GEO INVESTIGATE
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Soil Remediation and Validation Statement

Site: Bell Cabin, Low Lane, Dewsbury WF12 8LG
Client: Mr P Audsley
Date of Issue: April 2024
Ref.: G23326b

1. Introduction

Findings of an intrusive Phase 2 Site Investigation (SI) report on ground conditions at the above location (Geoinvestigate Ltd. report ref. G23326, issued October 2023) confirmed that contamination* was present in made ground at the site which was discovered to depths of up to 1.00m below ground level (BGL) (though the thickness of this material is expected to be variable).

*The word *contamination* in this context is used to describe instances where potential contaminants are present at levels in excess of the allowable limits for residential land use. This does not necessarily mean that the site would be classed as contaminated land as per the Environmental Protection Act 1990: Part 2A definition or that it poses immediate danger to persons on site and neighbouring sites, only that the soils do not meet the required standards for the proposed residential development.

Reports previously prepared for this site which have been carried out by Geoinvestigate Ltd. comprise:

- A Phase 1 Desk Study investigation (Ref. G23326, issued October 2023).
- A Phase 2 (intrusive) investigation (Ref. G23326, issued October 2023).
- A Gas Monitoring Addendum (Ref. G23326, issued November 2024).

The Phase 2 SI discovered the following contaminant exceedances:

- Arsenic – BH4 (0.10m) & BH5 (0.20m)
- Lead – BH4 (0.20m)
- PAH Benzo[a]anthracene – TPC (0.02-0.05m)
- PAH Benzo(a)pyrene – BH2 (1.00m) & TPC (0.02-0.05m)
- PAH Benzo(b)fluoranthene - BH2 (1.00m) & TPC (0.02-0.05m)
- PAH Dibenzo(a,h)anthracene - BH2 (1.00m) & TPC (0.02-0.05m)

A remediation exercise therefore would need to be carried out to deem the site as a whole, fit for purpose as a residential development:

- It was concluded that presence of the elevated levels of contaminants in the near surface topsoil may represent a potential hazard with regard to human health, specifically to the end users of the site (residents) over potentially long-term exposure.
- The source of the identified contamination is unknown. The phase 2 SI report does not speculate on the potential source.
- Based on the encountered ground conditions, the issue is anticipated to be restricted to the topsoil horizons, which has been proven to extend to depths of 1.00m in parts of the site.
- No significant risk is anticipated to personnel employed in the remediation of the site or the construction of the new development.
- No evidence is apparent that would suggest any noteworthy risk to ground and surface waters.

Note that only garden and soft landscaped areas will require remediation works. Soils below buildings and hardstanding will not pose a risk to end users of the site as no human contact will be possible, and as such may remain in situ.

The Phase 2 Intrusive Investigation demonstrated that the topsoil is directly underlain by natural gravels and sandstone, with the topsoil occurring to a maximum depth of 1.0m bgl, therefore the remediation method advised in the Additional Contamination Investigation report states the most cost-effective and appropriate method of remediation is likely the cover system strategy, whereby the contamination source is confined at depth by replacing the top layer of soils with a capping layer of proven uncontaminated material.

Note that this document and the works proposed herein are concerned only with the remediation of soil contamination. No geotechnical considerations are within the scope of these works. No ground gas remediation is provided by this report.

2. Options Appraisal

Consideration has been given to a number of possible solutions or technologies with the following emerging as the most cost effective and implementable options:

- **A cover (capping) system** whereby the contamination source is confined at depth by replacing the top layer of soils with a capping layer of proven uncontaminated material to an agreed depth (normally 600mm below finished ground levels). The affected made ground has previously been found to be present to depths of up to 1.40m, but generally becoming shallower moving toward the new building. This method is in places where the potentially contaminated soils extend to greater depth but do not pose a risk to controlled waters as it will be possible to remove the pathway which would otherwise exist between the contamination source and the receptors at the site surface (humans) while minimizing the amount of waste which may be removed from site to appropriate landfill (i.e. ceasing excavation at a predetermined depth with deeper potentially affected soils left in-situ and confined below a layer of uncontaminated replacement soils).

Other common remediation methods which were considered but ruled out included:

- A "dig and dump" strategy whereby all contaminated material is excavated under proper supervision and transported to appropriate landfill followed by purchase and placing of clean fill material. This method is normally retained only for sites where the contaminated material reaches only very shallow depths or where contaminant mobility is a potential issue. As the contaminated material extends beyond 0.60m, even when taking into account the level of hard standing cover to be installed at the site, there would be significant quantities of contaminated soil to be removed off site.
- Bioremediation and/or Soil washing: Given the sporadic presence of both metals and PAH contamination, these methods would be either ineffective or would require a combination of technologies and would not be financially viable for such a small quantity of soils.
- Soil stabilisation: The large plant required for this method together with the cost and small site would render this method economically and operationally difficult. Additionally, the areas in question will need to comprise garden areas and soils treated using this method would not comprise a suitable growing medium.

3. Remediation Exercise

As discussed in Section 2, a 600mm cover system approach is considered to be the most viable means of removing the identified pollutant linkages at the site. This method entails the contamination source being confined at depth by replacing the top layer of soils with a capping layer of proven uncontaminated material to an agreed depth of 600mm.

Pertinent points to note on the implementation of this remedial method include:

- Much of the site is or will be covered by hardstanding and buildings and where these are present in the final development no pathway will exist by which receptors will be able to come into contact with implicated soils. As such, remedial works will only be required in areas proposed to comprise gardens or soft landscaping.
- The design and verification of the capping system should meet specifications outlined in the Yorkshire and Lincolnshire Pollution Advisory Group (YALPAG) document, "Verification Requirements for the Remediation of Contaminated Land Cover Systems, version 4.1". This includes methodology for recording excavation depths and sampling frequency and appropriate analysis suites for new materials brought into the site.
- Validation sampling and analysis would be required of any imported clean fill in order to confirm the final condition of the site. It is recommended that this is carried out ***prior*** to bringing the soils to site should the soils be found to be of unsuitable quality. This includes gravel used in formation works, for which it is strongly recommended that virgin quarried stone be used to ensure good quality.

This will require the safe and successful excavation of surface material, under supervision by a qualified and experienced geo-environmental engineer, in order to not only ensure sufficient contaminant source removal, but also to prevent wasteful over-excavation.

It is also noted that any previously unidentified obvious contamination hotspots may require additional remediation (and potentially investigation prior to this) depending on their nature.

3.1 Chronology of Plan

Commencing from a yet to be determined date, a chronological summary of the objectives of such a remediation exercise is as follows:

1. Identification of areas to be remediated – see above. All proposed garden and soft landscaped areas identified in Figure 3. Allowance should also be made for possible removal of previously unidentified contamination hotspots. The proposed development plan presented later shows these areas clearly.

2. Excavation of potentially contaminated material under supervision by a qualified and experienced geo-environmental engineer.

- A watching brief will be maintained for the potential presence of any other contaminants such as visible fragments of asbestos containing materials (ACMs) or hydrocarbon residues/odours within material removed (though none are expected).
- No sorting, separation, temporary stockpiling, treatment or re-use of excavated soils is intended at the site. Nor is it anticipated that any such activity would prove useful/feasible.
- It is unlikely that wheel washing of vehicles taking the soils from the site will be necessary given the potential for a relatively clean loading area to be established at the site entrance.
- It is anticipated that, given the estimated volume of soils to be removed, an estimate of around 32 wagon loads may be necessary (assuming a $10m^3$ maximum capacity for each load, a $523m^2$ area and a constant excavation depth of 0.60m). Additional allowance may be required for any unexpected contamination that might be discovered. Given the space available at the site it is not anticipated that traffic control measures will be needed during the works.

Normal practice for Geoinvestigate Ltd. is to both inspect reduced-level excavations and excavate inspection pits on completion of the work.

3. Complete, safe exportation of identified contaminated material to a suitable licenced landfill or disposal/recycling facility; this should include collation of copies of relevant consignment/waste transfer notes for provision to Geoinvestigate Ltd.

4. Validation sampling and analyses. Where new soils are brought into site to make up levels, to provide a stone surface for the building site, or to provide subsoil and/or topsoil for soft landscaping (i.e. private gardens) these should be sampled and tested in accordance with YALPAG guidance, testing regimes are included in Figure 1 later. Soils should be tested at the suppliers' premises prior to purchase of material to ensure no unsuitable soils are brought into the study site.

The proposed soft landscaped area, when excavated to 0.60m is anticipated to require $468m^3$ of soil. As such, the minimum rates as defined by YALPAG are considered to be adequate and it is unlikely that the minimum volume of any type of soil will be reached that might necessitate additional sampling (for YALPAG requirements).

If the 1 per $50m^3$ rate was adopted for greenfield/manufactured topsoil, the minimum of 3 samples would be inadequate for the $468m^3$ anticipated to be required on site and 10 samples would be required.

Provision of a factual and interpretative (Validation) report detailing the works undertaken and presenting the following evidence which will confirm the successful implementation of this remediation strategy:

- Site plan detailing areas and depths excavated and/or thickness of raised site levels.
- Photographic record of works undertaken showing all work has been carried out safely and thoroughly and showing thickness of cover system.
- Results of chemical analyses of new soils brought into site to restore levels to show that all soils at the site in its final condition (with which human contact might be likely) are fit for purpose in the proposed residential end use.
- Consignment notes for material removed from/brought into site.

- On completion of the above works no discernible pollutant linkage would remain at the site –

It is often useful to also excavate some post-remediation inspection pits to validate the composition and thickness of newly installed material. This is a requirement if the consultant has not been present before/during the installation of the new materials.

There are not considered to be any circumstances likely to occur which would prevent the removal of the contamination source to sufficient depth unless significantly different ground conditions or contaminants to those previously encountered were to be uncovered by the works. Given the findings of previous site investigation works this is thought to be unlikely. Allowance should be made for the additional excavation and removal of contamination hotspots but none are currently expected to be discovered.

There is also no expectation that there will be any requirement for ongoing monitoring of the site as the contamination has been shown not to be and no ongoing addition of contamination to the ground is expected to be possible given its historical origin.

4. Pollutant Linkages

The conceptual ground hazard model (CGHM) presented in the phase 2 S.I Report (Geoinvestigate report G23326) outlines the pollutant linkages currently considered to exist at the site and potentially posing risk to identified receptors.

Consideration to plant uptake has also been allowed for previously as it is possible that fruit/vegetables may be cultivated for consumption in the private gardens of the new development. Negligible risk in this regard will be present following removal of the implicated soils and replacement with a sufficient thickness of proven uncontaminated surface material.

As discussed in Section 1, this document (G23326b) is concerned only with the remediation of soil contamination. No ground gas protection measures are required, and geotechnical considerations are outside of the scope of these works.

5. Validation and Risk assessment

Contamination analyses will need to be undertaken on samples of soil brought into the site to show that potential contaminants are within acceptable limits with regard to human health requirements in a residential setting. If sufficient information cannot be provided by the soil supplier, provision of sufficient chemical testing as below will be required. Soils should be sampled in accordance with the recommendations of the YALPAG guidance referred to earlier in this document and in Figure 1 on the following page (**NOTE**: this should be carried out with results confirmed **prior** to purchase, and at very least the placing of the material in the excavations, to prevent a repeat exercise being necessary should soils fail to meet the required standard).

Results from the soil analyses that will be carried out will be compared to soil assessment criteria used by Geoinvestigate Ltd. which will comprise either DEFRA C4SLs* (used in preference where available) or LQM/CIEH S4ULs* and where they fall below these limit values, will be deemed safe for a residential end use.

*For residential land use *with* allowance for consumption of homegrown produce. The soil organic matter options for the assessment criteria will be determined by the new imported topsoil given that the pre-existing topsoil, for which data was previously used, is to be removed from all pertinent locations.

Other evidence required for the validation of the site following remedial works are outlined in point 5. of Section 3.1 earlier. Photographic evidence and soil samples should be gathered by the attending geo-environmental engineer while the developer should provide transfer notes/tickets for soils/aggregate and an up-to-date development plan.

No mitigation measures or ongoing monitoring are considered necessary for the new development following the successful remediation, as the contamination source is considered to be historical in nature, and no mobile contamination or pathway for migration is anticipated, and hence no ongoing addition of or exposure to contamination is anticipated at the site following the proposed remedial works.

Figure 1: Testing requirements (reproduced from the YALPAG guidance) for various new fill material types are as stated below:

Type	Number of Samples	Testing Schedule	Assessment Criteria
	Please note that these guidelines apply to a typical residential development, and relaxation of the guidelines or more stringent requirements may apply dependent on local and site specific factors. Therefore, all parameters need to be agreed with the Local Authority.		
Virgin Quarried Material	1 or 2 depending on the type of stone utilised, to confirm the inert nature of the material.	Standard metals/metalloids (should include as a minimum As, Cd, Cr, CrVI, Cu, Hg, Ni, Pb, Se, Zn)	The assessment criteria need to be UK based, e.g. LQM S4ULs, Defra C4SLs or other similarly derived GACs.
Crushed Hardcore, Stone, Brick (excluding asphalt)	Minimum 1 per 500m^3	Standard metals/metalloids (as above), PAH (16 USEPA speciation), asbestos, total TPH. Any additional analysis dependant on the history of the donor site (e.g. phenol, total cyanide, BTEX, MTBE).	
Greenfield/ Manufactured Soils	Minimum 3 Dependent on source and receptor, between 1 per 50m^3 and 1 per 250m^3	Standard metals/metalloids (as above), PAH (16 USEPA speciation), asbestos, pH and soil organic matter (SOM) (or calculated from total organic carbon (TOC)).	
Brownfield/ Screened Soils	Minimum 6 Dependent on source and receptor, between 1 per 50m^3 and 1 per 100m^3	Standard metals/ metalloids (as above), PAH (16 USEPA speciation), TPH (CWG banded), asbestos, pH and SOM (or calculated from TOC). Any additional analysis dependant on the history of the donor site (e.g. phenol, total cyanide, BTEX, MTBE).	

If you have any queries about the strategy outlined above or require any more details about recommended working practices or requirements for validation works, please do not hesitate to contact me.

Kind regards,

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Principal Geoenvironmental Engineer
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Figure 2: Proposed Development Plan

Figure 3: Remediation Location Plan