REMEDIATION PROPOSALS REPORT

Proposed Kingsgate School
Liddell Road
London NW6

Client: London Borough of Camden

J14212B

December 2016

GEA Geotechnical & Environmental Associates

Document Control

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1.0 INTRODUCTION

Geotechnical and Environmental Associates (GEA) has been commissioned by London Borough of Camden to provide advice for the remediation of the soils at Liddell Road, London NW6 2EW. A Desk Study and Ground Investigation has previously been carried out by GEA (ref J14212 Issue 2, dated 4 November 2014) and supplemented by additional soil testing and soil gas monitoring, the findings of which are summarised in a letter report (ref J14212A/AI/01 dated 25 September 2015). This report should be read in conjunction with the previous reports.

1.1 Proposed Development

It is proposed to redevelop the site through the demolition of the existing single storey commercial units, and the subsequent construction of a two-storey primary school in the northeast of the site, a five-storey commercial building in the south, and a new 12-storey commercial building in the northwestern corner. The development will also include new housing fronting onto Maygrove Road, and a new multi-storey building in the north of the site. It is understood that the majority of the site will be lowered and regraded as part of the proposed development.

This report is specific to the proposed development and the advice herein should be reviewed if the development proposals are amended.

1.2 Site History Summary

The earliest map studied, dated 1871, shows the site as largely undeveloped, with an embankment in the south and a footpath crossing the site in the east. The Midland Railway is shown to follow the northern boundary and crossed the northwestern corner of site, whilst the area in general was occupied by fields. By 1896, the area in general was developed with housing and the site formed part of the 'West End' railway sidings, with Maygrove Road located to the south. By 1954, the centre of site was a coal depot and the 1974 map shows the site to have been cleared of sidings and in use as a scrap metal yard. By 1985, the existing buildings had been constructed, connecting with Maygrove Road in the southeast. The site and surrounding area have since remained essentially unchanged.

1.3 Ground Conditions

The ground investigation encountered a significant thickness of made ground over the London Clay to the full depth of the investigation, of 25.00 m (26.60 m OD). The made ground generally comprised silty sandy clay with gravel, frequent brick, glass, coal and concrete fragments, ash and roots, becoming dark brown and blackish very silty clay with organic material, and extended to depths of between 3.30 m (47.85 m OD) and 4.90 m (46.70 m OD). The London Clay was initially found to be gravelly, to a maximum depth of 5.30 m. It then generally comprised soft becoming stiff brown, orange-brown and grey mottled low to high strength fissured silty clay with pockets of orange-brown silt, occasional fine shell fragments and fine to coarse selenite crystals and extended to depths of between 10.60 m (40.50 m OD) and 12.20 m (39.13 m OD). This was underlain by firm becoming very stiff dark brown and greyish brown high to very high strength fissured silty clay with occasional shell fragments, fine selenite crystals, occasional pockets of pale brown, white and grey silt and was encountered to the full depth investigated, of 25.00 m (26.60 m OD).

Groundwater was only encountered during drilling within Borehole No 6, at a depth of 4.75 m (46.94 m OD) and was measured in a standpipe installed in Borehole No 5 at depths of 1.04 m (50.11 m OD) and 1.09 m (50.06 m OD).

1.4 Soil Contamination

The contamination testing of soil samples collected during the original investigation indicated elevated concentrations of arsenic, lead, total PAH including benzo(a)pyrene and total organic carbon and elevated concentrations of dissolved arsenic, chromium and nickel within a single sample of groundwater.

During the additional investigation, contamination testing of selected samples of made ground indicated slightly elevated concentrations of arsenic, lead, TPH, total PAH including benzo(a)pyrene, sulphide and total organic carbon. In addition, elevated concentrations of dissolved arsenic, chromium and nickel were measured within a single sample of groundwater. Since the previous report was issued the Soil Guideline Values and Generic Guideline Values have been updated and on the basis of the revised guidelines only lead, arsenic, TPH, total PAH and total organic carbon concentrations are above their updated respective guideline values as shown below.

Contaminant of Concern	Maximum concentration (mg/kg)	Location(s) of elevated concentration(s) [depth (m)]	Generic Risk-Based Screening Value (mg/kg)
Lead	390	BH2 [1.2], BH10B [0.4], BH11 [0.8], BH8 [0.5]	200
Arsenic	48	BH6 [0.8], TP10B [0.4]	37
TPH	2400	BH10 [0.9]	1000
Total PAH*	150	BH10 [0.9], BH7 [0.7], BH8 [0.5]	62.1
Total Organic Carbon	29	BH6 [0.8], CBR3[0.45], BH10 [0.9], BH8 [0.5], TP10A [0.3], TP10B [0.4], TP17 [1.5], TP10C [0.3]	6
Sulphide	50	TP10A [0.3], TP10B [0.4], TP10C [0.3], TP18 [0.3]	120

The source of the lead and, arsenic contamination is probably extraneous fragments such as burnt coal or ash. The lead compounds are considered to be non-volatile or of a low volatility and they do not therefore present a significant vapour risk. In addition, the lead compounds are considered likely to be of low solubility and a risk to groundwater from these contaminants has not been identified. These contaminants could, however, pose an unacceptable risk to human health through direct contact, accidental ingestion or inhalation of soil or soil derived dust.

Elevated total organic carbon was recorded within eight samples of the made ground tested. Total organic carbon is one of the contamination indicative parameters but in itself does not represent a risk. Organic carbon is non-toxic and commonly naturally occurring in soils, and whilst a high total organic carbon can be indicative of a methanogenic potential in some circumstances it cannot be used as a direct indicator of a methanogenic risk.

An elevated concentration of TPH was measured during the original investigation in a single sample of made ground from Borehole No 10. Three additional boreholes were subsequently drilled in the vicinity of Borehole No 10 at a distance of approximately 4 m away, in order to provide an indication of the extent of the TPH contamination. Analysis of samples recovered from the additional boreholes did not indicate the presence of elevated TPH at these subsequent locations, suggesting that the contamination may not have migrated to other areas of the site within the shallow soils.

Elevated concentrations of some PAHs and total PAHs were measured during the original investigation in three locations. Analysis of the levels of the individual PAHs indicate a potential coal tar based tarmac source. This is considered to be in an insoluble form and therefore does not present a significant risk to groundwater or end users.

1.5 Soil Gas

Soil gas monitoring did not measure any combustible gas. A maximum carbon dioxide concentration of 7.1 % vol. was measured, with some oxygen depletion recorded at a concentration of 12.3 % on that occasion. A minimum oxygen level of 10.7 % was recorded during gas monitoring on two occasions.

Ambient carbon dioxide and oxygen concentrations were typically recorded, although a carbon dioxide concentration of 7.1% was recorded on one occasion within Borehole No 18. The higher concentration of carbon dioxide occurred in conjunction with a reduced oxygen level.

No abnormal temperatures were recorded within the standpipes; a negative flow recorded on one occasion within a single borehole was as a result of instrument error.

In determining the significance of soil gas concentrations both the gas concentrations and borehole flow rates are used to define a characteristic situation for a site based on the limiting borehole gas volume flow, renamed as the Gas Screening Value (GSV) for methane and carbon dioxide. In this case the following GSVs have been determined, in accordance with guidance provided by CIRIA.[1]

Gas	Max concentration % vol.	Ave flow rate l/hr	GSV
Methane	0	0	0
Carbon Dioxide	7.1	0	0

On the basis of the GSV the site would be defined as Characteristic Situation 1; however, as carbon dioxide concentrations in excess of 5.0 % have been recorded, this should be upgraded to Characteristic Situation 2, such that the site is defined has having a low risk.

A watching brief should also be maintained throughout the groundworks and if any occurrences of odorous soils are encountered further investigation should be undertaken.

1 Wilson, S, Oliver, S, Mallett, H, Hutchings, H and Card, G (2006) *Assessing risks posed by hazardous ground gases to buildings* CIRIA Report C659

2.0 GENERAL REMEDIATION PROVISIONS

All site procedures and design matters associated with handling any potentially contaminated soil will be assessed with reference to the following.

- The health and safety of construction workers and the general public during the construction operations.
- The health and safety of the end users of the development and the general public in the longer term.
- Compliance with waste management regulations.
- The durability of the construction and its constituent materials.
- The minimisation or avoidance of cross-border pollution, particularly within the groundwater.
- The health of plants and animals.

Good construction practice and health and safety procedures will be adhered to at all times. In particular the specific requirements of Health and Safety Executive (HSE) guidance[2] and the COSHH[3] guidance must be followed in addition to the current Building Regulations. Guidelines prepared by CIRIA[4] should also be taken into account.

The HSE document sets out the approach to be adopted and the aspects that must be considered under the COSHH Regulations, including an assessment of the risks to health of both employees and the general public and identification of the means by which any risks may be controlled.

2.1 Safety Organisation

A safety structure will be produced which identifies an individual at senior level who has a primary responsibility for safety and has the authority to direct all other activities on site and identifies all other staff with particular safety responsibilities. The structure will define the lines of communication and responsibility for safety matters and identify the interfaces with both the regulatory authorities and emergency services.

The safety organisation will be supervised by an occupational hygienist and / or the Client's safety officer as appropriate. A documented contingency plan will be developed in order to ensure the provision of an appropriate level of first aid to handle medical emergencies effectively. All persons visiting or working on the site during the 'dirty' phase will be trained in the particular hazards and risks that may be present on site and the health and safety precautions required.

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2 HSE 1992 HS(G)66 – *Protection of workers and the public during the development of contaminated land* HMSO
3 HSE 1998 – *Code of practice for the Control of Substances Hazardous to Health and Control of Carcinogenic Substances 2nd Edition*
4 CIRIA Report 132 – *A Guide for Safe Working on Contaminated Sites*

2.2 Safety Method Statements

A detailed method statement will be provided by any contractor intending to work on the site during the 'dirty' phase, prior to the commencement of any such work. The site manager, under the advice of the occupational hygienist and / or safety officer, will review and approve the safety method statements and be responsible for the safe co-ordination of different activities. The statements will include a risk assessment and exposure minimisation, together with details for the provision, maintenance, training for and use of any personal protective equipment (PPE) that is required either routinely or as part of emergency procedures.

2.3 Risk Assessments

Prior to carrying out any element of the site work, the potential risks that are present as a result of site contamination will be identified and the potential for harm will be determined and recorded. The methodology employed for COSHH assessments is appropriate.

Following the risk assessment, working methods should be modified as necessary to minimise the potential exposure to contaminated substances. Where the risk cannot be controlled by modified designs or working methods, a suitable level of personal protective equipment should be provided.

In addition to the site workers, consideration will also need to be given to possible impacts upon neighbouring sites, the local residents and the general public driving or walking outside the site boundary, trespassers and the environment (air, water, soil).

3.0 SPECIFIC REMEDIATION PROVISIONS

The objective of any remedial works will be to mitigate the environmental risks identified.

On the basis of the findings of the investigation it is considered that the following remediation proposals are appropriate in respect of the potential contamination which may remain beneath this site. A conceptual model of the envisaged contamination is presented in the form of a source–pathway–receptor analysis and precise objectives for the remediation are stated. Methods of achieving these objectives are then discussed.

3.1 Conceptual Model

The proposed development comprises the construction of a primary school, new five-storey and 12-storey commercial buildings, new housing fronting onto Maygrove Road and a multi-storey building in the north of the site. Consequently there will be new pathways for end users to come into contact with the contamination identified within the made ground. It is assumed at this stage that young children will have access to the communal soft landscaped areas, albeit for a shorter duration than if the soft landscaped areas were for private use.

Each investigation measured elevated concentrations of dissolved arsenic, chromium and nickel within a single sample of groundwater.

The locations at which elevated contaminant concentrations were measured in samples of made ground from both investigations are indicated in the table overleaf.

Contaminant of Concern	Maximum concentration (mg/kg)	Location(s) of elevated concentration(s) [depth (m)]	Generic Risk-Based Screening Value (mg/kg)
Lead	390	BH2 [1.2], BH10B [0.4], BH11 [0.8], BH8 [0.5]	200
Arsenic	48	BH6 [0.8], TP10B [0.4]	37
TPH	2400	BH10 [0.9]	1000
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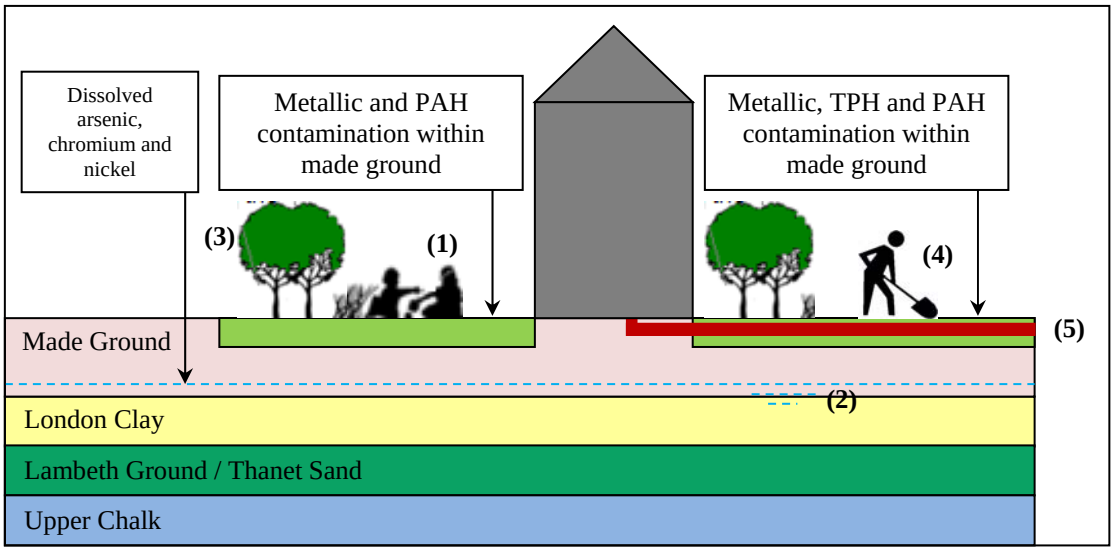
Sulphide	50	TP10A [0.3], TP10B [0.4], TP10C [0.3], TP18 [0.3]	120

* Not including speciated results

The elevated concentrations of the contaminants found are not deemed to pose a risk to end users, as it is assumed that the majority of the site will be lowered and the material excavated and removed from site as part of the proposed development.

One of the requirements of the Environment Act (1995) is that local authorities carry out inspections of their area with a view to identifying sites that may be contaminated. When assessing whether a site is contaminated the local authority will attempt to establish the presence of a 'pollution linkage'. A pollution linkage requires there to be a source of contamination, a sensitive receptor that can be adversely affected by the contamination and a pathway via which contamination can reach the target or receptor. For this site, the pollution linkages are set out in the diagram below.



From this model the following potential pollution linkages have been identified;

1. End users exposed to contamination through ingestion and inhalation of soil or dust, by skin contact.

2. Plant uptake in landscaped and garden areas.

3. The migration of contamination off site in shallow groundwater.

4. Site workers exposed to contamination through ingestion of soil, dust or vegetation, skin contact or inhalation.

5. Exposure of buried plastic services to PAH and TPH contaminated soils.

On this basis, the following remedial objectives have been identified:

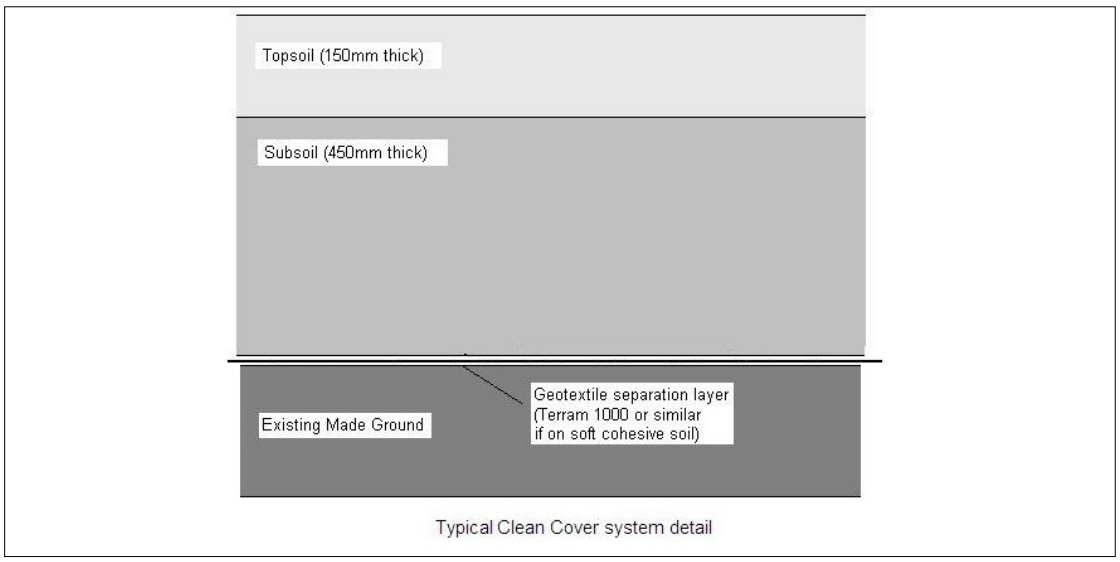
- protect end users in landscaped and garden areas;
- remove mobile contamination and prevent migration off site;
- protect site workers; and
- protect buried services.

3.2 Remediation Proposals

3.2.1 Protection of End Users and Planting

Only in gardens and landscaped areas could end users come into direct contact with the contaminated soils and suitable precautions will need to be taken in these areas to protect end users and to allow successful plant growth.

It is recommended that a cover thickness of imported subsoil and topsoil of 600 mm in thickness should be specified to ensure successful plant growth in domestic gardens, which will include a minimum thickness of 150 mm of topsoil, in accordance with recommendations from BRE[5]. It may be possible to reduce the final thickness of cover required, but this will need to be determined once final levels have been established and the concentrations of potential contaminants within the imported material are known. Furthermore, it is recommended that a geotextile membrane marker layer of Terram100, Hi Vis or similar is used above the made ground, to prevent mixing of the imported topsoil and subsoil with the underlying made ground.



Typical Clean Cover system detail

[5] BRE (2004) *Cover systems for land regeneration. Thickness of cover systems for contaminated land.* BRE pub 465

3.2.2 Groundwater

Each investigation measured elevated concentrations of dissolved arsenic, chromium and nickel within a single sample of groundwater.

The source of the contamination is unknown, but tracing and remediating the source is unlikely to be practical. As such, it is considered that there is no benefit in attempting to remediate the contamination in the groundwater, particularly as the groundwater encountered was, for the majority, likely to be present as pockets within the made ground and as such would be impractical to remediate.

3.2.3 Soil Gas

The gas monitoring has indicated that basic gas protection measures are required within the proposed development. The results indicate the need for the ventilation of confined spaces within the new buildings, a well-constructed floor slab (suspended, non-suspended or raft) with low permeability gas membrane and minimum penetration of the ground slab by services. Due to the proposed end use of the new building, there may also be a requirement to include underfloor venting in combination with the above measures in accordance with BS 8485[6], although this should be confirmed with the local authority.

3.2.4 Protection of Site Workers

Site workers should be made aware of the possible presence of contamination and a programme of working should be identified to protect workers handling any soil or groundwater; the method of site working should be in accordance with HSE guidelines and the requirements of the Local Authority Environmental Health Officer. Such requirements are likely to include that all site workers are protected from skin contact with any soil, and eating, drinking and smoking on site should be strictly confined to clean areas. Guidelines prepared by CIRIA should also be taken into account.

Prior to the commencement of ground works a site induction meeting should be held, attended by the developer and site workers, where the appointed geoenvironmental engineer should brief the workers on the history of the site and the nature of any contaminated soils they may encounter. This information will be included in the Discovery Strategy which should also be displayed in the site office, along with the contact names and numbers of the geoenvironmental engineer, so that contact can easily be made if any suspicious substances are encountered. Provision should be made for the inspection of any suspect soils by the geoenvironmental engineer with a view to determining the requirement for additional remedial works.

3.2.5 Protection of Buried Services

The contamination encountered is considered to be largely insoluble and therefore is not expected to pose a risk to buried services. However, consideration may still need to be given to the protection of buried plastic services laid within the made ground. Details of the proposed protection measures for buried plastic services will in any case need to be approved by the EHO prior to the adoption of any scheme. It is possible that barrier pipe will be required or additional testing will need to be carried out.

6 The British Standards Institution (2015), *BS 8484:2015 Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings.* 2nd Ed. BSI Standards Ltd

3.3 Imported and Placed Soil

Certificates will need to be obtained for all imported soil to demonstrate that it is free from contamination and these certificates will form part of the validation process. Validation testing will be required on site once the imported soil has been delivered to confirm the expected levels of contaminants. If certificates are not provided, then further testing will be required to demonstrate the suitability of the material.

4.0 VALIDATION

The remedial works should be monitored and validated by a suitably qualified geoenvironmental engineer. In areas of soft landscaping, validation will be carried out to confirm that the made ground has been removed to the required depth where necessary and that the imported sub-soil and topsoil is uncontaminated and placed within areas of proposed soft landscaping. The suitability of the imported soil will be assessed with reference to the CLEA Soil Guideline Values for residential properties where plants are to be grown.

If any suspicious material is encountered outside of the above remediation activities, a geoenvironmental engineer will attend site immediately to inspect the area in accordance with the Discovery Strategy. The decision-making process outlined above will then be implemented.

The installation of soil gas protection measures should also be observed and documented by a suitably qualified geoenvironmental engineer.

Upon completion of the remediation monitoring and verification analyses a completion report will be prepared detailing the works carried out and the monitoring of this work. This report will present the results of the onsite screening and photographic and site records of the remedial works together with waste disposal dockets for any contaminated soils removed. The report will provide an assessment of the success of the remediation and will assess the risk posed by any residual contaminants. If the work on site reveals further areas of contamination that cannot be addressed through an extension of the excavation works, a review of the remedial scheme will be carried out following consultation with the Environment Agency and Local Authority Environmental Health Department and details will be provided in the completion report.

APPENDIX

Risk Assessment Tables

Site Plan

Classification of Consequence

Classification	Definition	Examples
Severe	Short term (acute) risk to human health likely to result in "significant harm" as defined by the Environment Protection Act 1990, Part IIA. Short-term risk of pollution (note: Water Resources Act contains no scope for considering significance of pollution) of sensitive water resource. Catastrophic damage to buildings / property. A short-term risk to a particular ecosystem, or organism forming part of such ecosystem (note: the definitions of ecological systems within the Draft Circular on Contaminated Land, DETR, 2000).	High concentrations of cyanide on the surface of an informal recreation area. Major spillage of contaminants from site into controlled water. Explosion, causing building collapse (can also equate to short-term human health risk if buildings are occupied).
Medium	Chronic damage to Human Health ("significant harm" as defined in DETR, 2000). Pollution of sensitive water resources (note: Water Resources Act contains no scope for considering significance of pollution). A significant change in a particular ecosystem, or organism forming part of such ecosystem (note: the definitions of ecological systems within Draft Circular on Contaminated Land, DETR, 2000).	Concentrations of a contaminant from site exceed the generic, or site-specific assessment criteria. Leaching of contaminants from a site to a major or minor aquifer Death of a species within a designated nature reserve.
Mild	Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services ("significant harm" as defined in the Draft Circular of Contaminated Land, DETR, 2000). Damage to sensitive buildings / structures / services or the environment.	Pollution of non-classified groundwater Damage to building rendering it unsafe to occupy (e.g. foundation damage resulting in instability).
Minor	Harm, although not necessarily significant harm, which may result in a financial loss, or expenditure to resolve. Non-permanent health effects to human health (easily prevented by means such as personal protective clothing etc). Easily repairable effects of damage to buildings, structures and services.	The presence of contaminants at such concentrations that protective equipment is required during site works. The loss of plants in a landscaping scheme. Discolouration of concrete.

Classification of Probability

Classification	Probability
High likelihood	There is a pollution linkage and an event that either appears very likely in the short term and almost inevitable over the long term, or there is evidence at the receptor of harm or pollution.
Likely	There is a pollution linkage and all the elements are present and in the right place, which means that it is probable that an event will occur. Circumstances are such that an event is not inevitable, but possible in the short term and likely over the long term.
Low likelihood	There is a pollution linkage and circumstances are possible under which an event could occur. However, it is by no means certain that even over a longer period such an event would take place, and is less likely in the shorter term.
Unlikely	There is a pollution linkage but circumstances are such that it is improbable that an event would occur even in the very long term.

From Rudland, DJ, Lancefield, RM and Mayell, PN (2001) *Contaminated land risk assessment. A guide to good practice.* CIRIA Pub C552

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Risk Assessment Description

Risk Assessment Matrix

		Consequence			
		Severe	***Medium***	***Mild***	***Minor***
Probability	***High likelihood***	**Very high risk**	**High risk**	**Moderate risk**	Moderate / low risk
	Likely	**High risk**	**Moderate risk**	Moderate / low risk	Low risk
	Low likelihood	**Moderate risk**	Moderate / low risk	Low risk	Very low risk
	Unlikely	Moderate / low risk	Low risk	Very low risk	Very low risk

	Description of the assessed risks and likely action required
Very high risk	There is a high probability that severe harm could arise to a designated receptor from an identified hazard, OR, there is evidence that severe harm to a designated receptor is currently happening. This risk, if realised, is likely to result in a substantial liability. Urgent investigation (if not undertaken already) and remediation are likely to be required.
High risk	Harm is likely to arise to a designated receptor from an identified hazard. Realisation of the risk is likely to present a substantial liability. Urgent investigation (if not undertaken already) is required and remedial works may be necessary in the short term and are likely over the longer term.
Moderate risk	It is possible that harm could arise to a designated receptor from an identified hazard. However, it is relatively unlikely that any such harm would be severe, or if any harm were to occur it is more likely that the harm would be relatively mild. Investigation (if not already undertaken) is normally required to clarify the risk and to determine the potential liability. Some remedial works may be required in the longer term.
Low risk	It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild.
Very low risk	There is a low possibility that harm could arise to a receptor. In the event of such harm being realised it is not likely to be severe.

From Rudland, DJ, Lancefield, RM and Mayell, PN (2001) *Contaminated land risk assessment. A guide to good practice.* CIRIA Pub C552

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Site Plan

Site	Proposed Kingsgate School, Liddell Road, London NW6 2EW
Client	London Borough of Camden
Engineer	Price & Myers

Job Number J14212

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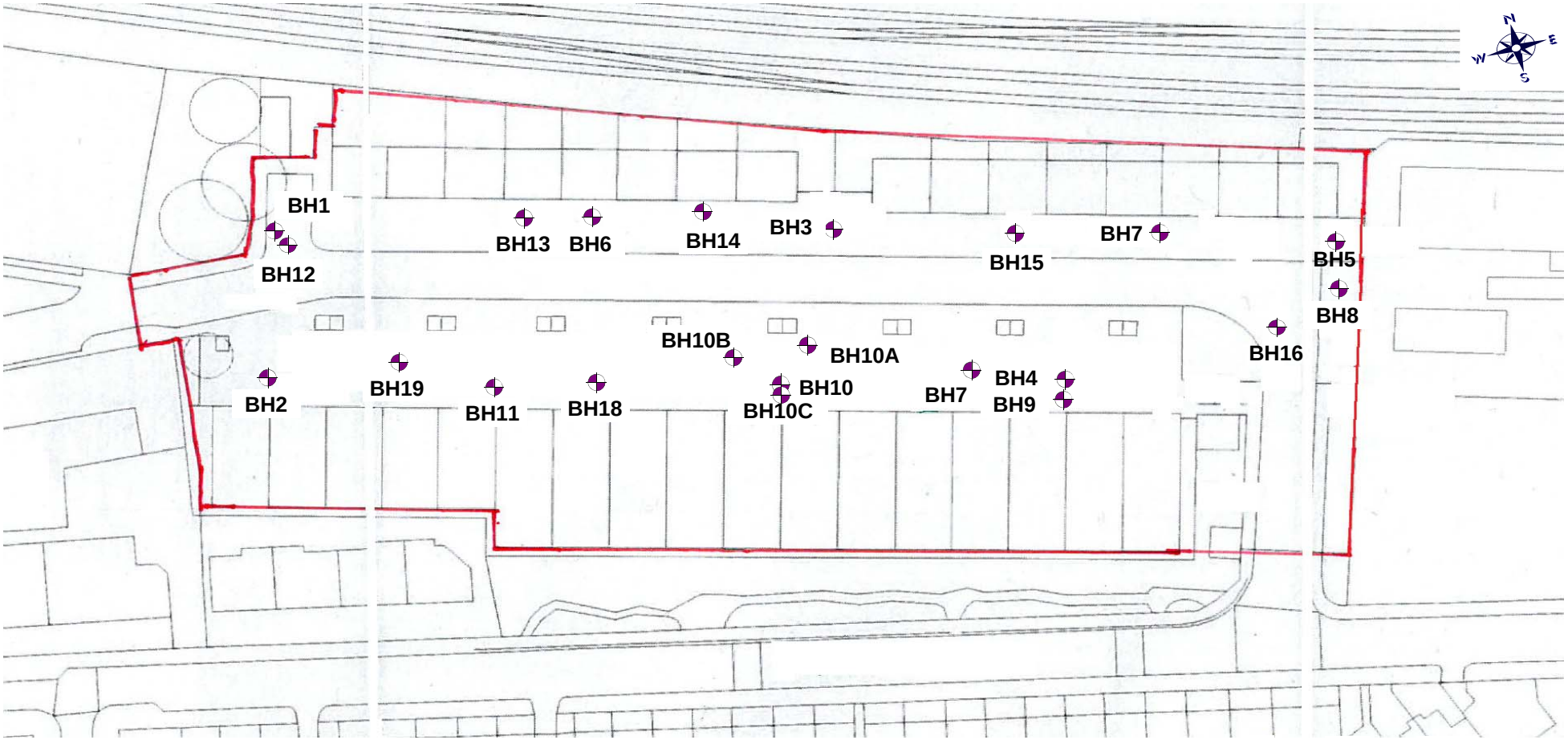

Approximate Scale in metres

Geotechnical & Environmental Associates (GEA)
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