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Model metadata report for Manchester and Salford, NW England

Land Use Planning and Development Programme

Open Report OR/12/068

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Price, S J, Kessler, H, Burke, H F, Hough, E and Reeves, H J

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British Geological Survey offices

BGS Central Enquiries Desk
Tel 0115 936 3143 Fax 0115 936 3276
email enquiries@bgs.ac.uk

Kingsley Dunham Centre, Keyworth, Nottingham NG12 5GG
Tel 0115 936 3241 Fax 0115 936 3488
email sales@bgs.ac.uk

Murchison House, West Mains Road, Edinburgh EH9 3LA
Tel 0131 667 1000 Fax 0131 668 2683
email scotsales@bgs.ac.uk

Natural History Museum, Cromwell Road, London SW7 5BD
Tel 020 7589 4090 Fax 020 7584 8270
Tel 020 7942 5344/45 email bgslondon@bgs.ac.uk

Columbus House, Greenmeadow Springs, Tongwynlais, Cardiff CF15 7NE
Tel 029 2052 1962 Fax 029 2052 1963

Maclean Building, Crowmarsh Gifford, Wallingford OX10 8BB
Tel 01491 838800 Fax 01491 692345

Geological Survey of Northern Ireland, Colby House, Stranmillis Court, Belfast BT9 5BF
Tel 028 9038 8462 Fax 028 9038 8461

www.bgs.ac.uk/gsni/

Parent Body

Natural Environment Research Council, Polaris House, North Star Avenue, Swindon SN2 1EU
Tel 01793 411500 Fax 01793 411501
www.nerc.ac.uk

Website www.bgs.ac.uk
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Foreword

This report is the published product of a study by the British Geological Survey (BGS). It describes the data and information required for the approval of a 3D geological model of Manchester and Salford. The 3D geological model of Manchester and Salford forms part of the wider Lower Mersey Corridor development zone, NW England.

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Summary

This report describes the creation of a 3D geological model of natural and artificial superficial deposits in Manchester and Salford, NW England. The Manchester and Salford model forms part of the Lower Mersey Corridor, NW England. The Lower Mersey Corridor includes models within the region comprising:

- Manchester-Salford
- Warrington
- Liverpool
- Irlam

The location of the geological models is shown in Figure 1 and the spacing of cross-sections is shown in Figure 2.

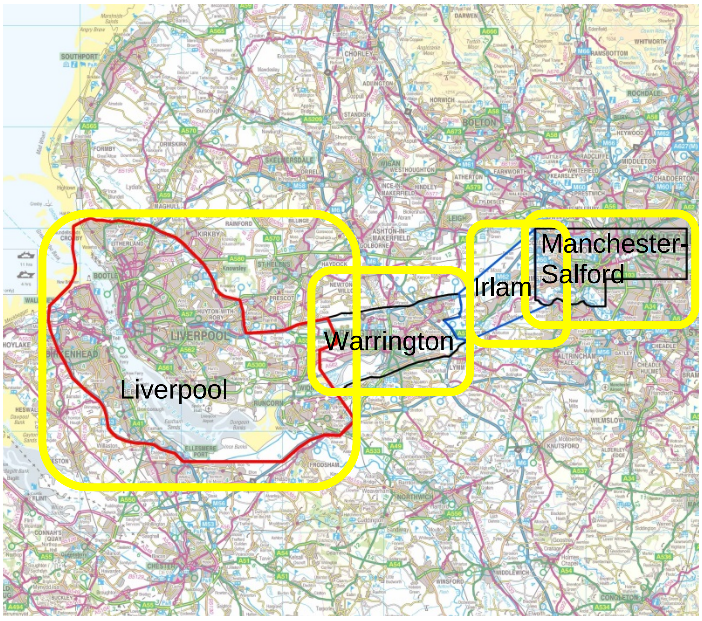

Figure 1 Location of Manchester and Salford 3D geological model and its relationship to others in the Lower Mersey Corridor area of NW England.

The 3D models include natural and artificial superficial deposits. Cross-sections for Manchester and Salford include schematic bedrock correlations for illustration only. Bedrock is not included in the calculated model

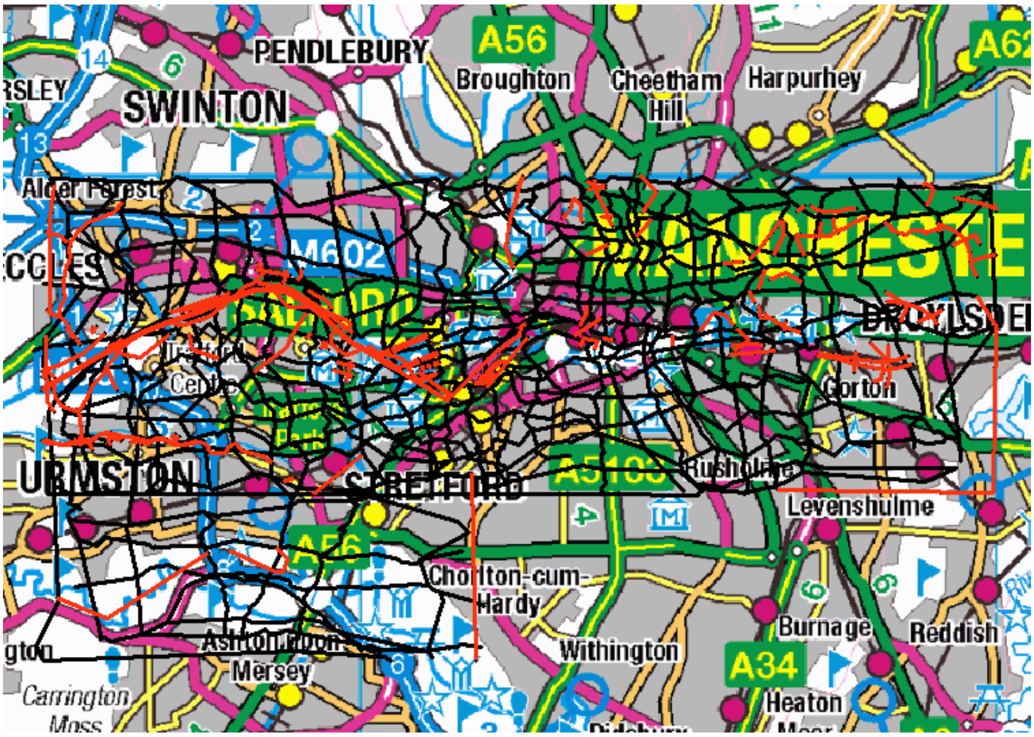

Figure 2 Distribution of geological cross-sections used to construct the Manchester and Salford 3D geological model.

Cross-sections in red indicate helper sections used to aid calculation of complex or thin artificial and natural superficial deposits

1 Modelled volume, purpose and scale

Metadata for the Manchester and Salford model is available in the 3D Modelling System.

Model	Metadata ID	Related reports or publications
Manchester-Salford	13602968	Bridge, D M, Butcher, A, Hough, E, Kessler, H, Lelliott, M Price, S J, Reeves, H J, Tye, A M, Wildman, G and Brown, S. 2010. Ground conditions in central Manchester and Salford: the use of the 3D geoscientific model as a basis for decision support in the built environment Price, S J, Bridge, D, Kessler, H and Terrington R. 2007. The Manchester and Salford 3-D Superficial Deposits Model: a guide to the model and its applications

The model area covers an area of 75km^2 in central Manchester and Salford, including Trafford Park. The Manchester and Salford area is underlain by a complex sequence of superficial deposits comprising glacial, post-glacial and anthropogenic (man-made) material. For example, the area beneath Trafford Park is characterised by over 40 m of superficial material infilling an incised valley cut into the underlying bedrock. The geological model includes the top, base and thickness for each natural and artificial superficial deposit within the area.

The geological model was developed for the purpose of characterising lithological variability within superficial deposits and depth to rockhead. It is intended to be used for the assessment of engineering geological and geological ground conditions and their influence on aquifer vulnerability and recharge potential. The model, in part, was developed in partnership with the Environment Agency for that purpose. The 3D geological model is not intended as a replacement for invasive ground investigation. It provides an additional tool for the development of a conceptual ground model in Manchester and Salford.

The model was constructed to be compatible with, and equivalent to, a detailed 1:10 000 scale geological map. The model therefore includes geological units that would normally be resolved at 1:10 000 scale.

2 Modelled surfaces/volumes

Figure 3 shows the schematic relationships of superficial deposits in the Manchester and Salford area.

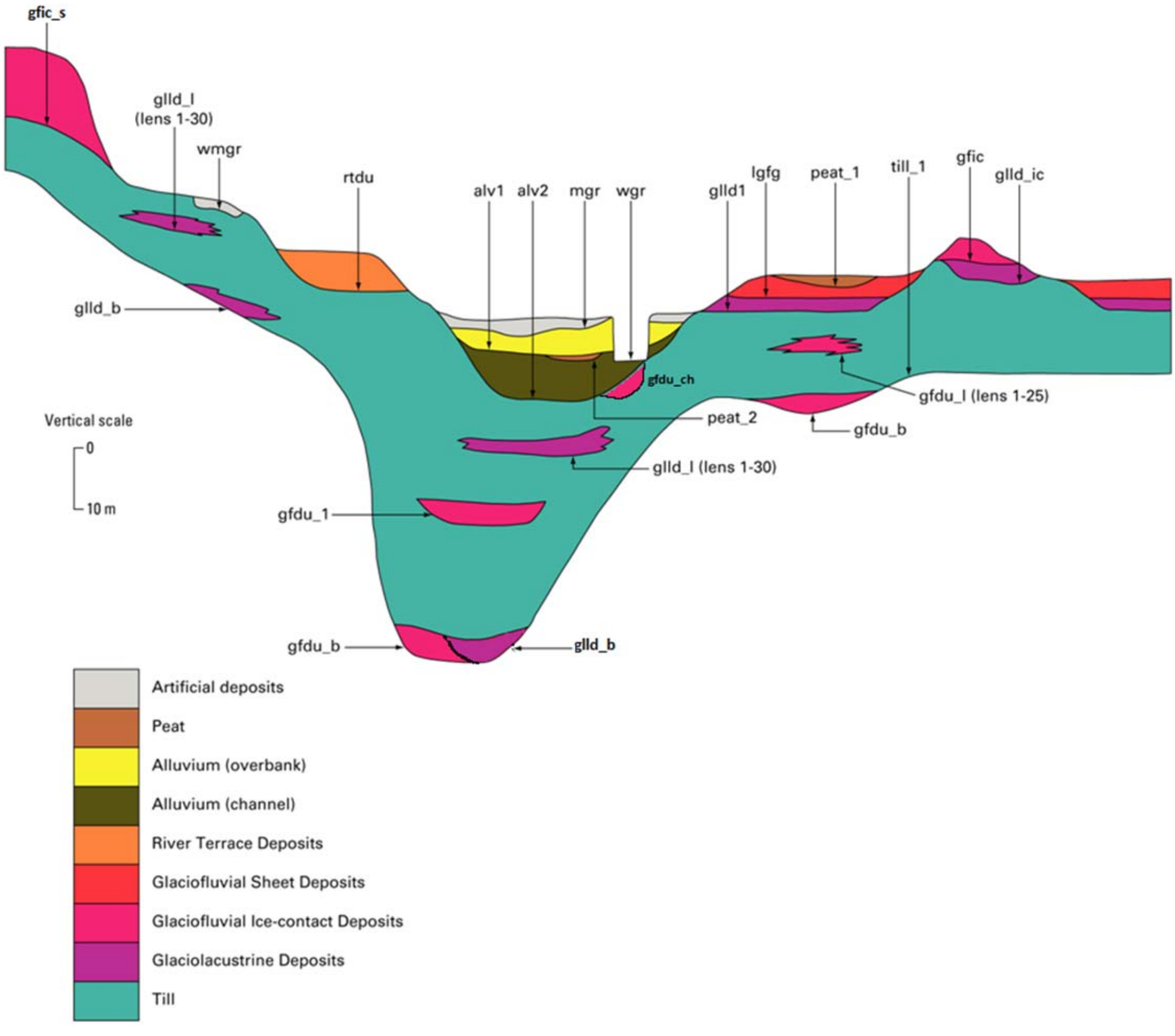

Figure 3 Schematic relationship of superficial deposits within the Manchester and Salford 3D model

Table 1 summarises the individual and groups of superficial deposits within the Manchester and Salford model.

	Map unit	Model unit	Lithology	Environment (inferred)	Model notation
Holocene	**Worked Ground**	WORKED GROUND (MANCHESTER SHIP CANAL)		Anthropogenic (Artificial ground)	WGR_CNL
	Made Ground	MADE GROUND	Mixed (see Table 2)		MGR
	Infilled Ground	INFILLED GROUND	Mixed (see Table 2)		WMGR
	Peat (lowland bog)	PEAT	Peat	Organic	PEAT_1
	Alluvium	OVERBANK FLOODPLAIN DEPOSITS Peat	Silt, clay, Peat Peat lens within Alluvium	Fluvial	ALV_1 PEAT2 PEAT_ALV1
		RIVER CHANNEL DEPOSITS	Sand, gravel	(may include glaciofluvial element)	ALV_2
	River Terraces: Undivided, First Second	RIVER TERRACE DEPOSITS (UNDIVIDED) (River Irwell, River Medlock)	Sand, gravel	Fluvial/Ice marginal	RTDU,
Pleistocene (Devensian)	**Glaciofluvial Sheet Deposits:** Sheet deposits (formerly Late Glacial Flood Gravels)	1. SHEET DEPOSITS (including Late Glacial Flood Gravels) 2. BASAL SAND AND GRAVEL	Sand, gravel	High level terrace	LGFG GFDU_B
	Ice-contact Deposits	1 Buile Hill deposits 2. Intra-till channel deposits (major) 3. Intra-till lens and sheet deposits (minor)	Loose, fine sands Sand, gravel	Ice-contact glaciofluvial/ glaciolacustrine Sub/supra glacial drainage	GFIC_S GFDU_1 GFDU_CH GFDU_1(1-25) and GFDU_2_L (1-11) and 100, 101 102 and 103
	Glaciolacustrine Deposits	1 LATERALLY EXTENSIVE (KM-SCALE DEPOSITS) 2. Intra-till deposits (restricted distribution) 3. Deformed deposits	Laminated silts	Ice-distal Ice-proximal Ice-contact ?push moraine Ice distal?	GLLD_1 GLLD_L(1-20) and GLLD_2(1-11 and 100-101)GLLD_IC GLLD_B
		Moraine complex Till, sand and laminated clay, undivided	Till, sand, gravel,	?Push moraine	GFIC
	Till	TILL	Till, interbedded sands, impersistent laminated clays	Lodgement and melt-out tills, undivided	TILL_1,
Bedrock					BEDROCK

Table 1 Summary of modelled geological units in the 3D geological model

NB. Table is not in stratigraphical or model GVS order but is organised by genesis to indicate relationships.

Figure 5 shows a screen capture from GSI3D listing all superficial units that have been modelled (from GVS file Manchester_GVS_V3.3.gvs), it is apparent how many lenses were delineated, as discussed in this report many of those have been be rationalised and merged in the model outputs.

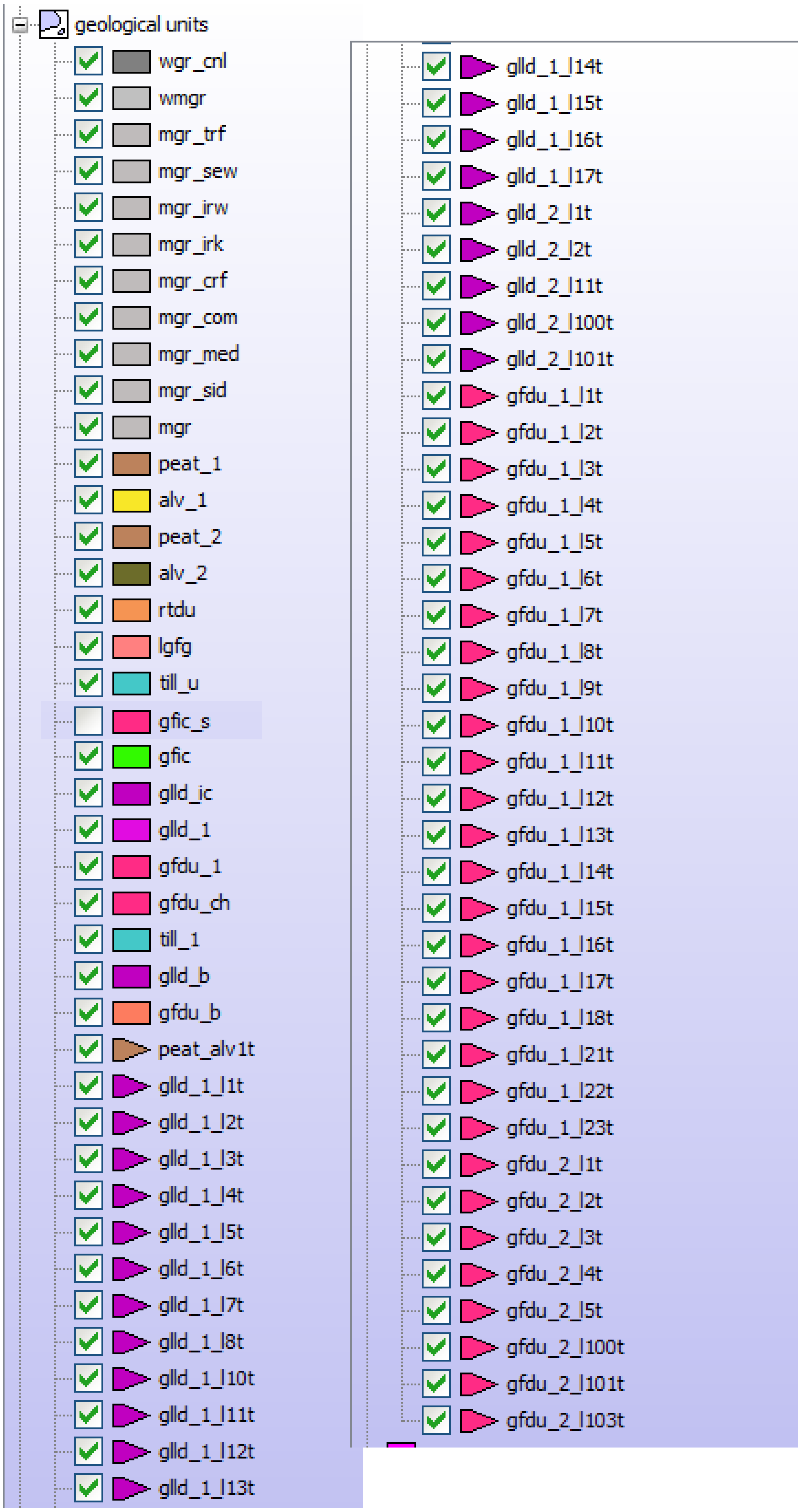

Figure 5 Screenshot from GSI3D listing all superficial units in the model

	Category	Thickness	Composition	Model notation
Made Ground	1 Undivided 60% coverage of the district	Typically 1 to 2 m, locally 3 to 7 m in Manchester and Salford city centres	Variable mix of construction waste (demolition rubble) and material associated with commercial, industrial and residential infrastructure, processes and waste streams. It is probable that both inert and hazardous materials are present.	mgr
	2 River Irwell Meander loops of the River Irwell, infilled during construction of the Manchester Ship Canal	Typically 3 to 7 m but commonly >8 m around Salford Quays	Colliery spoil and material excavated from the main channel of the Manchester Ship Canal. Organic and inorganic domestic refuse also proved by drilling. Infilling of the River Irwell pre-dated the development of Trafford Park, which now extends across the former meander belt. Ground conditions in this complex area of Made Ground are, therefore likely to be highly variable.	mgr_irw
	3. Sewage works and domestic refuse sites (Peel Green Road) Restricted to the west of the district, to the north of Davyhulme	Typically 3 to 7 m thick but reaches 10 m in the area of the southernmost sewage works.	Oily sandy ash with common organic refuse. (60 boreholes)	mgr_sew
	4. Trafford Park Industrial Estate	1 to 2 m but commonly 3 to 7 m. Over 8 m in the eastern part of the Park.	Material associated with extensive post-war industrial development that included the establishment of many chemical manufacturing industries. Also, material excavated during the construction of the Manchester Ship Canal used to raise land adjacent to the main navigation	mgr_trf
	5a. Valley infill Medlock river valley	3 to 7 m but commonly 8 to 12 m.	Construction material associated with building into the river valley and also extensive tipping of colliery spoil from the Ashton Branch Railway that ran from Bradford Colliery along the northern slopes of Clayton Vale. Textile works, including bleach and dye works, were common along the length of the Medlock valley and it is probable that waste streams from these works were deposited within the valley. (230 boreholes)	mgr_med
	5b Valley infill Crofts Bank valley	3 to 7 m	The nature of the fill is unknown. A brickworks with extensive spoil mounds is shown on the 1909 edition of Ordnance Survey map Lancashire103SE, and spoil material may be present in the valley. During a field survey in 2001, numerous gas vents were observed at the margins of the valley and it is interpreted that at least in part, the valley has been infilled with domestic refuse. The material proved in boreholes generally comprises brick, metal and wood fragments with common ash waste. (12 boreholes)	mgr_crf
	5c Valley infill River Irk	Typically 1 to 4 m but locally reaches 7 m, particularly in the south-west of the area.	Railway land of the Manchester, Whitefield & Radcliffe line running out of Victoria Station; numerous textiles factories and dyeworks, and spoil from former brick pits and sandstone quarries. (70 boreholes or trial pits)	mgr_irk
	6. Railway sidings Gorton, east of Manchester city centre	1 to 4 m Borehole control is limited to the central part of this area.	Made Ground related to an extensive network of railway sidings, goods depots and locomotive works associated with Ancoats Junction situated at the junction of the Crewe & Manchester and the Manchester, Sheffield & Lincolnshire lines. The eastern part of the area includes Gorton foundry. The Made Ground is likely to include abundant railway ballast, ash and coal. (over 90 boreholes)	mgr_sid
	7. East Manchester commonwealth site	1 to 4 m but commonly exceeds 7 m, particularly in the north- east of the area.	Material associated with a number of diverse industrial processes and culverting of the River Medlock between 1894 and 1909. In general, the northern part of the site is dominated by material from the infrastructure, processes and waste streams associated with Bradford Road Gas Works. The southern part of the area is dominated by buildings, rail tracks and spoil heaps associated with Bradford Ironworks. Bradford Colliery was sited adjacent to the east of the site and spoil associated with coal mining may also be present. (over 50 boreholes)	mgr_com

Worked Ground	8. Manchester Ship Canal		The most extensive area of worked ground in the Salford area is related to excavation and construction of the main Manchester Ship Canal navigation. The canal extends from Pomona Docks in the Old Trafford area, through Salford Quays and westwards towards the Liverpool and the River Mersey. Both bedrock and natural superficial deposits were excavated to a depth of approximately 8 m along the length of the canal (Gray, 2000). The main phase of construction took place between 1887 and 1894 with a minor phase in 1901, during construction of Number 9 dock, adjacent to the present day Lowry Centre. Borehole records within the study area show that the base of the canal is mainly excavated in superficial deposits of glacial or post-glacial age, but in places is cut directly into bedrock.	wgr_cnl
Infilled Ground	9. Includes all significant pits, quarries and artificial lakes that have been subsequently partially or wholly backfilled. Individual reservoirs, small sand and clay pits and small bedrock quarries have not been considered.		The composition of the material used to backfill these workings is uncertain. Over 90 boreholes prove artificial ground infilling identified former worked ground areas. Most commonly, the fill material comprises redeposited natural material from the workings with common ash, clinker and brick fragments. For example, the fill material of the former Strangeways brick pit, proved in borehole SJ89NW425, comprised over 1 m of sandy clay with ash, clinker and brick also recorded. The thickness of the fill material is extremely variable across the study area, ranging from 1 m to over 15 m in the former Sherwood Sandstone quarry at Little Bolton (SJ784985). Some former brick works and quarries are partially filled while others are completely backfilled. For example, Crofts Bank Brickworks (SJ760958), was operational between 1896 and 1909 (historic map Lancashire103SE) but is shown on the 1930 edition of the same map as being completely backfilled and marked by an area of boggy or marshy ground. In contrast, Little Bolton sandstone quarry (SJ784985) is partially filled. Over 15 m of fill material is proved in the western part of the quarry, while in the central and eastern parts, only thin fill is present, preserving a 5 to 7 m high sandstone face from the former quarry.	wmgr

Table 2 Summary of modelled artificial ground in the Manchester and Salford geological model

Lithological variability within till is high. Till is generally a poorly-sorted, unstratified mixture of rock fragments in a matrix of stiff, greyish-brown sandy clay. In many places, especially to the north of the area, many discrete lenses of glaciolacustrine silt and clay and glaciofluvial sand and gravel occur. Each lens of a similar elevation was modelled as a separate unit and given a separate name. The names of lenses within the Manchester and Salford are restricted to this area only.

Each geological unit was classified according to its engineering geological behaviour and inferred permeability. The engineering classification is shown in Table 3.

ENGINEERING GEOLOGICAL UNITS		GEOLOGICAL UNITS	DESCRIPTION/ CHARACTERISTICS	ENGINEERING CONSIDERATIONS			
				FOUNDATIONS	EXCAVATION	ENGINEERING FILL	SITE INVESTIGATION
ENGINEERING SOILS							
HIGHLY VARIABLE ARTIFICAL DEPOSITS		Made Ground (mgr) Infilled Ground (wmgr)	Highly variable composition, thickness and geotechnical properties.	Highly variable. May be unevenly and highly compressible. Hazardous waste may be present causing leachate and methane production.	Usually diggable. Hazardous waste may be present at some sites.	Highly variable. Some material may be suitable.	Essential to determine depth, extent, condition and type of fill. Care needs to be taken as presence of pollution and contaminated ground likely. Essential to follow published guidelines for current best practice.
COARSE SOILS		Alluvium - River Channel deposits (Alv_2) River Terrace Deposits (rtdu) Glaciofluvial sand & gravel (lgfg, gfdu & gfdu_b)	Medium dense to dense SAND & GRAVEL with some buried channels and lenses of clay, silt & peat.	Generally good. Variable thickness of deposit. Thick deposits in buried channels may be significant in foundation design due to differential settlement.	Diggable. Support may be required. May be water bearing.	Suitable as granular fill.	Important to identify the presence and dimension of buried channels and characteristic of infilling deposits. Geophysical methods may be applicable.
		Buile Hill Sands (glld_s)	Loose to medium dense fine to medium SAND.	Poor foundation.	Easily diggable. Generally poor stability. Running sand conditions possible below the water table and in pockets at perched water tables.	Unsuitable as granular fill .	Determine the presence, depth and extent of deposit and depth to sound strata.
FINE SOILS	FIRM	Till (Till_1)	Firm to very stiff sandy, gravelly CLAY with some channels and lenses of medium dense to dense sand and gravel	Generally good foundation, although sand lenses may cause differential settlement. Possibility of pre-existing slips can also cause a strength reduction.	Diggable. Support may be required if sand lenses or pre-existing slips encountered. Ponding of water may cause problems when working.	Generally suitable if care taken in selection and extraction. Moisture content must be suitable.	Determine the depth and extent of deposit, especially the frequency and extent of lenses and channels. Investigate whether any pre-existing slips and shear planes are present.
	SOFT	Alluvium (Alv_1)	Soft to firm CLAY occasional sand, gravel and peat lenses.	Poor foundation. Soft highly compressible zones may be present, risk of differential settlement.	Easily diggable. Moderate stability, decreasing with increasing moisture content. Running sand conditions possible below the water table and in pockets with perched water tables. Risk of flooding.	Generally unsuitable.	Determine the presence, depth and extent of soft compressible zones and depth to sound strata.
		Glaciolacustrine Deposits (glld_1, glld_lenses & glld_ic)	Soft to stiff laminated CLAY with occasional lenses of sand.	Generally poor foundation as long term consolidation and differential settlement possible.	Easily diggable. Support may be required if sand lenses encountered in deep excavations. Ponding of water or exposure to rain may cause softening of formation.	Generally suitable if care taken in selection and extraction. Moisture content must be suitable.	Determine the depth and extent of deposit, especially the frequency and extent of lenses.
ORGANIC SOILS		Peat	Very Soft to soft brown fiberous or amorphous PEAT.	Very poor; very weak; highly compressible foundation. Acidic groundwater.	Diggable. Poor stability. Generally wet ground conditions.	Generally unsuitable.	Determine the depth and extent of deposit and groundwater's acidity.

Table 3 Engineering geology of the Manchester and Salford model

3 Modelled faults

Faults have not been modelled in the Manchester and Salford 3D geological model. It includes natural and artificial superficial deposits only. Bedrock and structures affecting, are shown schematically on cross-sections however.

4 Model datasets

An outline of key datasets used and processed for the purposes of 3D geological modelling is given below:

- The digital terrain model (DTM) used as a capping surface was derived from the CEH DTM with a 50 m cell size. The CEH DTM was derived from Ordnance Survey Landform profile spot heights and 5 m interval contours. The model calculation used a 10 m cell size subsampled version of the CEH DTM.
- Rockhead model derived by extracting all boreholes coded with Terminal Depth (TD) and rockhead (RH) from BGS Borehole Geology database and drawing and digitising hand contours.
- Digital downhole geological data was extracted from the BGS Borehole Geology database. Where a borehole record included two or more downhole interpretations, their content was prioritised. Boreholes coded for the project and conforming to the standards described in Cooper et al, 2006) and content code DY in borehole geology was prioritised. For boreholes not selected for further interpretation and coding, existing entries in Borehole Geology corresponding to Content Codes NW and URB were selected. Lithological codes corresponding to these Content Codes did not conform to those specified in Cooper et al but conformed to bespoke lithological codes within the BGS Rock Classification Scheme (RCS) http://www.bgs.ac.uk/bgsrcs/.

The project area contained 4840 interpreted downhole borehole and trial pit records. Of those, 2328 were used to create the GSI3D model through cross-section construction and geological correlation.

The GSI3D borehole index file (.bid) and downhole geology file (.blg) were subsequently incorporated into a master borehole dataset for the full extent of the Lower Mersey Corridor Area. A Microsoft Excel routine was run to identify and prioritise duplicate coded boreholes. The priority order for the derivation of interpreted downhole geological data was:

1. GT
2. LM
3. X
4. DY
5. NW
6. LO
7. PR

- Borehole coding was done before the commencement of modelling and the lithostratigraphic interpretations might have been over-ruled in the context of all evidence during section drawing and modelling. Neither the blg borehole file nor the corporate borehole database have been updated with these decisions.
- Borehole and trial pit index information including coordinates and elevation (start height) of the borehole or trial pit were derived from the BGS Single Onshore Borehole Index. Where start height records were absent, the elevation of the record was estimated manually using Ordnance Survey Landform Profile spot height and contour data.
- Digital, 1:50 000 scale geological map data was derived from DiGMapGB50 in 2004. Remapping of Manchester (Bridge, Ellison, Hough) occurred simultaneously with the generation of this model, changes in linework during the modelling and introduction of new units (morainic deposits for example) were not fed back into the newly revised DiGMapGB50 product post mapping.
- Historical Ordnance Survey maps were used to identify major areas of artificial ground and land use histories. In addition, information derived from Gray, (2000) was used to determine the depth of excavation during construction of the Manchester Ship Canal.

5 Dataset integration

The digital terrain model, digital geological linework and interpreted downhole geological information were used to construct 81 cross-sections.

6 Model development log

The model development log for the Manchester and Salford is not available.

7 Model workflow

The 3D geological model was created using GSI3D Version 1.1 and 1.5 between 2003 and 2004. The GSI3D workflow of that time was used. The workflow comprised cross-section construction defined by borehole locations, geological correlation, envelope construction and model calculation. 81 cross-sections were constructed in addition to 128 helper sections, including 111 for artificial ground. Their spacing was approximately 250 m apart and their length is between 5 and 10 km. Boreholes were not attached to the DTM, but to their own start height, which was derived from the records, or in some cases read from the DTM, therefore start height issues might exist in the model.

Geological cross-sections were named with a prefix of MANCHESTER_SALFORD_SECTION. For cross-sections orientated north-south, a suffix NS was used. East-west orientated cross-sections were given a suffix W for the those in the western part of the model area and E for those in the east.

Model QA was undertaken by the project team including Holger Kessler, Simon Price and Dave Bridge (formerly sub-programme manager for Urban Geoscience). It was also checked for geological consistency by the former district geologist for NW England, Dick Crofts.

8 Model assumptions, geological rules used etc

All sand and gravel deposits where they were proved in within the main till were assigned to individual lenses and interpreted as ice-contact deposits. Laminated clay and silt deposits were modelled within the main till and interpreted as glaciolacustrine deposits. Deposits at similar elevations were given the same name.

9 Model limitations

The 10 m cell size DTM is likely to be less accurate than those available to use now.

Borehole coding was done before the commencement of modelling and the lithostratigraphic interpretations might have been over-ruled in the context of all evidence during section drawing and modelling. Neither the blg borehole file nor the corporate borehole database has been updated with these decisions.

Digital, 1:50 000 scale geological map data was derived from DiGMapGB50 in 2004. Remapping of Manchester (Bridge, Ellison, Hough) occurred simultaneously with the generation of this model, changes in linework during the modelling and introduction of new units (morainic deposits for example) were not fed back into the newly revised DiGMapGB10/50 product post mapping. *A J Mark Barron comment 30/7/14;There is a consequent requirement to compare the two linework datasets and agree the necessary interventions to harmonise these.*

The geological lines of section (excluding helper sections) were constrained only by the location of boreholes (knickpoint insertion did not yet exist) and therefore may cross geological units obliquely.

The number of lenses within the main till is excessive and should be amalgamated into fewer lithological units.

The model was constructed in 2003 and 2004 using GSI3D Versions 1.1 and 1.5. This pre-dated formal model approval procedures other than those conducted by the geological modelling team, the project manager and District Geologist.

10 Model images

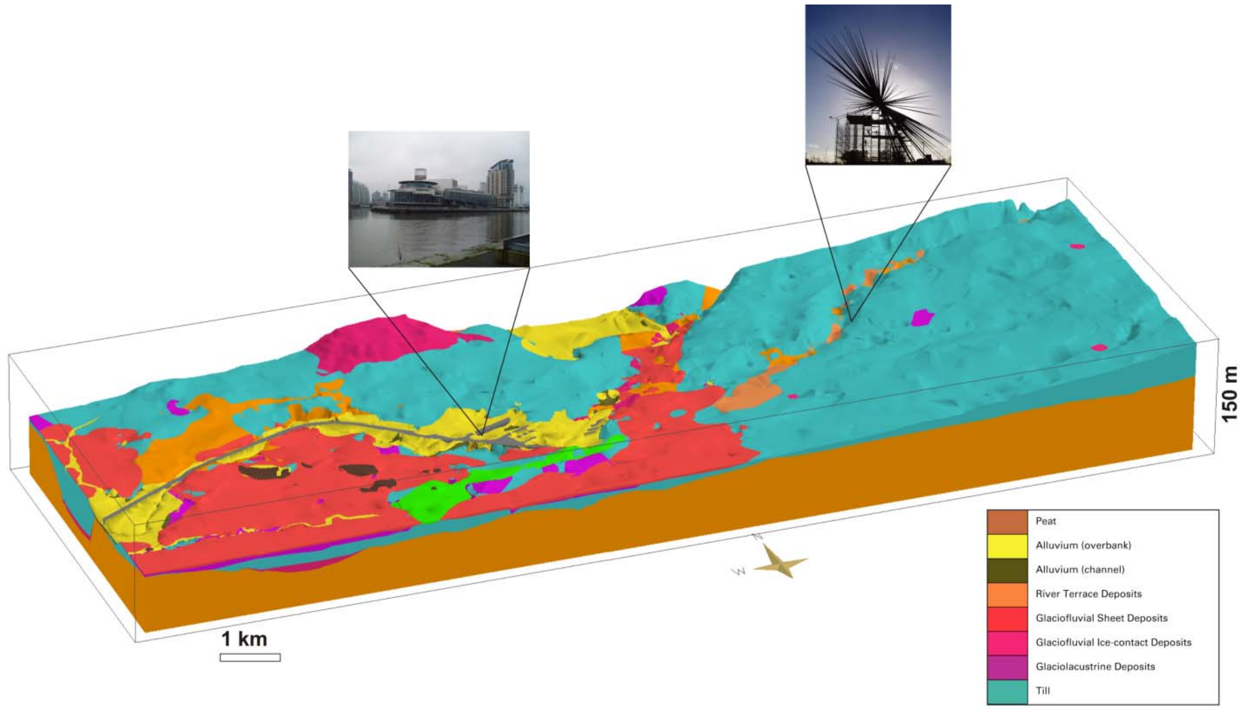

Figure 4 Manchester and Salford 3D geological model with key landmarks

Lowry Centre, Salford Quays (left) and the 'B of the Bang' sculpture, Eastlands Stadium, Manchester. Sherwood Sandstone Group bedrock shown in orange beneath superficial deposits. Legend is for natural superficial deposits only

11 Model uncertainty.

None calculated.

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.

Cooper, A H, Kessler, H and Ford, J. 2006. A revised scheme for coding unlithified deposits (also applicable to engineering soils). British Geological Survey Internal Report IR/05/123

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