**Table 1b** Modifications to Table 1 for other types of concrete

| Concrete type | General Recommendations |
|---|---|
| Poorly compacted concrete designed for full compaction | Not acceptable for sulphate resistance |
| Cast insitu concrete over 450mm thick. Precast ground beams, wall units or piles with smooth surfaces which, after normal curing, have been exposed to air but protected from rain for several weeks. | For Classes 2, 3 and 4 the requirements for type of cement, cement content and water/cement ratio given in Table 1 may be *reduced* by one class if other durability and structural considerations permit. |
| Cast insitu concrete (other than ground floor slabs) less than 140mm thick or having many edges and corners. | *Increase* classification in Table 1 by one class. |
| Precast concrete blocks | Blocks should comply with BS 6073 and with BS 5628: Part 3 relating to use below ground for Classes 2 and 3 of Table 1. As an alternative to compliance with the minimum cement content and water/cement ratio given in Table 1 for Classes 1 to 3, autoclaved blocks (including aerated blocks - *Aircrete* - with a minimum density of 600 kg/m$^3$) or pressed blocks with more than 50% of their least cross-sectional area carbonated* may be used. |
| Concrete bricks | Compliance with BS 6073 and with Table 1. |
| Concrete pipes | Classification with respect to type of cement may be *reduced* by one class for pipes complying with Parts 100 and 120 of BS 5911. Cement contents and water/cement ratios in Table 1 are not relevant. |
| Porous concrete pipes | Compliance with BS 1194. Porous concrete pipes are not suitable for use in Class 3, 4 or 5 soils. |

* Estimated by breaking block and applying phenolphthalein - *see BRE Information Paper 6/81*

**Table 1c** Types of Cement

| Code | Type or combination | Code | Type or Combination |
|---|---|---|---|
| A | Portland cement to BS 12 | H | Sulphate-resisting Portland cement to BS 4027 |
| B | Portland blastfurnace cements to BS 146 | I | High-slag blastfurnace cement to BS 4246 containing not less than 74% slag by mass of nucleus |
| C | High slag blastfurnace cement to BS 4246 | | |
| D | Combination of Portland cements to BS 12 and blastfurnace slag to BS 6699 | J | Combination of Portland cements to BS 12 and blastfurnace slag to BS 6699 containing not less than 70% slag and not more than 90% slag by mass of slag plus cement |
| E | Portland pfa cements to BS 6588 | | |
| F | Combinations of Portland cement to BS 12 and pfa to BS 3892: Part 1 | K | Portland pfa cements to BS 6588 containing not less than 26% pfa by mass of nucleus |
| G | Pozzolanic pfa-cement to BS 6610: 1991 | L | Combinations of Portland cements to BS 12 and pfa to BS 3892: Part 1 containing not less than 25% pfa and not more than 40% pfa by mass of pfa plus cement |

In Codes I and J, slag with alumina ($Al_2O_3$) content over 14% should be used only with Portland cement having low to moderate $C_3A$ content (typically less than 10%)

**Water table and mobility of groundwater**

A 'dry' site, for which a standing water table is hard to identify in any season, is unlikely to give rise to any significant chemical attack on concrete placed in it. Where water is found, its movement may be vertical or horizontal depending on seasonal variations in rainfall and on the geology of the site and its environs. A low sulphate or acid content in the soil does not eliminate the possibility of attack since groundwater may flow from adjacent areas, particularly if the soil has been disturbed, eg by laying pipes. However, in undisturbed and unfissured clay soils, the movement will be very slow. The principal requirement in assessing the likely degree of chemical attack, particularly in the case of acid attack, is to establish whether the water adjacent to the concrete is essentially static or mobile. A subjective assessment can often be made taking into account observations of the rate of percolation into excavations, the type of strata and local topography. Accumulations of free water or water in highly permeable material should be regarded as mobile - See Table 1a.

Table 2 Requirements for concrete exposed to attack from acids of pH>2.5

| Use | Concrete in contact with: | pH | Mobility water *(Table 1a)* M = Mobile S = Static | Aggressive $CO_2$ *(Table 3)* H = High L = Low | Change in classification with respect to minimum cement content and maximum water/cement ratio for the type of cement recommended on the basis of sulphate in Tables 1, 1a and 1b *When advancing classes for cements A - G into Classes 3 - 5, choose the higher cement content option* |
|---|---|---|---|---|---|
| Foundations including poured cast insitu piles. *For piles made by special techniques using low water/cement ratio slightly less stringent requirements may be applicable* | Natural ground | >5.5 | S or M | - | No change |
| | | 3.5 to 5.5 | S | - | No change |
| | | | M | - | Advance by one class |
| | | <3.5 | S | - | Advance by one class |
| | | | M | - | Advance by one class |
| | Ground containing waste or made up ground | >5.5 | S | - | No change |
| | | | M | - | Advance by one class |
| | | 4.5 to 5.5 | S | - | Advance by one class |
| | | | M | - | Advance by two classes |
| | | <4.5 | S | - | Advance by one class |
| | | | M | - | Advance by three classes |

## CLASSIFICATION OF SITES AND RECOMMENDATIONS FOR CONCRETE

Classification of a site on the basis of groundwater samples is preferred. The acid extraction of the sulphate in a soil or fill will reveal the total potential reservoir of sulphate but will not reflect its solubility. The use of a 2:1 water:soil extract takes relative solubility into account. Higher values for sulphate concentration are given in column 3 of Table 1 than in the equivalent groundwater classification, in recognition of the difficulties of obtaining representative samples and of achieving a comparable extraction rate to that indicated by analysis of groundwater samples.

Having classified the site on the basis of the sulphate level (Table 1), type of exposure (Table 1a) and type of concrete (Table 1b), the further recommendations for concrete in acidic conditions are given in Table 2. The pH of the soil extract or groundwater should be determined by the method given in Clause 9 of BS 1377:Part 3.

Some suitable methods for the analysis of groundwaters for sulphates are given in BS 1377:Part 3 and in BRE Current Paper 2/79 which also gives methods for the determination of magnesium.

**The above are extracts from BRE Digest 363: June 1991, Sulphate and Acid Resistant Concrete in the Ground**

## RESULTS OF CONTAMINATION ANALYSIS

*ICRCL 59/83 (Second Edition) Table 3*

**Contract:** Highgate West Hill, Highgate **Report No:** *99/4169/KJC*

| Location | Depth m | Sample Description | Arsenic mg/kg | Cadmium mg/kg | Chromium (Hexavelent) mg/kg | Chromium (Total) mg/kg | Lead mg/kg | Mercury mg/kg | Selenium mg/kg | Boron (Water Soluble) mg/kg | Copper mg/kg | Nickel mg/kg | Zinc mg/kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH 1 | 0.50 | Made ground | <1 | <1 | | 10 | 38 | <1 | <1 | <1 | 8 | 2 | 19 |
| WS 5 | 1.00 | Made ground | <1 | <1 | | 23 | 348 | <1 | <1 | <1 | 53 | 6 | 76 |
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| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Threshold Trigger Concentrations for open space | | | 40 | 15 | | 1000 | 2000 | 20 | 6 | 3 | 130 | 70 | 300 |

## RESULTS OF CONTAMINATION ANALYSIS

*ICRCL 59/83 (Second Edition) Table 4*

**Contract:** Highgate West Hill, Highgate **Report No:** 99/4169/KJC

| Location | Depth m | Sample Description | PAH mg/kg | Phenols mg/kg | Cyanide (Total) mg/kg | Cyanide (Free) mg/kg | Cyanide (Complex) | Thiocyanate mg/kg | Sulphate (Total) mg/kg | Sulphide mg/kg | Sulphur mg/kg | Acidity (ph) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BH 1 | 0.50 | Made ground | <20 | <0.5 | <1-0 | <10 | <10 | | 100 | <10 | 100 | 7.7 |
| WS 5 | 1.00 | Made ground | 472 | <0.5 | <10 | <10 | <10 | | 500 | <10 | 300 | 8.2 |
| | | | | | | | | | | | | |
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| | | | | | | | | | | | | |
| Threshold Trigger Concentrations for open space | | | 1000 | 5 | | 25 | 250 | | 2000 | 250 | 5000 | <5 |



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## EVALUATION OF CONTAMINATION

The Interdepartmental Committee on the Redevelopment of Contaminated Land (ICRCL), have produced Guidance Note 59/83 (Second Edition, July 1987) entitled, "Guidance on the Assessment and Redevelopment of Contaminated Land". This document proposes the concept of trigger concentrations for different contaminants, depending on the end usage of the site and whether plants are to be grown.

Values for threshold trigger concentrations have been suggested for the various contaminants, these being a function of proposed end use. Where the laboratory test results fall below the value for threshold trigger concentrations, there is demonstrably no contamination. It follows, therefore, that laboratory results which are consistently above the threshold values, imply that contamination is present. Some contaminants have been provided with an "action" level. Concentrations recorded above this level require remedial measures to be undertaken as part of development. It should be noted that not every contaminant has an "action" level quoted. Should contamination values lie between the threshold and action concentrations, then an engineering assessment should be made as to the degree of remedial measures required.

A summary of Tables 3 and 4 of Guidance Note 59/83, presenting the threshold and action concentrations is presented with this précis. The threshold concentrations are given below the individual contaminants on the test results sheets. It should be noted that the ICRCL 59/83 guidelines are the generally accepted criteria against which sites are assessed. It should be appreciated, however, that not all contaminants are covered by these guidelines. In these circumstances, it may be possible to consider the proposals made on a similar basis by the Dutch authorities, these being particularly useful with regard to other contaminants, for example, pesticides and aromatic compounds.

References


| | | |
|---|---|---|
| ICRCL Guidance Note | 17/78 (Dec 1990) | "Notes on the development and after use of landfill sites" |
| | 18/79 (Apr 1986) | "Notes on the redevelopment of gasworks sites" |
| | 23/79 (Nov 1983) | "Notes on the redevelopment of sewage works and farms" |
| | 42/80 (Oct 1983) | "Notes on the redevelopment of scrap yards and similar sites" |
| | 59/83 (Jul 1987) | "Guidance on the assessment and redevelopment of contaminated land" |
| | 61/84 (Jul 1986) | "Notes on the fire hazards of contaminated land" |
| | 64/85 (Oct 1990) | "Asbestos on contaminated sites" |
| | 70/90 (Feb 1990) | "Notes on the restoration and aftercare of metalliferous mining sites for pasture and grazing" |

## ICRCL 59/83 (Second Edition) TABLE 3
## TENTATIVE 'TRIGGER CONCENTRATIONS' FOR SELECTED INORGANIC CONTAMINANTS

**Conditions**

1. This table is invalid if reproduced without the conditions and footnotes.
2. All values are for concentrations determined on "spot" samples based on an adequate site investigation carried out prior to development. They do not apply to analysis of averaged, bulked or composited samples, nor to sites which have already been developed. All proposed values are tentative.
3. The lower values in Group A are similar to the limits for metal content of sewage sludge applied to agricultural land. The values in Group B are those above which phytoxicity is possible.
4. If all sample values are below the threshold concentrations, then the site may be regarded as uncontaminated as far as the hazards from these contaminants are concerned, and development may proceed. Above these concentrations, remedial action may be needed, especially if the contamination is still continuing. Above the action concentration, remedial action will be required or the form of development changed.

| Contaminants | Proposed Uses | Trigger Concentrations mg/kg air-dried soil<br>Threshold | <br>Action |
|---|---|---|---|
| **Group A:** | ***Contaminants which may possess hazards to health*** | | |
| Arsenic | Domestic gardens, allotments | 10 | * |
| | parks, playing fields, open space | 40 | * |
| Cadmium | Domestic gardens, allotments | 3 | * |
| | parks, playing fields, open space | 15 | * |
| Chromium | Domestic gardens, allotments | 25 | * |
| (hexavelant)[1] | parks, playing fields, open space | | |
| Chromium (total) | Domestic gardens, allotments | 600 | * |
| | parks, playing fields, open space | 1000 | * |
| Lead | Domestic gardens, allotments | 500 | * |
| | parks, playing fields, open space | 2000 | * |
| Mercury | Domestic gardens, allotments | 1 | * |
| | parks, playing fields, open space | 20 | * |
| Selenium | Domestic gardens, allotments | 3 | * |
| | parks, playing fields, open space | 6 | * |
| **Group B:** | ***Contaminants which are phytotoxic but not normally hazards to health*** | | |
| Boron (water soluble)[1] | Any uses where plants are to be grown[2,6] | 3 | * |
| Copper[4,5] | Any uses where plants are to be grown[2,6] | 130 | * |
| Nickel[4,5] | Any uses where plants are to be grown[2,6] | 70 | * |
| Zinc[4,5] | Any uses where plants are to be grown | 300 | * |

**NOTES**

* Action concentrations will be specified in the next edition of ICRCL 59/83.

1. Soluble hexavelant chromium extracted by 0.1M HCL at 37°, solution adjusted to pH 1.0 if alkaline substances present.
2. The soil's pH value is assumed to be about 6.5 and should be maintained at this value. If the pH fails, the toxic effects and the uptake of these elements will be increased.
3. Determined by standard ADAS method (soluble in hot water).
4. Total concentration (extractable by $HNO_3/HClO_4$).
5. The phytotoxic effects of copper, nickel and zinc may be addictive. The trigger values given here are those applicable to the 'worst-case': phytotoxic effects may occur at these concentrations in acid, sandy soils. In neutral or alkaline soils, phytotoxic effects are unlikely at these concentrations.
6. Grass is more resistant to phytotoxic effects than are most other plants, and its growth may not be adversely affected at these concentrations.

## ICRCL 59/83 (Second Edition) TABLE 4:
## TENTATIVE 'TRIGGER CONCENTRATIONS' FOR CONTAMINANTS ASSOCIATED WITH FORMER COAL CARBONIZATION SITES

**Conditions**

1. This table is invalid if reproduced without the conditions and footnotes.
2. All values are for concentrations determined on "spot" samples based on an adequate site investigation carried out prior to development. They do not apply to analysis of averaged, bulked or composited samples, nor to sites which have already been developed.
3. Many of these values are preliminary and will require regular updating. They should not be applied without reference to the current edition of the report "Problems arising from the Development of Gas Works and similar sites".
4. If all sample values are below the threshold concentrations, then the site may be regarded as uncontaminated as far as the hazards from these contaminants are concerned, and development may proceed. Above these concentrations, remedial action may be needed, especially if the contamination is still continuing. Above the action concentrations, remedial action will be required of the form of development changed.

| Contaminants | Proposed Uses | Trigger Concentrations mg/kg air-dried soil Threshold | Action |
|---|---|---|---|
| Polyaromatic Hydrocarbons[1,2] | Domestic gardens, allotments, play areas | 50 | 500 |
| | Landscaped areas, buildings, hard cover | 1000 | 10000 |
| Phenols | Domestic gardens allotments | 5 | 200 |
| | Landscaped areas, buildings, hard cover | 5 | 1000 |
| Free Cyanide | Domestic gardens allotments, landscaped areas | 25 | 500 |
| | Buildings, hard cover | 100 | 500 |
| Complex Cyanides | Domestic gardens, allotments | 250 | 1000 |
| | Landscaped areas, buildings, hard cover | 250 | NL |
| Thiocyanate[2] | All proposed uses | 50 | NL |
| Sulphate | Domestic gardens | 2000 | 10000 |
| | Buildings[3] | 2000[3] | 50000[3] |
| | Hard cover | 2000 | NL |
| Sulphide | All proposed areas | 250 | 1000 |
| Sulphur | All proposed uses | 5000 | 20000 |
| Acidity (pH less than) | Domestic gardens, allotments, landscaped areas | pH5 | pH3 |
| | Buildings, hard cover | NL | NL |

**NOTES**

NL No limit set as the contaminant does not pose a particular hazard for this use.

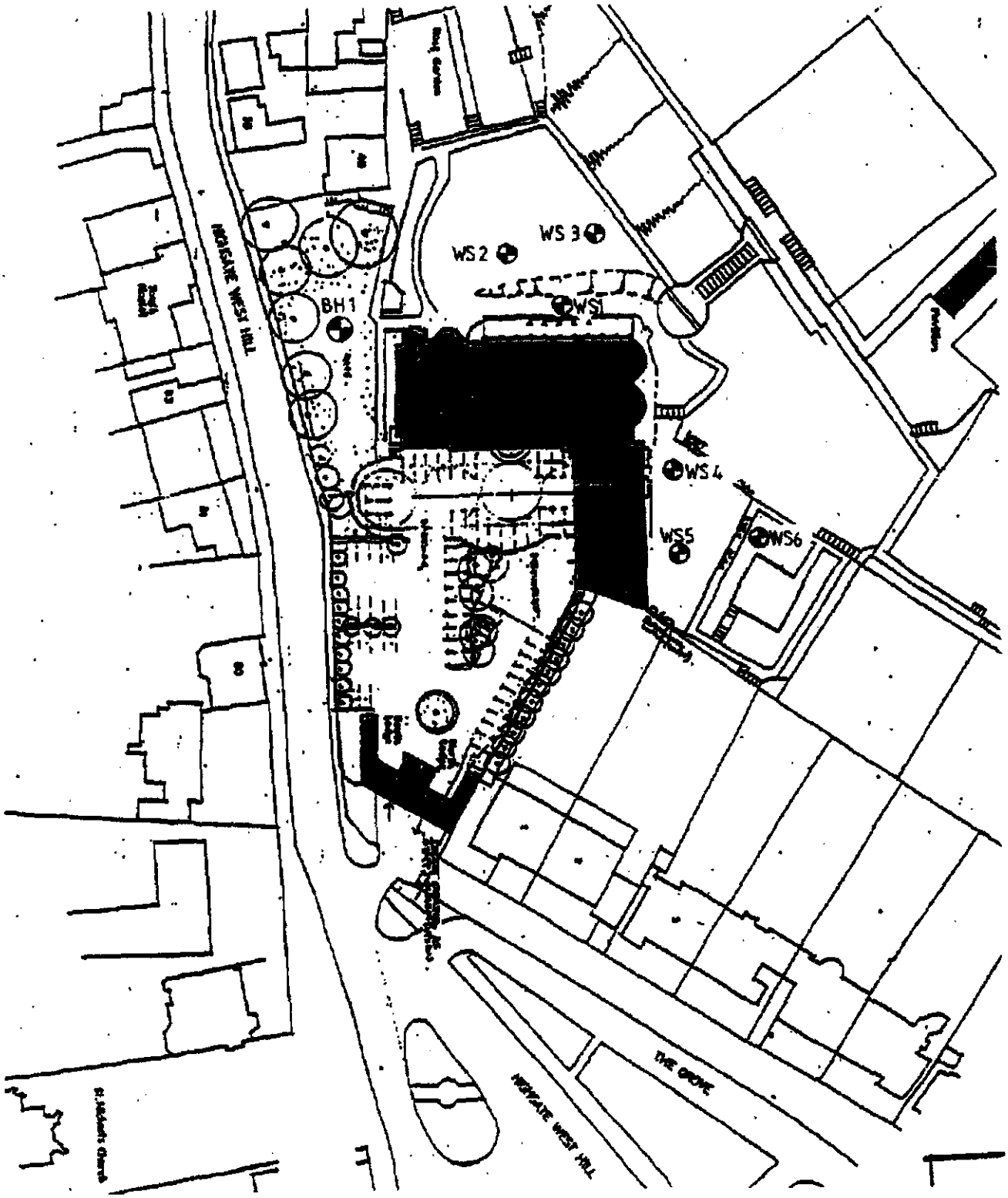
1. Used here as a marker for coal tar, for analytical reasons. See "Problems Arising from the Redevelopment of Gas Works and Similar Sites" Annex A1.

2. See "Problems Arising from the Redevelopment of Gas Works and Similar Sites" for details of analytical methods.

3. See also BRE Digest 250: Concrete in sulphate-bearing soils and groundwater.

# APPENDIX IV

## SITE PLAN

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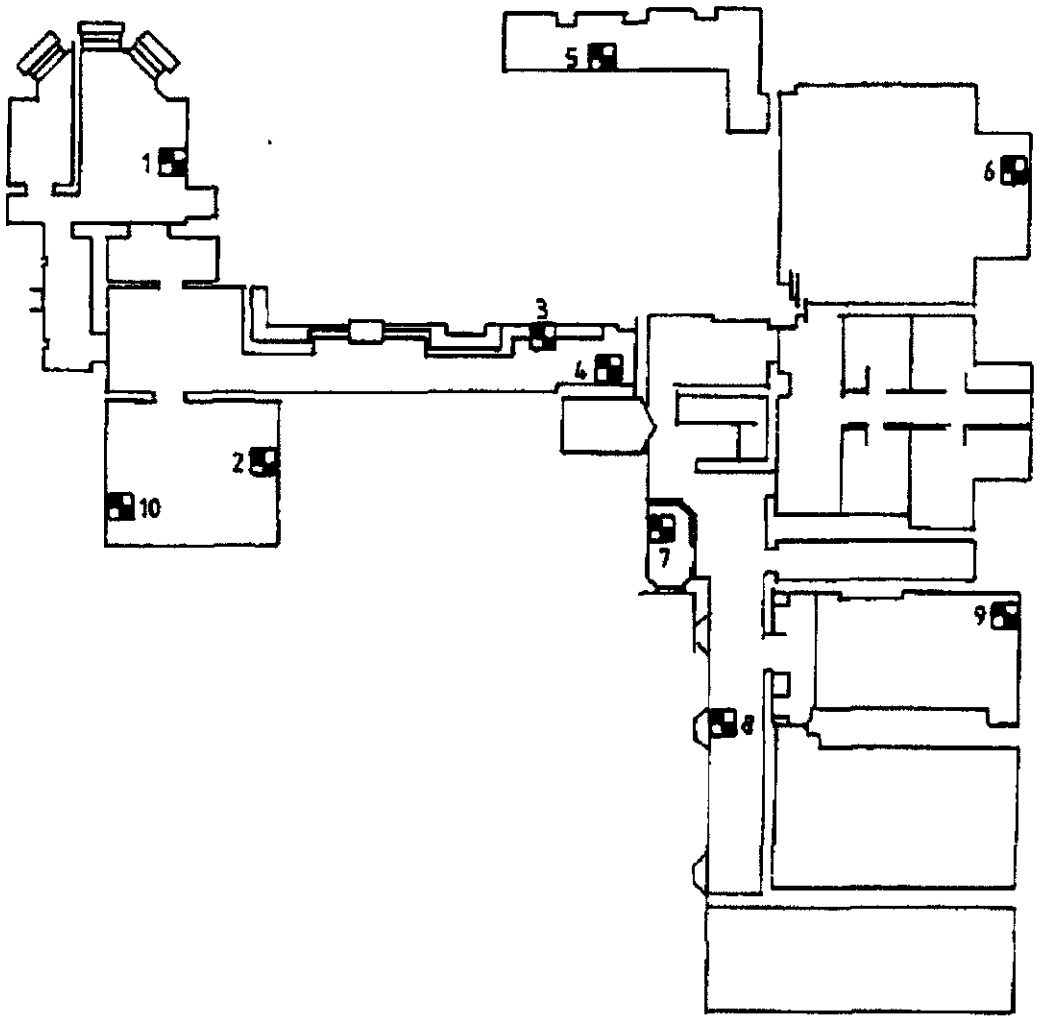


TRIAL PIT LOCATIONS
PLAN AT BASEMENT LEVEL

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HIGHGATE WEST HILL , HIGHGATE

Scale
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Drg No
99/4169/12

MBP

**APPENDIX C**

Site Investigation Report – Ground Engineering

Separate Document

MBP

**APPENDIX D**

Interpretive Geotechnical Report – GCG