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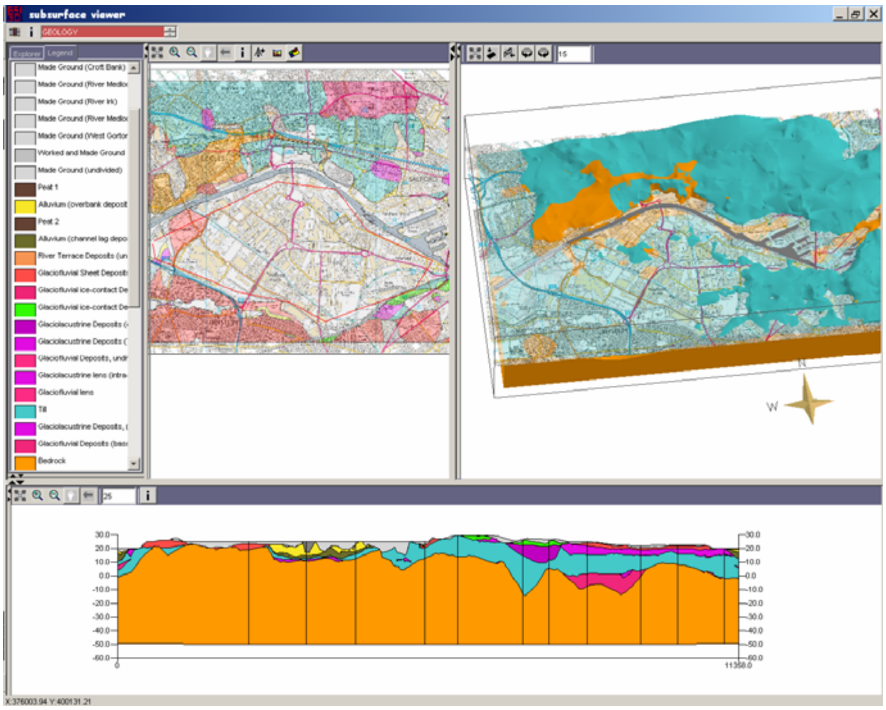
The Manchester and Salford 3-D Superficial Deposits Model: a guide to the model and its applications

Physical Hazards Programme

Internal Report IR/07/001



BRITISH GEOLOGICAL SURVEY

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The Manchester and Salford 3-D Superficial Deposits Model: a guide to the model and its applications

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Front cover

Example of 3-D geological model and synthetic section in Trafford Park including the Manchester Ship Canal

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Foreword

This report is the published product of a study by the British Geological Survey (BGS) Physical Hazards Programme within the Environment and Hazards Directorate. The report and the associated digital 3-D geological model of the superficial deposits in Manchester, Salford and Trafford Park represents part of the results of a five year research project into constructing attributed 3-D geological models in urban areas underlain by complex natural and artificial deposits. The work, initiated as part of this research programme is currently on going in NW England within the Lower Mersey Corridor extending from Manchester to Liverpool.

Acknowledgements

In addition to the development of methods and techniques for building 3-D geological models of the shallow sub-surface, methods for visualising this data have also been developed by Insight GmbH. The Subsurface Viewer (© Insight Geologische Softwaresysteme GmbH) enables the full visualisation of the geological model either in 3-D, as 2-D maps and synthetic sections or as 1-D synthetic boreholes. The help of Hans-Georg Sobisch and Dr Alex Neber (lithosphere GmbH) is gratefully acknowledged.

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Summary

This report summarises the 3-D superficial geology beneath Manchester and Salford (including Trafford Park) and should be used in conjunction with the digital 3-D geological model supplied within the Subsurface Viewer (© Insight Geologische Softwaresysteme GmbH).

The 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. 3-D geological modelling in the shallow sub-surface provides a powerful tool for understanding and predicting potentially difficult engineering ground conditions and in Trafford Park, a powerful tool for assessing aquifer vulnerability and recharge to the underlying Sherwood Sandstone.

The geological model shows the top, base and thickness for each natural and artificial deposit within the area. Each unit is coloured according to its lithological composition, lithostratigraphy, inferred permeability and engineering classification. 2-D synthetic cross-sections and 1-D synthetic predictive borehole logs can be generated from the model in any area. For example, a cross-section can be drawn along the route of an existing or proposed road or around a proposed development area. Synthetic borehole logs can be generated to predict potential ground conditions at a point location.

The 3-D geological model of superficial deposits in the area is not intended as a replacement for any invasive site investigation. It provides an additional tool for the development of conceptual ground models for a range of users. The model provides a powerful means of assessing the nature of the ground, but with additional 3-D information, not previously available from any existing 2-D geological map. It provides essential applied geoscience information relevant to any requirement for information on ground conditions in the shallow sub-surface.

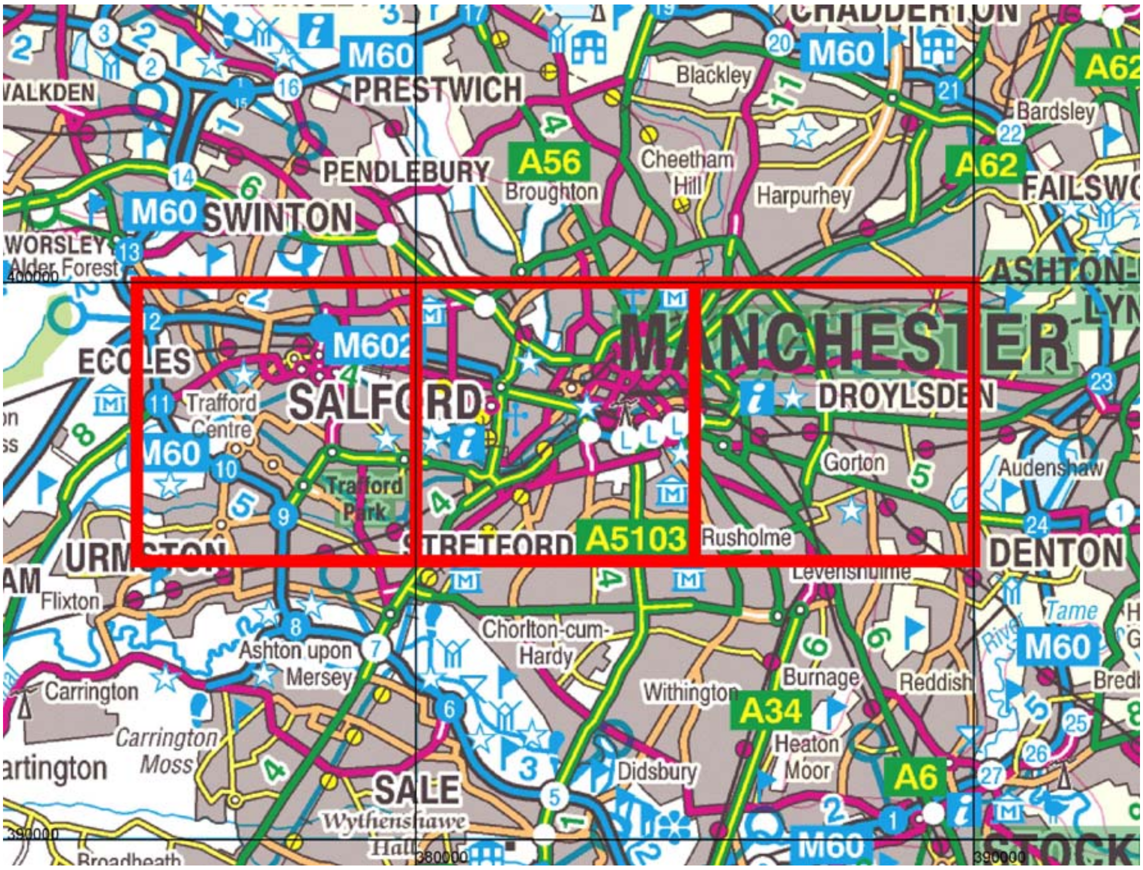
1 Introduction

The 3-D shallow sub-surface geology of central Manchester and Salford (including Trafford Park) has been modelled using interpreted site investigation, water and former colliery boreholes in combination with 2-D geological map data and other published information. This document summarises the glacial and post-glacial history of the Manchester area and the range of deposits left behind as a result. The document also discusses the possible application of the 3-D model of these superficial deposits in understanding the variability of ground conditions in one of the major population centres in the UK. More detailed information on the modelling process is given in Bridge *et al*. (2006).

1.1 AREA

The study area covers an area of 75 km^2 in central Manchester, Salford and Trafford Park (Figure 1). The area includes Trafford Park, the largest industrial estate in Europe, Manchester city centre, still undergoing redevelopment following the 1996 terrorist attack, and east Manchester, an industrially-depressed area now undergoing urban renewal aided by £2bn of public and private investment (Carroll, 2000). Smaller areas of intense redevelopment include the former Bradford Colliery and gasworks, redeveloped as the focal site of the 2002 Commonwealth Games, and Salford Quays, formerly the Manchester Ship Canal docklands, but now home to the Lowry Centre and the Imperial War Museum North.

Figure 1 Study area (outlined in red)



2 Geological Setting

The geological setting is briefly reviewed here to set the scene for the explanation of the 3-D superficial deposits model described in Section 3. Although not included in the geological model, a brief summary of the bedrock geology at rockhead, beneath the superficial deposits is given.

2.1 BEDROCK GEOLOGY

The cities of Manchester and Salford straddle the southern part of the South Lancashire Coalfield and the north-eastern part of the Permo-Triassic Cheshire Basin. The distribution of rocks present in the district is shown in Figure 2 and the succession is illustrated in the accompanying generalized vertical section. Bedrock exposure is poor throughout the district due to an extensive and often thick cover of superficial deposits. However, mine plans and records dating from the 19th and 20th centuries provide information about the structure and deep geology of the district. The oldest exposed rocks, of Westphalian age (c. 305 – 298Ma), are the coal-bearing strata of the South Lancashire Coalfield. Coal was worked from collieries at Patricroft [7629 9914] and Agecroft [SD 7999 0155] until the late 1970s. The smaller Bradford Coalfield forms a structurally isolated inlier, surrounded by Permo-Triassic rocks, and bounded to the east by the Bradford Fault. The inlier was worked from Bradford Colliery [8706 9845] until its closure in 1968.

The Coal Measures are overlain by a sequence of red beds (Etruria Formation) and grey measures (Halesowen Formation) forming part of the Warwickshire Group. These strata subcrop beneath superficial deposits around Alder Forest [SD 750 000], Brindle Heath [806 998], Bradford [865 988] and Medlock Vale [SD 900 000].

Permo-Triassic rocks (298 - 205 Ma) underlie much of the central, eastern and southern parts of Manchester, where they form the sedimentary fill to the north-eastern part of the Cheshire Basin. This sandstone-dominated sequence, up to 620 m thick, forms the most important groundwater aquifer in north-west England.

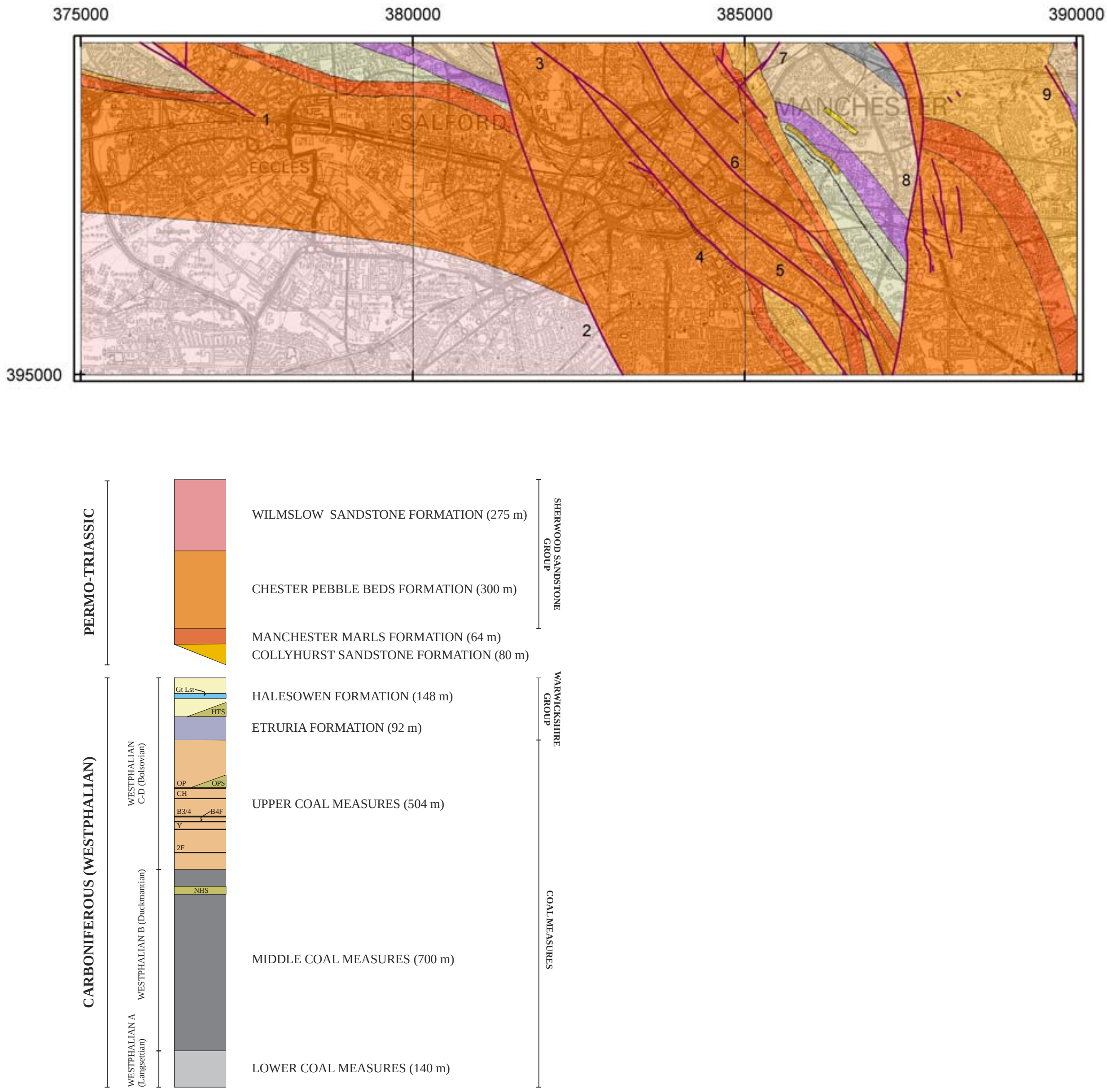


Figure 2 Bedrock Geology in the study area

2.2 SUPERFICIAL DEPOSITS

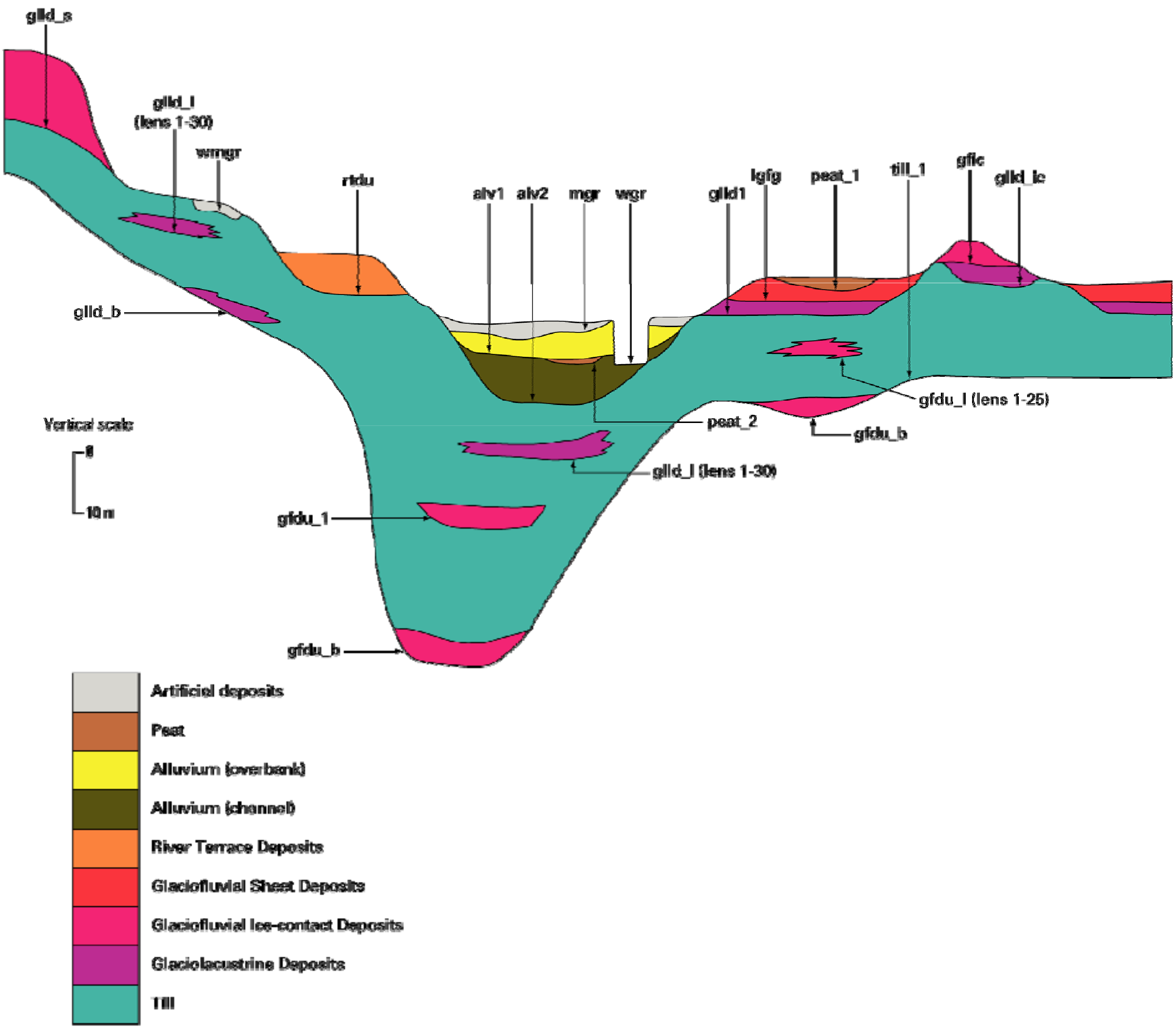
Much of the district is covered by extensive spreads of natural and artificial superficial deposits. These can be divided into three major categories: glacial deposits, presumed to be mainly of late-Devensian age c. 20 000 to 14468BP, post-glacial deposits associated with development of the River Irwell, and anthropogenic deposits, recording man's modification of the surface since the Industrial Revolution. The relationship of the main superficial deposits is shown schematically in Firgure 3.

During Late Devensian times, ice streams radiating from centres in the Lake District and adjoining Irish Sea Basin advanced across the district. The general pattern of movement, based on glacial striae and till fabrics (Worsley, 1968), supports ice streams entering the area from a north-westerly or westerly direction, with subsidiary streams constrained to the east by the Pennine escarpment.

The depositional products of the glaciation are dominated by till, which covers all but the most prominent bedrock features. The till is accompanied in the lowlands by sequences of outwash sediments forming multi-layered complexes in places over 40 m thick. Evidence of hummocky moraine on the higher slopes to the east of Manchester (north of the present district) suggests that downwastage of the ice was achieved locally by in situ stagnation. Prominent morainic ridges, such as Buile Hill [800 995], are presumed to be ice-contact in origin, and may represent standstill positions of the ice margin during deglaciation. During this phase large volumes of meltwater, released sub-and supraglacially, deposited sand and gravel in ice-contact and proglacial settings. At times throughout the wasting process, meltwaters were locally impounded to form transient glacial lakes. Silts and laminated clays deposited in these lakes are widely represented in the sub-surface but are rarely recorded at outcrop. Subsequent to the retreat of the Late Devensian ice, a local re-growth of permanent snow fields ca.11000 to 10000 BP provided a source of meltwaters which were channelled down the proto-Irwell and its tributaries to deposit a spread of 'flood gravels' across much of the Manchester embayment.

Post-glacial (Holocene) deposits are largely confined to the modern river valleys and include river terrace deposits and tracts of alluvium. A small area of lowland peat is preserved in Trafford Park.

Figure 3 Relationship of main superficial deposits



The superficial deposits within the 3-D geological model are summarized in Table 1. Table 2 gives further details on the main units of artificial ground within the 3-D model.

Table 1 Summary of units in the 3-D model

	Map unit	Model unit	Lithology	Environment (inferred)	Model notation
Holocene	**Worked Ground**	WORKED GROUND		Anthropogenic (Artificial deposits)	wgr
	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	Fluvial	alv_1 peat2
		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	glld_s gfdu_1 gfdu_1-25 l
	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	glld_1 glld_l(1-30) glld_ic
		Moraine complex Till, sand and laminated clay, undivided	Till, sand, gravel,	?Push moraine	gfic
	Till	TILL	Till, interbedded sands, impersistent laminated clays	Lodgment and melt-out tills, undivided	till_1,
Bedrock					bedrock

2.3 ARTIFICIAL DEPOSITS

2.3.1 Historical perspective

Although Manchester was the regional centre of south Lancashire prior to the Victorian era, it was little more than a small conurbation at the confluence of the rivers Irwell and Irk. During the 1800s, the population grew to over 2 million, fuelled by a need for labour to work in industries associated with cotton (weaving, dyeing and distribution), manufacturing and coal mining. The expansion of the city was facilitated by the construction of the Bridgwater Canal in 1763, the Ashton Canal in 1799 and the Rochdale Canal in 1804. In the mid-1800s, the establishment of the rail network through the Manchester area allowed for a more efficient transport of goods. The Manchester Ship Canal, which took 8 years to construct, was opened in 1894. The canal provided a direct link between the docks at Salford and the sea, bypassing the need for imported goods to be off-loaded at Liverpool. The 1183-acre Trafford Park Estate, south of the Ship Canal, was sold in 1896, and transformation from a deer park into Europe’s largest industrial estate began shortly after. A measure of the importance of the area to the world economy is given by the fact that by 1913 over 65% of the worlds cotton was exported from Manchester. During the inter-war period, many heavy industries, including the manufacture of cars, turbines, generators, foodstuffs and chemicals, were based in Trafford Park. The Ship Canal was so successful that at this time Manchester became the fourth largest port in the country. However, the period following the Second World War saw a contraction of many of the traditional ‘heavy’ industries and closure of numerous large factory sites. The 1960s saw a programme of city-wide slum clearance, with traditional housing replaced by high-rise residential buildings in Salford, Hulme and east Manchester. This period also saw the closure of the Port of Manchester. During the 1980s, under the guardianship of the Trafford Park Development Corporation, Salford Quays was redeveloped, and new light industries were established in Trafford Park. More recent areas of redevelopment include Manchester city centre and the former Bradford Colliery site.

2.3.2 Artificial deposits

The legacy of Manchester and Salford’s industrial past is a widespread cover of anthropogenic (artificial) deposits, which often have no well-defined landform and whose boundaries are ill-defined or gradational. Nevertheless, by combining information from a variety of sources, it has proved possible to map out the more significant deposits. Three categories of anthropogenic deposits and voids are recognised:

Made Ground - where material is known to have been placed on the pre-existing land surface.

Worked Ground - where the pre-existing land surface is known to have been excavated.

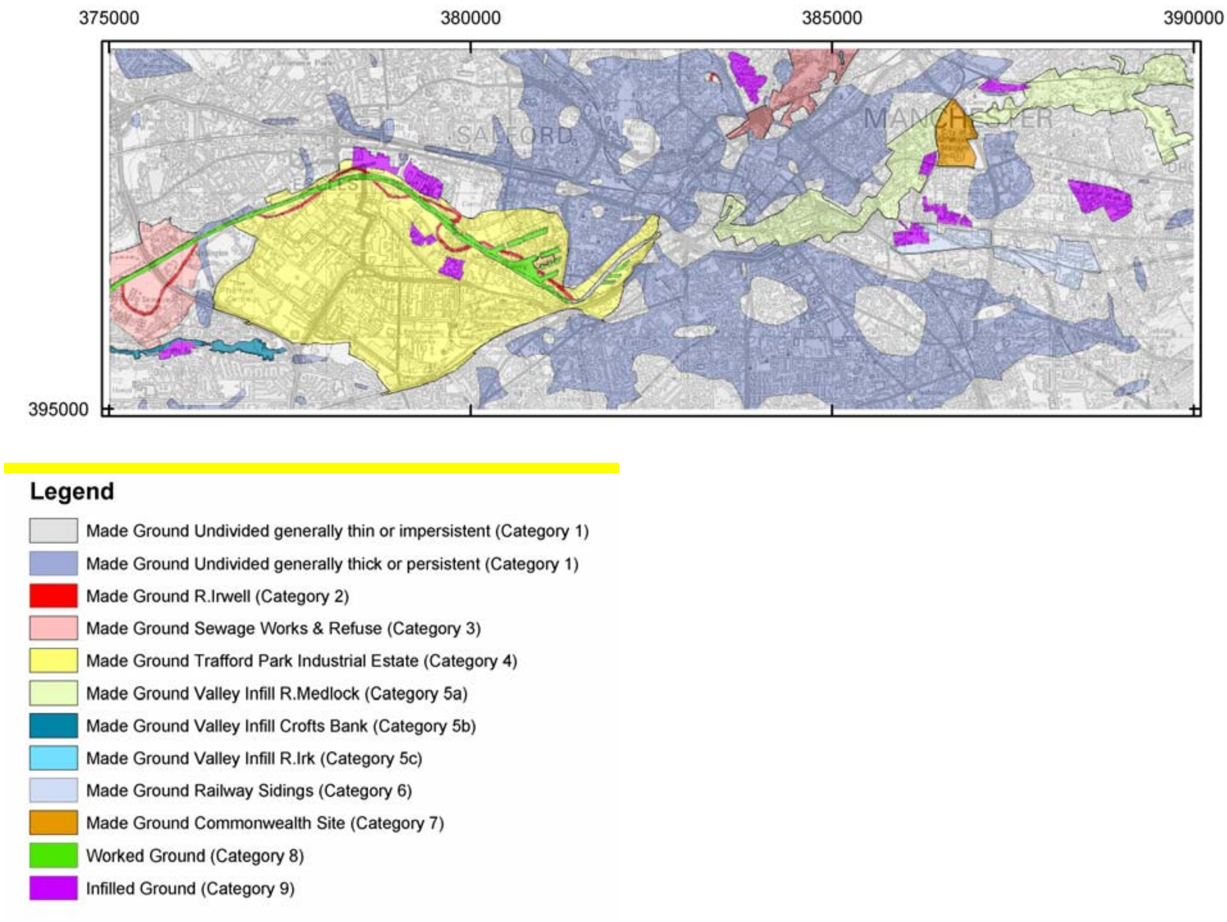
Infilled Ground - where the pre-existing land surface has been excavated (Worked Ground) and subsequently partially or wholly backfilled (Worked and Made Ground) by man.

Table 2 Summary of artificial deposits

	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



3 3-D Superficial Geology Model

3.1 SCOPE AND MODEL RESOLUTION

The 3-D superficial geology model includes natural and artificial superficial deposits that lie beneath Manchester and Salford city centres. An arbitrary depth bedrock base to the model is provided for visualisation purposes only. It does not contain any further bedrock or structural models.

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. It includes detailed units of most artificial ground and small lenses within the major Till unit developed across the project area. By modelling at this scale in 3-D, information not previously available or possible to show on 2-D paper maps can be visualised. For example, buried Glaciolacustrine deposits and deep incised valleys beneath Trafford Park or the relationship between the Manchester Ship Canal and the infilled course of the River Irwell.

3.2 OVERVIEW OF MODEL CONSTRUCTION

The geological model was constructed using GSI3D (Geological Surveying and Investigation in Three Dimensions) developed by Insight GmbH with advice and development feedback from BGS geologists. Over 4000 interpreted and coded borehole logs stored within the National Geoscience Records Centre were used to provide the core geological data for building the model.

Boreholes were used to create a grid of cross-sections with a spacing of approximately 250 m across the area. In total, 81 cross-sections were used, each between 5 km and 10 km in length. All geological units were then correlated between boreholes on screen by a BGS geologist. Additional “helper” sections were constructed by the geologist in areas where deposits are thin or in areas with poor borehole coverage. Helper sections reflect the interpretation made by the geologist during modelling of the thickness and geometry of thin units such as Alluvium or some types of artificial ground.

This framework of cross sections provides the “skeleton” of the geological model. It is then combined with digital geological map data and digital models of the ground surface (Digital Terrain Models) to calculate the top, base and thickness of each unit as a series of stacked surfaces in the form of TINs (Triangular Irregular Networks). The resulting 3-D model is a volume of each geological unit constrained either by the boundaries of other geological units, underlying bedrock or the ground surface.

3.3 ATTRIBUTION

In addition to the lithological and lithostratigraphic attribution of each geological unit in the model, inferred permeability and engineering classification properties have also been added and represented by different colours. Permeability was assessed on the gross lithological properties of the material and attributed as permeable or weakly permeable. The engineering attribution is defined 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 appliciable.
		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 classification

3.4 APPLICATIONS OF THE 3-D MODEL

There are many potential applications for the 3-D model in urban areas. The Manchester and Salford model has already been used by the Environment Agency for the assessment of aquifer recharge and vulnerability in Trafford Park. There are many other potential applications and some of those are discussed here.

Most importantly, the 3-D superficial deposits model provides an interpretation of ground conditions in 3-D in the shallow sub-surface. It allows potentially variable and difficult engineering ground conditions to be predicted and accounted for in any geoscience related study. Colours are used to represent each geological unit based on its lithology, lithostratigraphy, engineering classification and inferred permeability. It is possible therefore to use the 3-D model as a decision support tool for assessing ground conditions in 1-D, 2-D and 3-D.

The 3-D model is also conceptual model. A conceptual ground model (in any format or scale) forms an essential component to any risk based assessment where understanding the underlying geology is critical. For example, it may be used in the development of a conceptual model to understand potential contaminant pathways in the assessment of contaminated land.

The model also provides a tool to assist in decision making related to planning and development where an assessment of the nature of the shallow sub-surface is required to assess suitable foundation conditions for example. It may also be used to assess potential hydrogeological flow paths through superficial deposits into the underlying bedrock or laterally through the superficial deposits themselves. By assessing the 3-D relationships between permeable and weakly permeable deposits, areas of potential recharge to an underlying aquifer can be identified. Similarly, differences in areas of vulnerability to the aquifer from pollution may be identified.

3.5 LIMITATIONS AND INTENDED USE

It is intended that the 3-D geological model be used as a decision support tool. It is not intended that the model should replace invasive site investigation. It provides a means of visualising and interrogating attributed, 3-D geoscience information in the shallow sub-surface to predict the potential variability in ground conditions. The model can be interrogated to visualise the top, base and thickness of all modelled units in 1-D, 2-D and 3-D and coloured up according to the property being displayed. As such, it provides geological information in much the same way as a traditional geological map during the preparation of a desk study for example, except that it provides information on the critically important third dimension.

The Subsurface Viewer (© Insight Geologische Softwaresysteme GmbH) provides a tool for the visualisation of 3-D models. It does not have any export functionality of data layers other than the ability to save screen shots in each of the windows. Other GSI3D modelling software packages are available via the British Geological Survey where export of digital surface data is required.

References

Most of the references listed below are held in the Library of the British Geological Survey at Keyworth, Nottingham. Copies of the references may be purchased from the Library subject to the current copyright legislation.

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