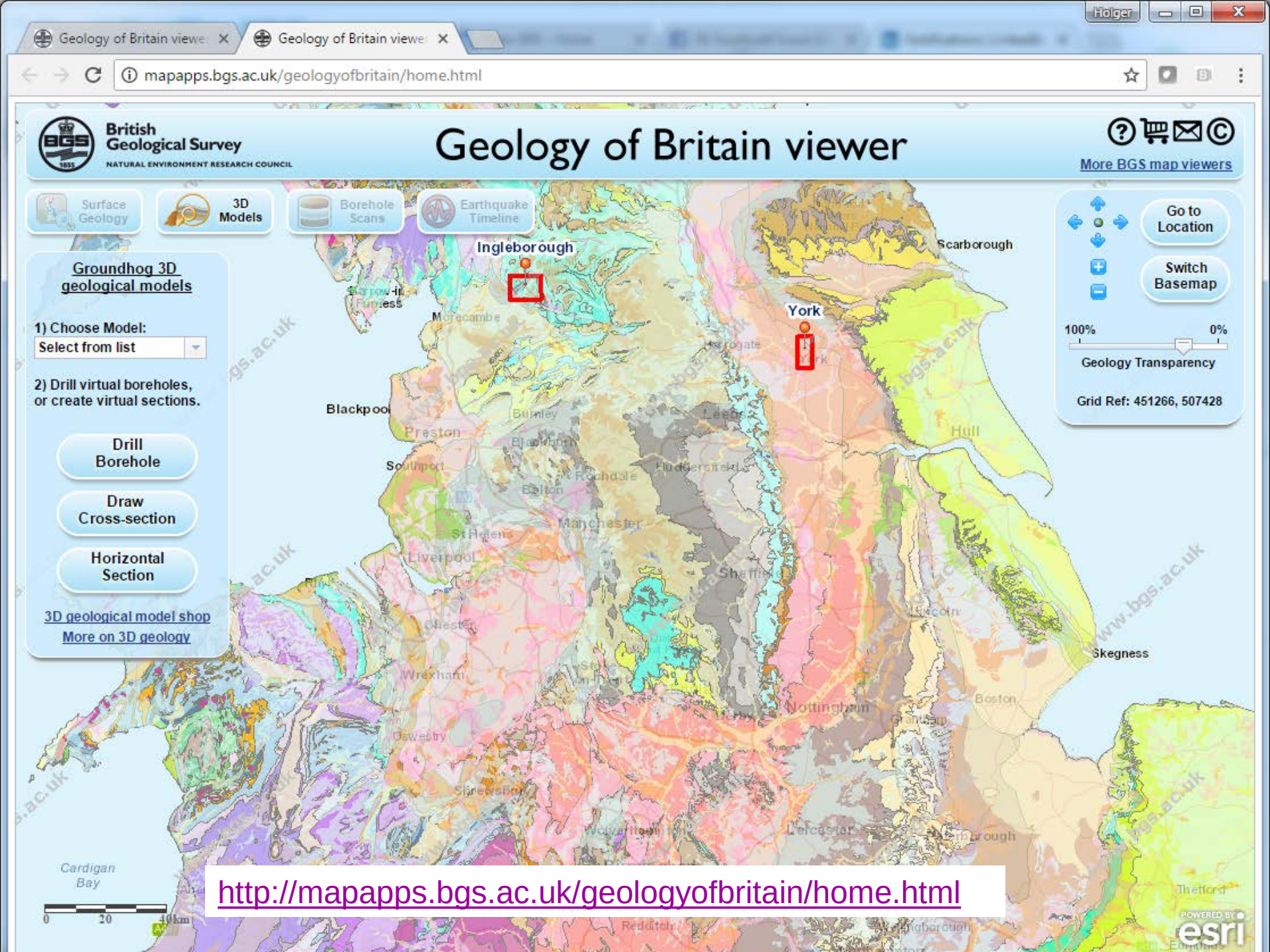
UK3D - National Bedrock Model

- An impartial reference-frame for the UK subsurface
- Successor to 1:625,000 scale map
- Synthesises a wealth of data and interpretation
- Captures geologists' knowledge in a consistent framework
- Peer-reviewed, open dataset








Geology of Britain viewe
Geology of Britain viewe
Holger
mapapps.bgs.ac.uk/geologyofbritain/home.html
British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL
Geology of Britain viewer
More BGS map viewers
Surface Geology
3D Models
Borehole Scans
Earthquake Timeline
Ingleborough
Scarborough
York
Go to Location
Switch Basemap
100%
0%
Geology Transparency
Grid Ref: 451266, 507428
Groundhog 3D geological models
1) Choose Model:
Select from list
2) Drill virtual boreholes, or create virtual sections.
Drill Borehole
Draw Cross-section
Horizontal Section
3D geological model shop
More on 3D geology
Blackpool
Preston
Southport
Morecambe
Burnley
Leeds
Hull
Manchester
Liverpool
Chester
Wrexham
Nottingham
Boston
Skegness
Lincoln
Cardigan Bay
0
20
40km
http://mapapps.bgs.ac.uk/geologyofbritain/home.html
esri

Point and section prognosis

Home | Browser | Basket | Info | Help | T&Cs | Privacy | Contacts

3D Geological Models from the British Geological Survey

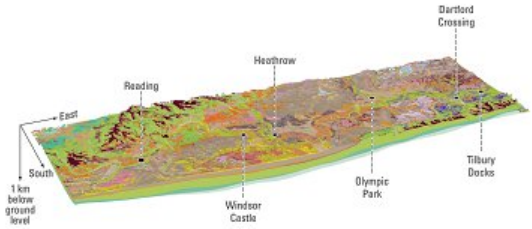
The British Geological Survey's National Geological Model is a 3D representation of the UK subsurface. This model shows not only the geological units at the surface (akin to a map), but also their variation with depth.

Models can be used to identify the thickness and order of geological units as well as provide information about how the elevations of geological surfaces vary spatially.

Currently, there are two types of model available:

- **Deep, regional-scale models**
  typically used for natural resource estimates and groundwater studies
- **Shallow, local-scale models**
  typically used for ground investigations, groundwater studies and tunnelling projects

Model coverage will increase over time as we load more models, so please visit us regularly.



Use the Model Browser to view our 3D geological model coverage and explore what outputs are available.

Explore models and shop

3D Geological Model Outputs

Synthetic Borehole Reports — **£10.00** *(+VAT)*
Place a point on a map and obtain a prediction of the depths of the modelled units at that location. Download an Example Synthetic Borehole Report (PDF 903KB)

Cross Section Reports — **£30.00** *(+VAT)*
Place two points on a map to define a line and obtain a predicted cross section of the modelled geological units. Download an Example Cross Section Report (PDF 963KB)

Horizontal Section Reports — **£30.00** *(+VAT)*
Select a rectangular area on a map and obtain a geological map at an elevation below the ground surface. Download an Example Horizontal Section Report (PDF 896KB)

3D Geological Model Data
Geological unit surfaces, thicknesses and 3D grids can be exported from the models and licensed in GIS/text formats. Some models can be delivered in interactive 3D viewers. Please contact us to discuss your requirements.

Commercial service via the BGS shop

https://shop.bgs.ac.uk/groundhog

Geological models

A geological model is a virtual representation of the geology in three dimensions. Geological models can provide information on geological unit surface elevations or thicknesses and can be queried to generate synthetic boreholes and vertical and horizontal cross-sections.

Geological models are created by geologists using geological data and expert knowledge. Data such as borehole records, geophysics, field observations and digital terrain models are interpreted and the conceptual geological understanding is captured via geological cross sections, geological maps and/or point interpretations that describe a surface. The 3D geological model is created by interpolation between all interpreted points.

The accuracy of the geological model is dependent on, for example, the data density, the prevailing understanding of the geology at the time of modelling and the geological complexity. The geological map herein indicates the sites of borehole records considered by the geologist and also the locations of interpreted cross sections; the density of these around the area of interest provides an indication of uncertainty.

Limitations

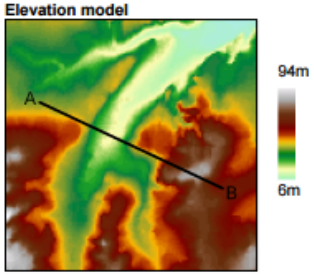
The quality of observations and interpretations may be affected by the availability of new data, by subsequent advances in knowledge, improved methods of interpretation, improved databases and modelling software, and better access to sampling locations. The top surface of the geological model is constrained by the digital terrain model; this may contain artefacts and may have been sub-sampled at a lower resolution and thus minor mismatches between geomorphological features and modelled units may occur.

The information herein should not be used as a replacement for site investigation. For further information on the limitations of modelling in this area, see the relevant metadata report available from enquiries@bgs.ac.uk and view the current terms and conditions at http://shop.bgs.ac.uk/Groundhog. For comprehensive information of the geology at this point, please use our BGS GeoReports Service at http://shop.bgs.ac.uk/GeoReports/.

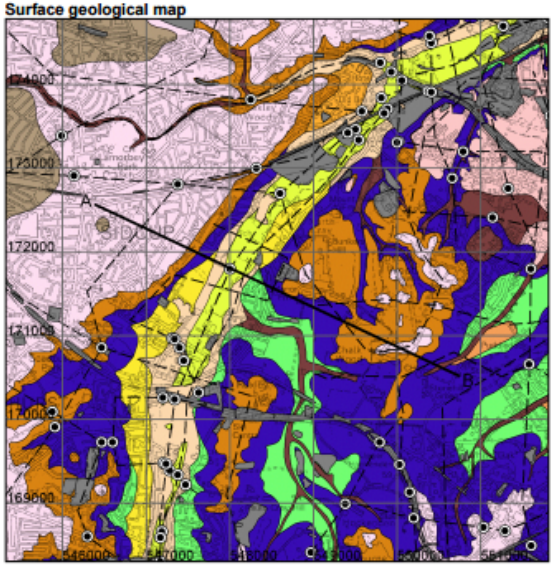
Feedback

To improve geological models your feedback is essential. Please contact enquiries@bgs.ac.uk if your site investigations yield data that could improve our interpretations.

Elevation model



Surface geological map

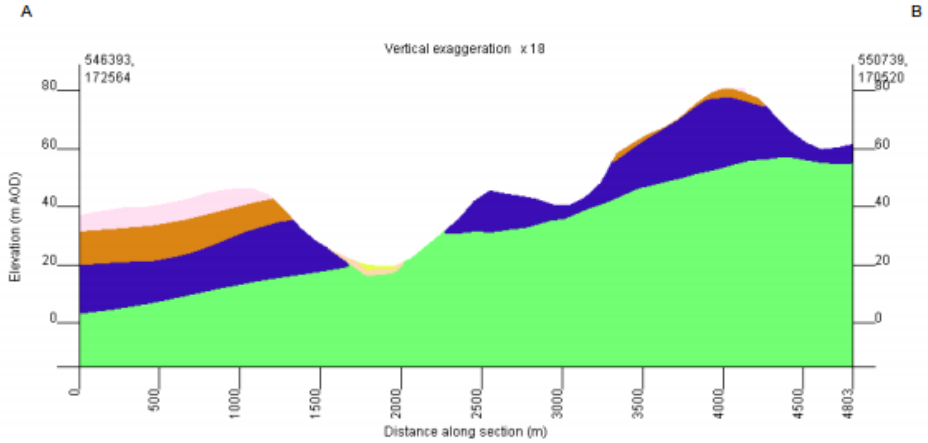


Legend

- Worked Ground (Void)
- Made Ground (Variable composition)
- Infilled Ground (Variable composition)
- Landscaped Ground (Variable composition)
- Alluvium (Clay, Silty, Sandy, Gravelly)
- River Terrace Deposits (Gravel, Sandy)
- Head (Clay, Silty, Sandy, Gravelly)
- Crayford Silt Formation (Silt, Sandy)
- Taplow Gravel Formation (Gravel, Sandy)
- Lynch Hill Gravel Formation (Gravel, Sandy)
- Boyn Hill Gravel Formation (Gravel, Sandy)
- London Clay (Clay, Silty, Sandy)
- Harwich Formation (Sand, Gravelly)
- Lambeth Group (Clay, Silty, Sandy, Gravelly)
- Thanet Sand Formation (Sand)
- Chalk Formation, undifferentiated (Chalk)
- Gault and Upper Greensand Formations (Mudstone, Sandstone and Limestone)
- Lower Greensand Formation (Sandstone and Mudstone)
- Wealden and Jurassic strata, undifferentiated (Mudstone, sandstone and limestone)

Borehole record
Interpreted cross section
Synthetic cross section

Geological cross section



British Geological Survey
NERC SCIENCE OF THE ENVIRONMENT

Sidcup to Hextable

Report ID: GH_100074/134

Model: London and Thames Valley geological model

Regional geological model originally created by H Burke, S Mathers, J Ford, R Terrington, S Thorpe, P Williamson. Model released: 2014.

The information on this map sheet, including the surface geological map and the synthetic cross section, is derived from the National Geological Model. Geological models provide an indication of reality; alternative interpretations of the same data are possible. The surface geological map is based on the published geological map, with revisions based on new interpretations and may therefore differ from published geological maps and products. Truncation of the lowest unit in the cross section does not necessarily denote its basal depth. Heights are in metres.

Deposits of artificial ground, head and clay with flints typically form thin veneers and whilst they are present on the surface map, they may be absent in the synthetic borehole or section.

Boreholes shown on the map were considered during the construction of the geological model. The original borehole records can be viewed at http://shop.bgs.ac.uk/Groundhog.

East Anglia - Geological 3D Model

Geological 3D model prepared by S J Mathers, S Thorpe and R L Terrington
Interactive 3D PDF by C Ritchie

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Produced by the British Geological Survey www.bgs.ac.uk

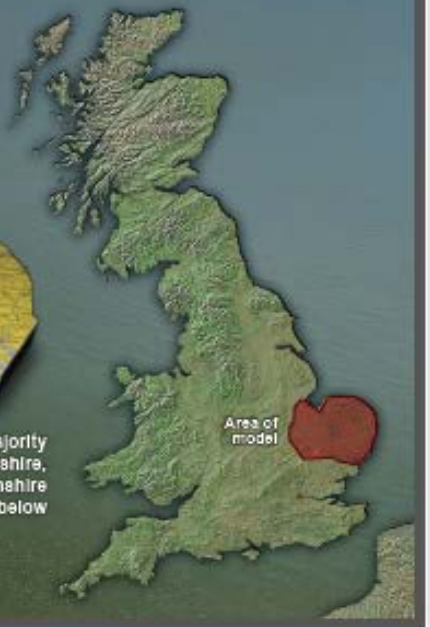
Orfordness, Suffolk from the southwest
Photograph © Mike Page 2016

This model provides a unique visualisation of the 3D geology of the East Anglia region. It is provided to accompany the new regional guide to the geology of this area produced by BGS. The model shows the subsurface arrangement of the sedimentary rocks and associated igneous intrusions to a depth of 1.5 kilometres.

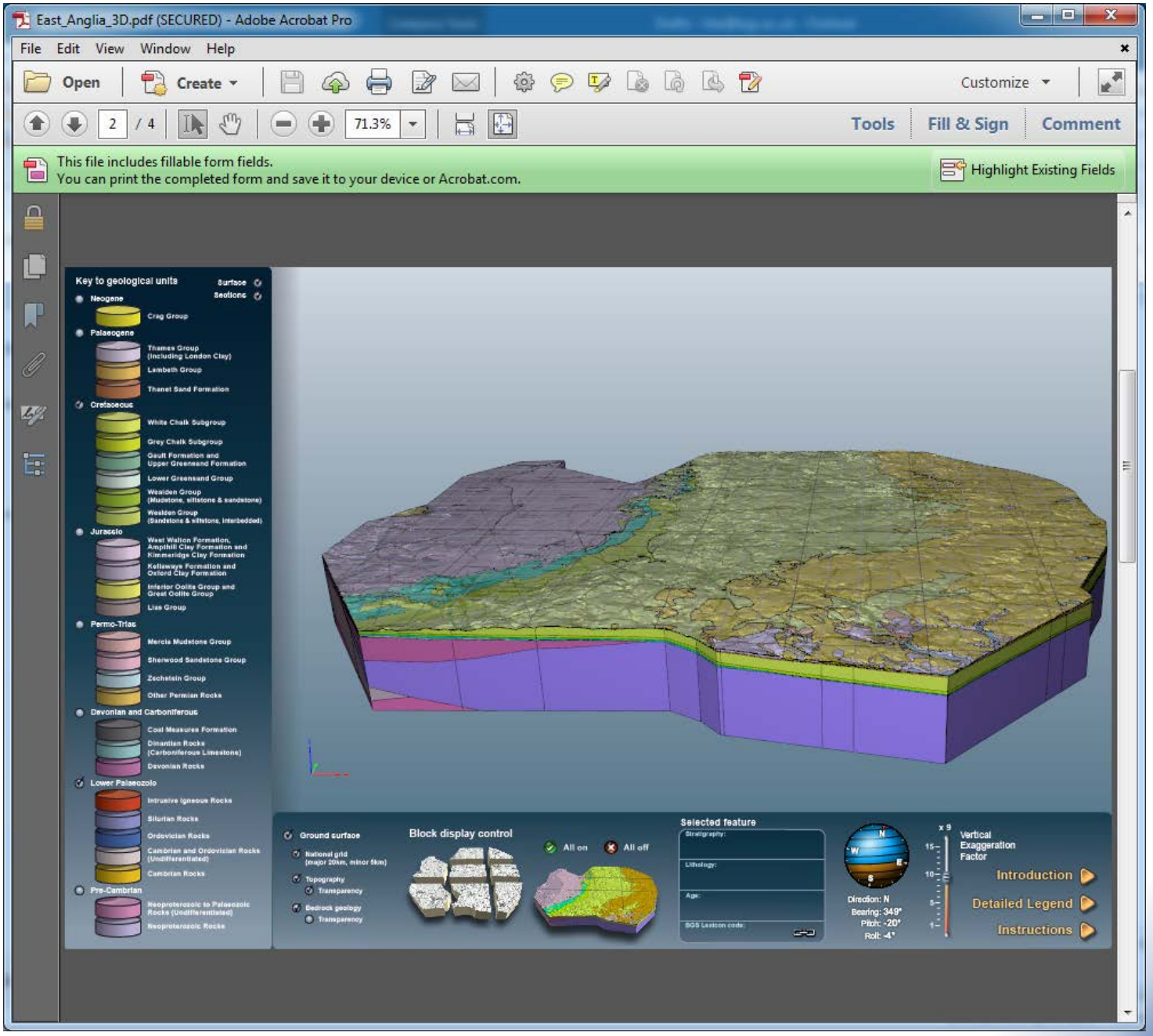
This document is divided into four pages: this introductory page; the 3D geological model with display and interrogation tools, an expanded geological legend for the model and instructions on how to navigate and use the tools with the model. You can navigate quickly between pages using the page links to the right.

Geological Model
Detailed Legend
Instructions

This publication forms part of an ongoing program to improve delivery methods for BGS geological information – we welcome your feedback. Please feel free to send us your comments at the following email address: *lmap@bgs.ac.uk*

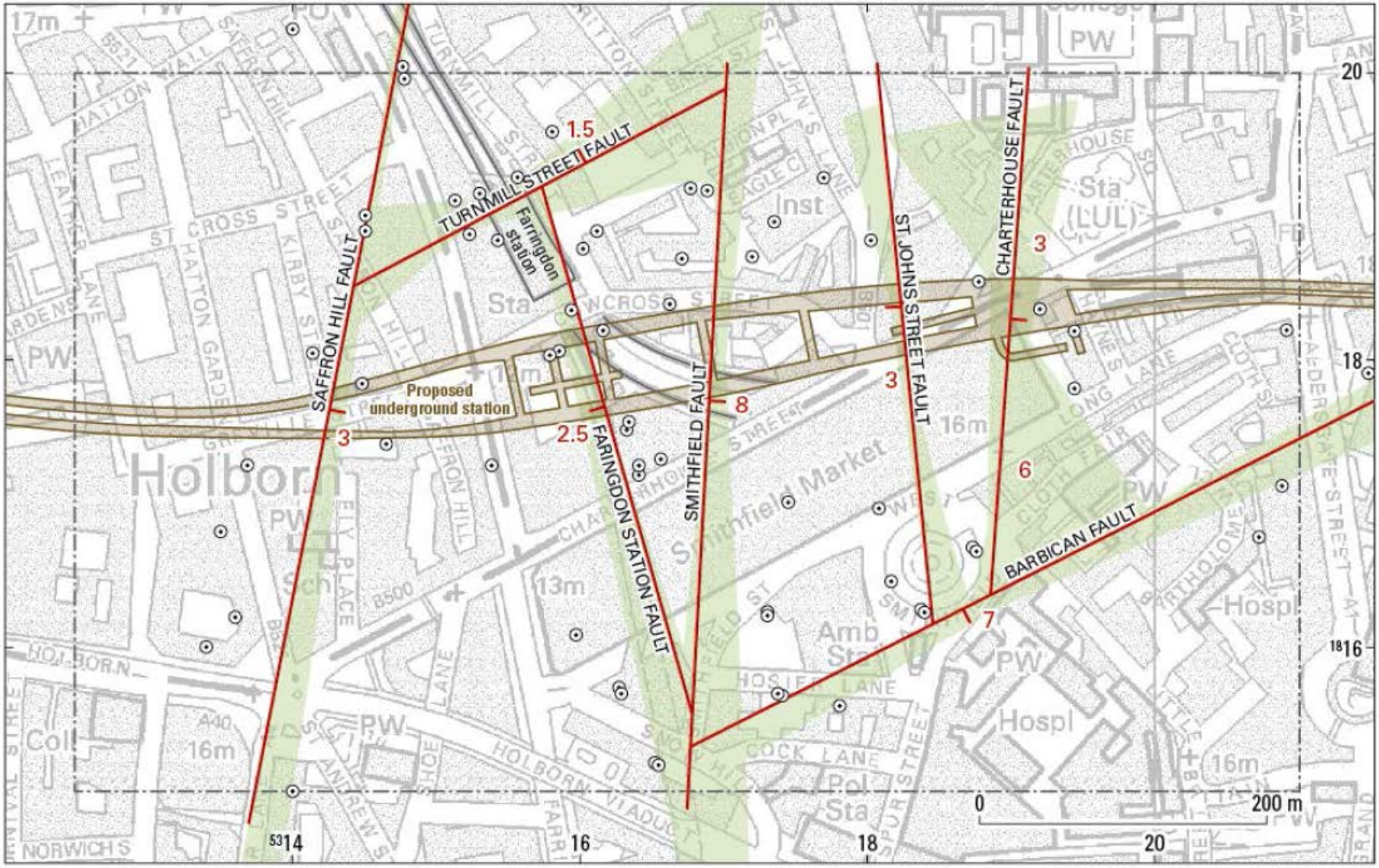


The 3 dimensional model covers the majority of the counties of Norfolk, Cambridgeshire, Suffolk and the south east of Lincolnshire extending to a depth of 1.5 kilometres below sea level.

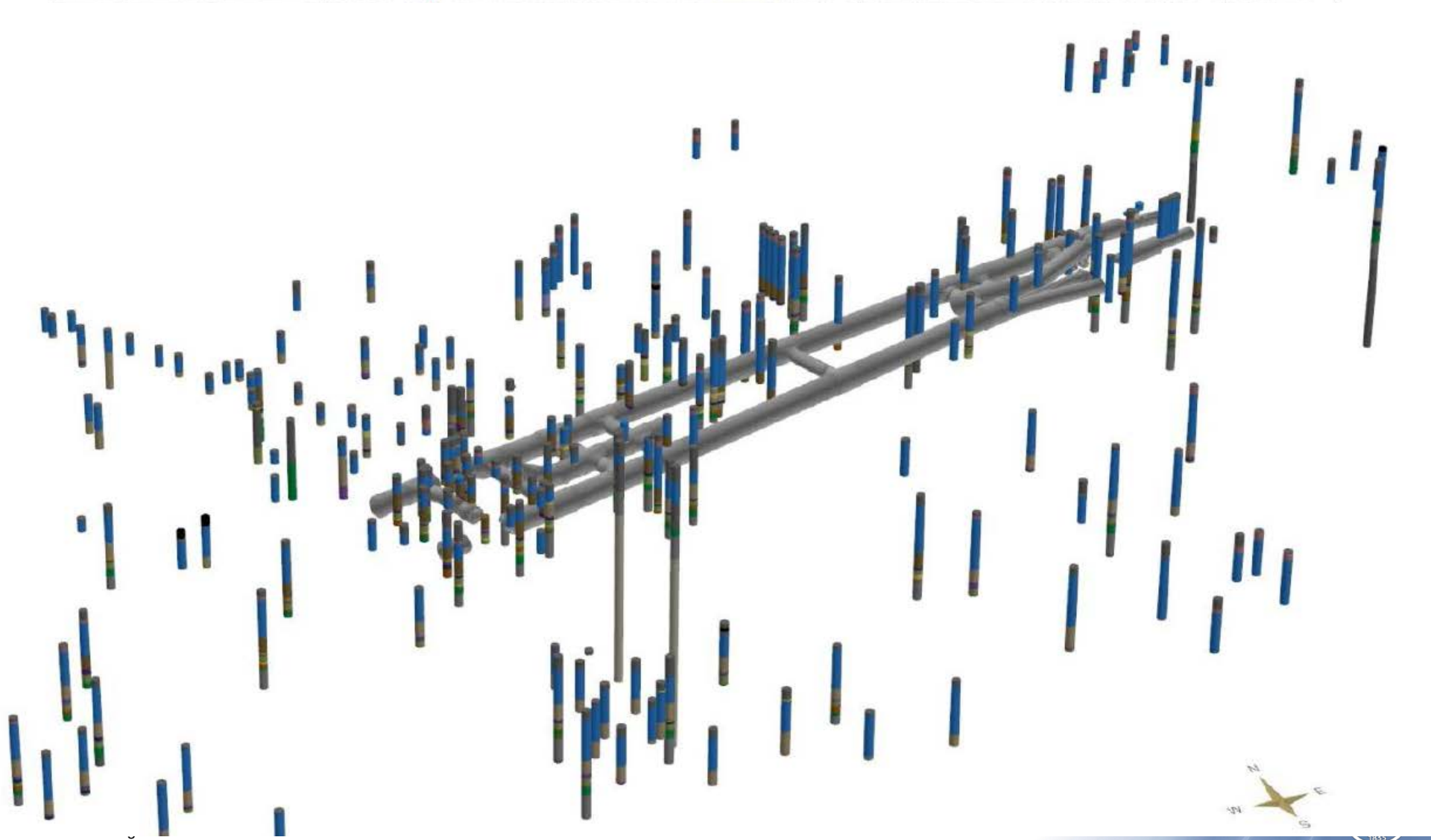


http://www.bgs.ac.uk/services/3Dgeology/lithoframeSamples.html

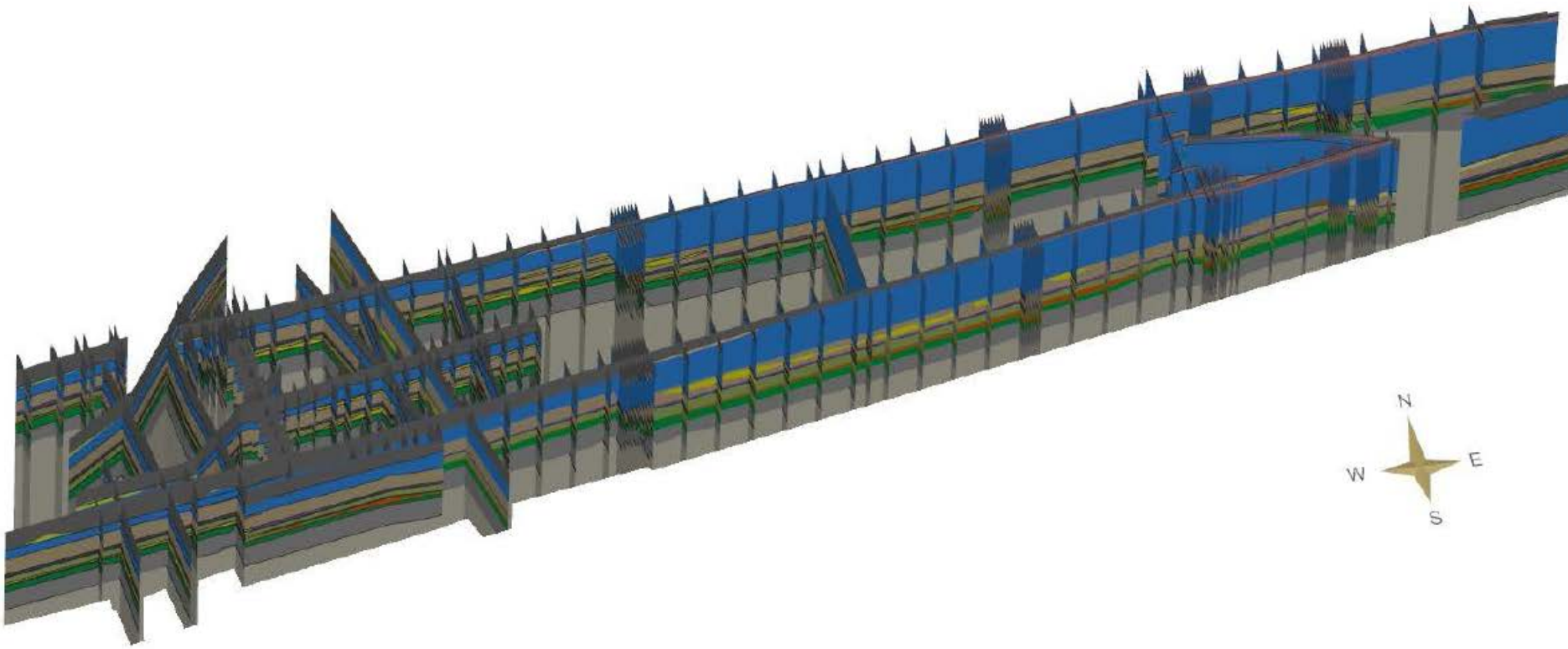
3D geological risk management approach at Farringdon Crossrail Station



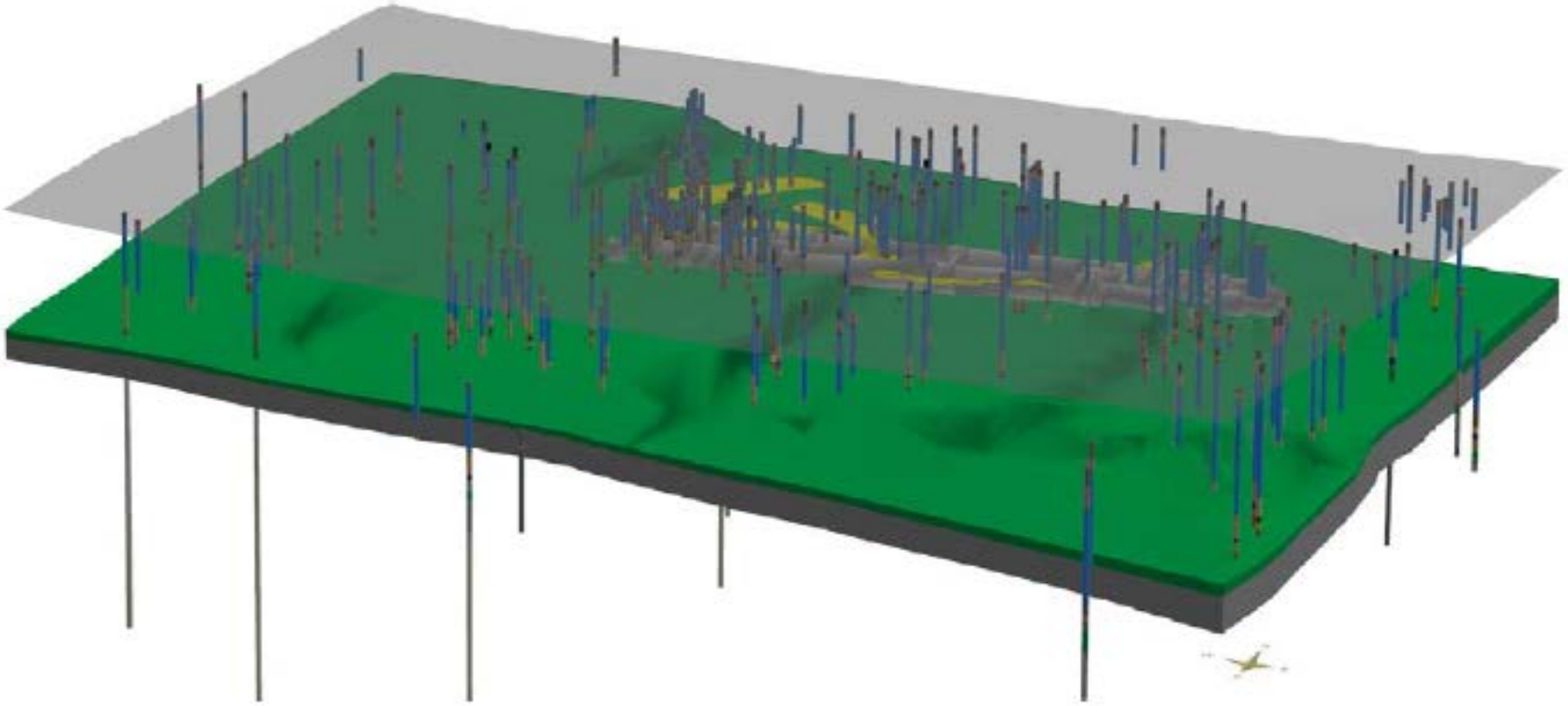
3D geological risk management approach at Farringdon Crossrail



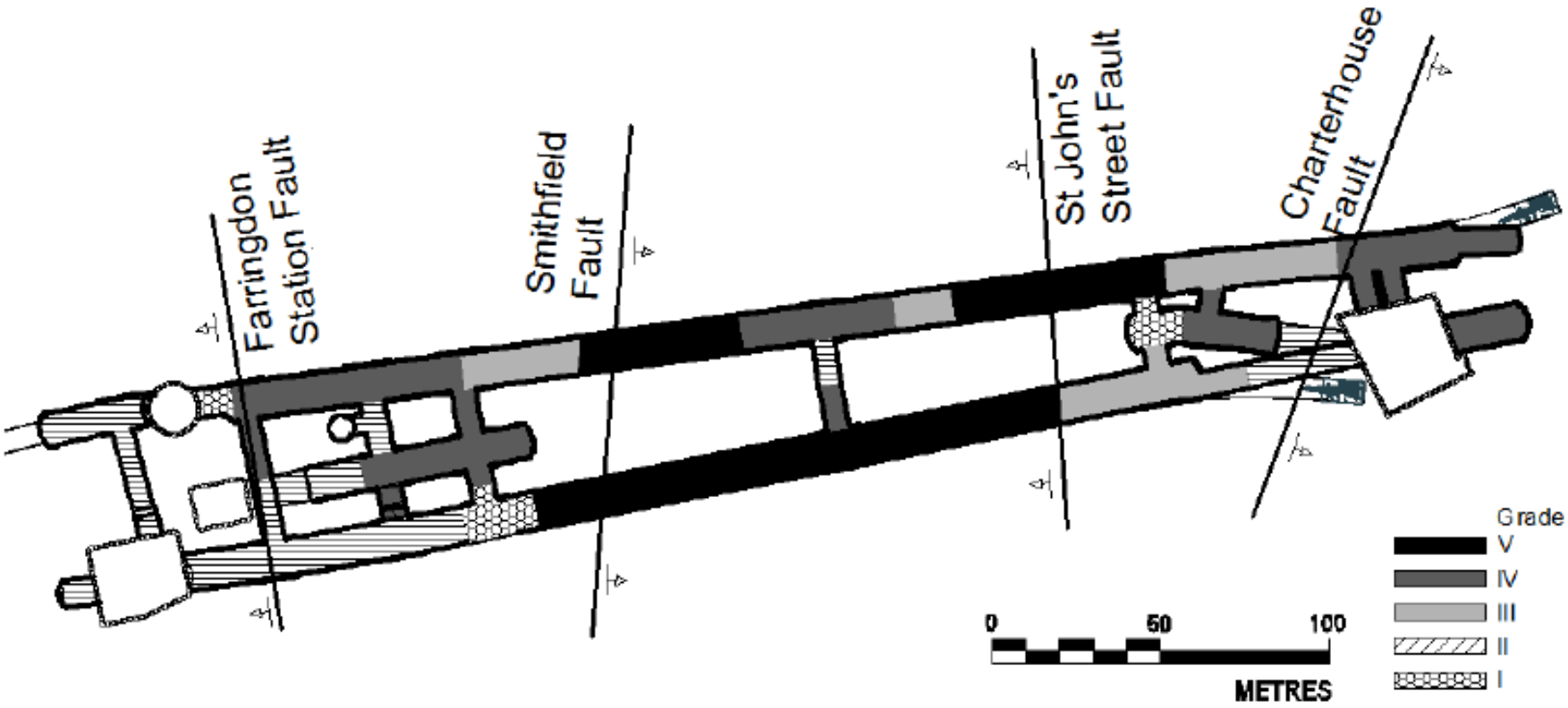
3D geological risk management approach at Farringdon Crossrail



3D geological risk management approach at Farringdon Crossrail



Geological risk mapping prior to tunnelling – based on 3D geological model

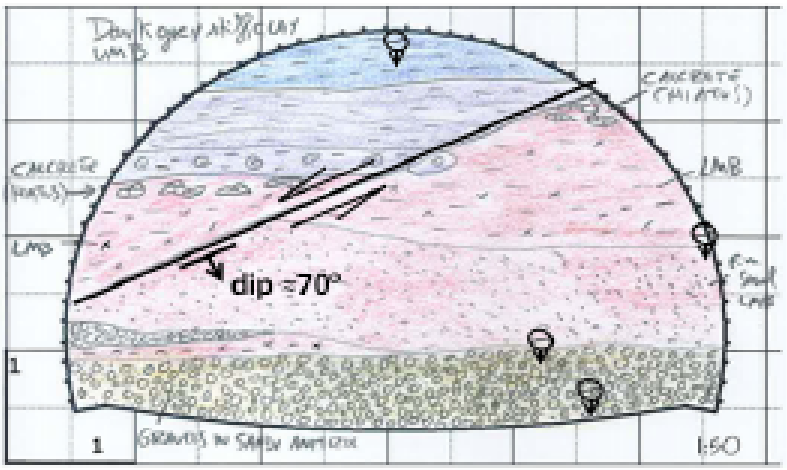


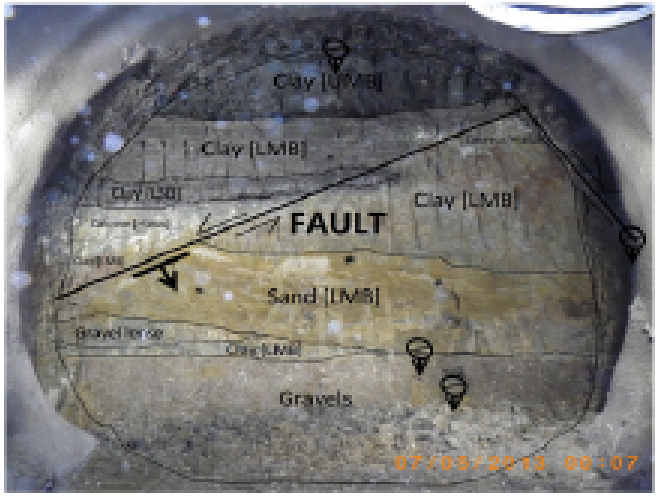
(LSB) stiff, dark grey silty CLAY with white shell fragments

(LMB) stiff to very stiff, multi-coloured, mottled, partly silty sandy CLAY

Notes:

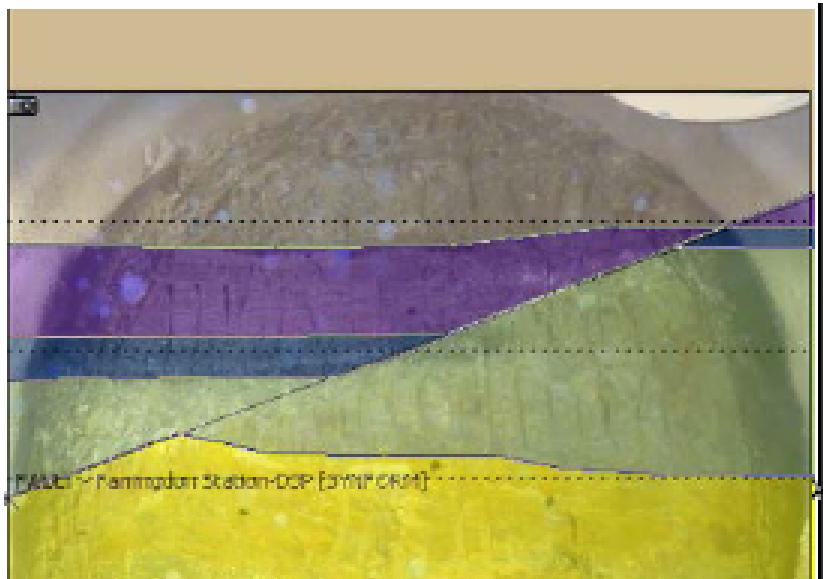
Notes: Some water dripping on right sidewall through discontinuite line

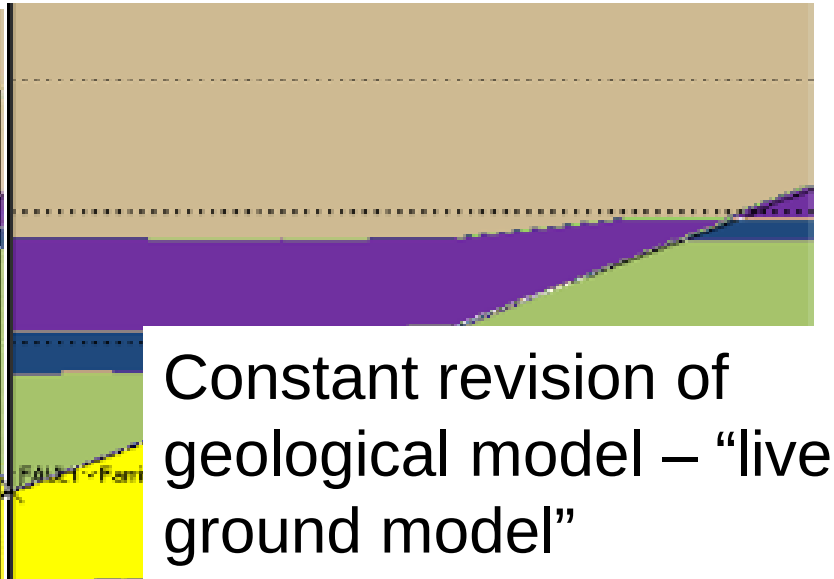




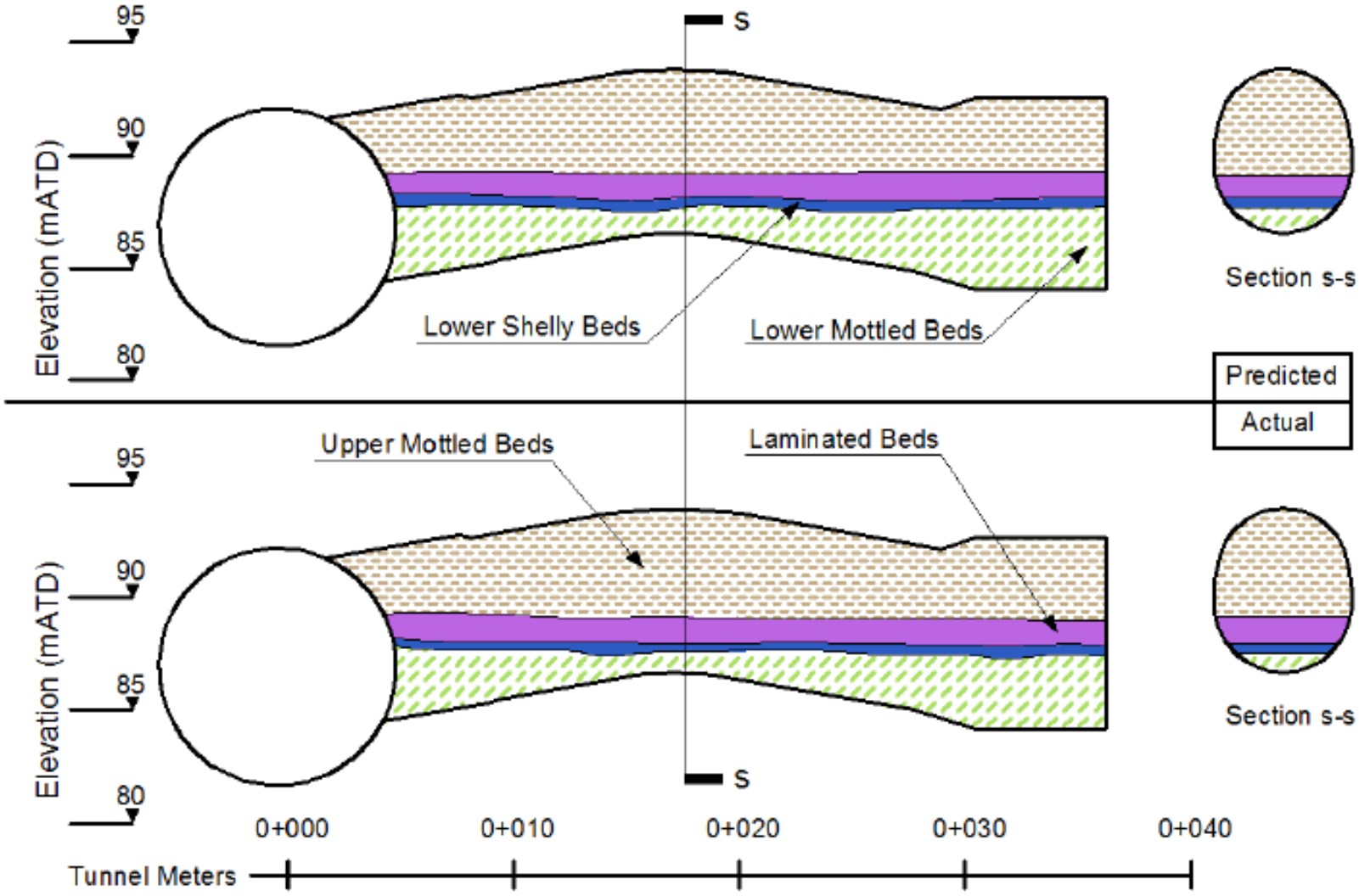
Water Inflow	Excavation Stability
Seepage was noted in the topmost probe hole, the gravels of LMB and the RHS sidewall.	Face was in general stable with minor instabilities occuring in the areas where seepage occurred.

Obstructions / Voids	Notes
No obstructions were encountered during the excavation of the current advance.	Farringdon Fault was encountered.



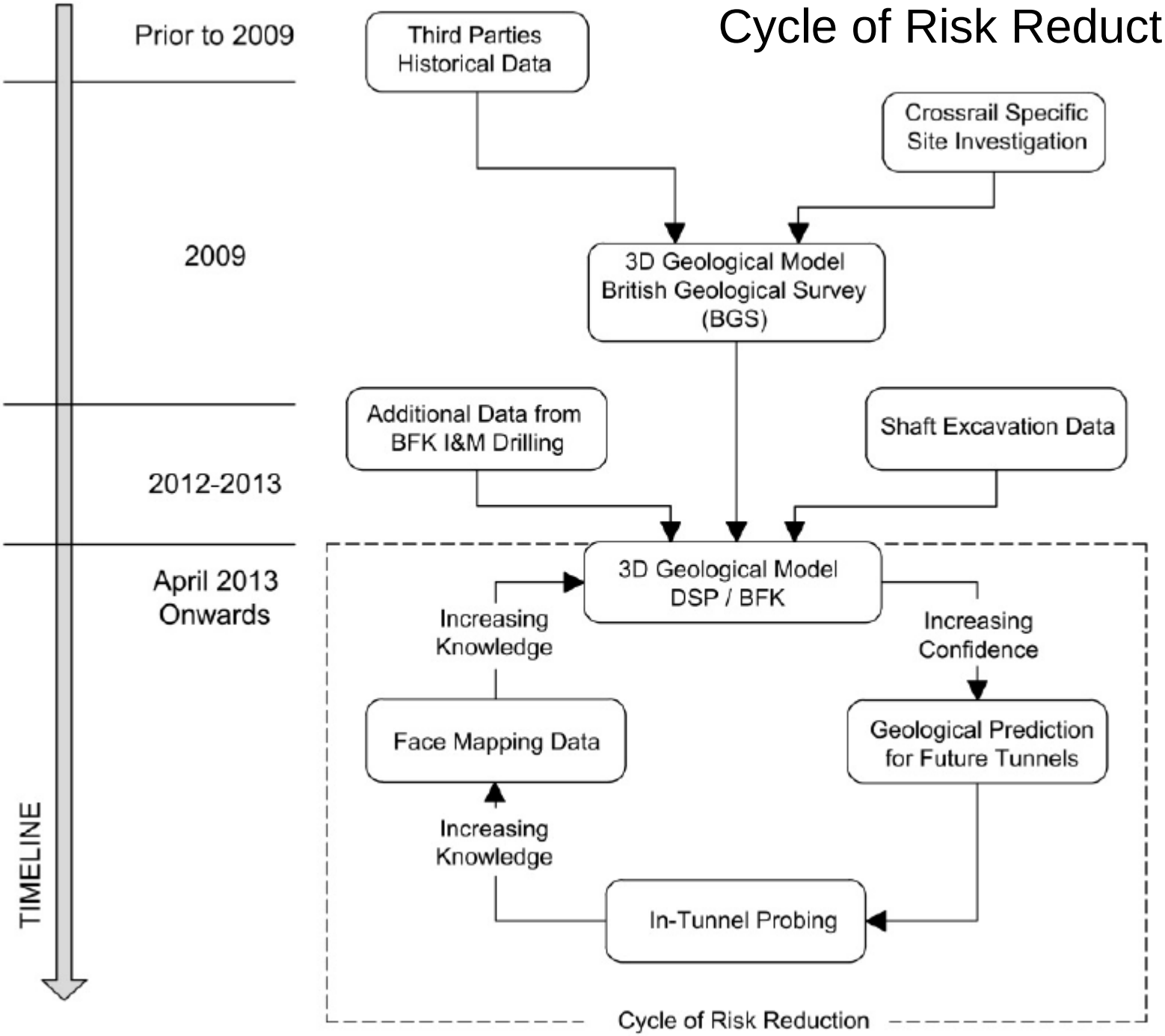


Constant revision of geological model – “live ground model”



Comparison between predicted and actual geological conditions in adit VA1

Cycle of Risk Reduction



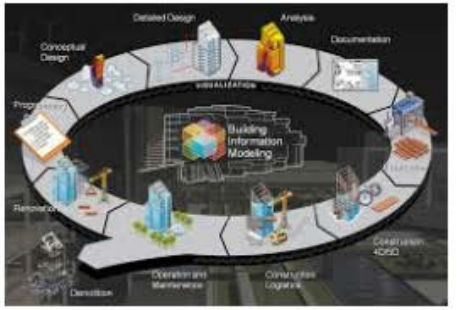
bim cycle - Google Searc

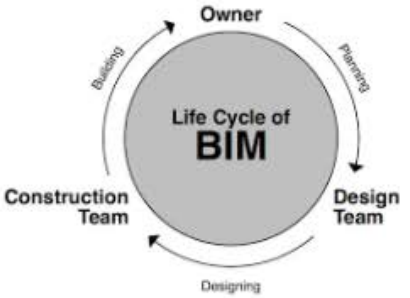
https://www.google.co.uk/search?q=bim+cycle+of+improvement&tbm=isch&imgil=wF8HXhxwh6Vd1M%253A%253BGGeL6QFIQkPRhM%

Google

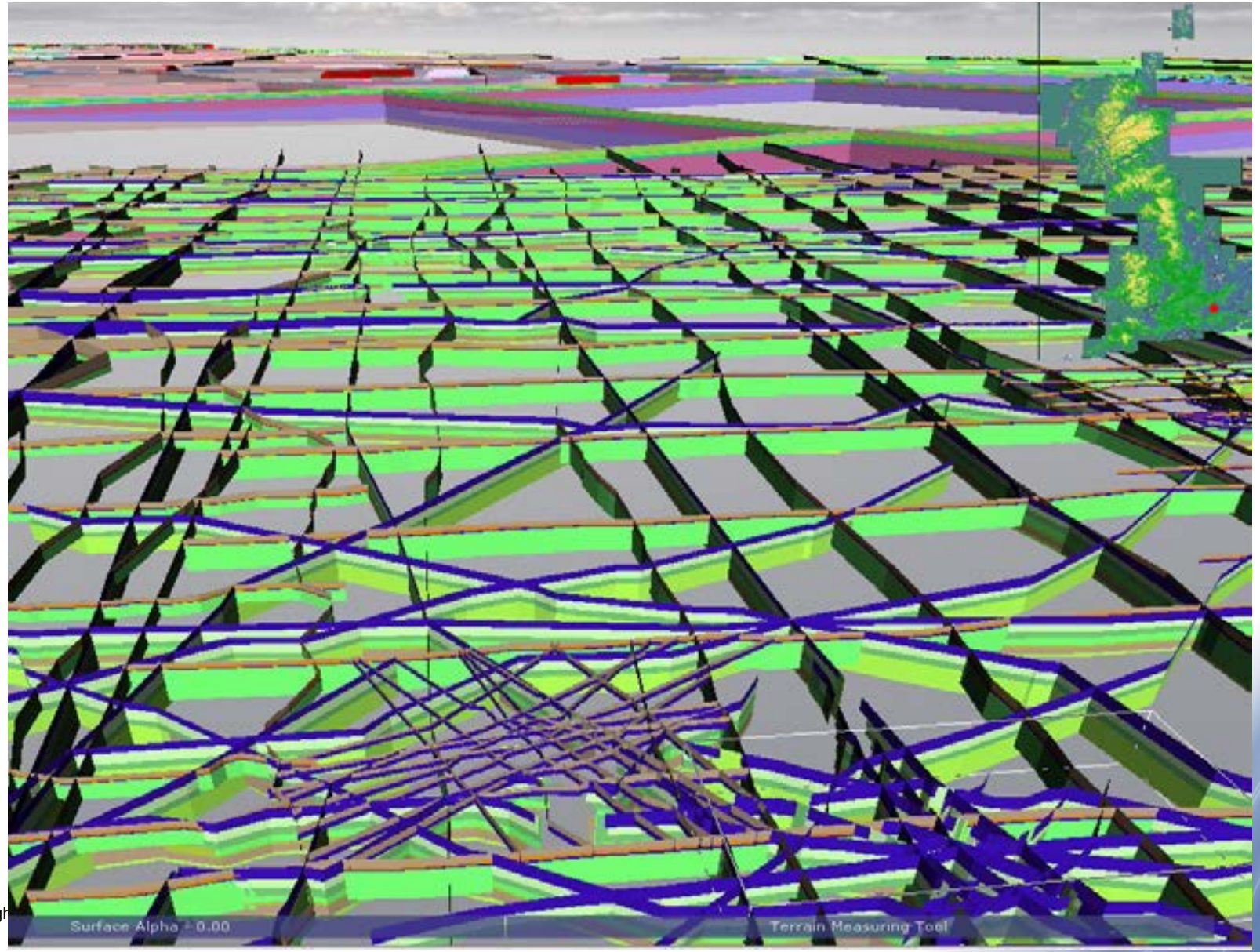
bim cycle

All | Images | News | Videos | Maps | More | Settings | Tools | View saved | SafeSearch





Farringdon model in context of the regional and national geological model



Crossrail Project: Infrastructure design and construction – Volume 3
ISBN 978-0-7277-6129-3

doi: 10.1680/cpid.61293.431

3D geological model of the completed Farringdon underground railway station

Angelos Gakis Dr. Dipl-Ing, MSc DIC, CEng MICE, Dr. Sauer & Partners Ltd, London, UK
Paula Cabrero BSc, MSc, Dr. Sauer & Partners Ltd, London, UK
David Entwisle BSc Hons, CGeol, FGS, British Geological Survey, Nottingham, UK
Holger Kessler MSc, FGS, British Geological Survey, Nottingham, UK

Abstract

The complexity and the unknowns of the geology at Farringdon, primarily associated with the Lambeth Group, required a state-of-the-art geotechnical approach in order to manage the risks related to the open face, sprayed concrete lining (SCL) tunnelling. This was aided by the 3D geological model developed by the British Geological Survey (BGS) in 2009 for the proposed Farringdon underground railway station and which was provided to the contractor's team in 2013, in order to continue the revision of the model.

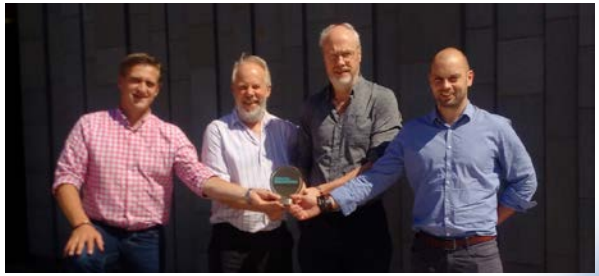
The model was initially updated with additional ground data from boreholes and shaft excavation (2009 to 2013). It then became an integral part of the site supervision workflow, being updated daily with data from the tunnel face.

This dynamic model became a 'live' geological database of increasing accuracy with time, allowing for geological predictions for the forthcoming tunnel excavations. In parallel, the understanding of the complexity of the Lambeth Group geology was significantly improved, refining the location and characteristics of the multiple faults and the thickness and continuity of the high-risk sand lenses.

This paper aims to describe how a BGS 3D geological model was developed to be used in combination with tunnelling works for the first time, the benefits from its use and the lessons learned with respect to the geology of the Lambeth Group.

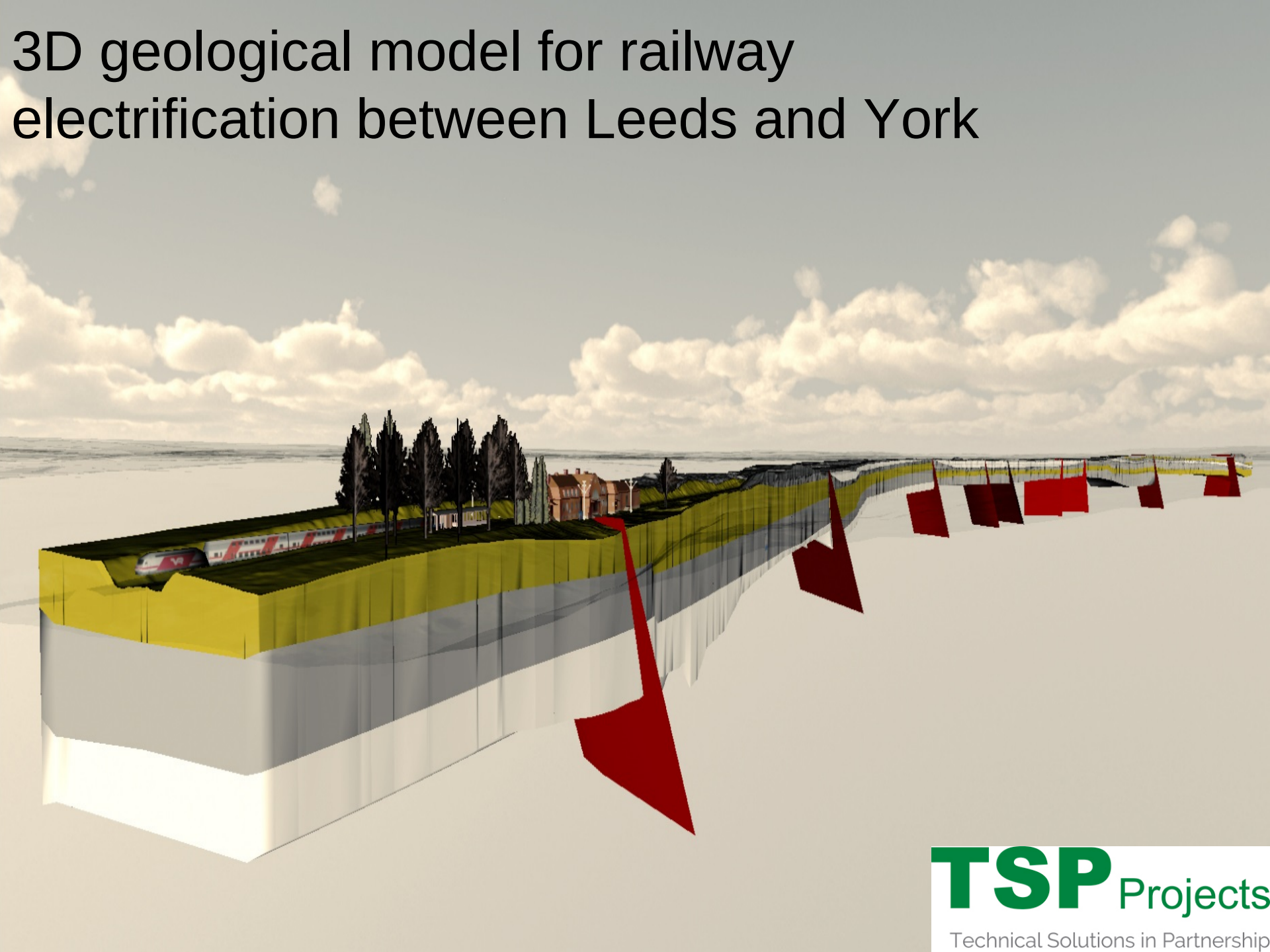
Notation

BFK BAM Ferrovial Kier Joint Venture, the main contractor
BGS British Geological Survey
CAD Computer Aided Design
DSR Dr. Sauer & Partners, BFK's specialist SCL designer



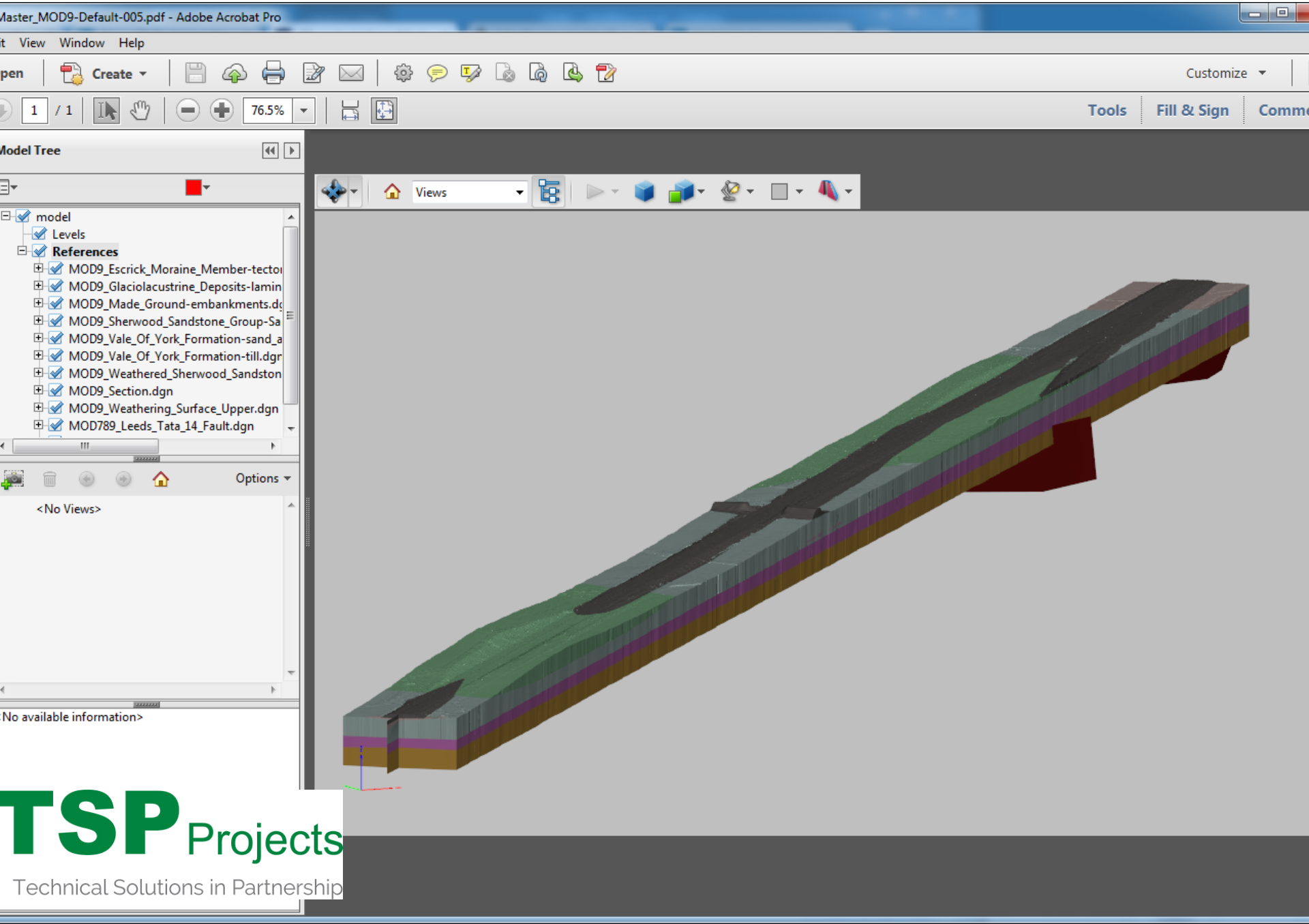
http://learninglegacy.crossrail.co.uk/documents/3d-geological-model-completed-farringdon-underground-railway-station/

3D geological model for railway electrification between Leeds and York



TSP Projects

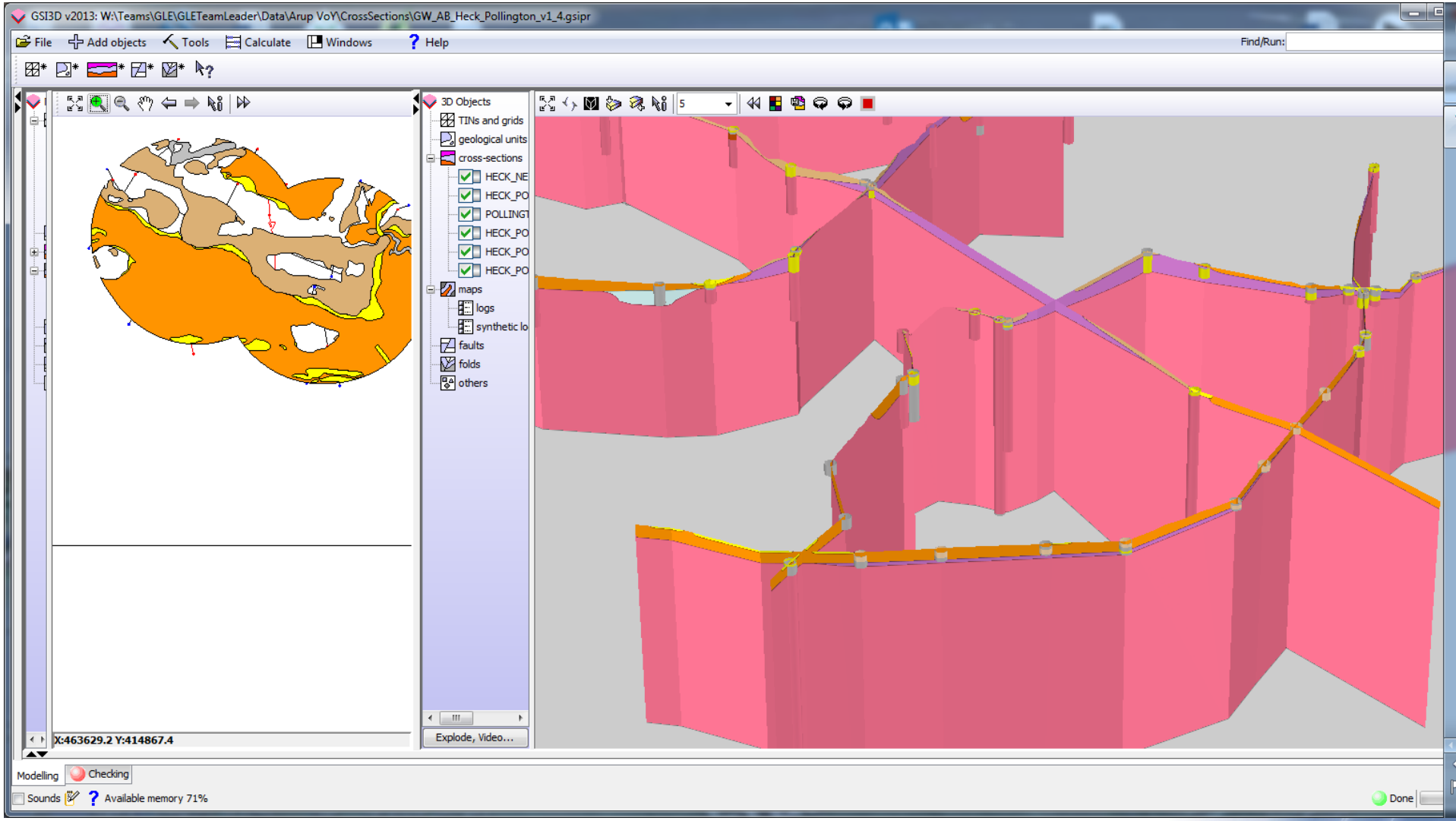
Technical Solutions in Partnership



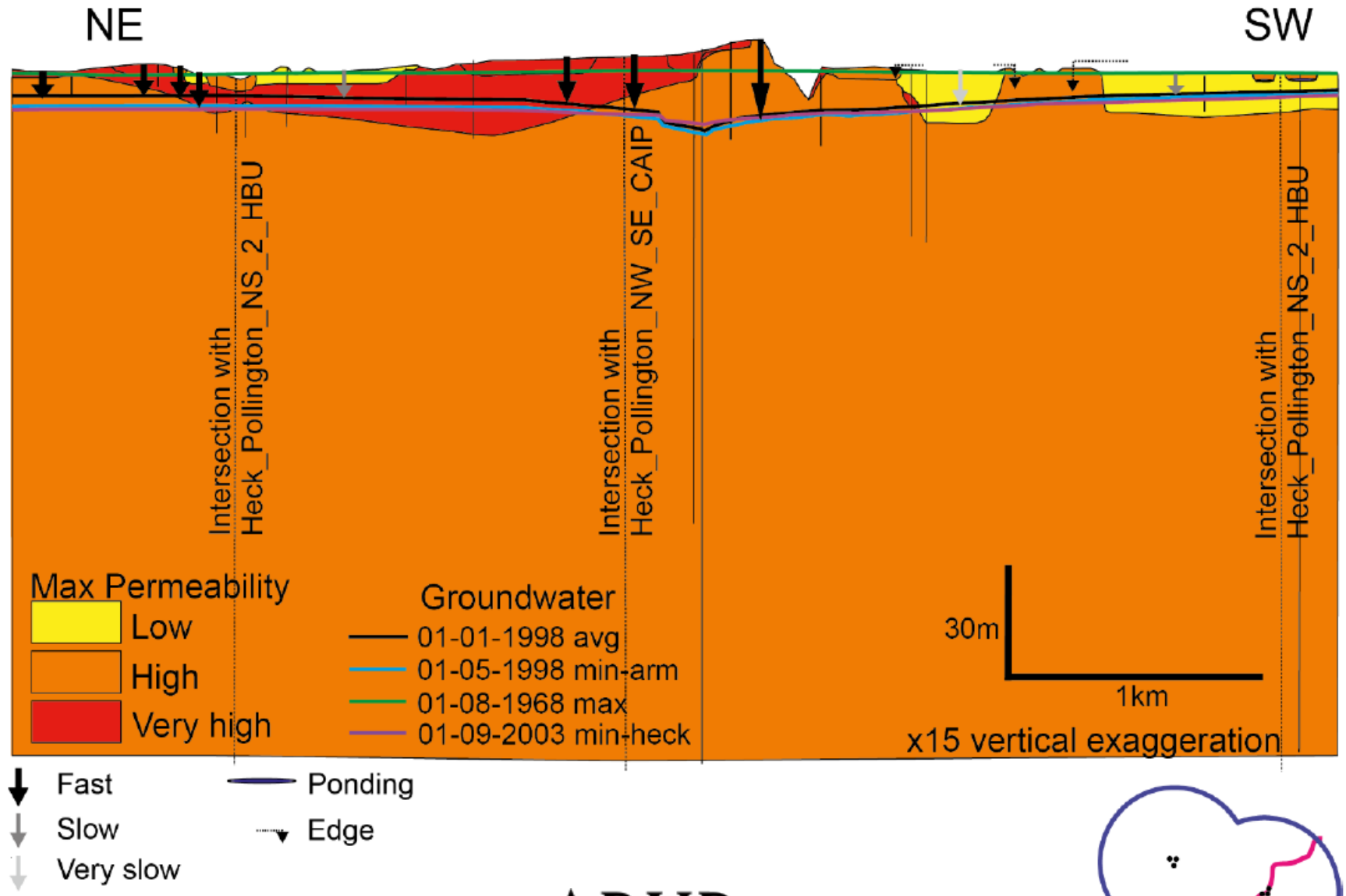
TSP Projects

Technical Solutions in Partnership

Site specific ground model to understand recharge and pathways at Yorkshire Water abstraction sites

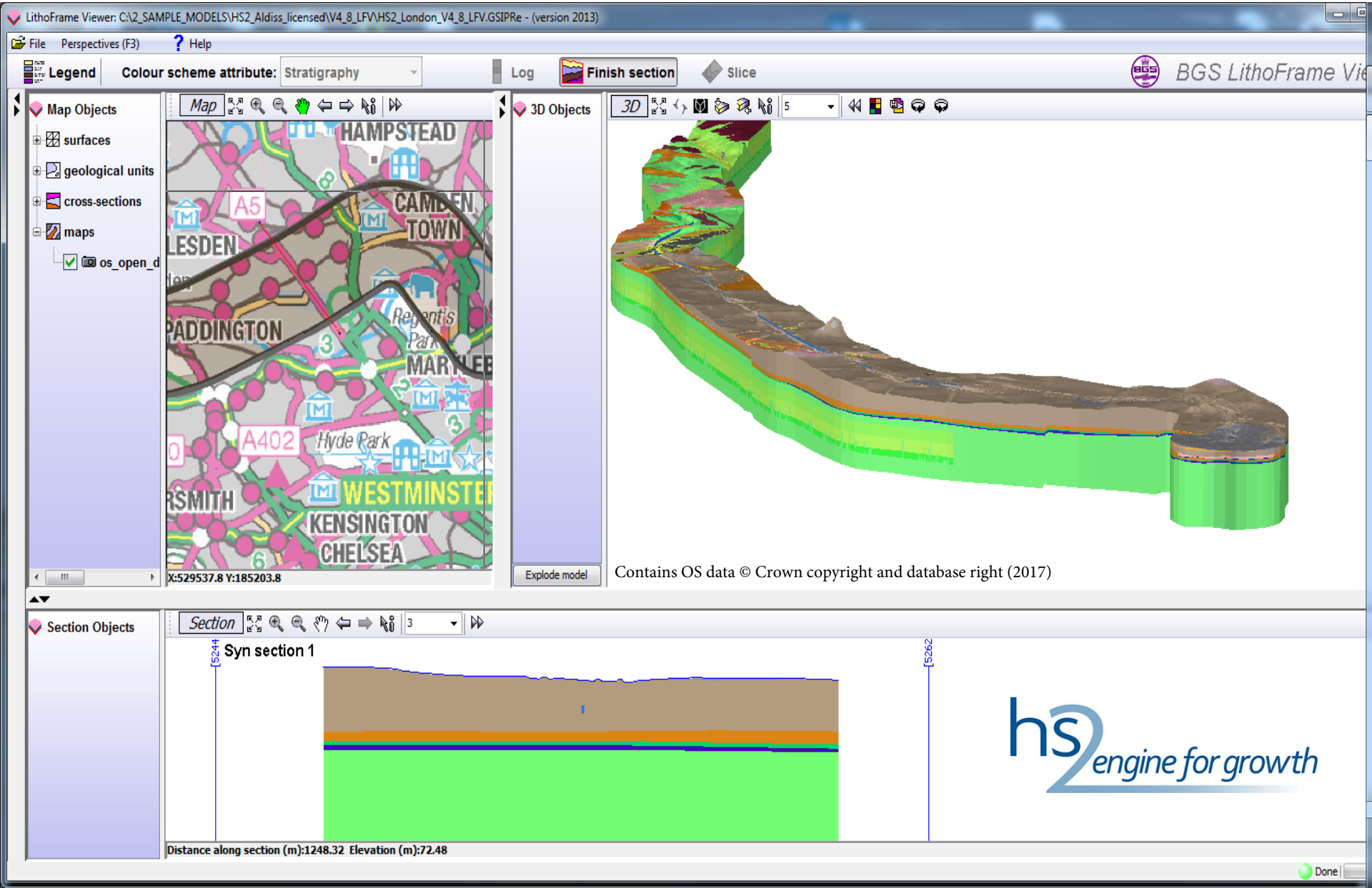


Site specific ground model to understand recharge and pathways at Yorkshire Water abstraction sites



ARUP

The BGS HS2 route 3D geological model visualised in map, section and 3D



BIM for the subsurface

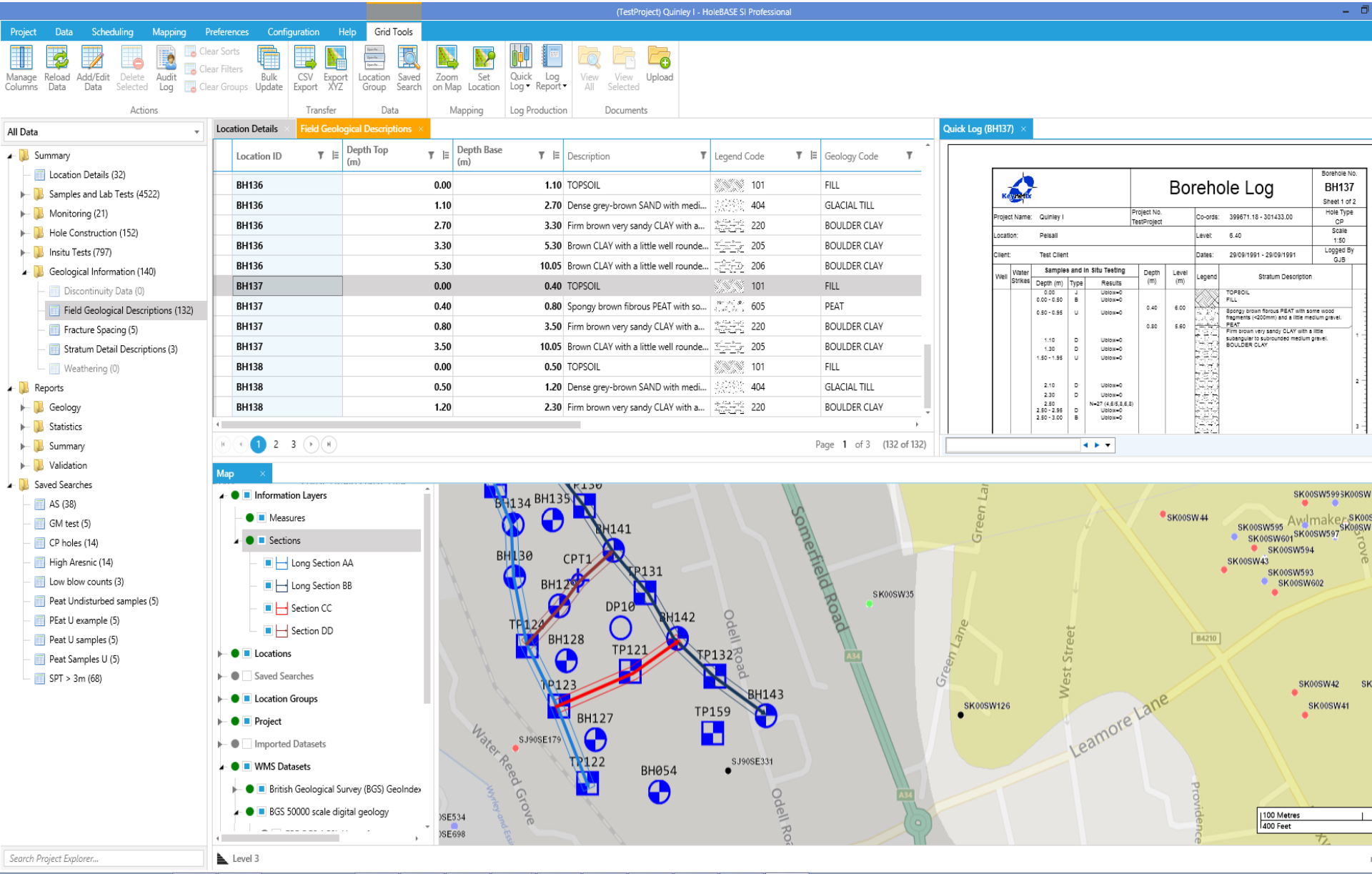
2 year project funded by InnovateUK

Innovate UK
Technology Strategy Board

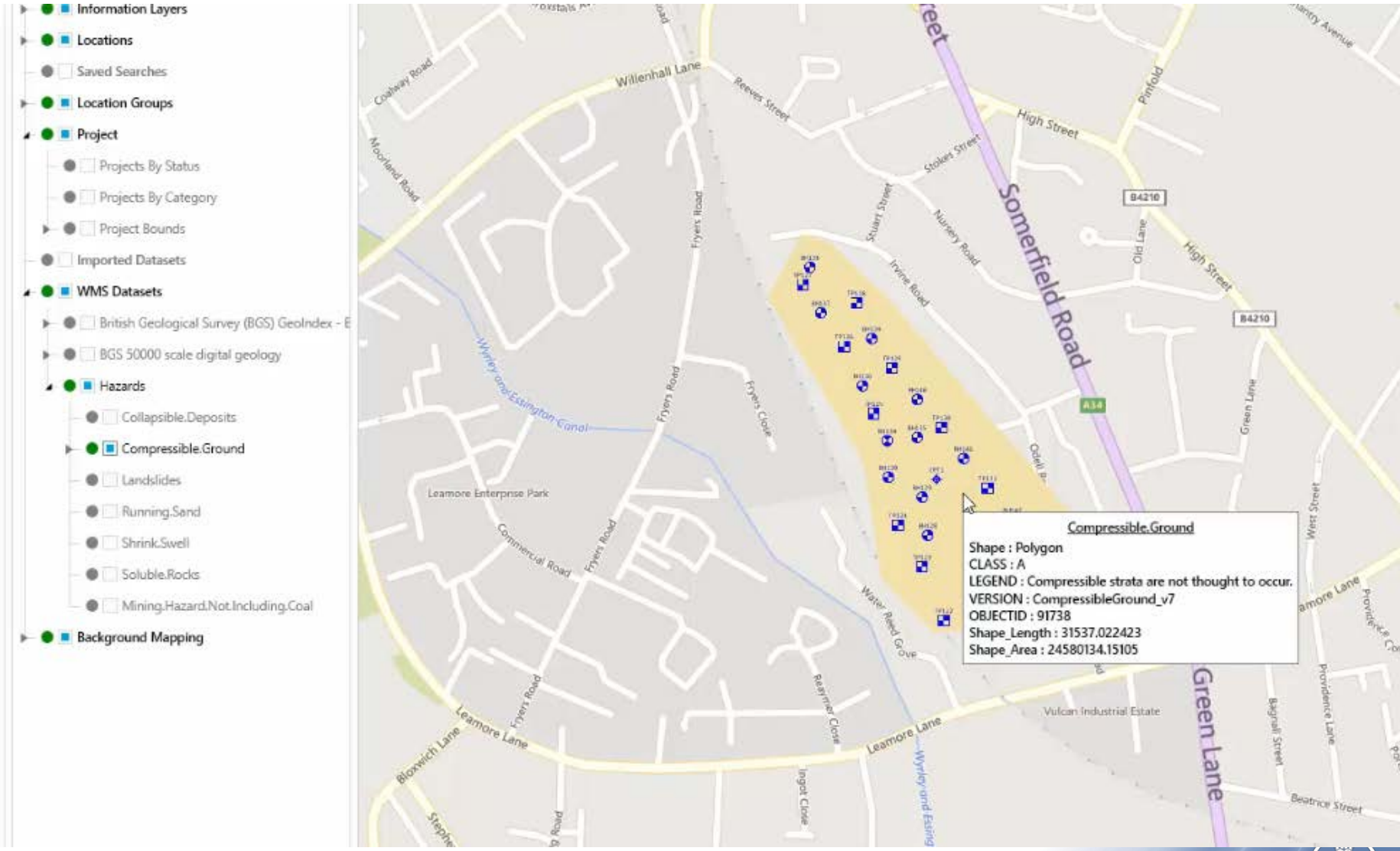
- **Unforeseen ground conditions - major causes of project delay** contributing to **~ 1/3 of construction programme over-runs.**
- Partly due to **limited availability of high quality geotechnical data & interpretation.**
- Project to **apply BIM process to ground investigation & subsurface infrastructure design**.
- **Integrate with BGS's national databases** and implement **BGS methodologies & standards for 3D geological modelling**.

Keynetix AUTODESK ATKINS British Geological Survey NATURAL ENVIRONMENT RESEARCH COUNCIL

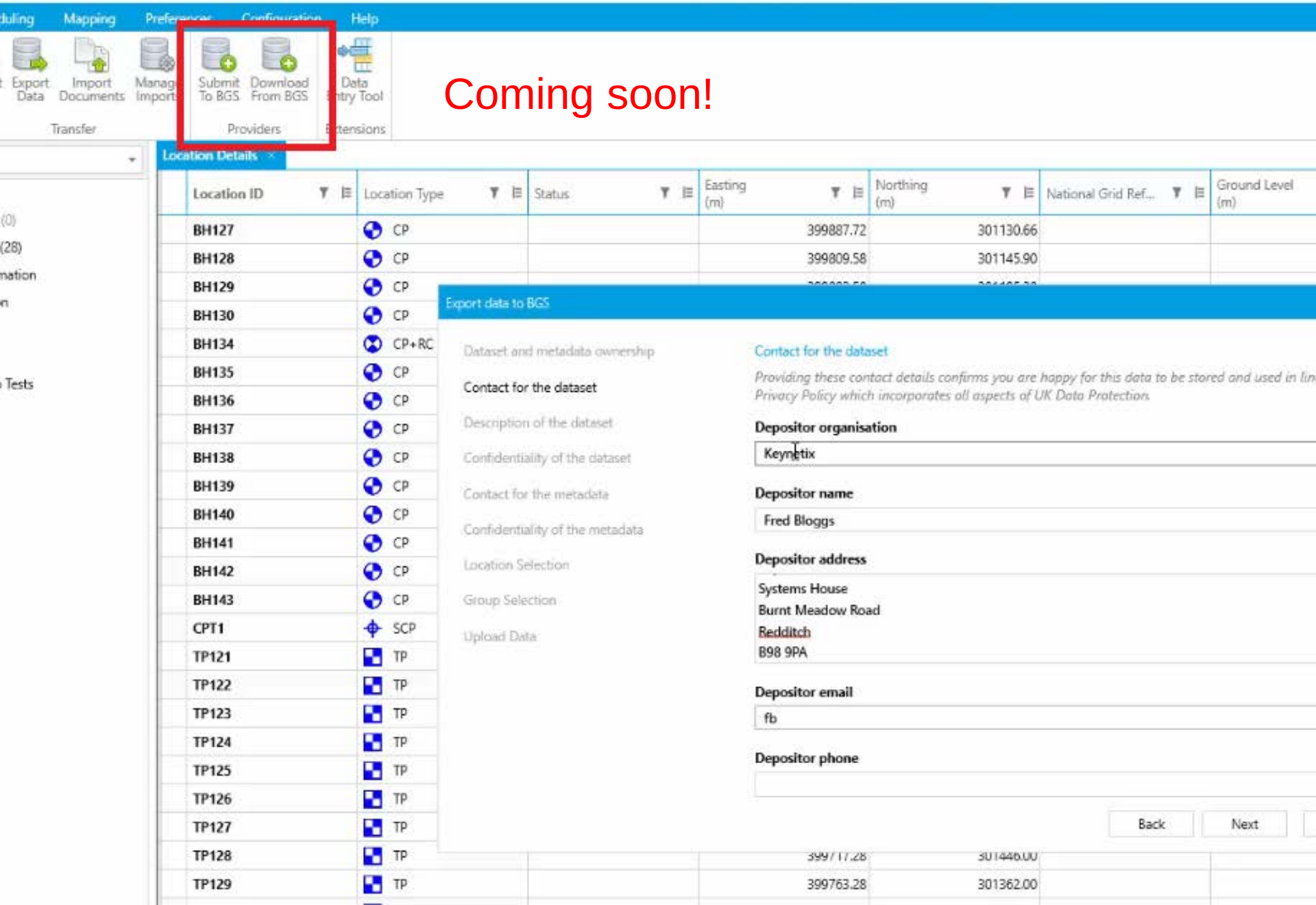
Direct access to free geological maps and boreholes in HoleBASE SI - released



Direct access to BGS products in HoleBASE SI – released in beta



Upload and download of AGS data from BGS data centre



Detailed accession searc | 404 - File or directory no | Items where NERC Auth | Regional Geoscientist

webservices.bgs.ac.uk/accessions

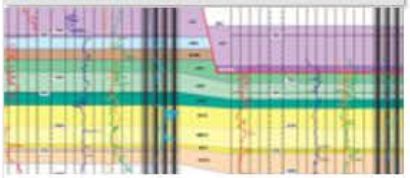
Home | Our data | Our research | Our services | Our people | Discovering geology | News & Events

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL
Gateway to the Earth

About us | Downloads

Home » Our data » NGDC information & data » Data management » Digital accessions

Our data

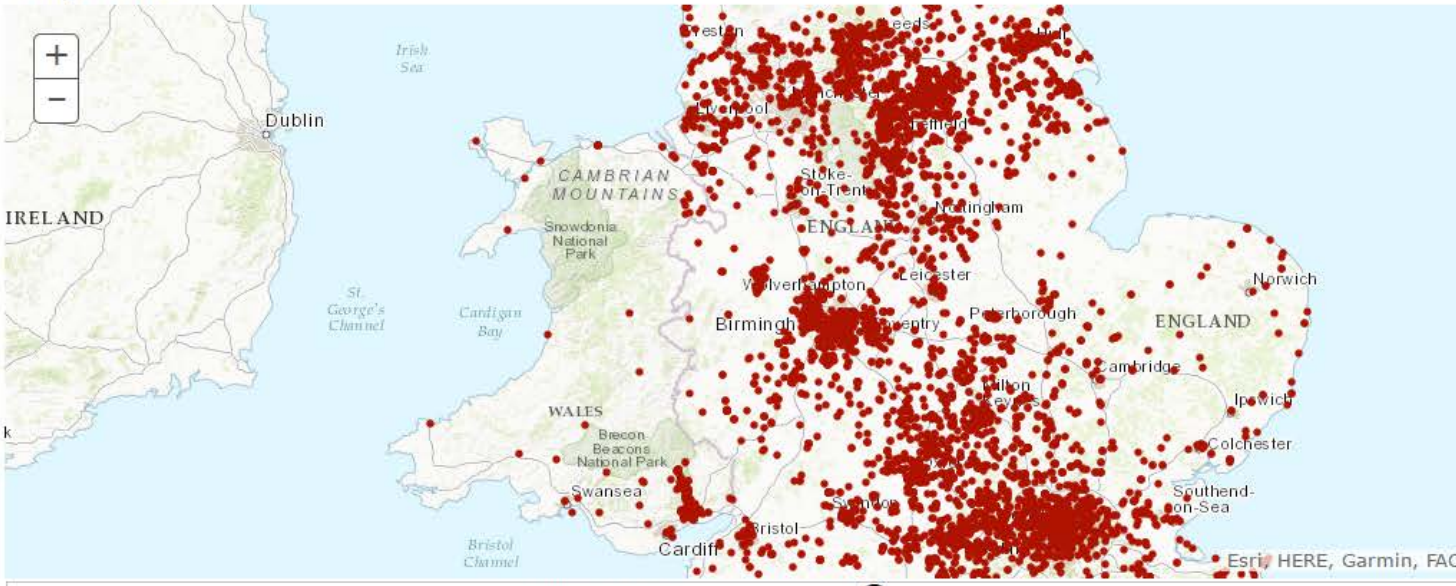


- Our products
- OpenGeoscience
- National Geological Repository
- National Geoscience Data Centre
  - NGDC index
  - Cited data
  - Data management
  - Earth Science Academic Archive
  - National Hydrocarbons Data Archive
- Premium data services

Detailed accession search

Map Search

Map Filter



Draw Extent | Clear Extent

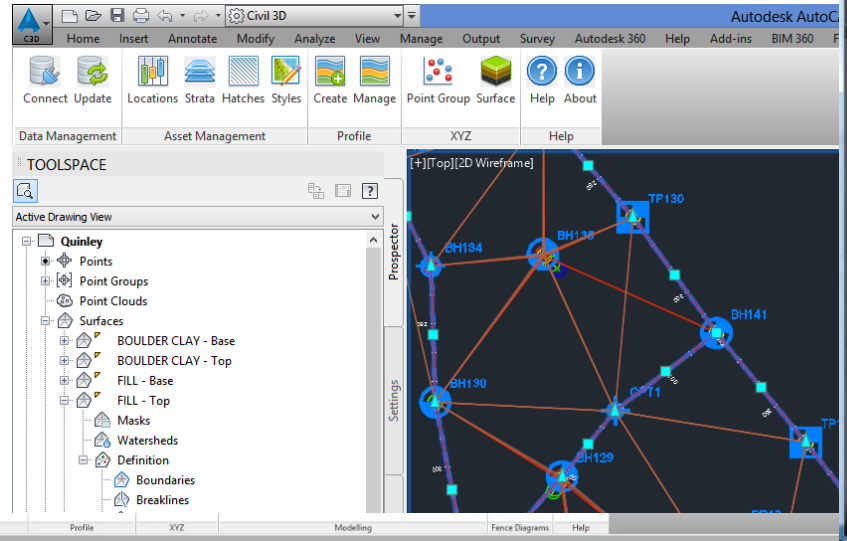
Simple Search:

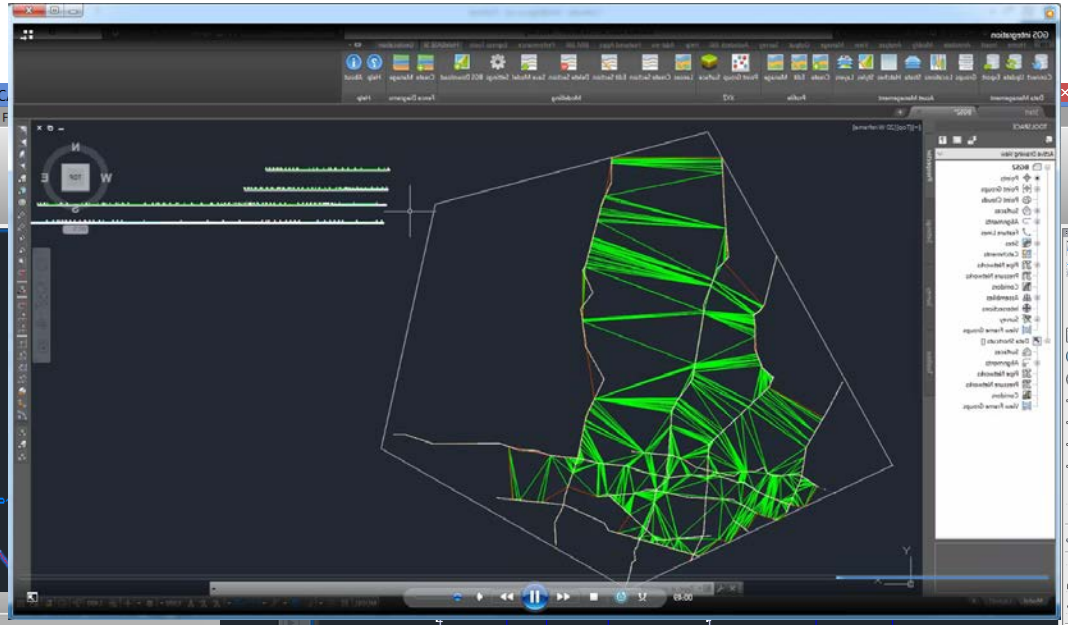
PSL5335_schedule ....a...

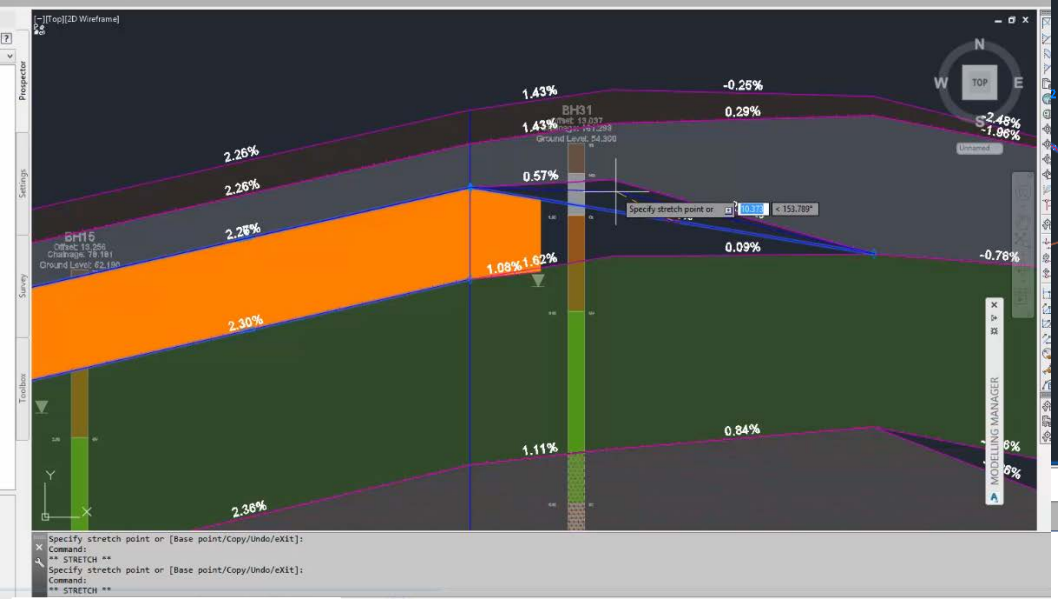
http://webservices.bgs.ac.uk/accessions

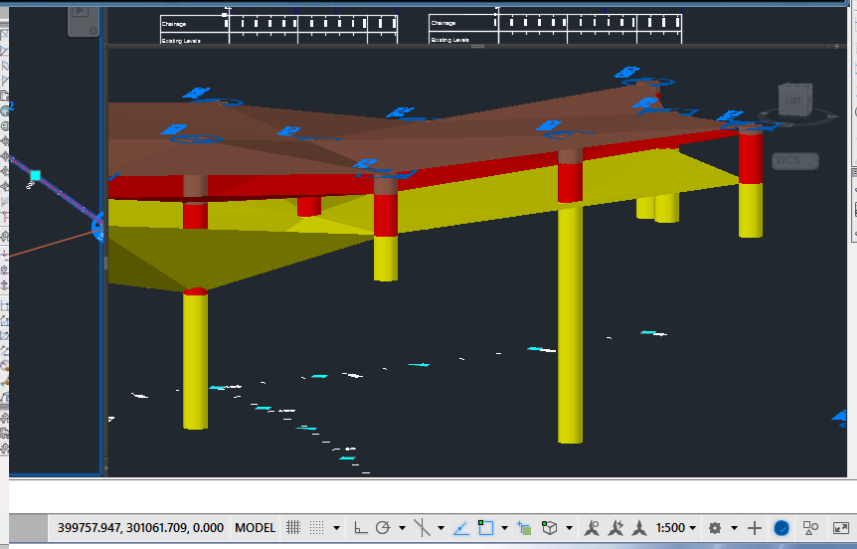
Implementation of 3D modelling in AutoCAD Civil 3D

Coming soon



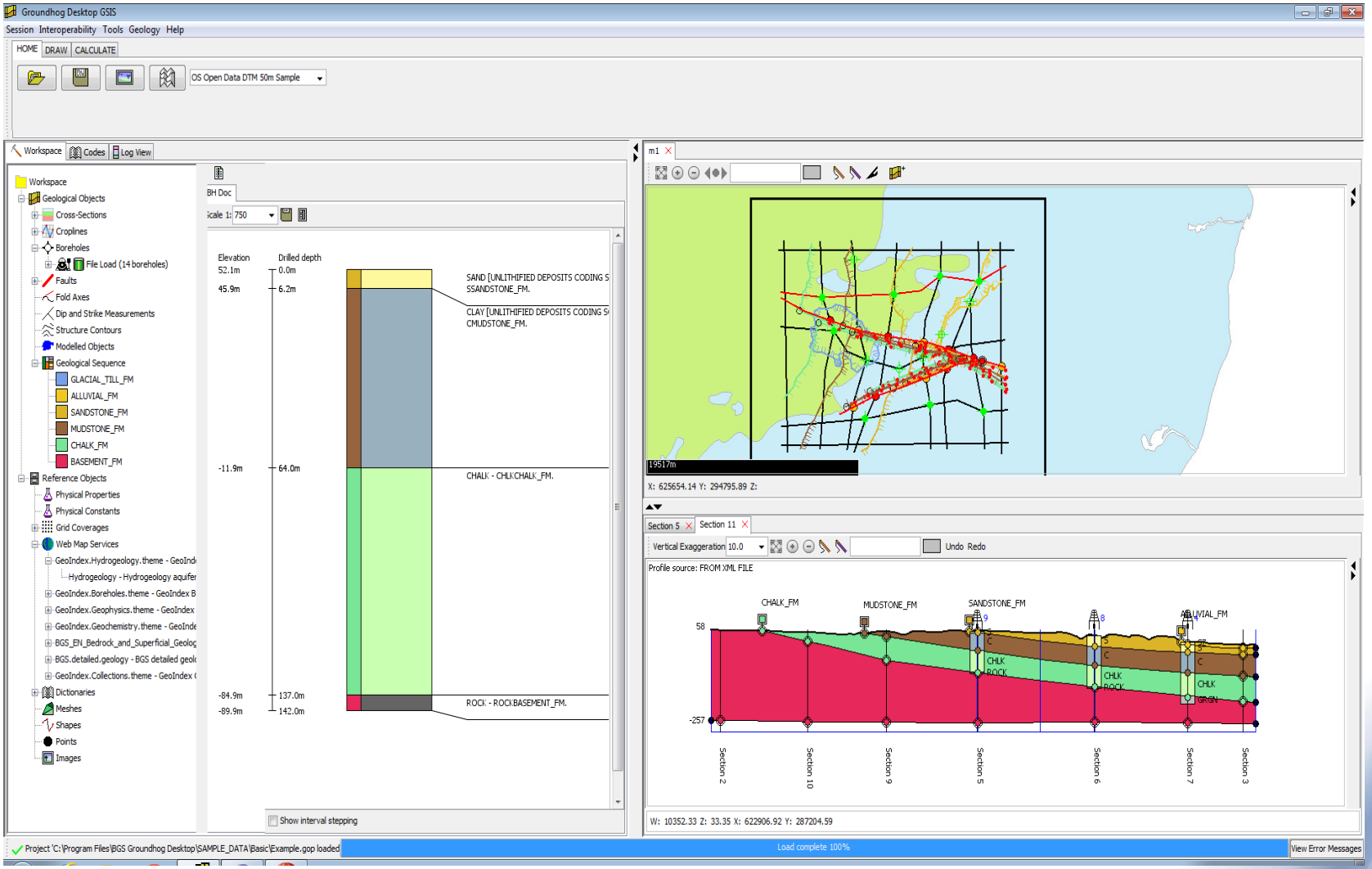






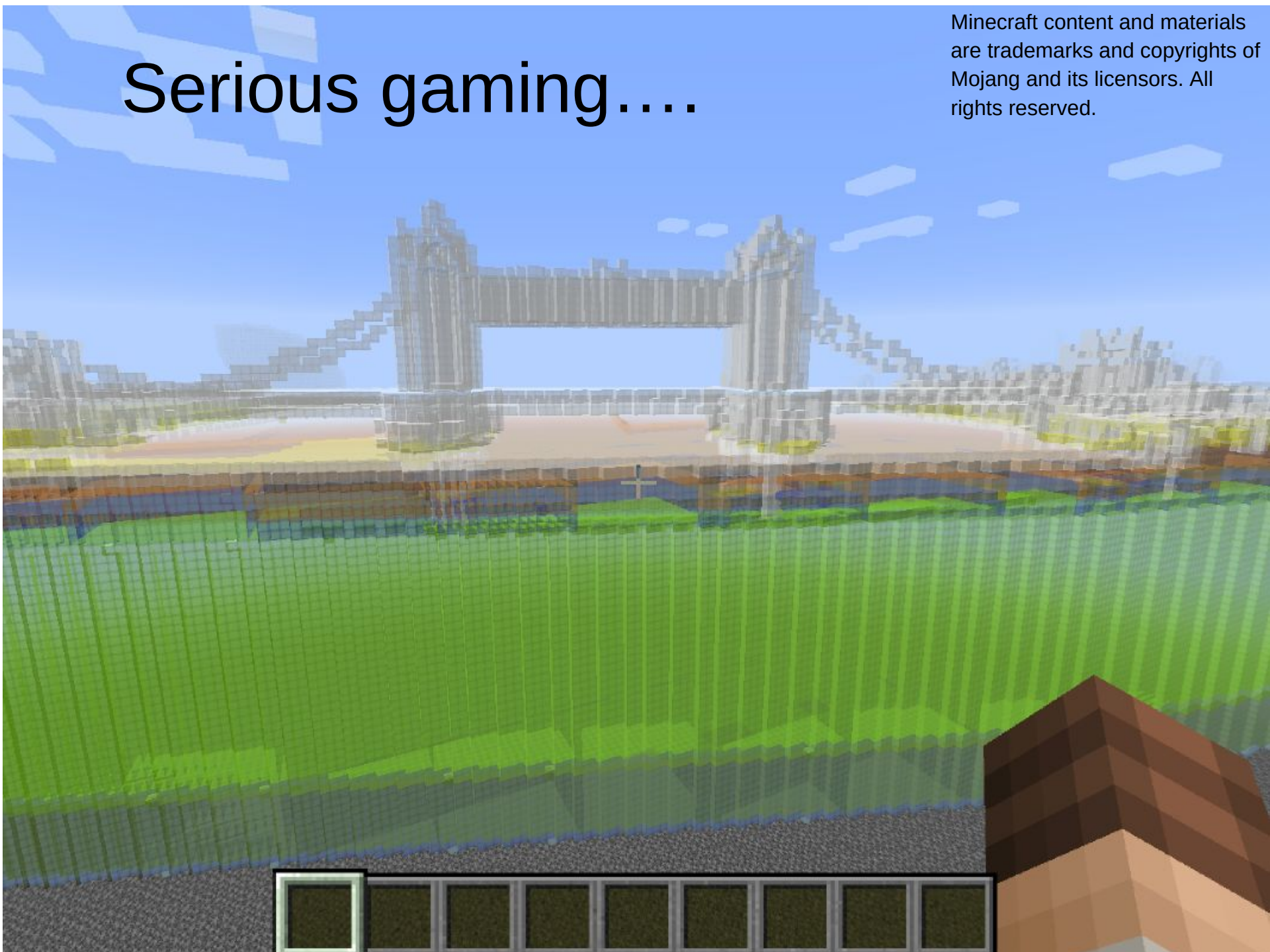
Future possibility of direct access to geological sections…

Groundhog Desktop GSIS -
free tool for geological interpretation and visualisation



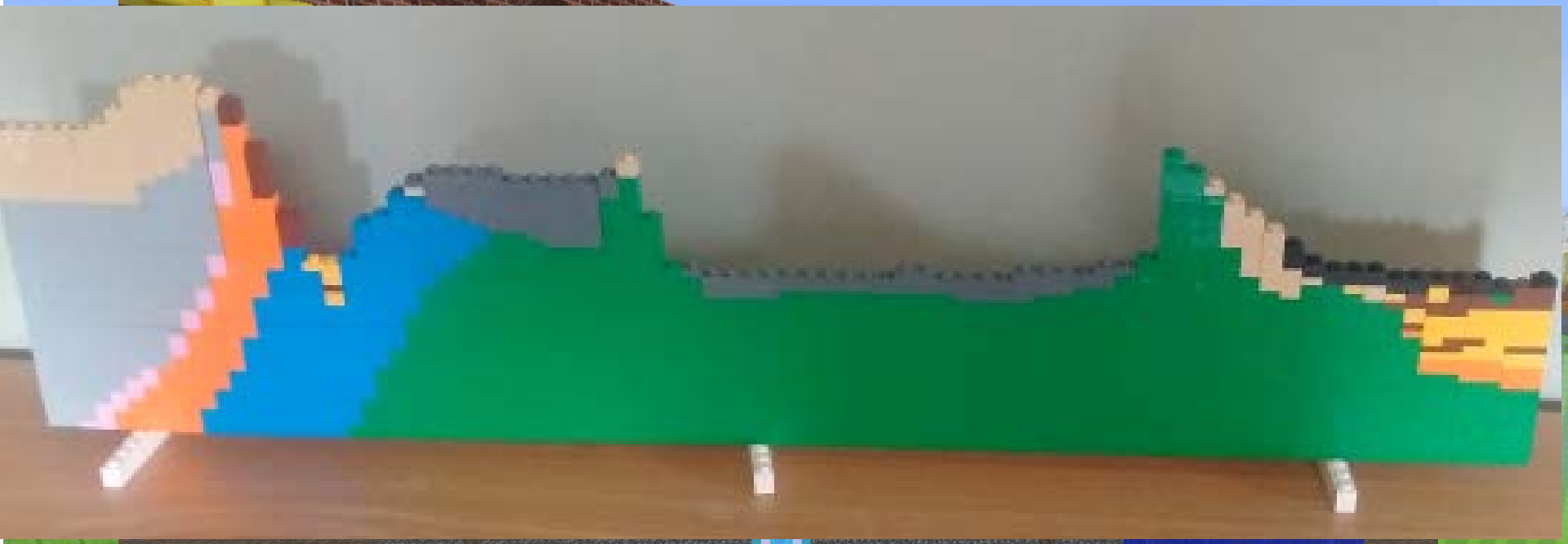
http://www.bgs.ac.uk/research/environmentalModelling/groundhogDesktop.html

Serious gaming….



Serious gaming….

Serious gaming….



Thank You – Any Questions?

hke@bgs.ac.uk

Open 3D Geological Modelling Community

1,629 members