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Model metadata report for North Kent 3D geological model

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Model metadata report for North Kent 3D geological model

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SW corner 569722,154087
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Map

Sheet 272 and 288, 1:50 000 scale, Chatham and Maidstone

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Foreword

This report accompanies the North Kent Maidstone-Chatham Revision model which was created by the British Geological Survey (BGS) under commission by the Environment Agency.

Acknowledgements

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Summary

This report contains the metadata for the revised 3D geological model of North Kent and is accompanied by the Commissioned Report CR/15/039 (Farrant et al. 2015).

1 Modelled volume, purpose and scale

The North Kent 3D geological model was commissioned by the Environment Agency to gain a better understanding of the structure of the bedrock in the area to help understand groundwater movement; this report contains the model metadata, for the full report see Farrant et al. (2015). The GSI3D (Geological Surveying in 3D) software was used to construct the model, following the established workflow described in Kessler et al, (2009). The model comprises 30 correlated cross-sections constrained by 290 boreholes held in the BGS archive. Figure 1 shows the distribution of boreholes and correlated cross-sections.

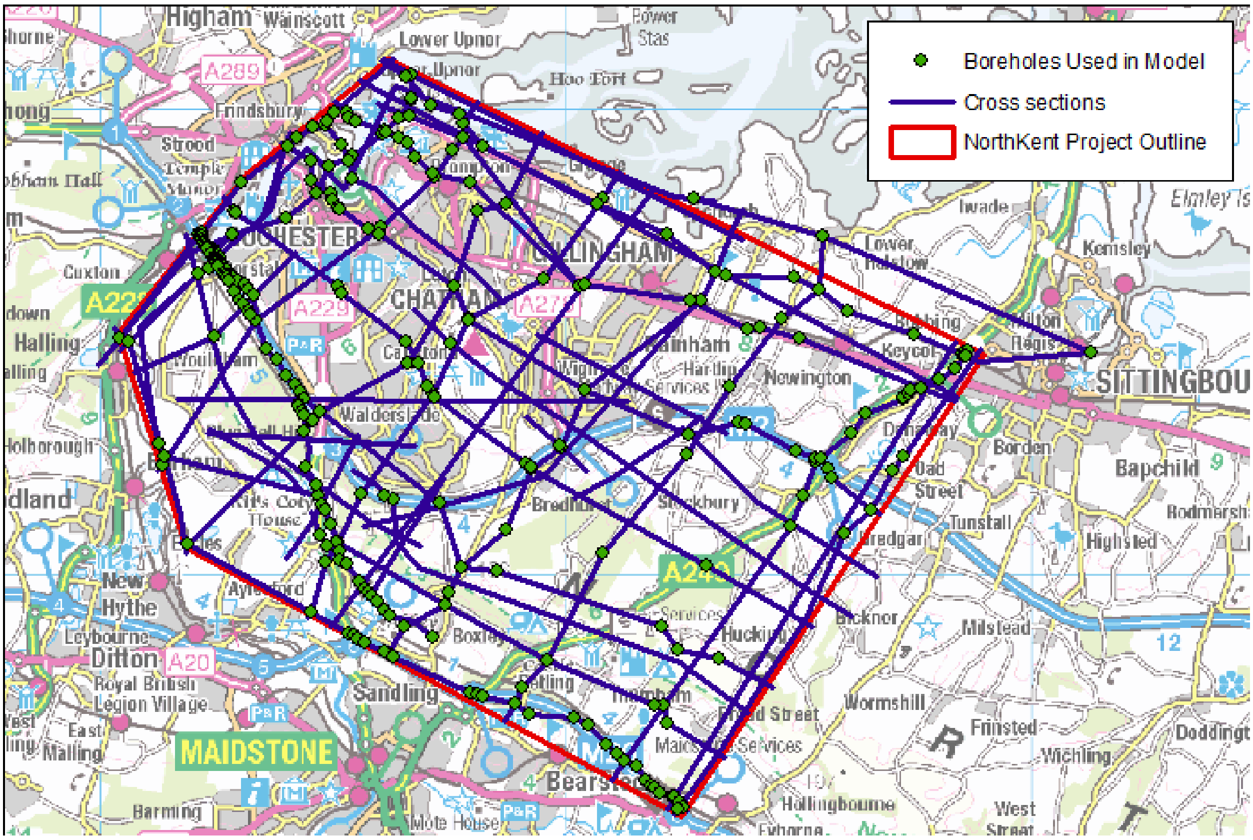

Figure 1 Distribution of borehole records used to constrain the cross-sections constructed in the model.

Modelled surfaces/volumes

A total of 8 Bedrock units and 9 Superficial units are modelled. The base of the Gault Formation is taken as the base of the model at the client's request as the Gault forms the base of the Chalk aquifer. The modelled geological units are described in Table 1.

Table 1 List of geological units modelled, in descending stratigraphical order

Name in model	Geological unit	Age	Description
BTFU-XCZS	Beach and Tidal Flat Deposits	Quaternary	Composite of 'Beach deposits': Shingle, sand, silt and clay; may be bedded or chaotic; beach deposits may be in the form of dunes, sheets or banks, and 'Tidal Flat Deposits': commonly silt and clay with sand and gravel layers; possible peat layers; from the tidal zone. In the model area these are mostly Tidal Flat deposits.
ALV-CZPS	Alluvium	Quaternary	Normally soft to firm consolidated, compressible silty clay, but can contain layers of silt, sand, peat and basal gravel. A stronger, desiccated surface zone may be present.
HEAD-XCZSV	Head	Quaternary	Polymict deposit: comprises clay, silt, sand and gravel (often flint rich) depending on upslope source and distance from source. Poorly sorted and poorly stratified deposits formed mostly by solifluction and/or hillwash and soil creep.
HEAD1-XCZSV	Head 1	Quaternary	Polymict deposit: comprises clay, silt, sand and flint-rich gravel depending on upslope source and distance from source. Poorly sorted and poorly stratified deposits formed mostly by solifluction and/or hillwash and soil creep.
RTD-XSV	River Terrace Deposits	Quaternary	Sand and gravel, locally with lenses of silt, clay or peat.
RTD1-XSV	River Terrace Deposits 1	Quaternary	Sand and gravel, locally with lenses of silt, clay or peat.
RTD2-XSV	River Terrace Deposits 2	Quaternary	Sand and gravel, locally with lenses of silt, clay or peat.
RTD3-XSV	River Terrace Deposits 3	Quaternary	Sand and gravel, locally with lenses of silt, clay or peat.
CWF-XCZSV	Clay-with-Flints Formation	Quaternary	The dominant lithology is orange-brown and red-brown sandy, silty clay with abundant nodules and rounded pebbles of flint. The Clay-with-Flints Formation is a residual deposit formed from the dissolution, decalcification and cryoturbation of bedrock strata of the Chalk Group and Palaeogene formations and, in the extreme west of the outcrop, the Upper Greensand Formation. It is unbedded and heterogeneous. Angular flints are derived from the Chalk, and rounded flints, sand and clay from Palaeogene formations. There is commonly a discontinuous basal layer up to 100 mm thick, with dark brown to black matrix, stiff, waxy and fissured, with relatively fresh flint nodules stained black or dark green with manganese or glauconite. The deposit locally includes bodies of yellow fine- to medium- grained sand, reddish brown clayey silt, and sandy clay with beds of well-rounded flint pebbles, derived from Palaeogene formations.
PGU-SSCL	Palaeogene Rocks (Undifferentiated)	Palaeogene	This unit comprises the London Clay Formation (silty to very silty clay, clayey

			silt and locally silt, bioturbated or poorly laminated, blue-grey or grey-brown, slightly calcareous, with some layers of sandy clay), which overlies the Lambeth Group (vertically and laterally variable sequences mainly of clay, some silty or sandy, with some sands and gravels, minor limestones and lignites and occasional sandstone and conglomerate) overlying the Thanet Formation (pale yellow-brown, fine-grained sand, locally clayey and glauconitic, with rare calcareous or siliceous sandstones, overlying basal glauconite-coated, nodular flint bed) .
SECK-CHLK	Seaford Chalk Formation	Late Cretaceous	Firm white chalk with conspicuous semi-continuous nodular and tabular flint seams. Hardgrounds and thin marls are known from the lowest beds. Some flint nodules are large to very large.
LECH-CHLK	Lewes Nodular Chalk Formation	Late Cretaceous	Composed of hard to very hard nodular chalks and hardgrounds (which resist scratching by finger-nail) with interbedded soft to medium hard chalks (some grainy) and marls; some griotte chalks. The softer chalks become more abundant towards the top. Nodular chalks are typically lumpy and iron-stained (usually marking sponges). Brash is rough and flaggy or rubbly, and tends to be dirty. First regular seams of nodular flint, some large, commence near the base and continue throughout.
NPCH-CHLK	New Pit Chalk Formation	Late Cretaceous	Principally blocky, white firm to moderately hard chalk with numerous marls or paired marl seams.
HCK-CHLK	Holywell Nodular Chalk Formation	Late Cretaceous	Generally hard nodular chalks with thin flaser marls and significant proportions of shell debris in part. Base marked by the interbedded coloured marl and chalk succession characteristic of the Plenus Marls Member (a term applicable in both the Southern and Northern Provinces). The Melbourn Rock Member above the base can be distinguished by its lack of shell material.
ZZCH-CHLK	Zig Zag Chalk Formation	Late Cretaceous	Mostly firm, pale grey to off-white blocky chalk with a lower part characterised by rhythmic alternations of marls and marly chalks with firm white chalk. Thin gritty, silty chalk beds act as markers in the sequence.
WMCH-CHLK	West Melbury Marly Chalk Formation	Late Cretaceous	Buff, grey and off-white, soft, marly chalk and hard grey limestone arranged in couplets.
GLT-MDST	Gault Formation	Early Cretaceous	Pale to dark grey or blue-grey clay or mudstone, glauconitic in part, with a sandy base. Discrete bands of phosphatic nodules (commonly preserving fossils), some pyrite and calcareous nodules.

2 Modelled faults

Several faults occur within the modelled area, these have been modelled using the 'stepped units' method (i.e. a single line across the fault plane) rather than the fault functionality within GSI3D.

3 Model datasets

The model consists of the following datasets, however this is not an exhaustive list of all data sources consulted:

- Digital Terrain Model (DTM) – the model is capped by the Bald Earth DTM, which represents the ground surface. The Bald Earth DTM is a UK-wide ground elevation model that uses NextMap elevation data spliced with Ordnance Survey Landform Profile data for wooded areas. The Bald Earth DTM used in the model has a cell size of 50m.
- Borehole data – 290 borehole records constrain the North Kent geological model. To enable these borehole logs to be viewed in the 3D modelling software, the downhole information recorded in them was entered into corporate databases according to corporate guidelines and standards. Scans of all non-confidential borehole logs held in the BGS archive can be accessed on-line using the Onshore GeoIndex on the BGS web site at http://www.bgs.ac.uk/geoindex/home.html.
- Geological map data – currently unpublished 1:10,000 scale geological map data was used to inform the model. This geological map data results from an appraisal of existing geological data and a field-based re-survey of the area by Andrew Farrant and Keith Westhead during February 2015.
- Hand drawn surfaces that were created for the previous BGS North Kent EarthVision model (Farrant and Aldiss, 2002) were imported into GSI3D (Base Lewes Chalk, Base Seaford Chalk and Base Palaeogene). However, due to the new information used within this model, these were used only as guidance in areas with no alternative data.
- Cross-sections along the route of the Channel Tunnel Rail Link as documented in Warren and Mortimore (2003).

4 Model development log

The North Kent 3D geological model was constructed using GSI3D software according to corporate standards and methodology. This involves databasing borehole records, correlating cross-sections using geological map data, borehole and auger records to constrain the modelled units. The spatial distribution of each unit is based on geological map data for those that crop out at the surface and the cross-sections are queried for the distribution of concealed units. A development log of modelling metadata compiled during the construction of the model is available on request from the author.

Borehole files: the location information (National Grid co-ordinates and start heights) of the boreholes used in the model are stored in the file *NorthKent_SOBI_BoGe_Coded_BID.bid*. The downhole information is stored in the file *NorthKent_Boreholes_Coded_BLG_v2.blg*.

Generalised Vertical Section (GVS): this file tells the 3D modelling software the stratigraphic order of modelled geological units. The North Kent 3D model uses the file *NorthKent_GVS_v2.gvs*.

Legend file (GLEG): this file tells the 3D modelling software which colour to use for each geological unit. The North Kent model uses the file *NorthKent_GLEG_v1_0.gleg*.

GSI3D model file (GSIPR): the final version of the North Kent model file is *NorthKent_3D_Model_V1_39_ILC_ST_check.gsipr*.

5 Model workflow

Standard GSI3D modelling workflow and procedures were followed during construction of the North Kent 3D geological model (Kessler et al 2009). The exception to the standard methodology is the use of 'scattered data points' to generate the base for the two units HEAD and HEAD1. Thin units such as Head cannot successfully be calculated using the cross-section approach alone because they do not contain enough nodes to constrain the calculation. The use of scattered data points allows extra nodes to be added to the base of these units and enables a more robust surface to be calculated.

These scattered data points are constructed by:

1. Copying the current model DTM (using a tool within GSI3D) to reduced the whole surface by a given distance, decided by the modeller (in this case 1.5m)
2. Switching on edit for this new surface (which will be the base of HEAD) and adding the polygons for HEAD into it.
3. Switching off edit and trimming TIN to Boundary.
4. Exporting as 'Scattered Data Points'.
5. Importing Scatter Data Points to the HEAD geological unit.
6. Calculating and check it looks ok.
7. Repeating whole process for HEAD1 unit

6 Model assumptions, geological rules used

6.1 THICKNESSES

The North Kent Geological Model uses borehole and mapping data where available but elsewhere makes assumptions about Chalk formation thicknesses as derived from geophysical borehole interpretation (by Mark Woods), as below:

Seaford Chalk Formation: up to 45 m below Palaeogene cover (there is no evidence for outcropping or sub-cropping Newhaven Chalk Formation – see attached summary map for occurrence of Newhaven Chalk in lower Thames Basin)

Lewes Nodular Chalk Formation: 40 m

New Pit Chalk Formation: 45 m

Holywell Nodular Chalk Formation: 23 m

Zig Zag Chalk Formation: ?40m*

West Melbury Marly Chalk Formation: 20 – 30 m*

*There is no reliable data for the two formations of the Grey Chalk Subgroup from boreholes. The Chatham memoir suggests about 60 m – 70 m. Kennedy (1969) detailed the Grey Chalk succession at Blue Bell Hill/Burnham [TQ615 735]. His written log suggests that the Zig Zag Chalk here is perhaps 40 m thick, leaving 20 to 30 m for the underlying West Melbury Marly Chalk.

7 Model limitations

- On steep wooded slopes, such as the main Chalk escarpment and some of the deeper dipslope valleys, the DTM used in the model is significantly different from the OS contour data. The difference in derived surface elevation impacts on the model in these areas and some of the exceptional thickness variations in the Chalk formations along the escarpment edge seen in calculated grids may be artefacts of the modelling, rather than true thickness variations.
- Faults were not expressly modelled as fault planes in GSI3D, but instead modelled as stepped profiles in the individual cross sections. Faults are shown as NULL lines only for guiding drawing, and the geological correlated line is stepped across the fault boundary to indicate the throw (acceptable practice for minor faulting).
- In some areas, the subsurface interpretation is based on very limited borehole data, and not supported by seismic or other geophysical data. Thus the confidence in the model in these areas is low and the interpretation should be viewed with caution. This is particularly the case in the northeast of the model area where the Chalk outcrop is concealed beneath Palaeogene and superficial deposits and few borehole logs exist. Many of the Chalk boreholes are old water wells the logs of which do not record the new Chalk lithostratigraphy. Consequently most of the Chalk surfaces are derived from the new geological mapping and not constrained by borehole data except where geophysical logs are available. Thus in the north of the region where only the Seaford and Lewes Chalk units are at outcrop, the lower Chalk units are interpolated using estimated thicknesses (see 6.1 above).
- The rock-head surface on the Chalk outcrop is likely to be highly irregular beneath the Clay-with-Flints (and any remnant Palaeogene deposits) due to the presence of dissolution pipes. These may extend up to 20 m into the underlying Chalk. Thus borehole records of the superficial deposits' thicknesses may be only relevant to spot locations and cannot be used to extrapolate the rock-head surface with any certainty. Thus the modelled base Clay-with-Flints surface is a smoothed approximation of the rock-head surface, rather than presenting a realistic actual rock head.
- In some areas, sands of the Thanet Formation are known to infill dissolution pipes extending down into the Chalk, for example beneath Rochester Airport. These are noted on the old field-slips.
- In some of the dry valleys, the DTM does not accurately reflect the Ordnance Survey contour profiles upon which the geological line work is based. Thus in some instances, the valley bottom Head deposits or Alluvium appear on the GSI3D model to occur on the valley sides rather than sit in the valley bottom. This is an artefact of the DTM used which includes trees, and therefore does not match OS contour data.
- The head deposits (Head and Head 1) were modelled not by correlating cross sections, but by using an assumed thickness of 1.5 m and using the outcrop pattern to create a surface 1.5 m below the DTM (see section 'Model Workflow'). Consequently the relationship between these deposits is not modelled accurately but appears as a vertical contact. In reality, these deposits merge into each other.
- No mass movement deposits were identified within the model area.

- Artificial deposits, including made, worked and artificial ground are not modelled, as these were not relevant to the client.
- The start heights of some borehole logs do not appear to match the DTM in the model. It is assumed that these boreholes were sited on a previous land surface, one that has either been artificially lowered by manmade activities (quarrying for example) or raised by earthworks (road embankments for example). These were assessed and assumed to be correct where there was clear evidence of post-borehole surface elevation changes 9as is the case with many of the Channel Tunnel rail link site investigation boreholes, hung on the DTM where the borehole elevation was inaccurate, or not used.

8 Model images

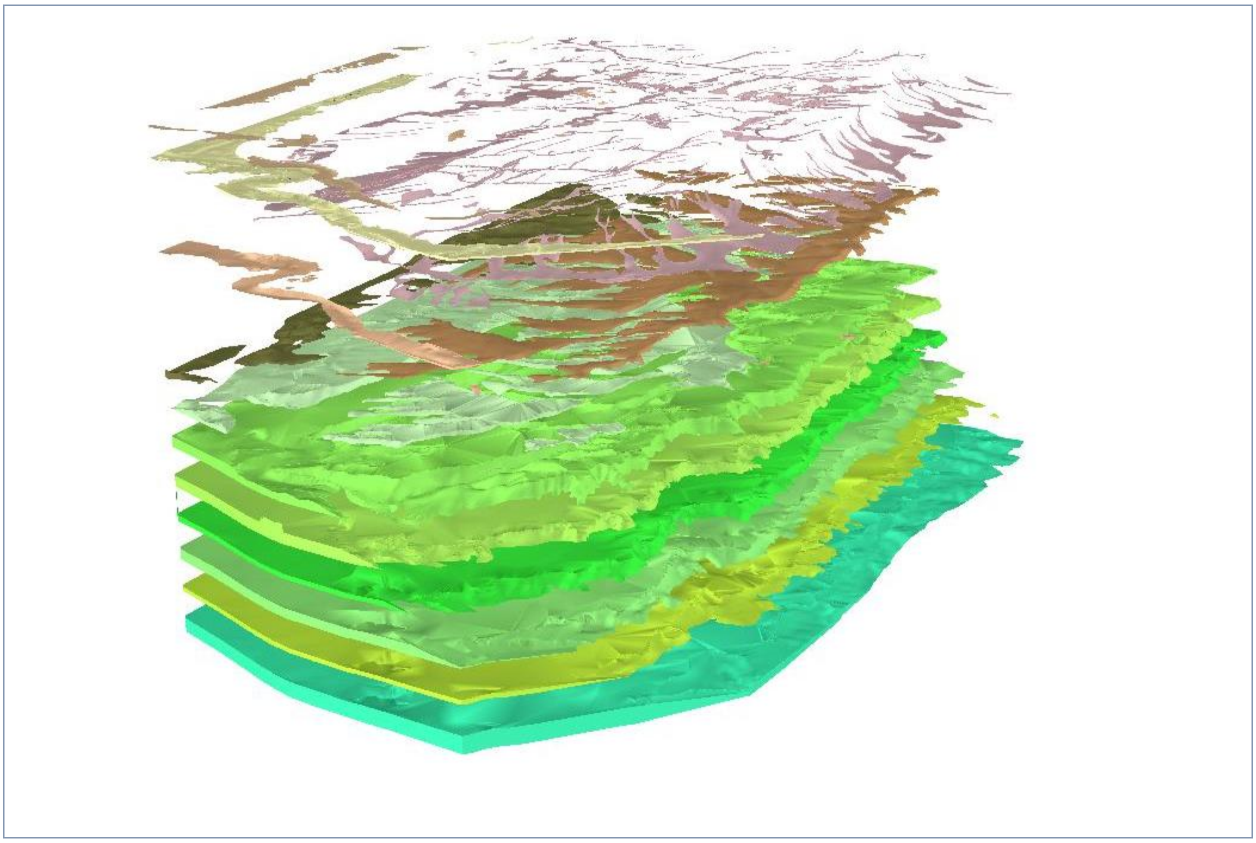

Figure 2: Exploded view of all calculated units (x5 exaggeration)

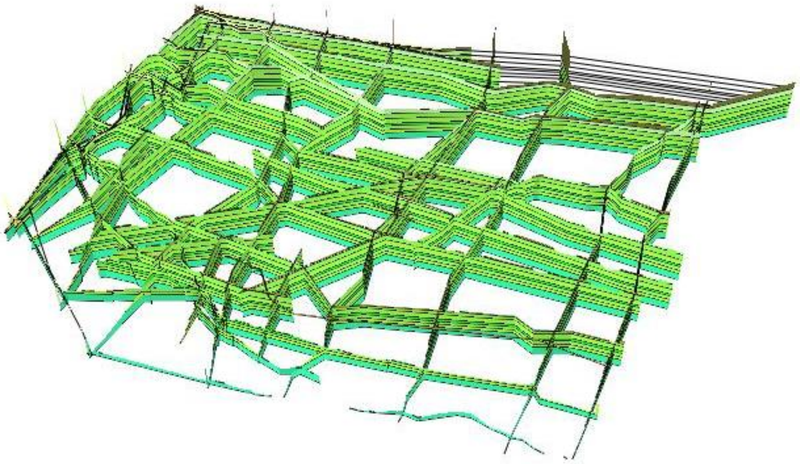

Figure 3: Cross sections used to calculate the model (x5 exaggeration)

9 Model uncertainty

Uncertainty within the model varies vertically and laterally. Recent geological mapping has enabled the units at the model surface to be relatively well constrained, although in some areas the DTM used in the model does not match the Ordnance Survey data used during the mapping. This is an issue on steep wooded slopes, notably along the Chalk escarpment and in some of the deeply incised wooded dip slope valleys. In these areas the model looks incorrect or the cross sections have been adjusted to make the model work. The distribution and variable quality of borehole data also influences confidence in the model. Many of the older Chalk boreholes are do not identify the modern Chalk formations, and thus do not constrain the model. More recent boreholes with full Chalk attribution are generally confined to the Channel Tunnel rail link and M2 sections around Borstal. These are along linear route-ways, so are not spread across the model area. Small faults with throws of <5 m and other minor geological structures that are known to exist in the Medway area are not resolvable at the level of the model.

References

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

Onshore GeoIndex: web based GIS of BGS data, including borehole scans, accessible via the BGS web site: http://www.bgs.ac.uk/geoindex/home.html

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