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# A guide to a new Geographical Information System for the Chalk of the Thames Basin: The Thames Chalk Information System (TCIS)

FutureThames cross-cutting Programme

Open Report OR/13/053



BRITISH GEOLOGICAL SURVEY

FUTURETHAMES CROSS-CUTTING PROGRAMME

OPEN REPORT OR/13/053

# A guide to a new Geographical Information System for the Chalk of the Thames Basin: The Thames Chalk Information System (TCIS)

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# Foreword

This report summarises the key features of a new geographical information system (GIS) resource for the Chalk Group of the Thames Basin, named the Thames Chalk Information System (TCIS). The work was commissioned by the FutureThames project as a means of bringing together disparate data into a single, easily accessible, geographically referenced structure.

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**Table 1.** The stratigraphy of the Chalk Group referred to in this report and used in the Thames Chalk Information System (TCIS) (not to scale).

# Summary

BGS work on the Chalk Group of the Thames Basin has amassed large quantities of geological information about thickness, facies, marker-beds, biostratigraphy and structure, only a small part of which is incorporated into the geological map. More recently there has been wider use and interpretation of borehole data to underpin the development of 3D geological models. There is a pressing need to organise these disparate data in a way that can easily be compared and interrogated, as well as to capture the results of relevant published research outside BGS. This project addresses this need by creating a new spatial database, the Thames Chalk Information System (TCIS). The database uses ArcGIS technology to display key information layers about the Chalk. As well as standard topographical and geological information, TCIS includes layers describing: Group, Subgroup, and formational thickness; structural data; detailed stratigraphical data; coverage of 3D geological models that include units or surfaces of the Chalk Group; regions where data coverage limits our understanding of the Chalk. Hydrogeological data is currently being compiled as part of a related project; it is not currently available for incorporation into the TCIS, but will eventually be added. Basic information about the content and methodology used to compile the data in the TCIS is outlined in the main body of this report. Hydrogeological data was delivered through a separate project, and its features are the subject of a separate report. The aim of this report is to provide sufficient background information to allow meaningful use of the TCIS database; there is no new data interpretation.

# 1 Introduction

Geological data relating to the Chalk Group of the Thames Basin have expanded dramatically over the last 25 years, particularly since the initiation of new Chalk-focused BGS mapping programmes in the early 1990s. Underpinning the newly-acquired digital geological map data for the Chalk is a wealth of other information, particularly relating to detailed (sub-formation) stratigraphy and regional changes in thickness and facies. In recent years a range of digital 3D geological models have also been developed for the London Basin, leading to new interpretations of regional structure and Chalk basin architecture. Whilst most of these data are held in various corporate archives, there is a need to draw these diverse strands of information together into a single spatially referenced format, allowing easy data comparison and interrogation. This work addresses that need by displaying all these data in a newly developed Arc-GIS format, named Thames Chalk Information System (TCIS). Table 1 summarises the stratigraphy of the Chalk referred to in this report.

In addition to standard topographical and geological map data, the TCIS contains:

1. Depth to top Chalk, depth to base Chalk, and thickness of Chalk Group, displayed as shaded surfaces to emphasise regional trends.
2. Chalk Group, Subgroup and formational thickness information, displayed as greyscale shaded surfaces to emphasise regional trends.
3. Structural information (faults and folds).
4. Chalk stratigraphy information including:
  - (i) Chalk boreholes with stratigraphy interpretations based (predominantly) on geophysical logs and borehole core. Interpretations are held in the BGS Borehole Geology (BoGe) database.
  - (ii) Sections and boreholes in the Chalk Group that have been illustrated in publications and BGS reports.
  - (iii) Chalk sample localities for which information about detailed lithostratigraphy and biostratigraphy is available in publications and reports.
  - (iv) Distribution of key hardground surfaces developed in the Lewes Nodular Chalk Formation described by Bromley and Gale (1982).
5. Summary of existing 3D geological models of the Chalk of the Thames Basin, and the purpose(s) for which each is best suited.
6. Summary of areas where lack of primary knowledge of the Chalk limits our understanding of its stratigraphy.
7. Hydrogeological data (data delivered as part of a separate project and not discussed further herein).

Information about the assembly and construction of the TCIS is provided in **2** (below), and data relating to each of the above themes (with the exception of hydrogeological data) are briefly discussed in **3** (below), and in greater detail in **4 – 9** (below). Where themes show the distribution of data that require interrogation through secondary sources (e.g. reports, references, corporate databases), information about these is also summarised.

This account does not provide any commentary about the conclusions that may be drawn from analysis of these data.



## 2 GIS construction

The Thames Chalk Information System (TCIS) has been created in ArcGIS version 10.0 and can be accessed here:

W:\Teams\SCCP\ThamesBasin\Data\Thames\_Chalk\_Information\_System\GIS\Thames\_Chalk\_Information\_GIS.mxd

For the purposes of the TCIS, each dataset has been clipped to the FutureThames project boundary (formerly the Thames Basin Cross-Cutting Project), with the exception of the fault layers, which have been included if they are within or overlap with the project boundary, but have not been clipped. It is important to emphasise that many of the datasets included in the TCIS extend beyond the FutureThames boundary. A GIS containing the pre-clipped data can be found here:

W:\Teams\SCCP\ThamesBasin\Data\Thames\_Chalk\_Information\_System\GIS\Thames\_Chalk\_Information\_GIS\_before\_cuts.mxd

The FutureThames project boundary represents the catchment of the River Thames and the Thames Estuary and was defined at the start of the Thames Basin Cross-Cutting Project and hence has been selected as the project boundary for the TCIS.

All of the clipped TCIS layers (shapefiles and raster datasets) can be found in the following geodatabase, for users who wish to incorporate any of the data into their own projects:

W:\Teams\SCCP\ThamesBasin\Data\Thames\_Chalk\_Information\_System\GIS\All\_clipped\_layers.gdb

ArcGIS layer files (which maintain the symbology created in the TCIS) of all the data within the TCIS, can be found here:

W:\Teams\SCCP\ThamesBasin\Data\Thames\_Chalk\_Information\_System\GIS\Clipped\_layer\_files

## 3 Description of data themes

### 3.1 CHALK GROUP

The following themes appear in the Table of Contents of the TCIS:

- Top Chalk: Displays extent of Chalk below younger, rockhead-forming strata (predominantly Palaeogene in age).
- Base Chalk: Displays total extent of Chalk, concealed and unconcealed, within the project area.
- Boreholes: Displays 3 subsets of boreholes: (i) those proving the contact of Chalk with younger rockhead formations ('Top Chalk (CK) surface picks (V5)'); (ii) all boreholes that prove the local top of the Chalk Group ('Top Chalk (CK) all boreholes (V5ii)'; (iii) all boreholes proving the base of the Chalk Group ('Base Chalk (CK) boreholes (V5)').
- Group Surfaces: Shows the top and base of the Chalk group as greyscale surfaces, shaded according to their OD value (pale colour = greater elevation above OD), with maximum (above OD) and minimum (below OD – negative) values indicated. Information about how the Group and the Formational surfaces were created is given below (5).

- Surface Control: Top Chalk and Base Chalk. This appears under both the ‘Chalk Group’ and the ‘Subgroup and formational data’ tabs in the GIS Table of Contents. It is a colour coded map of the density of boreholes used to control the calculation of Group, Subgroup and formational surfaces. Areas with a higher density are coloured green, those with lower density in red. The creation of these layers is described in greater detail below (5.4)
- Thickness (in metres) of the Chalk Group: Displays the thickness of the Chalk Group as a colour-shaded surface (dark colour = greater thickness), with maximum and minimum values indicated. The data are extrapolated for whole project area based on known values from boreholes. The negative thickness values are a spurious feature caused by different levels of data resolution, particularly contrasts between surveyed outcrop margin and modelled formational surfaces (see 10 below).

### 3.2 SUBGROUP AND FORMATIONAL DATA

- Outcrop: Displays the concealed and unconcealed (outcrop) extent of each of the named subgroups and formations for which data could be obtained.
- Borehole distribution: Displays geographical distribution of boreholes that intersect the tops/bases of the named subgroups/formations.
- Borehole thickness (in metres): Displays geographical distribution of boreholes containing named formations, with thickness ranges in these boreholes indicated by variable symbology (4 below).
- Formational surfaces: Displays the bases of named formations as greyscale surfaces shaded according to their OD value (in metres; pale colour = greater elevation above OD), with maximum (metres above OD) and minimum (metres below OD – negative) values indicated. Information about how the Formational surfaces were created is given below (5 below).
- Surface control: As for Group level data above, but shown for each named formation (5.4 below).
- Formational bases: Displays bases of named formations as surveyed at outcrop within the project area (7 below).
- Calculated thickness of Chalk formations (in metres): As for Group level data above, displayed as colour-shaded surfaces extrapolated for whole project area based on known values from boreholes. Includes thicknesses of traditional Lower, Middle and Upper Chalk units (6 below).

### 3.3 FAULT AND FOLD LINEAMENTS

- Two layers are displayed in the GIS. The first (‘Filtered structures (V1)’), shows all documented records of significant fold and fault lineaments in the project area. The second layer (‘Filtered structures (V10)’), shows only the larger fault lineaments, which in some cases have been linked together on the basis of more detailed structural analysis of marker-horizons and gravity data. See 8 (below) for further details.

### 3.4 CHALK STRATIGRAPHY INTERPRETATIONS

- Displays four layers, summarising details of: geophysical logs and cored boreholes with interpretations listed in BoGe; sections and boreholes illustrated in published media and BGS Technical Reports; chalk localities with stratigraphical details described in BGS Technical Reports; distribution of named hardgrounds forming the Chalk Rock Member in the lower part of the Lewes Nodular Chalk Formation. See 9 below for more details.

## 4 Boreholes

Formation tops were used as boundary indicators for defining the bases of immediately overlying formation surfaces. These data are shown as OD values listed under *T\_Depth\_OD* in the borehole attribute table. For example, the *Base\_SECK\_Top\_LECH\_V2\_0\_Boreholes.shp* records the Top LECH elevation relative to OD, and equates to the base Seaford Chalk Formation. A borehole dataset was generated for each Chalk formation (excluding combined formations) plus the Top and Base Chalk. An additional dataset was created showing the full borehole stratigraphy for each borehole used to construct the Top Chalk surface (*Top\_CK\_All\_Boreholes\_V5ii.shp*).

Thickness plots for use in GOCAD modelling were generated by identifying matches of boreholes between the different formational borehole datasets. A borehole match between datasets for adjacent formational units indicates that both the top and base of a formation are present in a given borehole, allowing its thickness to be calculated. For example, boreholes containing the Top SECK were matched against those containing Top LECH (equating with Base SECK). For each match in borehole ID, a relevant formational thickness was calculated for that borehole. These thickness values were then used to generate thickness plots for use in constructing formational surfaces.

## 5 Chalk Formational Surfaces

The following unfaulted formation surfaces have been derived, and are presented in the GIS as theme layers in the Chalk Group tab and the Subgroup and formational data tab:

1. Top Chalk – referred to as Top CK\*
2. Base Newhaven Chalk and Base Seaford Chalk combined – referred to as Base NCK SECK\*
3. Base Lewes Nodular Chalk – referred to as Base LECH\*
4. Base New Pit Chalk – referred to as Base NPCH\*
5. Base Holywell Chalk – referred to as Base HCK\*
6. Base Zig Zag Chalk – referred to as Base ZZCH\*
7. Base West Melbury Marly Chalk – referred to as Base WMCH\*
8. Base Chalk – referred to as Base CK\*

\*in the GIS and model datasets

The Seaford and Newhaven Chalk formations are combined because of sparse data (only 29 boreholes) for the Newhaven Chalk in the Thames Basin.

Each of the surfaces generated have the following naming convention in the relevant datasets:

b\_ = Base

t\_ = Top

CK = Chalk

NCK = Newhaven Chalk

SECK = Seaford Chalk

LECH = Lewes Nodular Chalk

NPCH = New Pit Chalk

HCK = Holywell Nodular Chalk

ZZCH = Zig Zag Chalk

WMCH = West Melbury Marly Chalk

‘v1\_4’ = relates back to the version of the surface in the GOCAD project.

## 5.1 SOURCE DATA FOR SURFACE CONSTRUCTION

Source datasets used to construct the formational thickness layers comprise:

- NextMap Digital Terrain Model (DTM) at 50 m resolution
- RockHead Elevation Model (RHEM) at 50 m resolution
- DigMapGB 50k Bedrock
- Contours from the Thames Estuary 250k offshore map (Top Chalk only)
- Correlation points from the GSI3D models (Top Chalk only) listed below:
  - Farringdon Station (Aldiss, 2009)
  - Lower Lea Valley Model (Royse, 2006 - 2007)
  - London Lithoframe 50k areas 1 to 14 (Mathers *et al.*, 2005 - 2013)
  - Southern East Anglia (Colchester and Ipswich models; Mathers, 2004 - 2008)
  - Thames Gateway Area 5 (Royse *et al.*, 2006 - 2007)

Contours were derived from these correlation points (using Discrete Spatial Interpolation in GOCAD) which were used to constrain the Top Chalk surface. The position of models in the above list shows order of priority for layer construction; highest in list = highest priority and takes precedence over lower priority models where they overlap. The extent of these models is shown on the BGS Geoscience data Index (GDI) models layer.

- Corporate borehole database (Borehole Geology – BoGe).

## 5.2 WORK FLOW FOR BOGE DATA IN SURFACE CONSTRUCTION

The following describes how data from the corporate Borehole Geology (BoGe) database was used in the construction of the GIS.

1. BoGe queried in MS Access for all boreholes with any mention Chalk (‘CHLK’) in the lithology and formation codes. These initial queries excluded combined formations, for example coded LSNCK, because of long processing times. These combined units can be used for future enhancement of formation surfaces (for example addition of faults).
2. Added Single Onshore Borehole Index (SOBI) data.
3. Added pseudo start height to boreholes using NextMap DTM where boreholes did not have a start height recorded in SOBI.
4. Removed exact duplicates and boreholes not proving formational boundaries.
5. Queried borehole top depth, which is used as the reference for determining formation elevation in boreholes. Terminal depth (TD) of boreholes is not consistently recorded in BoGe.
6. A point shapefile for each formation was exported which contained only the uppermost elevation of that formation recorded in a borehole.

7. The thickness of all Chalk formations in a given borehole was calculated by matching common borehole identifications in the shape files of formations, and subtracting the elevations of adjacent formation-tops, or where the formation is at rockhead, the elevation of rockhead from the elevation of the top of the underlying formation.

### 5.3 WORK FLOW FOR FORMATION SURFACE CONSTRUCTION

This work flow describes the sequence of steps used to derive base-formation surfaces shown on the GIS, beginning with the base of the combined Newhaven Chalk (NCK) and Seaford Chalk (SECK).

1. The derived Top Chalk surface spliced with the DTM and RHEM is used as the control surface from which the combined NCK and SECK formation surface would be constrained.
2. Create an isopachyte contour plot for the NCK/SECK generated from the thickness recorded in the borehole datasets (see 4 above for more information).
3. Isolate and smooth out extreme thickness values in the thickness contours caused by Discrete Smoothing Interpolation (DSI) in GOCAD.
4. Clip thickness contours by outcrop and project area for the combined NCK and SECK formations.
5. Vertically project (drape) the combined NCK and SECK thickness contours onto the Top CK surface.
6. Use the thickness values of the contours (saved as a property) subtracted from the projected elevation value relative to OD given by the Top Chalk surface to give the correct vertical position relative to OD for the base of the combined NCK and SECK.
7. Calculate the elevation of the base of the combined NCK and SECK formations for the whole project area, using an initial 1000 m mesh size. This calculation is based on known thickness contours (converted to OD values) and outcrop OD derived by draping of outcrop onto the RHEM/DTM.
8. Increase the resolution of the calculated base of the combined NCK and SECK surface to a 500 m mesh, using quality control in GOCAD structural workflow.
9. Apply thickness range constraints by assessing the range of thickness values found in boreholes (NCK\_SECK\_V2\_0\_With\_TH\_Merged.shp) to control the depth and thickness of the surface.
10. Apply *fit to points* to tighten the surface against the boreholes picks (in this case the Top\_LECH\_V2\_0 dataset in the Arc and GOCAD projects).
11. Removed cross-overs and smoothed out any anomalies (spikes) caused by the DSI in GOCAD. Some of this is a manual process so not all cross-overs were removed particularly close to outcrop. This explains the majority of negative thicknesses calculated (please see below for more information)
12. Surfaces clipped to combined outcrop and project area in GSI3D or GOCAD
13. Thickness plots generated in ArcGIS (subtracting the elevation of the base of the combined NCK and SECK from the Top Chalk) were lightly assessed for any extreme values and the process of removing cross-overs was repeated (point 11).







This process was repeated sequentially for underlying Chalk formations. Thus, base SECK forms the top control for the LECH.

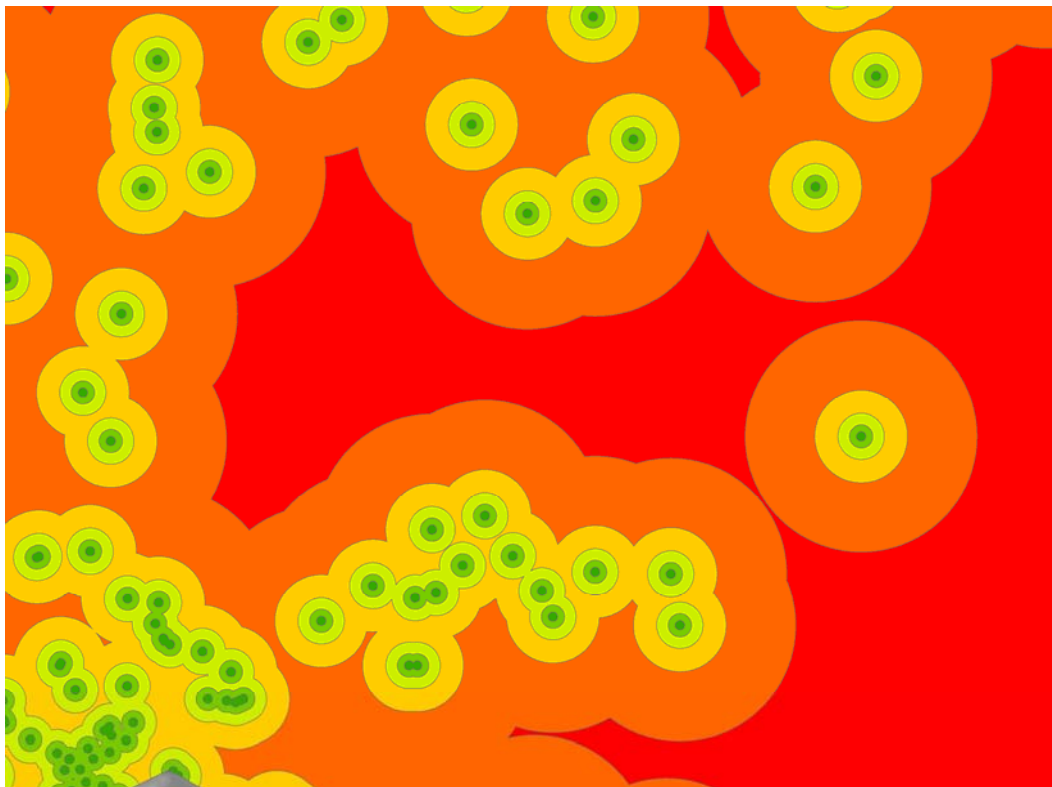
NB: the Version number given to the ESRI grid surfaces in the ArcGIS project are the same version numbers given to the surfaces in the GOCAD project. The GOCAD project can be found here:

W:\Teams\SCCP\ThamesBasin\Data\3D\Chalk\CK\_Formations\CK\_Formations\_V16.gprj

## 5.4 SURFACE CONTROL

For each of the surfaces generated, a borehole control multi-buffer extent was created to show areas in which there was a higher density of boreholes and hence greater borehole control, and those areas that had fewer boreholes controlling the surface. The following categories were generated:

Borehole Control	Distance (metres)	Key
Very High	0 -200	
High	200 – 500	
Medium	500 -1000	
Low	1000 – 2000	
Very Low	2000 – 5000	
Null (little or no borehole control)	Over 5000	



This multi-buffer density distribution plot does not take into account any faulting or folding, so should be used with caution. The distances used are arbitrary and can be refined if necessary. The following datasets were generated:

1. Top\_CK\_BH\_Control
2. Base\_SECK\_BH\_Control
3. Base\_LECH\_BH\_Control

4. Base\_NPCH\_BH\_Control
5. Base\_HCK\_BH\_Control
6. Base\_ZZCH\_BH\_Control
7. Base\_CK\_BH\_Control

The following layer file should be used to visualise the Surface Control layers:

W:\Teams\SCCP\ThamesBasin\Data\3D\Chalk\CK\_Formations\CONFIDENCE\SURFACE CONTROL.lyr

## 6 Calculated formational thicknesses

Based on the calculated formational surfaces shown on the GIS, the following thickness ranges were calculated for each formation:

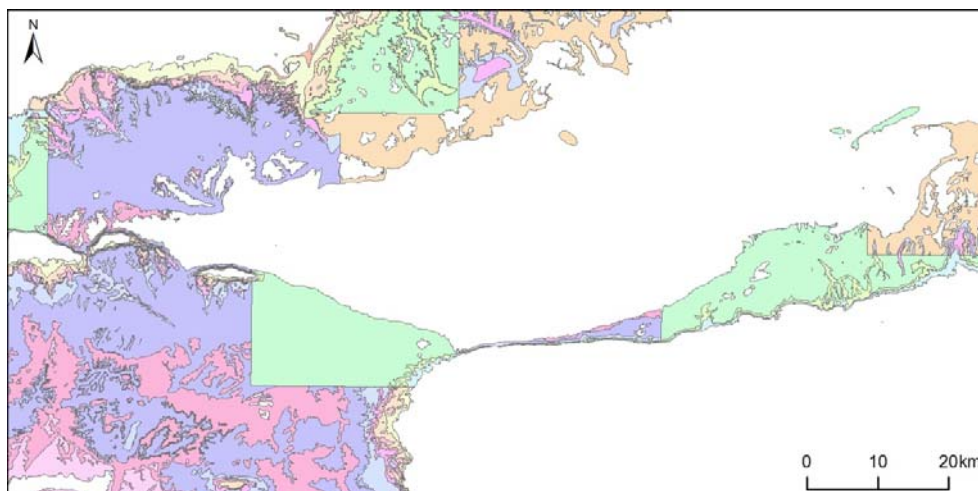
1. Chalk (generally 0 m to 307 m excluding extreme outliers)
2. NCK and SECK combined thickness (generally 0 m to 150 m excluding extreme outliers)
3. LECH (generally 0 m to 65 m excluding extreme outliers)
4. NPCH (generally 0 m to 80 m excluding extreme outliers)
5. HCK (generally 0 m to 50 m excluding extreme outliers)
6. ZZCH (generally 0 m to 60 m excluding extreme outliers)
7. WMCH (generally 0 m to 30 m excluding extreme outliers)
8. White Chalk (generally 0 m to 240 m excluding extreme outliers)
9. Grey Chalk (generally 0 m to 80 m excluding extreme outliers)
10. Upper Chalk (generally 0 m to 160 m excluding extreme outliers)
11. Middle Chalk (generally 0 m to 115m excluding extreme outliers)

Please use the following layer file to visualise these thickness plots:

W:\Teams\SCCP\ThamesBasin\Data\3D\Chalk\CK\_Formations\CHALK\_FORMATION\_THICKNESSES\CHALK THICKNESSES.lyr

## 7 Formational bases

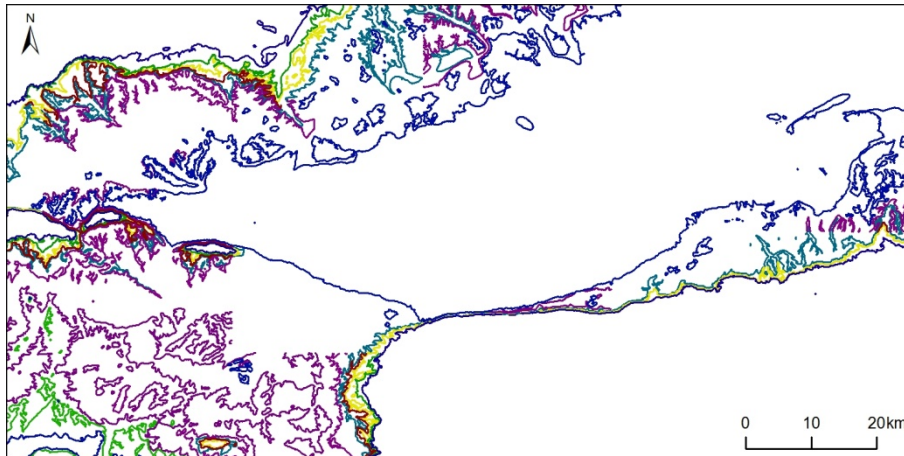
The gb\_50\_bedrock layer is a polygon shapefile which includes formation bases and tops, in addition to many non-geological boundaries between maps of different generations and various combinations of formations. An example of the resulting patchwork of polygons is shown below.



For example, the base Lewes Chalk is included in five different combinations of single or undifferentiated formations is shown below:

10	Polygon	LEWES NODULAR CHALK FORMATION
11	Polygon	LEWES NODULAR CHALK FORMATION AND SEAFORD CHALK FORMATION (UNDIFFERENTIATED)
12	Polygon	LEWES NODULAR CHALK FORMATION, SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)
13	Polygon	LEWES NODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)
14	Polygon	LEWES NODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION, CULVER CHALK FORMATION AND PORTSDOWN CHALK FORMATION (UNDIFFERENTIATED)

For modelling purposes we require only true stratigraphic contacts as polylines (which can be attributed with an elevation value) along formation bases (or formation tops), an example of the desired output which has been processed from the gb\_50\_bedrock map above is shown below. All non-geological contacts have been removed and gb\_50\_bedrock polygons have been processed into polylines along formation bases (or tops).



## 7.1 METHOD

1. Polygons from gb\_50\_bedrock were extracted using GP\_EQ\_D = "CHALK GROUP".
2. Polygons from the output above were dissolved on LEX\_D to remove sheet boundaries and create 36 multipart features for Chalk Formations.

gb_50_ChalkGroupDissolved		
FID	Shape *	LEX_D
0	Polygon	BURNHAM CHALK FORMATION
1	Polygon	CHALK GROUP
2	Polygon	CHALK ROCK MEMBER
3	Polygon	CULVER CHALK FORMATION
4	Polygon	FERRIBY CHALK FORMATION
5	Polygon	FLAMBOROUGH CHALK FORMATION
6	Polygon	GLAUCONITIC MARL MEMBER
7	Polygon	GREY CHALK SUBGROUP
8	Polygon	HOLYWELL NODULAR CHALK FORMATION
9	Polygon	HOLYWELL NODULAR CHALK FORMATION AND NEW PIT CHALK FORMATION (UNDIFFERENTIATED)
10	Polygon	LEWES NODULAR CHALK FORMATION
11	Polygon	LEWES NODULAR CHALK FORMATION AND SEAFORD CHALK FORMATION (UNDIFFERENTIATED)
12	Polygon	LEWES NODULAR CHALK FORMATION, SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)
13	Polygon	LEWES NODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)
14	Polygon	LEWES NODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION, CULVER CHALK FORMATION AND PORTSDOWN CHALK FORMATION (UNDIFFERENTIATED)
15	Polygon	MARGATE CHALK MEMBER
16	Polygon	MELBOURN ROCK MEMBER
17	Polygon	MELBURY SANDSTONE MEMBER
18	Polygon	NEW PIT CHALK FORMATION
19	Polygon	NEWHAVEN CHALK FORMATION
20	Polygon	PORTSDOWN CHALK FORMATION
21	Polygon	ROWE CHALK FORMATION
22	Polygon	SEAFORD CHALK FORMATION
23	Polygon	SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)
24	Polygon	SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)
25	Polygon	SPETISBURY CHALK MEMBER
26	Polygon	STOCKBRIDGE ROCK MEMBER
27	Polygon	TARRANT CHALK MEMBER
28	Polygon	TOP ROCK BED
29	Polygon	TOTTERHOE STONE MEMBER
30	Polygon	WELTON CHALK FORMATION
31	Polygon	WELTON CHALK FORMATION AND BURNHAM CHALK FORMATION (UNDIFFERENTIATED)
32	Polygon	WEST MELBURY MARLY CHALK FORMATION
33	Polygon	WEST MELBURY MARLY CHALK FORMATION AND ZIG ZAG CHALK FORMATION (UNDIFFERENTIATED)
34	Polygon	WEST MELBURY MARLY CHALK FORMATION, ZIG ZAG CHALK FORMATION, HOLYWELL NODULAR CHALK FORMATION AND NEWPIT CHALK FORMATION (UNDIFFERENTIATED)
35	Polygon	WHITE CHALK SUBGROUP
36	Polygon	ZIG ZAG CHALK FORMATION

3. Polygons were converted to a polyline feature class selecting the option to identify and store polygon neighbouring information.



**Polygon To Line**

Input Features

Output Feature Class

☒ Identify and store polygon neighboring information (optional)

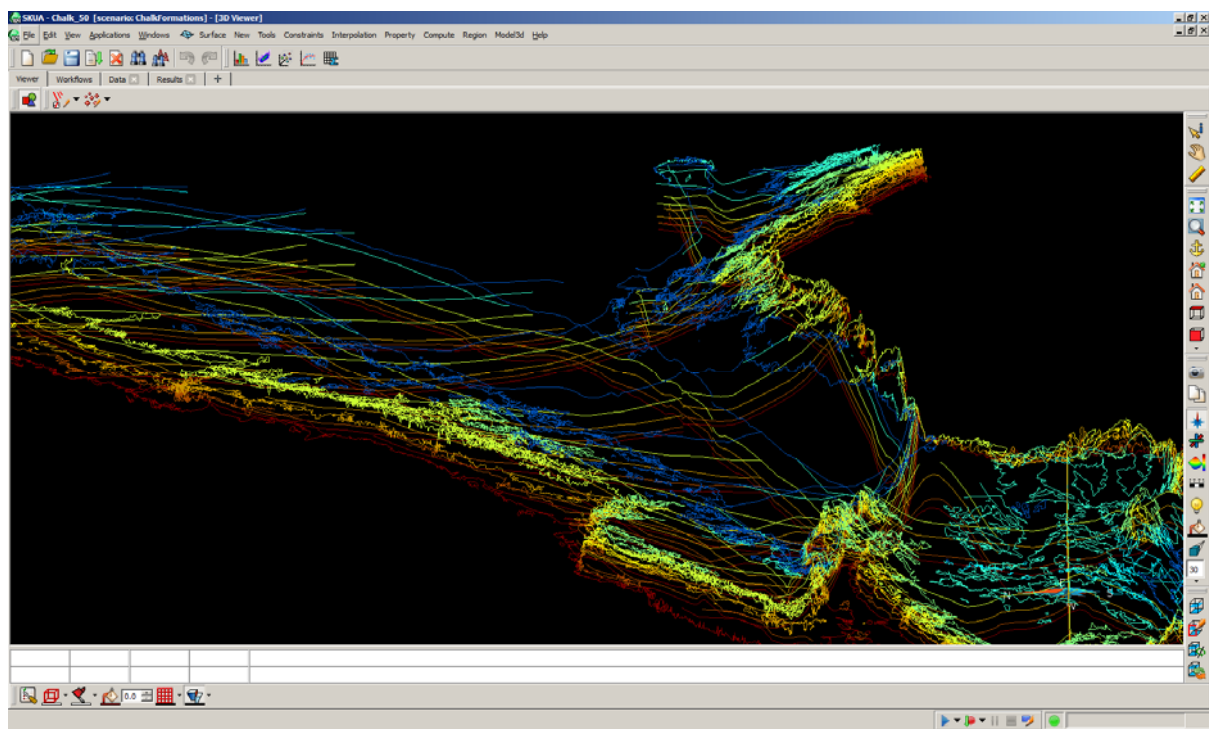
This generated a polyline shapefile with 142 features representing boundaries between different lithostratigraphical units (single or multiple undifferentiated features) or non-geological features.

Chalk Formation (LEXO) on either side of the polyline				
FID	FeatureID	FeatureID	LexID	LexID
1	-1	0	NULL	BURNHAM CHALK FORMATION
2	-1	1	NULL	CHALK GROUP
3	-1	3	NULL	CULVER CHALK FORMATION
4	-1	4	NULL	FERRIBY CHALK FORMATION
5	-1	5	NULL	FLAMBOROUGH CHALK FORMATION
6	-1	6	NULL	GLAUCONITIC MARL MEMBER
7	-1	8	NULL	HOLYWELL MODULAR CHALK FORMATION
8	-1	9	NULL	HOLYWELL MODULAR CHALK FORMATION AND NEW PIT CHALK FORMATION (UNDIFFERENTIATED)
9	-1	10	NULL	LEWES MODULAR CHALK FORMATION
10	-1	11	NULL	LEWES MODULAR CHALK FORMATION AND SEAFORD CHALK FORMATION (UNDIFFERENTIATED)
11	-1	12	NULL	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)
12	-1	13	NULL	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)
13	-1	14	NULL	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION, CULVER CHALK FORMATION AND PORTSDOWN CHALK FORMATION (UNDIFFERENTIATED)
14	-1	15	NULL	MARGATE CHALK MEMBER
15	-1	16	NULL	MELBOURN ROCK MEMBER
16	-1	17	NULL	MELBURY SANDSTONE MEMBER
17	-1	18	NULL	NEW PIT CHALK FORMATION
18	-1	19	NULL	NEWHAVEN CHALK FORMATION
19	-1	20	NULL	PORTSDOWN CHALK FORMATION
20	-1	21	NULL	ROWE CHALK FORMATION
21	-1	22	NULL	SEAFORD CHALK FORMATION
22	-1	23	NULL	SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)
23	-1	24	NULL	SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)
24	-1	25	NULL	SPETSURRY CHALK MEMBER
25	-1	27	NULL	TARRANT CHALK MEMBER
26	-1	30	NULL	WELTON CHALK FORMATION
27	-1	31	NULL	WELTON CHALK FORMATION AND BURNHAM CHALK FORMATION (UNDIFFERENTIATED)
28	-1	32	NULL	WEST MELBURY MARLY CHALK FORMATION
29	-1	33	NULL	WEST MELBURY MARLY CHALK FORMATION AND ZIG ZAG CHALK FORMATION (UNDIFFERENTIATED)
30	-1	34	NULL	WEST MELBURY MARLY CHALK FORMATION, ZIG ZAG CHALK FORMATION, HOLYWELL MODULAR CHALK FORMATION AND NEW PIT CHALK FORMATION (UNDIFFERENTIATED)
31	-1	35	NULL	WHITE CHALK SUBGROUP
32	-1	36	NULL	ZIG ZAG CHALK FORMATION
33	5	0	FLAMBOROUGH CHALK FORMATION	BURNHAM CHALK FORMATION
34	9	2	HOLYWELL MODULAR CHALK FORMATION AND NEW PIT CHALK FORMATION (UNDIFFERENTIATED)	CHALK ROCK MEMBER
35	9	7	HOLYWELL MODULAR CHALK FORMATION AND NEW PIT CHALK FORMATION (UNDIFFERENTIATED)	GREY CHALK SUBGROUP
36	9	8	HOLYWELL MODULAR CHALK FORMATION AND NEW PIT CHALK FORMATION (UNDIFFERENTIATED)	HOLYWELL MODULAR CHALK FORMATION
37	10	2	LEWES MODULAR CHALK FORMATION	CHALK ROCK MEMBER
38	10	8	LEWES MODULAR CHALK FORMATION	HOLYWELL MODULAR CHALK FORMATION
39	10	9	LEWES MODULAR CHALK FORMATION	HOLYWELL MODULAR CHALK FORMATION AND NEW PIT CHALK FORMATION (UNDIFFERENTIATED)
40	11	2	LEWES MODULAR CHALK FORMATION AND SEAFORD CHALK FORMATION (UNDIFFERENTIATED)	CHALK ROCK MEMBER
41	11	10	LEWES MODULAR CHALK FORMATION AND SEAFORD CHALK FORMATION (UNDIFFERENTIATED)	LEWES MODULAR CHALK FORMATION
42	12	2	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)	CHALK ROCK MEMBER
43	12	9	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)	HOLYWELL MODULAR CHALK FORMATION AND NEW PIT CHALK FORMATION (UNDIFFERENTIATED)
44	12	10	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)	LEWES MODULAR CHALK FORMATION
45	13	2	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)	CHALK ROCK MEMBER
46	13	9	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)	HOLYWELL MODULAR CHALK FORMATION AND NEW PIT CHALK FORMATION (UNDIFFERENTIATED)
47	13	10	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)	LEWES MODULAR CHALK FORMATION
48	13	11	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)	LEWES MODULAR CHALK FORMATION AND SEAFORD CHALK FORMATION (UNDIFFERENTIATED)
49	14	9	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)	HOLYWELL MODULAR CHALK FORMATION AND NEW PIT CHALK FORMATION (UNDIFFERENTIATED)
50	14	10	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)	LEWES MODULAR CHALK FORMATION
51	14	13	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)
52	16	8	MELBOURN ROCK MEMBER	HOLYWELL MODULAR CHALK FORMATION
53	16	9	MELBOURN ROCK MEMBER	HOLYWELL MODULAR CHALK FORMATION AND NEW PIT CHALK FORMATION (UNDIFFERENTIATED)
54	17	8	MELBURY SANDSTONE MEMBER	HOLYWELL MODULAR CHALK FORMATION
55	18	2	NEW PIT CHALK FORMATION	CHALK ROCK MEMBER
56	18	8	NEW PIT CHALK FORMATION	HOLYWELL MODULAR CHALK FORMATION
57	18	9	NEW PIT CHALK FORMATION	HOLYWELL MODULAR CHALK FORMATION AND NEW PIT CHALK FORMATION (UNDIFFERENTIATED)
58	18	10	NEW PIT CHALK FORMATION	LEWES MODULAR CHALK FORMATION
59	18	11	NEW PIT CHALK FORMATION	LEWES MODULAR CHALK FORMATION AND SEAFORD CHALK FORMATION (UNDIFFERENTIATED)
60	18	12	NEW PIT CHALK FORMATION	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)
61	18	14	NEW PIT CHALK FORMATION	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION, CULVER CHALK FORMATION AND PORTSDOWN CHALK FORMATION (UNDIFFERENTIATED)
62	19	3	NEWHAVEN CHALK FORMATION	CULVER CHALK FORMATION
63	19	8	NEWHAVEN CHALK FORMATION	HOLYWELL MODULAR CHALK FORMATION
64	19	10	NEWHAVEN CHALK FORMATION	LEWES MODULAR CHALK FORMATION
65	19	12	NEWHAVEN CHALK FORMATION	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)
66	19	13	NEWHAVEN CHALK FORMATION	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)
67	19	14	NEWHAVEN CHALK FORMATION	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION, CULVER CHALK FORMATION AND PORTSDOWN CHALK FORMATION (UNDIFFERENTIATED)
68	19	18	NEWHAVEN CHALK FORMATION	NEW PIT CHALK FORMATION
69	20	3	PORTSDOWN CHALK FORMATION	CULVER CHALK FORMATION
70	20	10	PORTSDOWN CHALK FORMATION	LEWES MODULAR CHALK FORMATION
71	20	14	PORTSDOWN CHALK FORMATION	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION, CULVER CHALK FORMATION AND PORTSDOWN CHALK FORMATION (UNDIFFERENTIATED)
72	20	19	PORTSDOWN CHALK FORMATION	NEWHAVEN CHALK FORMATION
73	21	5	ROWE CHALK FORMATION	FLAMBOROUGH CHALK FORMATION
74	22	2	SEAFORD CHALK FORMATION	CHALK ROCK MEMBER
75	22	3	SEAFORD CHALK FORMATION	CULVER CHALK FORMATION
76	22	8	SEAFORD CHALK FORMATION	HOLYWELL MODULAR CHALK FORMATION
77	22	9	SEAFORD CHALK FORMATION	HOLYWELL MODULAR CHALK FORMATION AND NEW PIT CHALK FORMATION (UNDIFFERENTIATED)
78	22	10	SEAFORD CHALK FORMATION	LEWES MODULAR CHALK FORMATION
79	22	12	SEAFORD CHALK FORMATION	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)
80	22	13	SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)
81	22	14	SEAFORD CHALK FORMATION	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)
82	22	15	SEAFORD CHALK FORMATION	MARGATE CHALK MEMBER
83	22	18	SEAFORD CHALK FORMATION	NEW PIT CHALK FORMATION
84	22	19	SEAFORD CHALK FORMATION	NEWHAVEN CHALK FORMATION
85	23	8	SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)	HOLYWELL MODULAR CHALK FORMATION
86	23	9	SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)	HOLYWELL MODULAR CHALK FORMATION AND NEW PIT CHALK FORMATION (UNDIFFERENTIATED)
87	23	10	SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)	LEWES MODULAR CHALK FORMATION
88	23	11	SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)
89	23	12	SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)
90	23	13	SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)
91	23	14	SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)	LEWES MODULAR CHALK FORMATION, SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION, CULVER CHALK FORMATION AND PORTSDOWN CHALK FORMATION (UNDIFFERENTIATED)
92	23	18	SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)	NEW PIT CHALK FORMATION
93	23	19	SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)	NEWHAVEN CHALK FORMATION
94	23	20	SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)	PORTSDOWN CHALK FORMATION
95	23	22	SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)	SEAFORD CHALK FORMATION
96	24	10	SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)	LEWES MODULAR CHALK FORMATION
97	24	20	SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)	PORTSDOWN CHALK FORMATION
98	24	23	SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)	SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)
99	24	25	SEAFORD CHALK FORMATION, NEWHAVEN CHALK FORMATION AND CULVER CHALK FORMATION (UNDIFFERENTIATED)	SEAFORD CHALK FORMATION AND NEWHAVEN CHALK FORMATION (UNDIFFERENTIATED)

These were manually sorted and selected to provide true stratigraphic contacts for the Chalk Formations shown below:

BaseBurnhamChalk.shp	03/09/2013 12:18	SHP File	110 KB
BaseCulverChalk.shp	03/09/2013 13:30	SHP File	271 KB
BaseFlamboroughChalk.shp	03/09/2013 12:12	SHP File	28 KB
BaseHolywellNodularChalk.shp	03/09/2013 12:06	SHP File	1,022 KB
BaseLewesNodularChalk.shp	03/09/2013 12:01	SHP File	1,600 KB
BaseMargateChalk.shp	03/09/2013 12:14	SHP File	99 KB
BaseNewhavenChalk.shp	03/09/2013 12:16	SHP File	556 KB
BaseNewPitChalk.shp	03/09/2013 12:13	SHP File	715 KB
BasePortsdown.shp	03/09/2013 13:34	SHP File	84 KB
BaseSeafordChalk.shp	03/09/2013 12:09	SHP File	1,131 KB
BaseWeltonChalk.shp	03/09/2013 12:18	SHP File	8 KB
BaseWestMelburyMarlyChalk.shp	03/09/2013 13:46	SHP File	599 KB
BaseZigZagBaseChalk.shp	03/09/2013 13:48	SHP File	244 KB
BaseZigZagChalk.shp	03/09/2013 12:11	SHP File	457 KB
TopChalk.shp	03/09/2013 14:31	SHP File	1,969 KB

Polyline shapefiles were imported to SKUA (Subsurface Knowledge Unified Approach; a 3D modelling package that uses 'stratigraphical rules' to import and integrate a wide variety of 3D data) and given a Z-attribution using the BGS bald earth digital terrain model.



The Z-attributed linework is shown above with Chalk Group cross-section picks from the NGM GB model. The two datasets can be used to generate a preliminary Chalk structural model.

## 8 Structural Data

The following shapefiles have been created and added to the Thames Chalk Information System:

1. All Structural data
2. Revised/synthesised fault network

The source data for the creation of these files are published papers and BGS reports, 3D models and maps. Much of these data are summarised by Haslam (in prep.), which also provides a list of reference sources for individual structures recognised in the project area.

The first layer ('Filtered structures (V1)') contains all the data available at the time of compilation including known structures in the deeper bedrock where no data is available for the Chalk. The lineaments represent either faults or the axial plane traces of folds. The category of each structure is revealed in the 'Identify' window when specific lineaments are interrogated in the GIS. No additional interpretation of the extent of lineaments is made in this layer.

The second layer ('Filtered structures V10') represents both a *simplification* and an *interpretation* of the first layer, focussing on the larger faults within in the Chalk; it comprises the known distribution of the larger faults seen in the first layer, and their inferred lateral extent based on further structural analysis. Simplification involved removal of duplicate faults, and faults smaller than approximately 2 km. Interpretation involved the linking and extension of the remaining larger fault structures. The methodology for analysing the behaviour of structures used colour-coded depth surfaces for the Top and Base Chalk, as well as borehole markers colour-coded for depth. Combining these data allowed correction for inconsistencies produced by incorrect or apparently incorrect borehole tops, and changes to lithostratigraphical surfaces that are not related to the constraining borehole data. Colour scales on the surfaces were varied to highlight as many changes within the surface as possible, especially in areas where the surface appears uniform due to censoring of the data by a particular colouring methodology. This is particularly important near surface boundaries and in deep sections. Modification of the depth-coded colour range for lithostratigraphical surfaces also allowed identification of structures in apparently uniform parts of surfaces, otherwise masked because the scale of the structures is below the threshold variation of the selected colour-scale.

Finally, to consolidate the lateral correlation of fault lineaments, the 1<sup>st</sup> vertical derived Bouguer anomaly gravity surface was modelled to the base of the Mesozoic succession. The Bouguer anomaly surface shows clear linear trends which match with published faults, allowing its use as a robust guide for projection of faults into areas with little to no data.

## 9 Chalk Stratigraphy Information

Chalk Group stratigraphy information in the TCIS comprises: boreholes with interpretations of Chalk Group stratigraphy held in the Borehole Geology (BoGE) database; distribution and bibliographic reference source of illustrated outcrop sections and boreholes; Chalk localities that have descriptions of detailed lithostratigraphy and biostratigraphy in publications and reports; distribution of key hardground units described by Bromley and Gale (1982) in the Lewes Nodular Chalk Formation.

### 9.1 BOREHOLE STRATIGRAPHY

Borehole stratigraphy information is contained in the 'Geophysical logs and cored boreholes layer', and comprises 333 data points. The layer shows the distribution of boreholes for which reliable Chalk stratigraphical interpretations exist in the BGS Borehole Geology (BoGe) database. Details of the SOBI index number for the relevant borehole are accessed by interrogation of data points with the Arc information tool. The SOBI index number can be used to search and view interpretations in BoGe. Access to BoGe requires an Oracle ID and interpreter code arranged through SNS and Ken Lawrie (Murchison House, BGS Edinburgh). Where interpretations are based on geophysical logs, access to the primary log data is either through RECALL (corporate archive for digital log data; information from Sandy Henderson, Murchison House, BGS Edinburgh) or the Intranet Data Access (IDA) at [http://bgsintranet/scripts/ida/menus/Geophys\\_data\\_menu.cfm](http://bgsintranet/scripts/ida/menus/Geophys_data_menu.cfm) for non-digital data. In both cases,

the SOBI number is the search key for accessing data for individual boreholes. These borehole interpretations provide primary control points for many of the 3D models of the Chalk in the Thames Basin. Assigned numerical values for each formation-base in BoGe indicate relative interpretation confidence.

## **9.2 OUTCROP SECTIONS AND BOREHOLES**

A wide range of publications, particularly BGS technical reports, illustrate outcrop sections and cored boreholes in the Chalk Group of the London Basin. This information is contained in the 'Illustrated sections and boreholes' layer, comprising 217 data points. These sections contain a wealth of data that is not captured by the geological map, such as the relative development of lithological features, biozonal data, and the presence of named marker beds that are of value for long-range correlation. Interrogation of individual data points with the Arc information tool reveals the source publication for accessing the illustrated information at the data-point location. Cited non-BGS publications are available through the BGS library. Access to BGS technical reports is through paper archives held in NGRC (National Geoscience Records Centre) or scanned archives. BGS library and NGRC staff can provide information about access to digital and hardcopy report collections. Digital availability of reports is incomplete because many were originally classified as restricted, and only title pages were available for archive by the BGS library.

## **9.3 CHALK SAMPLE LOCALITIES**

In the course of geological mapping, BGS has amassed vast biostratigraphical collections for the Chalk Group. The purpose of the collections is to provide control and evidence for the geological boundaries depicted on published maps. In many cases biostratigraphical data allows classification of the Chalk at a level of greater refinement than shown on geological maps, and can also provide information about the likely development of marker-beds that are important for long-range correlation. Data for macro-fossil sample sites in the London Basin is given in the 'Chalk localities (biostratigraphy/lithostratigraphy)' layer, and comprises 775 data points. BGS also has data for micro-fossil collections from the Chalk, but time constraints prevented inclusion of these in the data compilation.

Interrogation of individual data points using the Arc information tool reveals the source reference providing detailed information about Chalk stratigraphy at the data point location. Many of these reports are BGS technical reports spanning the last 20 years. These reports include re-evaluations of older, historical collections of macrofossils as well as material collected since the 1990s. Access to BGS technical reports is through paper archives held in NGRC or scanned archives. BGS library and NGRC staff can provide information about access to digital and hardcopy report collections. Digital availability of reports is incomplete because many were originally classified as restricted, and only title pages were available for archive by the BGS library.

## **9.4 LEWES NODULAR CHALK FORMATION HARDGROUNDS**

Work by Bromley and Gale (1982) described the stratigraphical and spatial development of hardgrounds in strata equivalent to the lower and middle parts of the Lewes Nodular Chalk Formation. Traditionally, these hardgrounds have been grouped into those forming the 'Chalk Rock' and those forming the 'Top Rock'. Bromley and Gale (1982) showed that three suites of hardgrounds (Lower, Middle and Upper Suite) comprise the 'Chalk Rock' (= Chalk Rock Member of current BGS terminology; Hopson, 2005), and that the development of these suites of hardgrounds is laterally variable. Stratigraphical details of the hardgrounds and their correlation are provided by Bromley and Gale (1982). The significance of these hardgrounds is that they affect the continuity of the preserved stratigraphy, so lateral variability in the development of hardgrounds occupying different stratigraphical horizons results in significant lateral changes in

the character of the preserved Lewes Nodular Chalk succession. The spatial extent of the individual suites of hardgrounds is shown in three layers: 'Lower Hardground Suite', 'Middle Hardground Suite', and 'Upper Hardground Suite'. Sites where Bromley and Gale (1982) identified hardgrounds comprising the 'Top Rock' (= Top Rock Bed of current BGS terminology; Hopson, 2005) are shown by the 'Top Rock' layer. The Top Rock Bed appears to have a more restricted spatial development than the Chalk Rock Member, and this may be significantly related to features of basin architecture.

## 9.5 3D GEOLOGICAL MODELS

The TCIS includes a layer showing the extent of 3D geological models covering parts of the Thames Basin. The key models are as follows:

- o Farringdon Station  
 Author: Aldiss, D T  
 Date: 2009  
 Key Reference: Aldiss et al. (2012)  
 Limitation: Covers a small geographical area (4Km<sup>2</sup>)
  
- o Lower Lea Valley Model  
 Author: Royse, K.  
 Date: 2006 – 2007  
 Key Reference: Royse et al. (2006)  
 Limitation: Focussed primarily on the Quaternary and Lambeth Group strata. Still to be approved.
  
- o London Lithoframe 50k areas 1 to 14  
 Authors: Mathers, S J, Burke, H, Thopre, S, Ford, J, Cripps, C, Terrington, R.  
 Date: 2005 to 2013  
 Reference: Ford et al. (2008).  
 Limitation: Modelled at 1:50 000 scale. Many boreholes considered but not all used for the modelling so may miss some key boreholes that prove the top of the Chalk. Some areas, lacking borehole coverage, infer top Chalk using thickness and local knowledge provided by memoirs and map sheets.
  
- o Southern East Anglia (Colchester and Ipswich models)  
 Author: Mathers, S J.  
 Date: 2004 to 2008  
 References: Mathers, S J. (2012a, b)  
 Limitations: Modelled at 1:50 000 scale. Many boreholes considered but not all used for the modelling so may miss some key boreholes that prove the top of the Chalk. Some areas, lacking borehole coverage, infer top Chalk using thickness and local knowledge provided by memoirs and map sheets.
  
- o Thames Gateway Area 5  
 Author: Royse, K.  
 Date: 2007  
 Reference: Royse et al. (2008)  
 Limitations: Modelled at 1:50 000 scale. Many boreholes considered but not all used for the modelling so may miss some key boreholes that prove the top of the Chalk. Some areas, lacking borehole coverage, infer top Chalk using thickness and local knowledge

provided by memoirs and map sheets. Will soon to be superceded by the London LithoFrame 50k modelling.

## 10 Data limitations

- Some minor negative thickness values near the outcrop margin of the Chalk result from contrasts between the high-resolution survey data available for controlling the Top Chalk surface compared to the more generalised data used to generate formational surfaces. These negative values have been manually edited out as far as practicable. Negative thickness values are also generated by erroneous cross-over (i.e. intersection) of calculated formational surfaces close to the outcrop margin of formations; these have been reduced but not entirely eliminated (**5.3**, bullet 11, above).
- When gridding the formational surfaces, some detail has been lost where formation outcrops were constrained at a resolution of 50 m, but modelled at a mesh resolution of 500 m. Some cross-over of formational surfaces may occur in these areas.
- A number of borehole checks have been performed on the Top and Base Chalk datasets to remove duplicates, check start heights and query Top Chalk and Base Chalk levels. These procedures were not repeated at formation level.

## 11 Recommendations for future improvements to the TCIS

- Further refine formation surfaces by addition of faults.
- Thickness data are based on true formational thickness values, using boreholes containing formational contacts. It would be useful to incorporate all boreholes that proved a minimum thickness of a chalk formation to ensure that the surfaces are constrained by these depths.
- Incorporate data from boreholes where Chalk formations have been coded as combined units, for example, LSNCK (= Lewes Nodular, Seaford and Newhaven Chalk).  
Location of these additional data:  
W:\Teams\SCCP\ThamesBasin\Data\3D\Chalk\CK\_Formations\ADDITIONAL\_DATA
- The Borehole Control layer can be further enhanced by scoring the buffers (e.g. 5 = Very High and 1 = Very Low, as used in Geosure and SuDS) and then appropriately adjusting the buffer scores where they overlap.

## 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: <http://geolib.bgs.ac.uk>.

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Stage	Biozonation					Traditional Subdivisions	Subgroup	Lithostratigraphy							
CAMPANIAN	<i>O. pilula</i>					U p p e r C h a l k	W h i t e C h a l k	Newhaven Chalk							
SANTONIAN	<i>U. anglicus</i>							M i d d l e C h a l k	G r e y C h a l k	Seafood Chalk Formation					
	<i>M. testudinarius</i>														
	<i>U. socialis</i>														
CONIACIAN	<i>M. coranguinum</i>									L o w e r C h a l k	G r e y C h a l k	Lewes Nodular Chalk			
	<i>M. cortestudinarium</i>														
TURONIAN	<i>P. (S.) plana</i>											C h a l k M a r l		New Pit Chalk	
	<i>T. lata</i>														Holywell Nodular Chalk
CENOMANIAN	<i>N. juddii</i>					G r e y C h a l k								(Plenus Marls Member)	
	<i>M. geslinianum</i>														Zig Zag Chalk Formation
	<i>C. guerangeri</i>							West Melbury Marly Chalk Fmn.							
	<i>A. jukesbrownei</i>														
	<i>A. rhotomagensis</i>		<i>T. acutus</i>												
			<i>T. costatus</i>												
	<i>C. inerme</i>														
	<i>M. dixonii</i>														
	<i>M. mantelli</i>		<i>M. saxbii</i>												
			<i>S. schluteri</i>												
<i>N. carcitanense</i>															

← Top Rock (variable)

Chalk Rock (variable)

← Melbourn Rock

Top Rock (variable)

Chalk Rock (variable)

**Table 1.** The stratigraphy of the Chalk Group referred to in this report and used in the Thames Chalk Information System (TCIS) (not to scale)