# THEMATIC GEOLOGICAL MAPPING FOR LAND USE PLANNING - LESSONS FROM A PARTLY SUCCESSFUL RESEARCH INITIATIVE

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views expressed are those of the presenter and not necessarily those of ODPM

# SCOPE OF TALK

- Land use planning
- Thematic mapping initiative
- Identify successes and limitations
- Draw conclusions

## LAND USE PLANNING

- Development Plans
  - Strategic
  - Local
- Development control
- SI and EIA
- Planning guidance

## GUIDANCE

Planning Guidance

- minerals
- hazards - landslides, subsidence, flooding
- contaminated land
- waste management

# THE PROBLEM

**Few planners trained in geosciences**

**Unaware of importance**

**Unable to use highly technical material**

**Little time**

## Engineering geology BRADFORD 1996

| ENGINEERING GEOLOGICAL UNITS | | GEOLOGICAL UNITS [SEE MAPS 2 & 3] | DESCRIPTION/ CHARACTERISTICS | ENGINEERING CONSIDERATIONS: Foundations | Excavation | Engineered Fill | Site Investigation |
|---|---|---|---|---|---|---|---|
| SOILS | | | | | | | |
| MIXED COHESIVE/ NON-COHESIVE SOILS | STIFF / DENSE (< 5m) | Till (boulder clay) | Stiff to very stiff, stony, sandy CLAY (boulder clay), with bands of laminated clays and interbeds and lenses of sand and gravel. | Generally good foundation conditions but dependent on presence of water-bearing sand and silt layers/lenses. | Diggable. Ponding of water may cause problems during working. Excavations in clays generally stable in short term. Running conditions may occur in sands below water table. | May be suitable if care is taken in selection and extraction. Laminated clays and silts and clays adjacent water-bearing sands/gravels may be unsuitable. | • Important to determine till thickness and lithology, particularly presence of laminated clays and water-bearing sands/silts. |
| | SOFT / FIRM (< 5m) | Head | Soft to firm sandy silty CLAY with stones, of low to medium plasticity and compressibility; locally may be silty sand or gravel. Clays may contain relict shear surfaces of low shear strength. | Relict shear surfaces may cause stability problems in Head on shallow slopes. Limited thickness usually allows economic removal prior to placing shallow foundations. | Diggable. | May be suitable as bulk fill, but may be too wet to achieve satisfactory compaction. | • Important to determine thickness/extent of Head and presence of any relict shear surfaces which may adversely affect stability of cuts in Head-covered slopes. |
| | SOFT / LOOSE (< 5m) | Alluvium Glaciolacustrine Deposits | Very soft to firm, occasionally laminated, sandy, silty CLAYS and SILTS with inconsistent peat and loose to dense fine to coarse-grained SANDS and GRAVELS with clay lenses | Soft, highly compressible zones may be present, with risk of severe differential settlements. Rafts or piles to dense gravels or sound bedrock may be required. | Diggable. Immediate trench support required. Running conditions likely in granular material. Cutoffs and/or dewatering usually required due to high water tables. | Generally unsuitable. | • Important to ascertain the presence, depth and extent of soft compressible zones and depth to sound strata. • Closely-spaced boreholes may be required. |
| NON-COHESIVE SOILS | MEDIUM DENSE (< 5m) | Alluvial Fan Deposits River Terrace Deposits Glaciofluvial Deposits Hummocky Glacial Deposits | Medium dense, fine to coarse-grained SANDS and medium dense to dense GRAVELS with occasional cobbles. Sandy clays and silts, sometimes laminated, occur locally. | Generally good foundation conditions. Thick deposits in buried river channels may be significant in foundation design | Diggable. Trench support required. May be water-bearing. | Sands and gravels suitable as granular fill. | • Important to identify presence and dimensions of buried channels and characteristics of infilling deposits. • Geophysical methods may be advisable. |
| ORGANIC SOILS | VERY SOFT | Peat | Up to 4m of fibrous/amorphous peat on moorland plateaux. Selectively worked to shallow depth in some areas. | Very poor foundation conditions. Very weak; highly compressible; acidic groundwater. Deposits at surface should be removed or designed for if below normal foundation depth. | Diggable. Generally wet ground conditions may require immediate trench support and dewatering. | Unsuitable. | • Important to determine extent and depth of soft compressible peat deposits • Groundwater acidity should be determined prior to selection of buried concrete |
| HIGHLY VARIABLE ARTIFICIAL DEPOSITS | | Made Ground Infilled Ground [SEE ALSO MAP 3] | Highly variable in composition, depth and geotechnical properties from site to site. | Very variable. May be highly compressible with severe differential settlements. Hazardous waste may be present. Ground improvement methods may be suitable/applicable. | Usually diggable. | Highly variable. Some material may be suitable. | • Essential to determine depth, extent, condition and type of fill material and chemistry of groundwaters. • Special techniques/precautions may be necessary. |
| LANDSLIP DEPOSITS | | Landslip [SEE ALSO MAP 6] | Variable deposits of clay, mudstone and sandstone debris, usually containing slip surfaces of low strength. Rockfall detritus may be of considerable extent below major sandstone scarps. | Generally unsuitable for built development unless made suitable by appropriate engineered remedial works. | Usually diggable. Extensive sandstone blocks and boulders may cause difficulties at some sites. | Generally unsuitable. | • Essential to ascertain stability conditions of slip site and adjacent slopes prior to any development and/or design of remedial works. |
| BEDROCK | | | | | | | |
| 'STRONG' SANDSTONES | | Sandstones of the Millstone Grit and Coal Measures | Moderately to well-jointed, thinly to thickly-bedded, fine to coarse-grained SANDSTONES, with mudstone and siltstone interbeds. Strong to moderately strong when fresh or slightly weathered. | Usually good foundation conditions. Bed thickness and depth of weathered zone important in design. | Dependent on joint spacing. Ripping, pneumatic tools or blasting. | Suitable as high grade fill if care taken in selection and extraction; suitable as bulk fill if uneconomic to separate from mudstone interbeds. | • Important to determine depth and properties of lithologically variable weathered zone. • In situ loading tests advisable to assess bearing strengths at selected sites. |
| MUDROCKS | | Mudstones,shales, claystones and siltstones of the Millstone Grit and Coal Measures | Fissured, weak to moderately strong, MUDSTONES, SHALES, CLAYSTONES, SILTSTONES weathering to a firm to stiff silty clay. Tendency to deteriorate and soften when exposed/wetted. | Generally good foundation conditions. Dependent on nature and thickness of weathered zone. Foundation levels may need protection in open excavations. | Weathered mudrocks are diggable; ripping or pneumatic breakers may be required at depth or for major excavations. | Suitable as fill under controlled compaction conditions. | • Important to determine depth and properties of lithologically variable weathered zone. • In situ loading tests advisable to assess bearing strengths at selected sites. |
| COAL SEAM AT OUTCROP | Not shown | Coal exposed at foundation levels poses the risk of combustion and should be removed and replaced/sealed prior to construction (eg. with mass concrete). Agreement of the mineral owner is required before any entry to or disturbance of the coal; this is generally the Coal Authority. | | | | | |
| GEOLOGICAL FAULT AT SURFACE | | Fault lines are characterised by zones of shattered rock which tend to promote deep weathering profiles and possible pathways for methane gas and contaminated groundwaters. Competent rock may also be juxtaposed with less competent strata. Structures straddling fault zones may be liable to uneven settlements unless accounted for in foundation design. Extent and nature of faulted ground should be ascertained by site investigation prior to construction. | | | | | |
| ZONE WHERE UNDERMINING MAY OCCUR WITHIN 30 m OF | | Consideration should be given to the localised development of 'crown holes' at ground surface due to collapse of shallow colliery-based workings and/or the penetration of foundations into near-surface voids. Similar considerations may apply to shallow sandstone workings (shown on Map 5) within and beyond these zones. The presence, depth and extent of shallow workings should be ascertained by site investigation prior to all construction. Appropriate void stabilisation methods (eg. grouting) may be required. | | | | | |

THICKNESS OF SUPERFICIAL DEPOSITS (SOILS)

1 to 5 metres — 5m thickness contour line — > 5 metres

Nature of underlying bedrock shown 'below' superficial cover of <5m (lighter colour shading)

Bedrock not indicated below superficial cover >5m (darker

## THE INITIATIVE

To prepare geological information for planners

Commissioned 50 studies

Selected geological/geomorphological settings

Range of planning/development issues

## WHAT WAS DONE

Basic mapping where needed

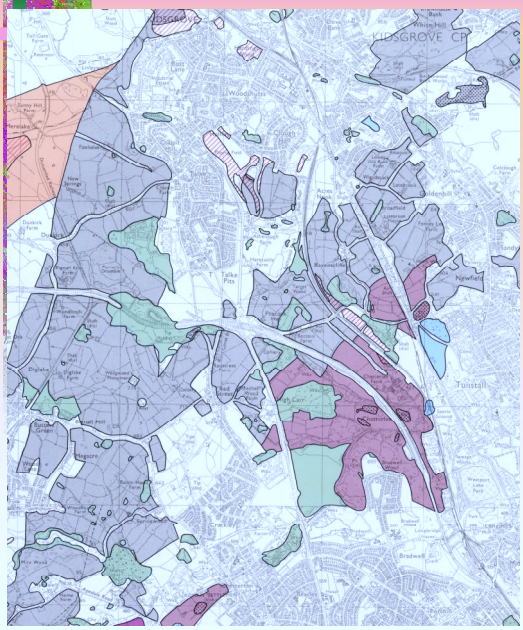
Collection of existing data

- site investigation reports,
- mine plans,
- well and borehole records

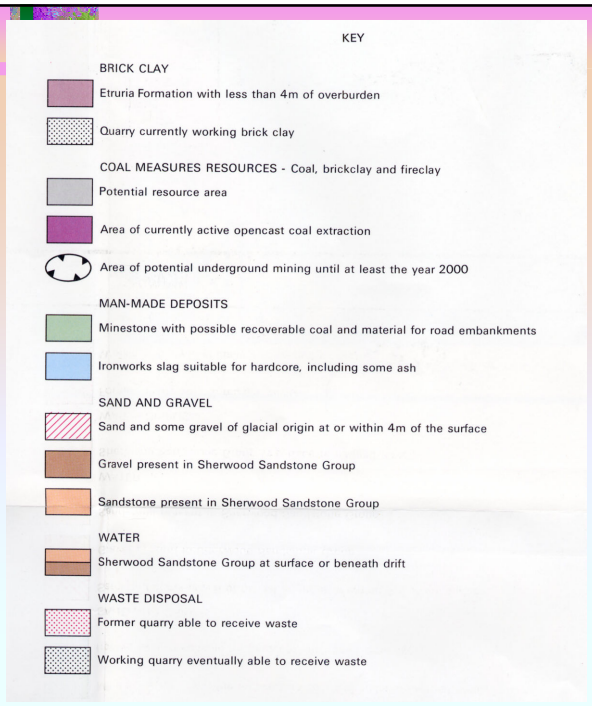
Later, geomorphological mapping

# INITIAL THEMES

- Mineral resources
- Water resources
- Engineering characteristics of
  - soils
  - bedrock
- Mined ground
- Slope angle/landslides



Stoke-on-Trent –resources (1991)

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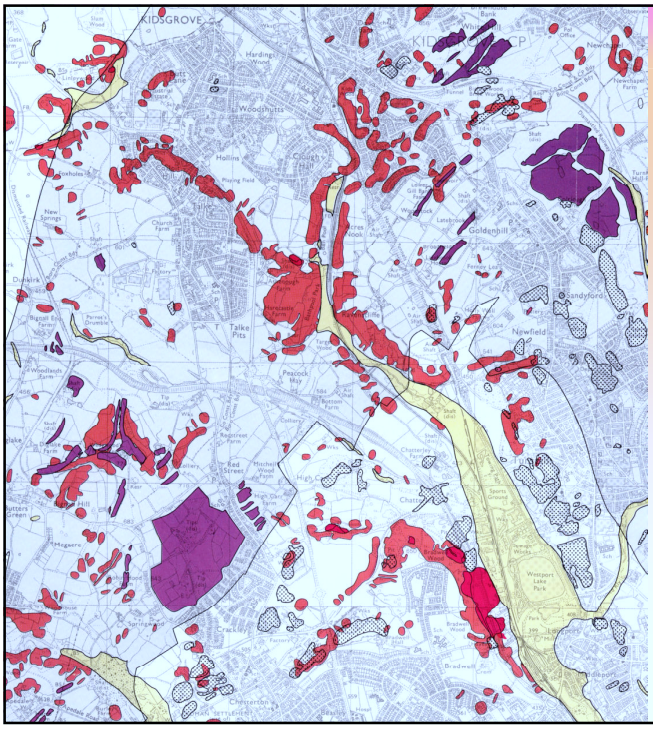



## Stoke – Ground stability constraints (1991)

KEY

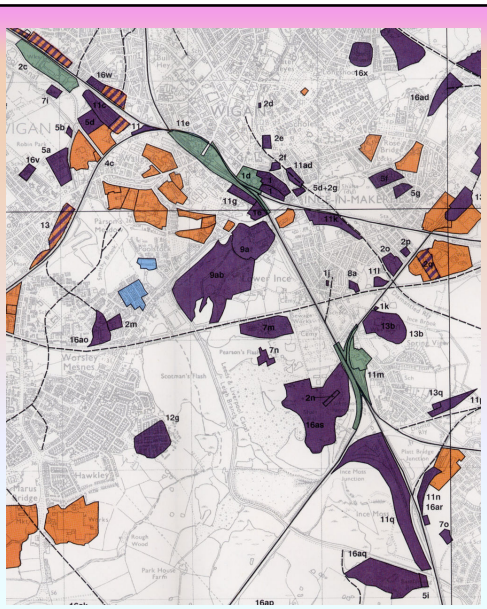
| GROUND CHARACTER | POTENTIAL HAZARD/PROBLEM | CONSTRAINTS TO DEVELOPMENT |
|---|---|---|
| LANDSLIPS | Ground disturbed by mass movement and likely to contain shear surfaces of low strength. Construction activity may reactivate slope movement. | Development on or close to landslipped ground should be avoided if possible, otherwise high costs may be incurred to ensure stability of slope and constructed works. |
| SLOPES STEEPER THAN 11° | Operation of wheeled construction plant very difficult. Precautionary site measures may be necessary to maintain local slope stability. | Generally too steep for all types of housing and industrial development. Extensive site preparation necessary even for small structures. |
| BACKFILLED QUARRIES<br>BACKFILLED OPENCAST SITES | Large differential settlements are possible over infill, particularly at edges, which may be concealed under blanket of made ground and difficult to locate. | If backfill is insufficiently compacted, large amounts of settlement may yet occur. Special foundations may be needed (e.g.rafting). The construction of linear structures over quarry edges should be avoided. |
| AREAS WHERE ABANDONED SHALLOW UNDERGROUND WORKINGS MAY OCCUR | Largely uncharted old coal and ironstone workings may occur within 30m of surface. Risk of ground collapse, particularly when loaded, or subjected to vibration or changes to groundwater regime. | Surface effects of collapse over old workings depends on the depth and geometry of the mines and the strength and integrity of pillars and surrounding rocks. Collapse of pillars may cause localised ground disturbance, crown holes or more general subsidence. Remedial treatment would probably involve concrete grouting or even complete removal and backfilling. |
| AREAS OF VALLEY ALLUVIUM | Variable deposits (including clay and local peat lenses) usually of low strength, high compressibility and high groundwater levels. Excavations require continuous support and pumping. | Generally unfavourable founding medium. Wide strip or raft foundations necessary even for domestic housing. Heavier structures require piling to firm strata. |

Refer also to Map 4 for numerous additional areas of made ground where fill may be differentially compacted, with consequent implications for foundation design.

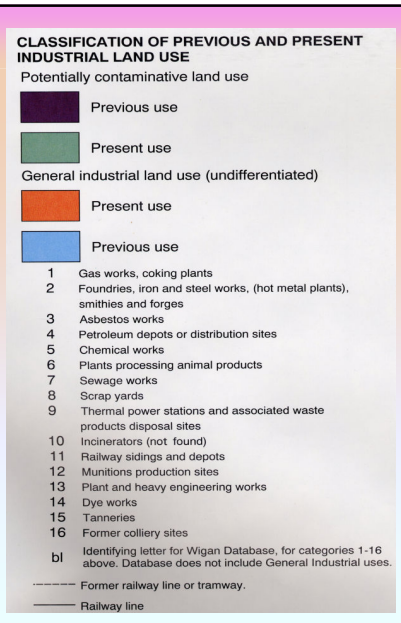
Stoke – Ground stability constraints (1991)

# LATER THEMES

- Potentially contaminative land uses
- Flood potential
- Simplified maps for planners
- Alert to issues
  - Who to ask
  - What to ask



## Applied geological mapping in Wigan - previous and present land use (1995)

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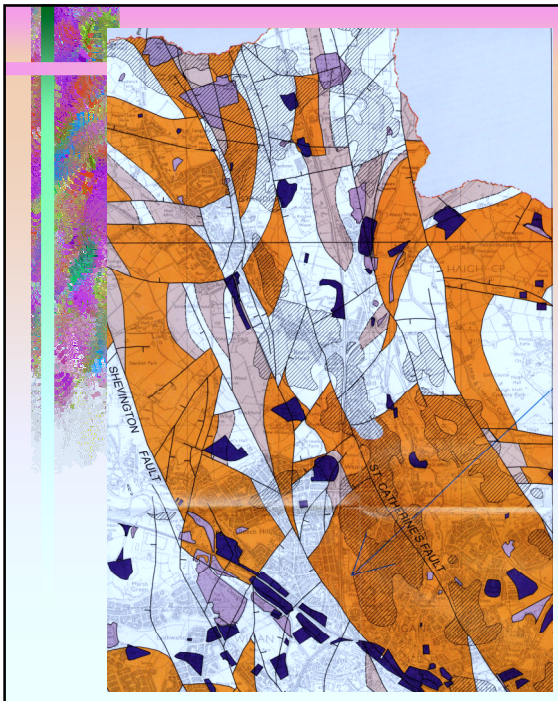
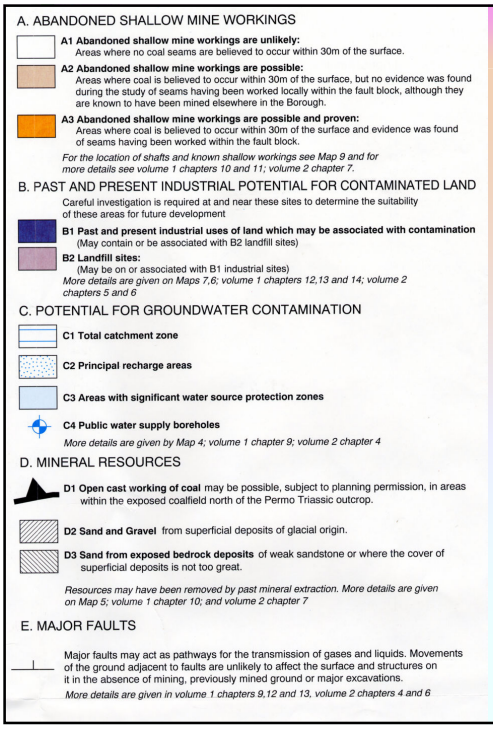



## Applied geological mapping in Wigan – key factors relevant to planning and development (1995)



A. ABANDONED SHALLOW MINE WORKINGS

**A1 Abandoned shallow mine workings are unlikely:**
Areas where no coal seams are believed to occur within 30m of the surface.

**A2 Abandoned shallow mine workings are possible:**
Areas where coal is believed to occur within 30m of the surface, but no evidence was found during the study of seams having been worked locally within the fault block, although they are known to have been mined elsewhere in the Borough.

**A3 Abandoned shallow mine workings are possible and proven:**
Areas where coal is believed to occur within 30m of the surface and evidence was found of seams having been worked within the fault block.

*For the location of shafts and known shallow workings see Map 9 and for more details see volume 1 chapters 10 and 11; volume 2 chapter 7.*

B. PAST AND PRESENT INDUSTRIAL POTENTIAL FOR CONTAMINATED LAND

Careful investigation is required at and near these sites to determine the suitability of these areas for future development

**B1 Past and present industrial uses of land which may be associated with contamination**
(May contain or be associated with B2 landfill sites)

**B2 Landfill sites:**
(May be on or associated with B1 industrial sites)

*More details are given on Maps 7,6; volume 1 chapters 12,13 and 14; volume 2 chapters 5 and 6*

C. POTENTIAL FOR GROUNDWATER CONTAMINATION

**C1 Total catchment zone**

**C2 Principal recharge areas**

**C3 Areas with significant water source protection zones**

**C4 Public water supply boreholes**

*More details are given by Map 4; volume 1 chapter 9; volume 2 chapter 4*

D. MINERAL RESOURCES

**D1 Open cast working of coal** may be possible, subject to planning permission, in areas within the exposed coalfield north of the Permo Triassic outcrop.

**D2 Sand and Gravel** from superficial deposits of glacial origin.

**D3 Sand from exposed bedrock deposits** of weak sandstone or where the cover of superficial deposits is not too great.

*Resources may have been removed by past mineral extraction. More details are given on Map 5; volume 1 chapter 10; and volume 2 chapter 7*

E. MAJOR FAULTS

Major faults may act as pathways for the transmission of gases and liquids. Movements of the ground adjacent to faults are unlikely to affect the surface and structures on it in the absence of mining, previously mined ground or major excavations.

*More details are given in volume 1 chapters 9,12 and 13, volume 2 chapters 4 and 6*

## Applied geological mapping in Wigan – key factors relevant to planning and development (1995)

# IMPROVED APPROACH

Direct involvement of planners in

- initial scoping
- throughout work
- designing maps and reports

# END OF THE PROGRAMME

"Not role of government"

" Leave to - industry, developers, BGS"

Seminar at Geological Society

Complete basic geological mapping

Terminated but for dissemination

Advice published in 1999 (informal)

## SUCCESSES

- Engaged planners in process
- Results fit for purpose
- Used by planners for:
  - development planning
  - control of development
- Well disseminated within study areas
- Databases - long-term value

## LIMITATIONS

- Expense of map sets
- Limited transfer of principles to other areas
- Failed to persuade “establishment” of importance
- No maintenance
- Limited corporate memory
- Not built into administrative procedures

## SUBSEQUENT EVENTS

- BGS standard thematic mapping
- GIS - dynamic mapping, lower costs
- Development of DGSM
- EIS - direct linkages to planning
- RTPI training of planners

## CONCLUSIONS

- Successful at technical level
- Limited success at administrative level
- Need to keep on repeating messages
- Build into regulation, legislation or guidance
- Link to training and CPD for planners.

[Maps kindly provided by BGS)