Available online at www.sciencedirect.com
SCIENCE DIRECT
ELSEVIER
Engineering Geology 69 (2003) 399–409
ENGINEERING GEOLOGY
www.elsevier.com/locate/enggeo

Classification of artificial (man-made) ground

M.S. Rosenbaum[a,*], A.A. McMillan[b], J.H. Powell[c], A.H. Cooper[c], M.G. Culshaw[d], K.J. Northmore[c]

[a] *School of Property and Construction, Nottingham Trent University, Newton Building, Burton Street, Nottingham NG1 4BU, UK*
[b] *British Geological Survey, Murchison House, West Mains Road, Edinburg EH4 3LA, UK*
[c] *British Geological Survey, Keyworth, Nottingham NG12 5GG, UK*
[d] *Nottingham Trent University, Geohazards Group, Nottingham NG1 4BU, and British Geological Survey, Keyworth, Nottingham NG12 5GG, UK*

Received 1 August 2002; received in revised form 12 December 2002; accepted 13 December 2002

Abstract

The legacy inherited from anthropogenic processes needs to be addressed in order to provide reliable and up-to-date ground information relevant to development and regeneration in the urban environment. The legacy includes voids as well as anthropogenic deposits (artificial ground). Their characteristics derive from former quarrying and mining activities, industrial processes creating derelict ground, variably consolidated made ground, and contaminated groundwater and soils. All need to be systematically assessed to inform the planning process and provide the basis for engineering solutions. Site-specific investigation needs to be conducted on the back of good quality geoscientific data. This comes from 'field' survey, remotely sensed data interpretation, historical maps, soil geochemical sampling, and geotechnical investigation. Three-dimensional and, in the future, four dimensional, characterization of superficial deposits is required to reach an understanding of the potential spatial lithological variability of artificial ground and the geometry of important surfaces, i.e. the boundary conditions. The classification scheme for artificial ground outlined in this paper and adopted by the British Geological Survey, will help in achieving this understanding.

Keywords: Artificial ground; Anthropogenic deposits; Made ground; Derelict ground; Contaminated land; Ground investigation; Superficial deposits

1. Introduction

The provision of reliable and up-to-date ground information for the urban environment has assumed increasing importance in recent years as towns and cities have become the focus for regeneration and development, and demands the best available geoscientific advice. Clearly the properties of naturally occurring superficial deposits and solid rocks need to be defined and understood but, in addition, the legacy inherited from anthropogenic processes needs to be addressed.

The legacy includes holes in the ground as well as materials. Their characteristics derive from former quarrying and mining activities (leading to subsidence

* Corresponding author. Fax: +44-115-848-6450.
E-mail address: mike.rosenbaum@ntu.ac.uk (M.S. Rosenbaum).

0013-7952/03/$ - see front matter © 2003 Elsevier Science B.V. All rights reserved.
doi:10.1016/S0013-7952(02)00282-X

and a modified groundwater regime), industrial processes creating derelict ground (leading to unexpected site characteristics—geohazards), earthworks (characterised by variably consolidated made ground), and polluted (even contaminated) groundwater and soils. Some might have been treated by one or more ground improvement techniques. All need to be systematically assessed to inform the planning process and provide the basis for engineering solutions (McMillan et al., 2001).

Thus, as major initiatives are taken to encourage greater usage of 'brownfield', 'inner city greenfield' and 'urban ring greenfield' sites for industrial development and redevelopment and for modern housing (DETR, 2000), so the demand grows for up-to-date information on ground conditions, geomorphology and topography together with baseline data against which polluted land and derelict land may be assessed.

This type of information is commonly assembled and stored as part of the data collection and mapping carried out by National Geological Surveys. Such information is often held digitally in databases, geographical information systems (GIS) and, increasingly, 3D models. To ensure consistency in the way geological materials are classified the British Geological Survey (BGS) has established schemes for rocks, sediments, superficial deposits and artificial deposits (Gillespie and Styles, 1999; Hallsworth and Knox, 1999; McMillan and Powell, 1999; Robertson, 1999). To ensure that the classification schemes are appropriate for the production of digital maps, the BGS initiated a review of its Rock Classification Scheme and parts of the stratigraphical lexicon in order to set up hierarchical schemes and master dictionaries of terms for the geological map and borehole digital database. The classification scheme needs to be designed specifically for applications to geological maps and datasets in the UK and, as such, needs to consider not only deposits which are mapped at 1:10 000 scale (the most mapping scale in the UK) but also larger scales relevant to site-specific investigations. The schemes have been based, with modification, upon the specifications for 1:10 000 and 1:50 000 scale maps, and field mapping procedures (BGS, 1995). They are designed to be used and interpreted by both geologists and non-geologists to allow thematic material comprising identified classes of geological material to be extracted from geological maps and other datasets. The schemes are currently being enhanced to extend the hierarchical schemes for both lithology and morphostratigraphy.

2. Genetic basis of the classification scheme

Mapping of artificial ground in the field requires recognition by geologists and geomorphologists of the diagnostic landform (morphology) and, where possible, recording of the physical, sedimentological and lithological (compositional) characteristics of the surface materials. During the process of map compilation these characteristics are interpreted to deduce the origin (genesis) of the deposits. Sequences may be deduced from temporary cuttings, natural sections and subsurface datasets including boreholes and trial pits. Where good subsurface datasets exist, maps of resources, geotechnical and lithological profiles may be constructed.

A single criterion may be sufficient to determine the origin of a deposit, but this is rare. In general, a combination of characteristics is required, though these may not always be available. For example, a landform may be mapped both on the ground and from remote datasets including aerial photographs and satellite imagery, but only limited information may be available on the nature of surface materials in terms of their composition, lithology and texture. Conversely, subsurface information from boreholes and trial pits will consist of lithological (or compositional) and other physical characteristics, but surface morphological information may be absent or insufficient to interpret the genesis of some deposits. Thus, in theory, it is possible to systematically subdivide any artificial ground into its textural, morphological and genetic components, but in practice it is seldom possible to do this.

The genetic approach applies both to artificial ground and natural superficial deposits. For artificial deposits, the human origin constitutes the primary criterion for classification and, if known, the nature of the ground and the composition of the artificial material can also be included. A hierarchical scheme is developed linking the principal genetic class (Level 1) with basic (Level 2) and more detailed

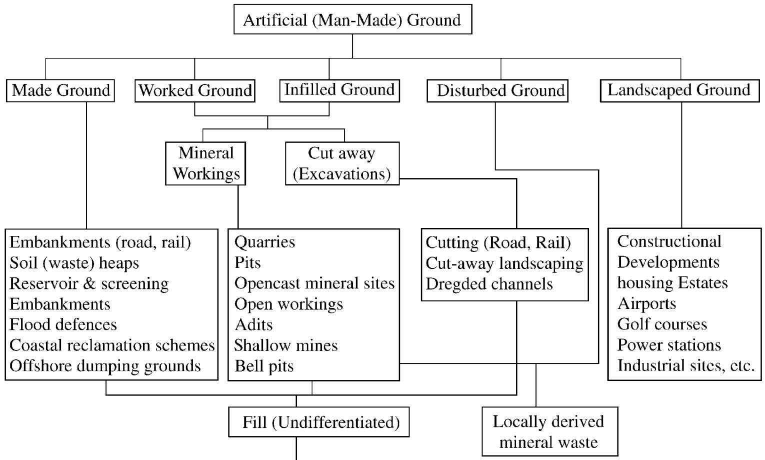
Table 1
Artificial (man-made) ground (from McMillan and Powell, 1999)

Level 1

Level 2
BGS mapping
subdivision (shown
at 1:10 000 Maps)

Level 3
Topographical/ Geographical
Category (may be flagged
on fieldslip or on 1:10 000 map,
or recorded on borehole log)

Level 4
Material type (deposit)
(may be flagged on fieldship or 1:10 000 map or
recorded on borehole log)
Cateogories of waste composition have been defined in the
DETR/EA draft UK Waste Classification Scheme (1998);
see Table 2a for the main (first level) categories of waste



List of commonly used terms for waste/fill in the UK (See Apendix 1)

Aggregate	21
Asbetsos waste	26
Ash	27
Ballast	24
Blast-furnace slag	27
Brick	21
Building rubble	22
Cardboard	22
Ceramic waste	21
Chemical waste (undifferentiated)	28,29,30
China clay waste	21
Clay (brick/tile) waste	21
Clinker	27
Coal shale	27
Colliery waste (spoil)/mine stone	27
Domestic/garden refuse	22
Effluent	22
Foundry sand	24
Foundry slag	27
Furnace ash	27
Garden waste	22
Herbicied	29
Industrial waste (undifferentiated)	many categories
Mine dumps (tailings)	27
Mineral waste (undifferentiated)	27
Oil shale waste	27
Organic waste (undifferentiated)	29
Paper	22
Peat	22
Pesticide	29
Plasterboard	22
Pulverised fuel ash	27
Quarry waste	27
Radioactive waste	31
Rock waste	21
Sewage sludge	22
Shale waste	27
Slate waste	27
Soil	22
Spoil	27
Toxic waste (undifferentiated)	many categories
Wood	20

(numbers refer to categories of the first category UK Waste Classification Scheme; Table 2a) mapping categories (Level 3). These three levels can be considered to be broadly related like the stratigraphical units of group, formation and member. They are included in the BGS stratigraphical lexicon of named rock units and may be searched via the Internet at http://www.bgs.ac.uk/lexicon/lexicon.html. Level 4 relates to the lithology of the deposit and is used in parallel with the morpho-stratigraphical divisions of Levels 1–3. For a fully attributed map polygon or borehole unit, the present BGS coding scheme assigns a Level 2 entry for the morpho-stratigraphy and a Level 4 code for lithology. Level 4 lithological codes, as they currently exist, are available in the BGS rock classification scheme, which may be searched via the internet at http://www.bgs.ac.uk/bgsrcs/searchRCS.html. Subdivisions and codes for Level 3 are currently being prepared and the lithological classificaton is being extended and revised. The scheme incorporates the necessary cross-references, synonyms and obsolete terms for digital retrieval purposes. The

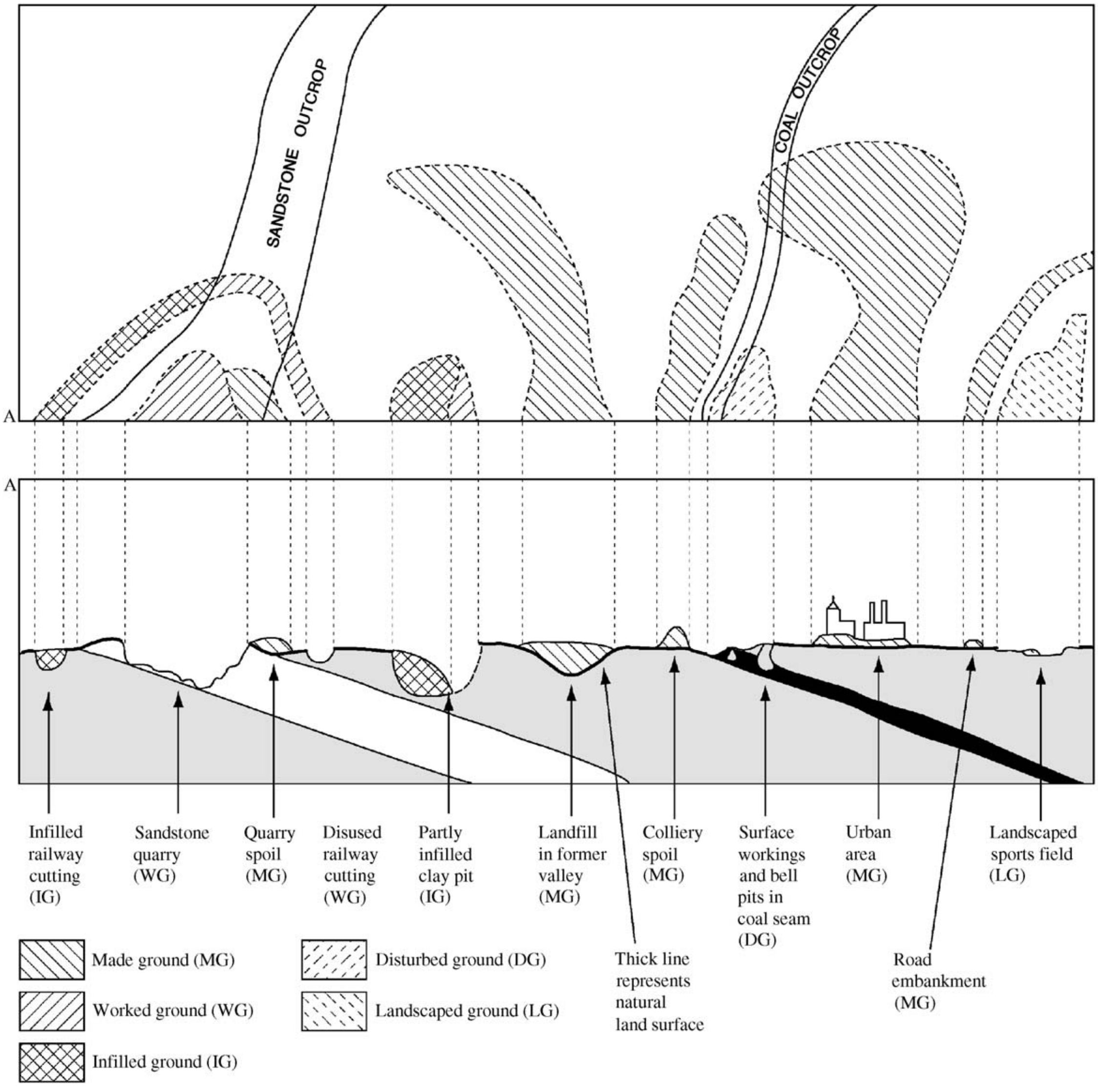


Fig. 1. Schematic map and cross-section (A–B) illustrating types of artificial ground (from McMillan and Powell, 1999).

definition of each genetic category and its subdivisions may include textural and other physical information, which may be common to more than one genetic class.

3. Classification of artificial ground

The major categories for artificial (man-made) ground mapped by the BGS over the past 50 years or so comprise: worked ground, made ground, infilled ground (also called 'worked and made ground'), landscaped ground and disturbed ground. A glossary of commonly used terms associated with these categories is provided (Appendix A).

These categories include both man-made deposits and voids, that is, areas that have been worked or excavated such as pits, quarries and cuttings. The categories have been used widely in recent BGS mapping projects, particularly in urban, applied (thematic) geological mapping studies supported by the former UK Department of the Environment (DoE) (Smith and Ellison, 1999), and are now routinely delineated on current BGS 1:10 000 geological maps (BGS, 1995). They will appear, to an increasing extent, on newly published BGS 1:50 000 series geological maps, a number of which incorporate urban areas surveyed during recent applied geological mapping projects (for example, Powell et al., 1992; Forster et al., 1995; Waters et al., 1996).

The classification of artificial ground (modified from McMillan and Powell, 1999) is shown in Table 1 and illustrated in Fig. 1. The basic mapping categories (Level 2 of Table 1) are defined thus:

Made ground: Areas where the ground is known to have been artificially deposited on the former, natural ground surface: engineered fill such as road, rail, reservoir and screening embankments; flood defences; spoil (waste) heaps; coastal reclamation fill; offshore dumping grounds; constructional fill (landraise).

Worked ground: Areas where the ground is known to have been artificially cut away (excavated): quarries, pits, rail and road cuttings, cut away landscaping, dredged channels.

Infilled ground (formerly Worked Ground and Made Ground): Areas where the ground has been cut away (excavated) and then had artificial ground (fill) deposited: partly or wholly back-filled workings such as pits, quarries, opencast sites; landfill sites (except sites where material is dumped or spread over the natural ground surface, as for landraise). (The category of infilled ground is currently under review; it is likely to remain as an entity on the 1:50 000 scale datasets, but for digital map compilation and modelling at a scale of 1:10 000 or greater, there are advantages to keeping all the worked ground in one category and the made ground in another. Infilled ground can then be derived from these two datasets, when it is required).

Landscaped ground: Areas where the original ground surface has been extensively remodelled, but where it is impractical or impossible to separately delineate areas of worked (excavated) ground and made ground.

Disturbed ground: Areas of surface and near-surface mineral workings where ill-defined excavations, areas of man-induced subsidence caused by the workings and spoil are complexly associated with each other, for example, collapsed bell pits and shallow mine workings.

4. Classification of fill, made ground and waste

There have been a considerable number of attempts to classify types of fill and waste material (for example: DoE, 1993; DETR/EA, 1998). However, fill at any one site is commonly an admixture of organic, chemical and inert materials. The nature of the fill can vary, both vertically and horizontally, over a short distance, and at sites where there is no record of the fill, or at poorly monitored landfill sites, the nature of the fill can only be determined by a densely spaced, borehole site investigation. The UK Waste Classification Scheme (DETR/EA, 1998), jointly produced by the UK's Department of the Environment, Transport and the Regions (DETR; since mid 2002, the Office of the Deputy Prime Minister) and the Environment Agency (EA) considered the classification of waste, and recommended that waste material should be classified in a consistent manner nationally. The index to the first level categories of waste composition the DETR/EA Scheme is listed in Table 2a.

Table 2
UK Waste and European Community Landfill Site Classification Schemes (from McMillan and Powell (1999))

(a) The UK Waste Classification Scheme
(Draft for consultation)
Index to the first category of waste[a]

Cat No.	Category of waste (first level)
21	Inert
22	General and biodegradable
23	Metals and discarded (scarp) composite equipment
24	Contaminated general
25	Healthcare risk waste
26	Asbestos
27	Mineral wastes and residues from thermal proocesses not listed elsewhere
28	Inorganic chemical
29	Organic chemical
30	Mixed chemical "small"
31	Radioactive
32	Explosives

[a] For furhter subdivisions and categories, see The UK Waste Classification Scheme DETR/Environment Agency; Draft for Consultation (version consulted is Draft 16, July 1998).

(b) Landfill Site Classification (European Community)[b]

i	Hazardous waste
ii	Municipal and non-hazardous waste and other compatible waste
iii	Inert waste

[b] This classification is not recomended for mapping of artificial ground due to the possibility of mixing during uncontrolled fill.

Due to the possible contentious problems in classifying fill types from a historical perspective, it is considered best practice to record only the proven types of fill at a site, or where there is uncertainty concerning the nature of the fill, it should be recorded as 'undifferentiated'. Since there is much disagreement and uncertainty concerning the classification of waste material, the current practice for mapping purposes is that the material type (deposit), where known, is classified using the list of common lithological terms for UK waste/fill—shown at Level 4 of Table 1, and defined in Appendix A. The categories are cross-referenced, by number, to the probable first level categories of the UK Waste Classification Scheme shown on Table 2a.

In some urban areas with extensive artificial deposits it is not always possible to determine whether a 'landfill' site registered by a local authority represents made ground (for example, spreads on the pre-existing ground surface, also known as 'Landraise') or infilled ground (for example quarries). It may be necessary to show such sites on thematic maps as 'Landfill site, undifferentiated'. The use of sequential generations of historical map data, such as UK Ordnance Survey topographical maps, can frequently help to delineate such problematical areas.

A European Community (EC) directive (OJ No. C 212/33, 1993) classifies landfill sites according to their origin:

- municipal waste
- industrial waste

and also according to their characteristics

- hazardous waste
- non-hazardous waste
- inert waste

However, since 'non-hazardous' may include some organic materials that could, under certain conditions, give rise to hazardous methane or carbon dioxide, this classification is considered as too ambiguous to be of use in classifying the material type. The EC classification of Landfill Sites is shown as an example of landfill subdivision (Table 2b), but it is not recommended for wider use.

5. Graphical portrayal—maps, digital images and borehole cross-sections

The mapping categories are shown on BGS 1:10 000 and 1:50 000 series geological maps by various styles of hatching over the underlying natural superficial deposit or bedrock; colour fill or colour hatching may be used on digitally generated maps. The boundaries are shown by a fine, dashed line on geologists' 1:10 000 scale standards, although digital prints in the past have shown the boundary as a continuous fine line.

The hierarchical scheme (Table 1) for the artificial ground classification scheme is as follows:

Level 1: This shows artificial ground undivided; it is a top level within the lexicon of named rock units.

Level 2: This is the currently used scheme portrayed on the majority of new 1:10 000 BGS digital and analogue geological maps. Users wishing to retrieve information on the map-face will generally select the major category such as made ground, or perhaps a combination of one or more of these with a particular type of underlying natural superficial deposit or bedrock. For example, an enquirer studying aquifer pollution from landfill sites may wish to show the incidence of infilled ground overlying sand and gravel deposits and/or sandstone bedrock. To date, the mapping categories (Level 2) have been only rarely subdivided to Level 3 on BGS 1:10 000 scale maps.

Level 3: Where good records exist, types of made ground and fill have been categorised. For instance the BGS Stoke-on-Trent Applied Geological Mapping Project for the DoE (Wilson et al., 1992) showed subdivisions of the made ground on a thematic map, including: colliery waste, ironworks slags and ceramic waste. Borehole logs received from outside sources, particularly site investigation records, commonly describe the nature of the made ground deposit in terms of Level 4 (lithology), and this information may be required to classify the Level 3 deposits. This type of information has not been systematically recorded or presented on standard 1:10 000 BGS maps. However, some individual sites such as sand and gravel quarries (worked ground), infilled opencast coal sites (infilled ground), railway embankments (made ground), and bell pits (disturbed ground) may have been denoted on the map face. The majority of borehole logs received by BGS do not record the Level 3 category, and the record will 'step' from the major category (Level 2) (for example made ground, infilled ground) to lithological details of the deposit or material type (Level 4) (for example ash, colliery waste, blast furnace slag).

Level 4: In the hierarchy this is the material type or lithology of the deposit. Common terms used for waste/fill material in the UK are shown in Table 1, and are defined in Appendix A. Computer codes for these deposits are available on the Internet site noted below. For analogue maps, the material may be denoted on the map face either on its own (for example, colliery spoil), or together with the topographical category (for example, disused pit infilled with blast furnace slag). The deposit was not systematically recorded by the BGS during mapping surveys, chiefly because it is commonly not visible, and because of the variable nature of the material, both horizontally and vertically, at many sites. More detailed mapping is now being undertaken in many places, but for some areas the lack of boreholes means that the lithology of the artificial ground remains unknown. As noted in the Stoke-on-Trent example (Wilson et al., 1992), above, some thematic maps may show subdivisions of infilled ground (worked and made ground) based on material type or a combination of material type and topographical category (Level 3) (opencast coal site, colliery waste). On BGS digital maps Level 4 as a lithology has not been much used, but more recent studies are attributing polygons with both the morpho-stratigraphy (Level 3) and the lithology (Level 4). In BGS digital borehole logs, Level 4 is coded in the lithology column with fuller details, or the complete description (mainly to BS 5930 (British Standards Institution, 1999) as presented in the log), noted in the comments column.

The revised scheme and the way that the BSG 1:10 000 scale map and borehole data is being gathered will give the geologist the freedom to record and digitally attribute many more types of artificial deposit in a quick and efficient manner. The geologist will no longer be restricted to trying to display layers of data using a few cross-hatching patterns and line types. Thematic maps can be generated easily from the data sets and attribution tables can hold many tiers of information ranging from date of formation to data source. It is likely that multiple layers representing different dates of material will be permitted and the digital geological map will become a much stronger tool for engineering applications and environmental protection.

6. Conclusions

The legacy inherited from anthropogenic processes needs to be addressed in order to provide reliable and up-to-date ground information relevant to the urban environment. The legacy includes voids as well as materials. Their characteristics derive from former quarrying and mining activities, industrial processes creating derelict ground, variably consolidated made ground, and contaminated groundwater and soils. All need to be systematically assessed to inform the planning process and provide the basis for engineering solutions.

Site-specific investigation needs to be conducted on the back of good quality geoscientific data. This comes from 'field' survey, remotely sensed data interpretation, soil geochemical sampling, and geotechnical investigation. Three-dimensional and temporal characterization of superficial deposits is required to reach an understanding of the potential spatial lithological variability of artificial ground and the geometry of importance surfaces, i.e. the boundary conditions.

The establishment of hierarchical corporate dictionary structures for classifying artificial deposits (morpho-stratigraphically and lithologically) allied with careful recording and attribution has great potential for artificial ground modelling. This can be used in digital datasets for maps and borehole databases, which will soon also allow the user to attribute the deposits with their ages, extracted from historical maps and aerial photographs. This will permit a new generation of 3D modelling of artificial deposits to be undertaken.

Acknowledgements

The authors acknowledge with thanks the BGS Review Panel and many other staff including Holger Kessler, Jon Ford and Simon Price for their advice and comments arising from work in progress on the revised classification scheme. This was prepared initially for BGS use, and is released for information. AAMcM, JHP, AHC, MGC and KJN publish with the permission of the Executive Director of the British Geological Survey (NERC).

Appendix A. Glossary of commonly used terms for artificial (man-made) ground

Most of the categories at Level 4 of the artificial ground classification scheme are self-explanatory, others less so. The listings comprise the categories most commonly encountered, at this 'material' level, in site investigation records and during field survey; it is not exhaustive, and it is assumed that further categories will be added. Categories of waste are listed in the UK Waste Classification Scheme (DETR/EA, 1998). Natural materials are commonly a component of artificial deposits.

Definitions are based on:

The Concise Oxford Dictionary of Earth Sciences, 1990. Allaby, A. and Allaby, M. (editors) (Oxford: Oxford University Press).

Penguin Dictionary of Geology, 1972. Whitten, D.G.A., and Brooks, J.R.V. (Harmondsworth: Penguin Books).

The Concise Oxford Dictionary (6th edition. 1976). Sykes, J.B. (editor) (Oxford: Oxford University Press).

aggregate in the building industry: a range of mineral substances, for example sand, gravel, crushed rock, stone, slag and other minerals which, when cemented, forms concrete, mortar, mastic, plaster. Uncemented, it can be used to as a bulk material in road-making and ballast

asbestos waste: waste material derived from of asbestos products or their manufacture
ash: general term for powdery residue left after combustion of any substance (also used geologically for volcanic particles less than 2 mm in size; (see Gillespie and Styles, 1999)
ballast: coarse stone mixed with sand, etc. Used to form bed of railway or substratum of road
bell pit in mining: a bell-shaped excavation in which the extracted material was dragged to a central shaft; an obsolete method for extracting mineral deposits from shallow depths. Disused bell pits are usually collapsed and/or partly backfilled with rock waste
building rubble: waste material derived from construction, usually consisting of brick, concrete, stone and plasterboard with minor amounts of wood and metal. May be partly organic in content
blast-furnace slag: semi-fused or fused waste material produced in the metal industry
brick: clay kneaded, moulded and baked (fired) or sun-dried; usually a small, rectangular block
cardboard: thick paper or paste board
ceramic waste (undifferentiated): waste material from the pottery and ceramic industries, commonly comprising partly fired and fired clay products
chemical waste (undifferentiated): waste material, and by-products derived from the chemical industry and chemical processes
china clay waste: kaolin and waste materials derived from the extraction of kaolin from granitic rocks
clay waste: generally clayey material usually containing at least 20% by weight of clay particles
clinker: semi-fused or fused, hard foundry slag; stony residue from burnt coal
coal shale: colliery waste, generally of a fissile shaly nature
colliery waste also known as spoil; tip and bing (Scotland): heterolithic waste material produced from the mining of coal or associated ironstone and fireclay; commonly a mixture of mudstone, siltstone, sandstone, carbonaceous ‘shale’ and coal, with minor amounts of ironstone. May contain secondary minerals such as pyrite and sulphur
domestic/garden refuse: undifferentiated organic and inorganic waste
effluent: waste liquid flowing from a sewage tank or industrial process
fill: general term for material used to infill a void or cavity in the earth’s surface or sub-surface; constructional fill (made ground) is material placed above the natural earth surface; engineered fill is material placed by a pre-determined process to ensure suitability for a specific use
foundry sand or sand waste: may be impregnated with organic materials produced in the metal and glass industries
foundry slag: semi-fused or fused waste material produced in the metal and glass industries
furnace ash: residue left after the combustion of any substance, but commonly coal in metallic blast furnaces
garden waste: predominantly organic waste including woody materials, grass and soil
herbicide: substance toxic to plants and used to kill unwanted vegetation
industrial waste (undifferentiated): waste products from industrial processes
landfill site: waste disposal site used for the controlled deposit of the waste onto or into land
landraise site: a specific type of landfill site (see above) where the waste is deposited on the pre-existing natural ground surface; the deposit is classified as made ground in the BGS Rock Classification Scheme
mine dumps (tailings): inferior part of ore or mineral or surrounding rock, usually deposited close to the mine (see mineral waste)
mineral waste (undifferentiated): general term for the waste products of mining and surface mineral workings
mine stone (synonym: *spoil*; see also *colliery waste*): generally the inorganic material commonly used for ballast or aggregate. May be partly organic in content
oil shale waste: waste products from the mining of dark grey or black shale containing organic substances that yield liquid hydrocarbons on distillation
organic waste (undifferentiated): waste materials containing carbon compounds, such as wood, plant materials, coal
paper: substance made from compacted interlaced fibres of rags, wood, straw

pesticide: substance used for killing pests, especially insects
plasterboard: board with a core of plaster for walls
pulverised fuel ash (pfa): pulverised (fine grade) ash waste from the burning of coal, usually in coal-fired power stations; commonly used as an inert fill material, or for the production of breeze blocks
quarry waste: general term for waste materials consisting mostly of rock with overburden drift deposits, derived from quarrying (see rock waste, slate waste, shale waste)
radioactive waste: general term for waste materials derived from nuclear processes that are contaminated with radionuclides; may be classified as low-level, intermediate or high-level waste
rock waste: general term for waste materials consisting mostly of rock, derived from quarrying or excavation
sewage sludge: solid waste material from sewage treatment works
shale waste: waste material derived from quarrying or mining of fissile mudstone (for example alum shale, bituminous shale)
slate waste: waste material derived from quarrying or mining of slate (cleaved, fissile, low-grade metamorphosed mudstone)
spoil: earth material (rock or unconsolidated sediment) thrown up or brought up in mining, excavating or dredging (synonym *mine stone*, which consists predominantly of *colliery waste*)
toxic waste poisonous waste
waste general term for superfluous material (refuse) and by-products of manufacturing, mineral extraction, or physiological process, no longer serving a purpose, and which the holder discards or intends or is required to discard. Some categories of waste, however, may constitute a re-useable resource, for example *colliery waste* (*spoil*) that is re-used (and re-classified as *mine stone*) as a fill material, or *pfa* (mixed with cement) re-used as a grouting material

References

BGS (British Geological Survey), 1995. Specification for the preparation of 1:10,000 scale geological maps (2nd edition). British Geological Survey Technical Report WA/95/64. ©NERC Copyright 1995 British Geological Survey, Nottingham.

British Standards Institution, 1999. Code of practice for site investigation, BS 5930:1999. Her Majesty's Stationary Office, London.

DETR (Department of the Environment, Transport and the Regions), 2000. Our towns and cities: the future—delivering an urban renaissance. White Paper, HMSO, London.

DETR/EA (Department of the Environment, Transport and the Regions, and Environment Agency), 1998. The UK Waste Classification Scheme; Draft 16 for consultation, HMSO, London.

DoE (Department of the Environment), 1993. The preparation of waste disposal (management) plans. Waste Management Paper No. 2/3-A Draft for Consultation. Department of the Environment, HMSO, London.

Forster, A., Arrick, A., Culshaw, M.G., Johnston, M., 1995. A geological background for planning and development in Wigan. British Geological Survey Tehnical Report, No. WN/95/3. ©NERC Copyright 1995 British Geological Survey, Nottingham.

Gillespie, M.R., Styles, M.T., 1999. BGS Rock Classification Scheme, Volume 1: Classification of igneous rocks. British Geological Survey Research Report, RR 99-06. © NERC Copyright 1999 British Geological Survey, Nottingham.

Hallsworth, C.R., Knox, R.W.O'B., 1999. BGS Rock Classification Scheme, Volume 3: Classification of sediments and sedimentary rocks. British Geological Survey Research Report, RR 99-03. © NERC Copyright 1999 British Geological Survey, Nottingham.

McMillan, A.A., Powell, J.H., 1999. BGS Rock Classification Sheme, Volume 4: Classification of artificial (man-made) ground and natural superficial deposits—applications to geological map and datasets in the UK. British Geological Survey Research Report, RR 99-04. ©NERC Copyright 1999 British Geological Survey, Nottingham, *Contributors*: Evans, C.D.R., Irving, A.A.M., Merritt, J.W., Morigi, A.N., Northmore, K.J.,

McMillan, A.A., Ellison, R.A., Fordyce, F., Golledge, N.R., Holmes, K.A., Jordan, C.J., Kessler, H., Monaghan, A., Northmore, K.J., Robins, N.S., Taylor, C., 2001. Superficial deposits characterisation in the urban environment: a best practice guide to mapping and research. British Geological Survey Internal Report, IR/01/68. ©NERC Copyright 2001 British Geological Survey, Nottingham, *Contributors*: Breward, N., Browne, M.A.E., Entwisle, D.C., Ferguson, A., Hopson, P., Lister, R., MacDonald, A.M., Rawlins, B.

Powell, J.H., Glover, B.W., Waters, CN., 1992. A geological background for planning and development in the Black Country. British Geological Survey Technical Report, No. WA/92/33. ©NERC Copyright 1992 British Geological Survey, Nottingham.

Robertson, S., 1999. BGS Rock Classification Scheme, Volume 2: Classification of metamorphic rocks. British Geological Survey Research Report, RR 99-02. © NERC Copyright 1999 British Geological Survey, Nottingham.

Smith, A., Ellison, R.A., 1999. Applied geological maps for planning and development. A review of examples from England and Wales, 1983 to 1996. Quarterly Journal of Engineering Geology. 32 (Supplement) 44 p.

Waters, C.N., Northmore, K.J., Prince, G., Marker, B.R., 1996. A geological background for planning and development in the City of Bradford Metropolitan District. British Geological Survey Technical Report, No. WA/96/1. ©NERC Copyright 1996 British Geological Survey, Nottingham.

Wilson, A.A., Rees, J.G., Crofts, R.G., Howard, A.S., Buchanan, J.G., Waine, P.J., 1992. Stoke-on-Trent: a geological background for planning and development. British Geological Survey Technical Report, WA/91/01 for the Department of the Environment.