LITHOS

Remediation Strategy

Land at Westgate, Cleckheaton

For Strata Homes Ltd

Report no: 3043/4D

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CONTENTS

APPENDICES

Appendix A – Drawings

Drawing	Revision	Title
3043/1	-	Site location plan
3043/2	C	Planning layout (Strata Homes)
QD1776-70-03	A	Development Platform (Queensberry Design)
3043/3	-	Site features
3043/4	-	Historic features
3043/7	-	Revised conceptual site model
3043/10	A	Made Ground extents
3043/14	-	Geological cross sections
3043/15	-	Remediation levels
3043/20	-	Section showing soil cover & underlying made ground

Appendix B – Lithos protocol for importation & use of soil cover

Appendix C – Lithos Tier 1 screening values

Appendix D - EA guidance: decommissioning redundant boreholes and wells

REMEDIATION STRATEGY
FOR LAND AT
WESTGATE, CLECKHEATON

1 INTRODUCTION

1.1 The commission and brief

1.1.1 Lithos Consulting Limited have been commissioned by Strata Homes Ltd to prepare a Remediation Strategy for land off Westgate, Cleckheaton.

1.1.2 Lithos have already issued the following reports:

- Geoenvironmental Appraisal of land at Westgate, Cleckheaton . Report No. 3043/2D, dated July 2023
- Quantitative Risk Assessment. Report No. 3043/3A, dated July 2023
- Earthworks Specification, Land at Westgate, Cleckheaton. Report No. 3043/7, dated November 2021

1.1.3 The appointed Remediation Contractor will need to familiarise themselves with the above Reports, and comply with all relevant recommendations contained therein.

1.1.4 This Remediation Strategy is **highly dependent** on site **levels**, particularly in Area A & B. Recommendations in this report are based on proposed Development Platform levels detailed on Queensberry Design **Drawing QD1776-70-03 (Rev A)**. If development levels change significantly from those detailed on Drawing QD1776-70-03, the approach to remediation may also need reassessment.

1.1.5 This document outlines the remediation objectives necessary to protect environmental receptors, and render the site suitable for the proposed development. A Method Statement should be prepared in order to detail how the objectives will be achieved.

1.1.6 The Method Statement should be accompanied by a Designer's Risk Assessment in accordance with the CDM Regulations, 2015. The Method Statement and Risk Assessment should be submitted to, and approved by Strata.

1.2 The proposed development

1.2.1 The proposed residential development comprises a total of 200 'traditional' two/three storey domestic dwellings with associated gardens and adoptable roads and sewers, as shown on Strata's Planning Layout Drawing 18-CL2-SEGB-WE-01 Rev J, dated 29th March 2023 (a copy of which is presented as Drawing 3043/2 in Appendix A).

1.2.2 The houses will be founded on shallow strip or deepened trench fill foundations where made ground is less than 2.5m thick (c. 40% of the total site area) and where underlying natural soils comprise weathered Coal Measures (not Alluvium). Piled foundations are likely to be required for the majority of two and three storey dwellings constructed on site (c. 60%), largely due to deep made ground and soft Alluvial deposits.

1.2.3 Access to the development will be from Westgate in the north.

2 Background

2.1 Site description

2.1.1 Site details are summarised below.

Detail	Remarks
Location	1km west of Cleckheaton town centre
NGR	SE 184 250
Area	6.5 ha (16 acres)
Known live services	Underground electric, water, BT, sewer and gas.

2.1.2 The site can be considered as **four** distinct areas; each area is shown on Drawing 3043/3. Areas are based on former land uses which still dominate the current site features. The areas are as follows:

- Area A (1.1 ha) – former chemical works in the north-west
- Area B (1.7 ha) – former rolling mill in the south & south-west; reservoir in north-west
- Area C (2.0 ha) – former Scrap Yard, Malthouse, Brickworks and Quarry in the east
- Area D (1.6 ha) – industrial area in the centre-north

2.1.3 A location plan and current salient features are shown on Drawings 3043/1 and 3043/3 in Appendix A.

2.2 Ground investigation

2.2.1 Fieldwork was supervised by Lithos in two phases; the first (exploratory) phase was completed from the 9th to the 15th January 2019; the second (supplementary) phase was completed between the 14th and 23rd September 2020 and comprised the exploratory holes listed below:

Technique	Exploratory holes	Final depth(s)	Remarks
Trial pitting (machine excavated)	TPs 401 to 410, 412 to 427, 429 to 430, 432 to 449 & 501 to 528.	0.4m to 5.0m (ave. c. 3.0m)	Vane tests where possible in cohesive soils.
Trial trenches (machine dug)	TTs 401, 411, 428 & 431	2.5m to 5.1m	Vane tests where possible in cohesive soils. Undertaken to identify high walls where possible.
Cable percussion boreholes	BHs 501 to 509.	4.4m to 12.0m	Boreholes typically advanced to refusal in bedrock. SPT tests undertaken throughout drilling. Monitoring wells installed.
Rotary cored boreholes	BHs 501 to 503.	15.4m to 17.2m	Rotary coring followed on from CP BHs 501 to 503.
Rotary open probeholes	PHs 501 to 520	5.0m to 12.0m	Monitoring wells installed.
Stitch probeholes	'Groups' ST501 to 510	3.5m to 20m	Undertaken in 'groups' across anticipated line of highwalls.

2.2.2 For ease of reference holes advanced in 2019 have been referenced in a '**400**' series whilst exploratory holes advanced in 2020 have been referenced in a '**500**' series.

Made Ground

2.2.3 Made Ground has been encountered across the entirety of **Area A** to depths of between 1.3m (TP436) and 10.7m (BH501). The made ground generally comprises granular and cohesive made ground, with some burnt shale, brickfill and filter sands.

2.2.4 Made Ground has been encountered across **Area B** to between 0.4m (TT428) and greater than 3.5m (TP524). The made ground generally comprises granular and cohesive made ground, with some ash & clinker and brickfill.

2.2.5 Made Ground has been encountered in **Area C** to between 0.8m (TP404) and 12.0m (BH504) and generally comprises granular made ground with ash & clinker.

2.2.6 Made Ground has been encountered across **Area D** to between 0.6m (TP517) and 9.0m (BH506). The made ground generally comprises granular and cohesive made ground, with some ash & clinker and brickfill.

2.2.7 Approximate depths of made ground is shown on Drawing 3043/10 in Appendix A.

Reservoir

2.2.8 According to historical OS plans, a former reservoir occupied an area of c. 1,000m^2, in the north-west of **Area B**. Anecdotal evidence suggests that the reservoir was associated with the chemical works rather than the former mills.

2.2.9 A total of 7 trial pits and one trial trench were advanced within and adjacent to the backfilled reservoir.

2.2.10 Major inflows of groundwater prevented deep trenching in the reservoir. Similarly, inflows of groundwater prevented the base and all extents of the reservoir being identified. However, 3rd party holes by AIG suggest the reservoir extends to depths of up to around 4m in its centre.

Natural ground

2.2.11 Natural ground was encountered in most exploratory locations across the site and generally comprised Cohesive and Granular Residual Soils (weathered bedrock).

2.2.12 Competent Coal Measures bedrock was recorded below residual soils in all areas comprising Sandstone and Mudstone.

2.2.13 Whilst not mapped, evidence of Alluvium drift deposits was recorded in the south adjacent to Blacup Beck.

Groundwater

2.2.14 Groundwater was encountered within the majority of exploratory holes excavated across Areas D and B as seepages and inflows from around 2.0m; most notably in the south (Area B).

2.2.15 Excavations in Areas A & C generally remained drier, with groundwater ingress comprising relatively minor seepages where encountered.

2.2.16 Based on groundwater monitoring to date, levels fluctuate across the entire site from 96mAOD to 101mAOD.

2.2.17 Historic monitoring of installations sealed in the Clifton Rock Sandstone, indicated a groundwater level of c. 90mAOD.

2.2.18 Two discrete water tables are considered likely within the Coal Measures (GW1 & GW2).

2.2.19 Whilst the geological map indicates the entire site is directly underlain by the Clifton Rock Sandstone, exploratory logs suggest that relatively thin Sandstone bands are separated by Mudstone. The low permeable Mudstone can lead to groundwater from unconnected Sandstone bands resting at different levels. Where deep backfill lies below the top of the Coal Measures, following quarrying, groundwater is recorded within the made ground.

2.2.20 A third possible groundwater table was recorded in BH507, 508 & 509 adjacent to Blacup Beck. In all cases groundwater appears to be flowing to the south with topography.

2.2.21 Groundwater levels and contaminant analysis are discussed further in Lithos' QRA Report (3043/3A, dated July 2023).

Obstructions

2.2.22 Historical plans and previous reports show that buildings have been present across around 35% of the site area. Furthermore, concrete hardstand, which is typically 0.2m thick, covers approximately 12,000m^2.

2.2.23 Drawing 3043/4 shows the footprints of the former structures, and areas of hardstand.

2.2.24 Trial pits were excavated along the lines of former building foundations, beneath former concrete slabs and along the line of former tanks.

2.2.25 Numerous obstructions were encountered from ground level to depths of 2.5m, including former walls, former basement floors and former tanks.

2.2.26 A list of below ground obstructions encountered are provided in the table below.

Hole	Area	Depth (m)	Obstruction encountered
TP437	A	0.8m - 2.7m	Curved brick chamber, likely former UST
		2.4m - 2.5m	Former concrete floor slab or basement floor slab
TP438		1.6m - 4.0m	Concrete slab with concrete sides, 2.5m wide with brick lining on its eastern side, possible former UST
TP439		1.4m - 2.3m	Curved brick chamber with layer of wood at 1.8m and former pipe work at 2.3m, likely former UST
TP442		0.0m - 0.7m	Brick wall 0.3m wide
TP503		1.5m - 2.1m	Poorly bonded brick wall on concrete footing orientated east – west in centre of trial pit.
TP504		1.4m - 1.5m	Concrete slab.
		1.5m - 2.3m	Poorly bonded brick & mortar wall o.4m wide orientated north-south uncovered in side of trial pit.
TP506		0.5m	Solid concrete obstruction; trial pit refused & was moved 2.0m south.
TP507		1.0m - 4.0m	Concrete slab in base of trial pit
		1.5m - 2.7m	Brick & mortar built arched tunnel orientated north to south (possible former sewer or drainage flue).
TP508		1.6m - 2.3m	Brick & mortar built arched tunnel orientated north to south (possible former sewer or drainage flue).
TP512		1.7m - 1.9m	Concrete slab.
		1.9m - 2.4m	Poorly bonded brick & mortar wall 0.4m wide orientated east to west.
TP513		1.3m - 2.3m	Brick & mortar built arched tunnel entrance with brick & mortar walls in trial pit walls. Orientated north to south (possible former sewer or drainage flue).
		2.8m	Poorly bonded brick & mortar wall.
TP514		0.4m - 0.6m	Concrete slab.
		2.0m - 2.2m	Poorly bonded brick 7 mortar relict floor slab with black bituminous coating.
TP520		0.25m - 1.8m	Poorly bonded brick & mortar wall in eastern wall of trial pit.

Hole	Area	Depth (m)	Obstruction encountered
TP418	B	0.4m - 2.0m	Brick chamber with former drainage pipe 0.2m wide at base
TP421		0.35m - 1.8m	Brick wall in W trial pit face
TP422		0.2m - 1.2m	Brick chamber along W trial pit face
TP525		1.0m - 1.8m	Brick & concrete structure in southern end of trial pit (likely relict reservoir wall or similar).
TP526		0.3m	Concrete slab.
TP527		0.4m	Concrete slab.
TP402	C	0.2m - 0.7m	Sandstone and brick wall 0.2m wide
TP404		0.1m - 0.6m	Concrete slab, 0.1m thick with brick wall below 0.3m wide
TP406		0.2m - 0.9m	Brick wall 0.4m wide to 0.7m with 0.2m thick concrete slab below
TP416		0.2m - 1.2m	Brick wall 0.6m wide
TP426	D	1.1m - 1.25m	Former concrete floor slab at least 0.15m thick
TP430		0.3m - 2.0m	TP excavated along brick wall
TP432		0.2m - >2.6m	Excavated through basement/cellar, brick walls in N and E TP faces, with a doorway in N TP face, depth to base no proven due to constant spalling of made ground
TP522		0.2m - 1.0m	Poorly bonded brick & mortar wall orientated north to south through centre of trial pit.
TP522		1.8m - 2.5m	Poorly bonded bricks and cobbles of sandstone wit mortar in northern wall of trial pit (relict footing).

2.2.27 Given the above, it is apparent that whilst some former buildings have been demolished (although several still remain), substantial foundations, bases etc remain below ground.

2.2.28 In addition, masonry boulders and stone lintels were encountered, most notably within the Granular Made Ground (Area B & D) and Brickfill (Areas A & B). It is estimated that within these made ground types, approximately 30% of the material is coarser than a house brick.

Hazardous gas

2.2.29 There is deep made ground across much of the site and an area of landfill is located just beyond the southern boundary.

2.2.30 Lithos issued a Gas Risk Assessment (Report No. 3043/5A) in July 2023. Conclusions were:

- **Area A:** Data is heavily influenced by organic contamination and as such this data was not considered further in the gas risk assessment. However, methane was only recorded in one location (PH515), during 3 of the 9 visits, at concentrations of between 0.6% and 2%. The maximum methane concentrations recorded are well below the Amber 2 threshold of 5% and therefore **Amber 1** measures are considered appropriate.

  Whilst areas of gross organic contamination will be remediated during site preparatory earthworks and made ground turned over to remove obstructions, remediation targets have assumed that the membrane placed in Area A plots will also be **hydrocarbon resistant**.
- **Areas B, C & D: Amber 1** measures required.

Contamination

2.2.31 An assessment of potential contaminants associated with the former uses has been undertaken, anticipated potential contaminants, within soil and/or groundwater include:

- Areas A & B – volatile and semi volatile organics, chlorinated solvents, acids, coal tar constituents, cyanide, metals (particularly lead), asbestos and petroleum products
- Area C – metals, PAH, petroleum products (predominantly lubricating oils), asbestos, combustible Ash & Clinker
- Area D – metals, PAH, petroleum products, asbestos

2.2.32 Targeted sampling of made ground and groundwater has confirmed the presence of metals (predominantly arsenic, lead and zinc), localised areas of petroleum products, possible tars and associated indictor compounds, as well as benzene, naphthalene and phenol.

2.2.33 Elevated concentrations of elemental sulphur were recorded in Area A and given the likely production of sulphuric acid, higher concentrations are anticipated. Whilst Sulphur has not been considered as a health or controlled waters risk, it will oxidise rapidly to sulphate and this can influence concrete mixes.

2.2.34 Concentrations of volatile and semi-volatile organic compounds were also recorded, predominantly in Area A, although in most cases these may be attributed to leaching from coal tar. These included low levels of trimethylbenzene, tert-butylbenzene, methylnaphthalene, dibenzofuran & carbazole.

2.2.35 Extensive ground investigation has been undertaken both to assess the potential for contamination and to consider geotechnical constraints. Whilst areas of gross contamination have not been identified and concentrations of contaminants do not consistently exceed generic screening values, the ground conditions are highly variable and complicated by the degree of historic earthworks.

2.2.36 The identification of volatile organic compounds in groundwater, particularly in Area A, supports the likelihood of the presence of source material that has not yet fully been identified.

2.2.37 It is considered highly likely that these source areas will be encountered during earthworks. Therefore, Lithos' QRA Report (Ref. 3043/3A, dated July 2023) was drafted to manage the identified risks and to be pre-emptive of anticipated source material based on previous site activities.

2.2.38 Furthermore, significant cut and fill is likely to be required to provide a suitable development platform. The depth to contamination will influence the risk to future site residents and groundwater / surface water. Lithos' QRA Report considered the effect of depth and also the potential need to move material between Areas to achieve sustainable earthworks balance.

2.2.39 It was recommended in the Geoenvironmental Appraisal (Lithos Report 3043/2D) that soil cover be placed in garden areas. The inclusion of a clean cover in garden and landscaped areas effectively breaks the **direct contact pathways** (ingestion, dermal contact & inhalation of dust).

2.2.40 Assessment of the site investigation data enabled formulation of a conceptual model, which is presented as Drawing 3043/9 in Appendix A.

3 RISK ASSESSMENT & TARGET CONCENTRATIONS

3.1 Lithos' QRA Report (Ref. 3043/3A, dated July 2023) assessed the risks posed by ground contamination to future site residents and controlled waters.

3.2 Plausible contaminant linkages include potential risks to:

- Future on-site residents through volatilisation of vapours in unsaturated soils
- Migration of shallow groundwater to Blacup Beck

3.3 Remedial target concentrations for soils were derived. These concentrations should be used as a "clean-up" criteria during the required remediation works.

3.4 Site-specific remedial target concentrations for health should be applied to **all** Areas (A to D), but only to the **uppermost 2m** of material placed below development formation levels.

3.5 Remedial targets levels for protection of **controlled waters** only apply to Areas **A & B** (as shown on Drawing 3043/3) and only to material placed **at or below 97mAOD**. Proposed Development Platform levels detailed on Queensberry Design Drawing QD1776-70-03 (Rev A) suggest these remedial targets will need to be considered for fill placed in the vicinity of **Plots 70 – 94 & 127 – 141**.

3.6 Drawing 3043/15 included in Appendix A shows the relevant remediation levels in context of the final development levels.

Remedial target concentrations for soils

Determinand	Human health soil (mg/kg)	Human health vapour (mg/m^3)	Controlled waters soil leachate (µg/L)
Naphthalene	5	9	130
Benzene	4	681	50
Methylphenol (cresol)	65,700	4,456	100
Phenol	2,860	30	46
TPH aliphatic C5-6	420	1,521,105	-
TPH aliphatic C6-8	420	702,399	-
TPH aliphatic C8-10	23	9,649	-
TPH aliphatic C10-12	23	2,024	-
TPH aromatic C5-7	156	24,804	-
TPH aromatic C7-8	9	3,581	-
TPH aromatic C8-10	5	239	-
TPH aromatic C10-12	243	2,306	-
PAH (with BaP as indictor)	-	-	0.27
Lead	-	-	14
Arsenic	-	-	50

3.7 During remediation works and validation sampling, careful consideration should be given to the source of any exceedances and whether determinants are likely to be in a form that is volatile, or locked within a matrix, such as coal fragments. Where concentrations exceed screening values, consideration should also be given to **vapour monitoring**.

3.8 It is envisaged that vapour monitoring would typically follow a three-step approach:

1. On site head space test in excavations and treated stockpiles using a PID.
2. Laboratory analysis of VOCs using a head space extraction of representative samples.
3. Where Steps 1 & 2 above indicate some contamination remains *insitu*, post earthworks, that could present a vapour risk, in-situ vapour monitoring should be undertaken in the upper 1m of re-engineered soils using targeted tenax absorbent tubes.

3.9 The need for *insitu* vapour monitoring may also be identified where it is impractical to excavate and treat impacted soils, i.e. due to high groundwater or instability.

3.10 The total allowable soil concentration in the remedial targets table above may result in a much lower screening value than would actually present a vapour risk and this is why the option of vapour monitoring is important in the remediation design, rather than conservatively just adopting soil target concentrations.

3.11 Further detail on the timings and application of vapour monitoring is included in Section 7.23.6 below.

3.12 It is understood that **Blacup Beck** will be diverted as part of the development. However, the travel distance from Areas A & B to the Beck is minimal and would not reasonably result in any significant dilution or attenuation of contaminants.

3.13 Details of the diversion are not known, but it has been assumed that this would not result in large sections of the Beck being placed in culvert as this is usually discouraged to increase the habitat potential of the watercourse. If it transpires that the Beck is being placed in closed culvert, the potential risk from, and interaction with, groundwater should be revisited.

3.14 In terms of the proposed redevelopment, a summary of plausible contaminant linkages are summarised below, along with feasible mitigation measures.

Receptors	Pathways	Contaminant source	Remediation options
Human health (Future residents) ◊	Consumption of contaminated vegetables	Inorganic & organic contamination in the made ground	Placement of a minimum 600mm clean soil cover in garden and landscaped areas. Treatment or removal of hydrocarbon and any identified free product.
	Ingestion		
	Inhalation (dust and/or vapours)		
	Dermal contact		
	Migration & accumulation of explosive gas	Methane, Hydrocarbons in the made ground	Amber 1 measures required for all plots, with hydrocarbon membranes required in Area A.
	Inhalation of vapours	Inorganic & organic contamination in the made ground	Adopt site specific screening values for material in the upper 2m below FFLs (see section 7.23 for treatment options)
	Infiltration of water supply pipes	BTEX, Halogenated aliphatics & aromatics, Phenol, CN, Sulphate, Sulphide & Chloride in the made ground	Treatment or removal of hydrocarbons. Water Company likely to insist on "Protectaline" pipework across entire site.
Buildings	Migration & accumulation of explosive gas	Methane, Hydrocarbons in the made ground	Amber 1 measures required for all plots, with hydrocarbon membranes required in Area A.
	Contact with "aggressive" soil and/or groundwater	Sulphate in the made ground	Sub-surface concrete in contact with made ground soils (Areas B, C & D) Design Sulphate Class DS-3 and ACEC Classification of AC-5. Sub-surface concrete in contact with natural ground soils in all areas Design Sulphate Class DS-2 and ACEC Classification of AC-5z. Further sampling and assessment required in Area A during site preparatory works, **or** sub-surface concrete in contact with made ground in Area A Design Sulphate Class DS-5, and ACEC Classification of AC-5.
Plants	Uptake of phytotoxic elements	Cu, Ni, Zn & B in the made ground	Placement of clean soil cover in garden and landscaped areas.
Groundwater	Migration of leachable components	Inorganic & organic contamination in the made ground	Deep groundwater not considered a viable receptor. Shallow groundwater a likely pathway to the surface water. Remediation focused on limiting / reducing loading through remediation of made ground.
Blacup Beck	Surface water run-off and groundwater migration	Inorganic & organic contamination in the made ground	Adopt site specific screening values below 97mAOD (see section 7.23 for treatment options)
		Metals, Hydrocarbons in contaminant-rich silts within redundant drains	Removal, sealing-off or diversion of all former (redundant) site drainage prior to site clearance and earthworks.
		Silt from construction activities	Silt Management Plan, inclusive of surface water grips etc to include regular site lead visual inspections and sampling.

◊ Transient risks to construction workers will be addressed by the adoption of appropriate health and safety measures in accordance with the Health and Safety at Work Act 1974, and regulations made under the Act including for example the COSHH Regulations.

4 GENERAL REMEDIATION CONSIDERATIONS

4.1 Remediation Options Appraisal

4.1.1 There is still some **uncertainty** regarding the extent of contamination that could be encountered. This uncertainty cannot be removed by further ground investigation given the current access limitations, undulating ground levels, highly heterogenous made ground and range of former site activities. See also Section 4.3 below.

4.1.2 However, the type of contamination likely to be encountered can be reasonably predicted based on the site's history and contamination identified to date in soils and groundwater.

4.1.3 The final remediation solution is likely to involve a range of techniques. Remediation options worthy of further consideration based on current site data are summarised below:

Remediation techniques (organic contamination in soil)

Technique	Remarks	Feasibility
Excavation & disposal	Not in line with current Government philosophy regarding sustainable development. Majority of soil that cannot be reused may be classed as hazardous waste, therefore costs likely to be prohibitive.	Some offsite disposal may be prudent, particularly in respect to the Reservoir silts and any localised areas of free product. Off-site disposal may also be considered to avoid stockpiling of highly odour material.
Isolation beneath cover	Organic contaminants in some areas likely to include a significant proportion of volatiles, therefore remediation of this fraction would be required prior to placement below any cover. Testing of groundwater and leachability of inorganics in soils / made ground suggest these do not present a risk to shallow groundwater or the beck, however organic contamination is more mobile and remediation to controlled waters targets would be required, irrespective of volatility.	A cover system would be suitable for managing exposure to inorganic and non-volatile organic determinants. Cover should complement other remediation treatment activity but is not a suitable solution on its own
Recovery of coarse fraction	The matrix is contaminated, but contains a significant proportion of oversize (brick, concrete, sandstone etc), which is "clean" (i.e. not heavily stained or impregnated).	This is likely to be the case in Area B, C & D. Recovery of course fractions likely to result in suitable material to process for engineered fill. Coarse fractions in Area A may be impregnated with contamination.
Use of cut-off wall or reactive barrier	The site is located adjacent to a watercourse, therefore use of a permeable, reactive barrier might be appropriate.	There is no intention to treat groundwater, instead this Remediation Strategy considers managing and reducing the source. This is considered more viable given the extensive amount of earthworks that is required.
Ex-situ bioremediati on	Field or laboratory trials would be needed to confirm: that contaminants are degradable; anticipated treatment duration; which nutrients and fungal enzymes are best suited	Some organic contaminants, particularly in Area C include a significant proportion of "heavy" TPH/PAH, therefore treatment could be difficult & lengthy. There is an indication that chlorinated solvents may be present in Area A or the reservoir in Area B. Bioremediation of these to carbon dioxide and water requires both anaerobic and aerobic conditions; careful consideration is needed to ensure complete degradation and not simply an increase in vinyl chloride or other daughter by products.

Technique	Remarks	Feasibility
Soil washing	Majority of contamination likely to be present in the granular matrix.	Testing indicates that the inorganic determinants are not particularly soluble, with limited impact on the groundwater. Soil washing might be useful for organic determinants, but some addition of surfactants may be required, and this would need further detailed discussion with the EA regard. Other techniques may be as or more effective and more straightforward to achieve.
Solidification or stabilisation	Laboratory trials would be needed to confirm the ability of E-Clays or cement-based products to immobilise the contaminants. Ex-situ treatment more likely to eb viable given the need for excavation of made ground across the entire site to a minimum 3m.	Solidification / stabilisation does not reduce the volatile fraction and as such would not be an appropriate independent remediation technique for human health risks. However, the technique could be applied, pending successful field trials, to material being placed at or below 97mAOD to prevent contamination of the Beck via leaching and groundwater migration.
Soil Vapour Extraction (SVE)	Majority of soil is granular therefore SVE could be appropriate for removal of VOCs.	SVE would only address the highly volatile determinants. It would not provide a remediation solution for weathered diesel, hydraulic oils or coal tar. SVE would also not address the inorganic determinants. Furthermore, shallow and fluctuating groundwater, particularly in the south, is likely to limit the effectiveness.
Thermal treatment	Steam injection could be appropriate for removal of VOCs and NAPL fluids. Ex-situ thermal desorption could be appropriate for removal most organics and inorganics.	Small scale units are available and could be used on site; however, because of the high energy requirement this technique is usually prohibitively expensive.

4.2 Mobile Plant Permit

4.2.1 Grossly contaminated soil/fill predominantly from Areas A, B & C is considered suitable for treatment on site using one or more of the techniques discussed in the remedial options appraisal in Section 4.1 above. It is anticipated that the volume of soil/fill requiring treatment will exceed 1,000m^3. Therefore, if on-site treatment is proposed, a Mobile Plant Permit (also referred to as a mobile treatment licence) will be required and a Deployment Form must be completed and submitted to the Environment Agency.

4.2.2 However, it cannot be assumed that all remediation treatment activities will be acceptable to the Environment Agency, even where these are shown to successfully address the contamination present on site.

4.2.3 The EA will consider the impacts of nuisance on adjacent residents when reviewing a submitted Deployment Form. Whilst Best Practicable Means must be employed at all times during on-site treatment, to minimise dust, odour and VOC generation, this is not always sufficient to prevent nuisance. Treatment activities that are likely to generator odours for example, are unlikely to be approved adjacent to a densely populated residential area.

4.3 Management of unknowns

4.3.1 Whilst extensive ground investigation has been undertaken across the site some uncertainties remain. It is highly unlikely that even with further intensive phases of ground investigation, these uncertainties would be addressed.

4.3.2 The remediation tasks detailed in Section 7 should provide a framework for addressing uncertainties as these arise.

4.3.3 Uncertainties include:

- The nature and location of **source material** – whilst some contamination has been identified, groundwater monitoring indicates this is likely to be more extensive. Source areas should be anticipated during excavation of made ground across all areas, but most specifically in:
  - Area A
  - the reservoir in Area B
  - former scrap yard in Area C.
- **Heterogeneity** of made ground and **suitability** for use as engineered fill – it has been assumed that the bulk of made ground in the backfilled quarries in the south of Area C and east of Area B can be processed and reused as engineered fill. This is supported by shallow trial pits, but detailed material description in boreholes is not possible and as such a provision for offsite disposal of some made ground should be included.
- Status of the **environmental permit** for the former scrap yard.
- Piles must be socketed into rock and not allowed to deflect off the **high wall**. Extensive work has been undertaken to confirm the location and gradient of the quarry highwall. However, changes and increased exposures of highwalls must be recorded during mass excavation of made ground.

5 EARTHWORKS LEVELS, REGRADE & ANTICIPATED FOUNDATIONS

5.1 The Geoenvironmental Appraisal Report (Ref. 3043/2D, dated July 2023) indicates the following foundation solutions are likely to be most appropriate (subject to the Strata's preferences regarding site preparatory works, final levels & costs associated with each foundation option).

% of site	Foundation solution(s)	Remarks (influencing factors)
40%	Deep strips/trench fill at 0.9m to 2.5m	Natural soils at minimum founding depth and made ground <2.5m thick (following preparatory earthworks
60%	Piles to between 4m and up to 17m	Deep made ground and shallow Alluvial soil

5.2 The foundation options summarised above assume that ground levels will not change significantly from those existing at the time of the ground investigation.

5.3 Final site levels will be determined by Strata, in conjunction with their Earthworks Contractor and Engineering Designer. However, Queensberry Design Post Remediation Development Platform Model Drawing (QD1776-70-03, Rev. A) indicates the development will be plateaued from existing ground levels in the north (approx. 105mAOD), to tie into the level of Blacup Beck in the south (approx. 95mAOD).

5.4 The feasibility Cut and Fill Drawing indicates that:

- Area A has between 1m of cut and 1m of fill
- Area B has between 0.5m of cut and 3.0m of fill
- Area C has between 3.0m of cut and 3.5m of fill
- Area D has between 1.5m of cut and 2.0m of fill

5.5 Furthermore, extensive excavation to remove obstructions and treat contamination are anticipated in all Areas. Given the extensive earthworks there may be opportunities to replace remediated made ground in engineered layers.

5.6 The final plot specific foundation solution is likely to be concluded on completion of the site preparatory and remediation earthworks. However, it is anticipated that this would still involve a combination of shallow and piled foundations.

5.7 Any digital terrain modelling undertaken by the Earthworks Contractor should be designed with a view to enabling a "materials balance" (i.e. volume of cut to broadly equals the volume of fill), and be made available to Strata's Engineering Designer. The digital terrain modeller should consider:

- Volume reduction caused by turnover (compaction of loose made ground; removal of obstructions/tanks etc)
- Whether or not processed arisings/treated soils are retained on site
- The thickness of the soil cover required in garden areas
- Consideration of the location of known quarry highwalls

5.8 Final site levels should then be issued by the Engineering Designer, via an External Works Drawing, which should show:

- Proposed finished floor levels
- Proposed finished road levels
- Garden & driveway levels and gradients

6 REMEDIATION STRATEGY (General)

6.1 Aims

6.1.1 Remediation aims are to:

- Resolve contamination issues in order to protect environmental receptors, and render the site suitable for the proposed development
- Provide a stable development platform (to agreed levels and gradients) for subsequent construction of the proposed development and associated infrastructure
- Satisfy requirements of the Local Planning Authority and the National House Building Council (NHBC)

6.2 Overview

6.2.1 The following remediation works are required:

- Treatment of Japanese Knotweed
- General site clearance of surface materials and vegetation
- Demolition of buildings
- Break-up of slabs and hardstand
- Crushing of all suitable artificial hard material (i.e. concrete/brick etc)
- Turnover (excavation, screening/sorting, treatment to meet screening values and replacement in engineered layers, with compaction) of the full thickness of made ground or 3m whichever is the lesser, including:
    - Removal of anticipated **tanks** from Area A
    - Excavation and treatment of the full depth of the **reservoir** in Area B
    - Removal of localised fuel/oil contamination; with subsequent treatment and/or off-site disposal, particularly in Areas A, B & C
    - Removal of below ground **obstructions**
    - Preparation of the ground for highway construction
    - Excavation and removal of localised contamination as identified (all Areas)
- Backfill of all resultant excavations, with appropriate compaction
- Possible creation of "clean corridors" for subsequent placement of sewers (and an attenuation tank in Area B)
- Treatment of hydrocarbon impacted soil, for subsequent re-use on site
- Regrade of site to levels specified in Queensberry Design Post Remediation Development Platform Model Drawing (QD1776-70-03, Rev. A), (leaving levels approximately 600mm below final "soft" end use areas to accommodate clean cover)
- Provision of a cover layer of 'clean' soils in all garden and landscaped areas.

6.3 Site set-up, organisation and safety

6.3.1 Site cabins and welfare facilities are to be established at a location to be agreed with the Engineer and Strata. All welfare facilities must be established in accordance with the relevant health & safety statutory requirements. Provision should be provided on site for car parking for all site employees.

6.3.2 All site personnel should undergo a site-specific health and safety induction prior to commencement of work on site.

6.3.3 Strata should be informed prior to any proposed entry of a confined space or deep excavation. Entry must be restricted to suitably qualified and equipped personnel.

6.3.4 Access into excavations etc. must be controlled and undertaken in accordance with the CDM Regulations 2015, most notably Regulation 22, to mitigate risk of collapse or asphyxiation.

6.3.5 During the remediation works, all personnel on site will comply with guidance provided in the Health and Safety Executive (HSE) document "Protection of Workers and the General Public during the Redevelopment of Contaminated Land". In summary, the following should be provided:

- A designated "clean" area should be fenced off and suitable warning signs posted. The only access to or from the "dirty" area should be via a hygiene facility (personnel) or wheel wash (vehicles)
- Protective clothing, footwear and gloves. (Personnel should be instructed in why and how they are to be used)
- Hand-washing and boot-washing facilities
- Designated smoking areas

6.3.6 If at any time during the works personnel begin to feel unwell, they are to inform the Engineer, who will determine appropriate action.

6.3.7 All visitors to site must enter and register at the main Site Office.

6.4 Contractor's responsibilities

6.4.1 Prior to the commencement of any works the Contractor (in agreement with Strata and, where appropriate, the Geoenvironmental Engineer), should:

- Comply with any requirements of Strata's contract documentation
- Establish the boundaries of the site and the working areas
- Undertake a dilapidation survey of site boundaries, adjacent properties and highways, via dated photographs or video footage
- Liaise with the Local Authority regarding working hours, noise/dust/odour control, and protected trees
- Liaise with the Local Water Company and secure discharge consents to cover proposed discharge to sewer
- Liaise with the Environment Agency regarding any work in close proximity to Blacup Beck, including timetable for diversion works.
- Complete a full services search and liaise with all relevant utility companies regarding work in close proximity to their apparatus
- Undertake a CCTV survey to record the condition of the current Blacup Beck culvert
- Obtain a pre-demolition (formerly Type 3) asbestos survey report for all buildings to be demolished
- Prepare a detailed Method Statement outlining how the objectives of this Remediation Strategy will be achieved (and obtain approvals)
- Inform the Engineer/ Strata of any risk, identified and assessed, which could impact upon the Engineer's activities
- Prepare the necessary COSHH statements and Health & Safety Plan in accordance with CDM regulations
- Provide and erect secure herras-type fence to protect monitoring wells until these are suitably decommissioned (see section 7.7)

6.4.2 The Contractor should satisfy the Health & Safety Executive with regard to all matters concerning the health, safety and welfare of persons on the site.

6.4.3 The Contractor should ensure that:

- Personnel, plant, materials and other equipment related to the contract are confined within the boundaries of the site.
- Any live services lying within the site boundary are marked and protected, or appropriate arrangements made to truncate them.
- Good practices relating to personal hygiene are adopted.
- Suitable precautions are implemented at all times to prevent off-site migration of contaminants via airborne dust and vapours.
- Suitable precautions are taken to prevent the spread of mud and debris on public highways.
- Refuelling of mobile plant is undertaken in a designated area. Above ground oil storage tanks should comply with the requirements of Pollution Prevention Guideline PPG2. A spill kit should be kept on site, adjacent to the designated refuelling area. (Lithos are aware that some of the EA PPG documents have been withdrawn from the gov.uk website. However, PPGs provided a summary of current UK guidance; the principles are still relevant and provide a useful, concise overview).

6.5 Materials Management Plan

6.5.1 This project will involve the re-use of both natural and made ground soils on site and the import of natural soils from another development site(s). Therefore, the Contractor will need to prepare a Materials Management Plan (MMP) in accordance with the CL:AIRE Code of Practice (v2, March 2011).

6.5.2 The MMP will document how all of the materials to be excavated during the proposed site preparatory and remediation earthworks are to be dealt with. In summary the MMP should provide:

- Details of the parties that will be involved with the implementation of the MMP
- A description of the materials in terms of potential use and relative quantities of each category
- The specification for use of materials against which proposed materials will be assessed, underpinned by an appropriate risk assessment related to the place where they are to be used
- Details of where and, if appropriate, how these materials will be stored
- Details of the intended final destination and use of these materials
- Details of how these materials are to be tracked
- Contingency arrangements that must be put in place prior to movement of these materials
- Verification Plan

6.5.3 The MMP should include consideration of the following factors:

- Any risks posed by the excavated materials to both human health and the environment
- Suitability for use
- Certainty of use
- Anticipated quantities of materials

6.5.4 The MMP should also detail how materials will be tracked throughout the earthworks in order that the subsequent Verification Report can provide an auditable trail. The tracking system must include:

- Annotated plans of the site(s) identifying different excavation areas, stockpile locations, treatment areas (if applicable) and placement locations
- Inspection procedures
- Registered waste carrier and non-waste haulier
- Tracking form / control sheets
- Treatment results (if applicable)
- Delivery tickets for non-waste materials (if moving from one site to another)
- Acceptance procedures for non-waste materials

6.5.5 Finally, the MMP will have to set out a Verification Plan that identifies how the placement of materials is to be recorded and the quantities of material to be used. It will contain a statement on how the use of the materials relate to the remediation or design objectives.

6.5.6 Once completed, the MMP will need to be reviewed by a Qualified Person (QP), who will submit an online Declaration to CL:AIRE and send a copy to Strata. It should be noted that in accordance with the Code of Practice, Lithos cannot act as the Qualified Person because we have undertaken the site investigation and prepared this Remediation Strategy. Lithos can however prepare the MMP.

6.6 Engineering supervision and verification

6.6.1 Site works should be supervised throughout by a suitably qualified Geoenvironmental Engineer, who will report to a Project Manager. Supervision may be part-time for certain activities, but must be full-time during the removal of any grossly contaminated soil/fill and any placement of fill to an engineering specification. It is anticipated, based on site conditions, that full time supervision would be required for:

- all excavations in Area A,
- excavation of the reservoir in Area B, and
- excavation of the northern section of Area C, formerly occupied by the scrap yard.

6.6.2 Supervision for all engineered backfill would also be prudent.

6.6.3 The Engineer will ensure that the requirements of this Remediation Strategy are complied with in a safe and orderly manner.

6.6.4 The responsibilities of the Engineer should include, but not be limited to, the following:

- Ensuring that all site personnel are suitably qualified and given an appropriate induction at the beginning of their first day
- Supervision of the remediation and ground preparatory works
- Provision of advice on the correct handling of materials and conditions encountered
- Provision of guidance on the appropriate protective clothing and safety equipment that is to be made available and used
- Ensuring that personal hygiene arrangements are adequate
- Retrieval of soil and water samples and the subsequent scheduling of appropriate laboratory analysis to enable verification of various aspects of the works, and to advise the Project Manager of progress
- Liaison with statutory authorities as required

6.6.5 The Engineer, or Strata Site Manager in the absence of the Engineer, will maintain records of the works to include the following:

- Daily record sheets to include a summary of the day's activities
- Date and weather conditions
- Plant, personnel and visitors present
- Aspects relating to Health and Safety, Environmental Control, or non-compliance with either this Remediation Strategy or the Contractor's Method Statement
- Site surveys as necessary to record the locations of demolition, excavation and filling activity
- Test results

6.6.6 On satisfactory completion of all the works the Engineer will prepare a Verification Report, in accordance with the Environment Agency's online guidance "Land Contamination Risk Management" which replaced CLR11 in October 2020. Copies of the Verification Report will be issued to the Strata, the Local Authority and NHBC.

6.6.7 The Verification Report will stand as certification that the remediation and ground preparatory works have been carried out in accordance with this Remediation Strategy.

6.6.8 The Verification Report will include:

- A summary of the preparatory & remediation works undertaken, including any works associated with unforeseen ground conditions
- Verification test results associated with "hot-spot" treatment, including plans showing sample locations & levels, and the extent of any "hot-spot" excavations
- Details of the fate of any arisings excavated from "hot-spot"
- Verification test results associated with proposed source materials for clean cover
- Moisture content and plate bearing test results associated with ground improvement beneath proposed highways and dwellings
- Copies of any correspondence with Regulators relating to specific aspects of the remediation works
- Reference to the MMP and associated tracking system, including alterations made and why.
- Treatment records
- Reference to waste transfer documentation, including return loads (if applicable)
- Signed delivery tickets (if applicable)
- Record of quantity of materials used
- A receipted copy of the Qualified Person's Declaration

6.6.9 The Verification Report will also provide recommendations with respect to:

- Foundation Solution(s)
- Gas Measures
- Placement of Soil Cover
- Handling of Contaminated Soils

6.6.10 The above recommendations will take account of the actual remediation works undertaken, and may differ from recommendations originally presented in the site investigation report.

7 REMEDIATION STRATEGY (specific objectives)

7.1 Managing unexpected contamination

7.1.1 Even after an appropriate preliminary investigation and ground investigation, with exploratory holes on a closely spaced grid (say trial pits at 30m centres), a geoenvironmental appraisal is typically based on inspection of the ground underlying less than 0.5% of the total site area (and much less at depths in excess of about 3.5m). Consequently, there is always a possibility that unanticipated ground conditions will be encountered during the remediation works.

7.1.2 Groundwater monitoring at Westgate indicates the presence of contamination, particularly in Area A & C, which was **not** reflected by soil sample data and **further unidentified** contamination is likely.

7.1.3 Where unanticipated ground contamination is encountered during the remediation works, the Contractor should immediately seek further advice from the Engineer.

7.1.4 In order to assess the nature of any unanticipated grossly contaminated soil/fill, and (if necessary) allow revision of this Strategy document, it should be placed in temporary stockpiles on hardstand or Visqueen, suitably covered and bunded.

7.1.5 Analysis of at least 6 samples, for an appropriate range of determinands should be undertaken. On receipt of the results, the Engineer will liaise with the Contractor regarding the most appropriate remediation option.

7.2 Japanese Knotweed

7.2.1 An invasive weeds survey has not been undertaken; however, it is likely that knotweed could be present on site. A formal survey should be undertaken prior to site clearance.

7.2.2 Knotweed treatment/removal will be required prior to redevelopment, and should be undertaken in accordance with Environment Agency guidance, most notably '*Managing Japanese knotweed on development sites – the knotweed code of practice*' (Environment Agency).

7.2.3 Treatment/removal should be undertaken by a suitably qualified sub-contractor, and options include:

- Herbicide treatment
- Excavation & off-site disposal
- Excavation & on-site burial
- Burning (only in combination with one of the above)

7.2.4 If treatment is required, consideration should be given to programme and seasonal implications.

7.3 Site clearance

7.3.1 Any trees currently under a preservation order should be identified and agreed with relevant authorities prior to the commencement of the works. All trees subject to a TPO should be clearly identified and protected by fencing in accordance with BS5837: 2012.

7.3.2 The site should then be cleared of all residual debris, any vegetation, shrubs, bushes and unprotected trees as instructed by Strata.

7.3.3 Localised Topsoil was identified but this was found to be impacted by inorganic determinants and was noted to have a sulphurous odour. Topsoil on site is not suitable for use in garden areas, but might be suitable for use in landscaped areas where turf is to be established.

7.3.4 Topsoil should be stripped and stockpiled separately from made ground arisings. It is likely that further testing would be advocated by the Engineer to determine the extent and location of reuse, or indeed confirm the need for of site disposal.

7.3.5 Topsoil would not be suitable for direct transfer to another development site.

7.4 Asbestos

7.4.1 Current legislation (as outlined in HSG 264) requires a pre-demolition (formerly Type 3) asbestos survey to be undertaken, immediately prior to demolition of any building. The Contractor should request a copy of the survey report from Strata. If no survey report is available, the Contractor will instruct an asbestos survey.

7.4.2 Localised fragments of asbestos cement sheeting were recorded in the ground investigation, predominantly at surface, and should be anticipated during the site remediation and preparatory works. All suspected asbestos-containing material should be recovered by hand and placed in double sealed bags, within a sealed skip for off-site disposal at a suitably licensed landfill site. Personnel involved in this activity should be equipped with appropriate personal protective equipment, including dust masks (minimum FFP3).

7.4.3 An asbestos ID (screen) was scheduled on 77 samples of made ground, with asbestos identified in 4 samples. Only one of these samples yielded amounts of asbestos above the limit of measurement (<0.001%). Given the heterogeneity of made ground, it should be assumed further discrete areas of asbestos fibres within made ground could be encountered and a precautionary approach should be taken.

7.4.4 However, provided soils are kept damp the risk of airborne fibre release, even during disturbance associated with excavation, should be negligible, and certainly below the control limit (as set by the Control of Asbestos Regulations 2012) of 0.1 f/cm^3 airborne fibres averaged over a 4-hour period.

7.4.5 Any made ground soils where asbestos is positively identified and considered representative of near-surface soils, will ultimately be isolated beneath the proposed minimum 600mm thick surface cover of "clean" soil (garden/landscaped areas), or hardstand (parking areas), or floor slabs (buildings) and therefore there will be no risk of release of asbestos fibres from the ground. Consequently, in line with the principles of sustainable development, there should be no need to export any soil from site due to the presence of asbestos.

7.5 Demolition

7.5.1 Demolition works should commence on completion of asbestos removal and a "soft-strip" of the existing buildings.

7.5.2 Existing buildings should be demolished in a safe and controlled manner.

7.5.3 All demolition operations should conform to BS 6187:2011 Code of Practice for Demolition. All personnel working on these operations should be fully qualified to do so.

7.5.4 A detailed Method Statement specific to the project must be prepared by the Contractor and submitted to Strata. The Method Statement should also be submitted to, and approved by, the Engineer and the Local Authority.

7.5.5 Once buildings have been demolished, all surface hardstand and floor slabs should be grubbed-up and stored in a location on site, to be agreed with the Engineer, prior to crushing (see Section 7.16). Any unsuitable materials should be removed to a suitably licensed landfill site (see Section 7.24).

7.6 Supplementary ground investigation

7.6.1 Lithos' SI report (Ref. 3043/2D) recommended some supplementary post demolition investigation once areas of hardstanding are grubbed-up. However, given successful remediation of this site requires turnover of up to 3m of made ground in all Areas (see Section 7.8 below), the need for this additional ground investigation is no longer valid.

7.6.2 Additional ground investigation at this stage would not support further refinement of this Remediation Strategy, or significantly reduce current uncertainties detailed in Sections 4.1 & 4.3.

7.7 Decommissioning of boreholes

7.7.1 Continued monitoring of **BHs 502, 508 & 509** along the southern boundary is recommended at weekly intervals during remediation in Area A and the former reservoir in Area B to identify any contaminant movement toward the beck (see Section 7.12). The Contractor should ensure these boreholes are protected by the erection of secure herras-type fence, until such time as agreed with the Engineer.

7.7.2 All monitoring wells should ultimately be decommissioned once no longer needed, in order to prevent the possibility of contamination in made ground migrating into the deep aquifer (Groundwater Body 2); see Drawing 3043/9.

7.7.3 Decommissioning should be undertaken **during** excavation and turnover of made ground by carefully removing soils around each borehole and removing the upper section of pipework to excavated levels, filling the remaining well with gravel and then bentonite pellets (uppermost 3m; to be wetted after placement). The headworks (raised helmet or stop-cock type cover) should be removed from site.

7.7.4 Treatment of the wells should be undertaken in accordance with the EA guidance document "*Decommissioning Redundant Boreholes & Wells*" included in Appendix D.

7.8 Turnover of made ground

7.8.1 Turnover (excavation, screening/sorting and replacement in engineered layers, with compaction) of the full thickness of made ground, or a minimum of **3m**, is required in all Areas in order:

- To remove relict foundations and **obstructions** (including below ground tanks, treatment chambers, reservoir silts, redundant sewers)
- To remove the soil/fill grossly contaminated with **hydrocarbons**, predominantly in Area A and the reservoir in Area B, although localised pockets may be present in Area C
- To prepare the ground beneath proposed new estate **roads**
- To confirm the absence of any significant source of carbon dioxide within made ground in the vicinity of **PH515**

7.8.2 Further details of specific operations associated with turnover are described in the following sections and also in Lithos Earthworks Specification (Report 3403/7).

7.8.3 Ideally, Made Ground from **Area A** should be **retained** in this Area, not used across Area B, C or D to minimise the need for protective concrete mixes and hydrocarbon resistant membranes.

7.8.4 Where made ground cannot be retained in Area A additional supplementary testing for sulphate should be undertaken, prior to placement and the extent of any relocated arisings from Area A should be recorded by **survey**.

7.8.5 See also Section 3 (notably Section 3.5) regarding remedial targets for soil.

7.9 General excavation

7.9.1 Excavation of made ground will be undertaken in a controlled manner, working from a line agreed with the Engineer in linear panels.

7.9.2 Excavated material should be removed from each panel and screened to remove oversize (> 200mm) and other unsuitable (e.g. anthropogenic or biodegradable materials), prior to replacement, or treatment under a mobile plant permit (see Section 4.2).

7.9.3 Each panel should be inspected by the Engineer, and have its depth and extent recorded by survey, prior to backfilling (see Section 7.17).

7.9.4 Any excavated and screened material that needs to be stockpiled temporarily should be placed in areas designated by the Engineer. Any stockpile of made ground should be assumed to contain elevated concentrations of inorganic contaminants, and it should be ensured that such materials are not allowed to cross-contaminate any clean soils or controlled waters.

7.10 Site regrade

7.10.1 Regrade of site is anticipated to facilitate the proposed housing layout. It is understood that Strata will require the appointed earthworks contractor to undertake digital terrain modelling, with a view to:

- Achieving a materials balance (thereby avoiding the need for any significant import or export of soils)
- Confirming final levels, including Plot FFLs
- Achieving acceptable highway and drive gradients
- Minimising foundation abnormals

7.10.2 Earthworks modelling should consider the possibility of using site-won subsoil as cover material (subject to the Engineer's approval, see also Section 7.25), and how excess foundation and drainage arisings will be accommodated.

7.11 Tank/treatment chambers

7.11.1 A number of former tanks are shown on historic maps within **Area A**. It is believed that some were below ground storage tanks, possibly containing coal tar. Others were treatment chambers for the production of sulphuric acid (likely lead-lined).

7.11.2 Each tank should be carefully identified and emptied of any residual product, purged of potentially explosive vapour, and safely disposed of from the site by an appropriately qualified and licensed contractor.

7.11.3 Some treatment chambers may have been constructed with an outer layer of brick or concrete. This brick / concrete should be visually inspected to establish the degree of impregnated oily contamination to decide if it is suitable for retention, or if the degree of contamination would make it unsuitable for on-site use in processed aggregate, therefore requiring off-site disposal.

7.11.4 Any underground distribution pipe work should be purged of any residual product and explosive vapours and then carefully removed.

7.11.5 The Engineer will inspect the resultant excavations, and supervise the chasing-out of any grossly contaminated soil/fill encountered (see Section 7.12).

7.12 Excavation of soil/fill with organic contamination

7.12.1 Lithos advocates the removal\treatment of soils that contain significant **free product**. This is because all risk assessment models assume there is no free product so do not accurately consider the risk. Also free product is considered a primary source of contamination, i.e. it will not degrade rapidly, if at all, and allows a continued loading of contamination to soil and groundwater.

7.12.2 In this context, significant free product would be readily identifiable to the naked eye, and pervasive throughout the soil mass, probably with noticeable seepages. Traces of free product in fissures or localised, cobble-sized pockets, would not normally be considered significant.

7.12.3 No evidence of significant areas of free product or extensive areas of hydrocarbon contamination have been recorded to date. However, the possibility that localised 'pockets' will be encountered during the site preparatory works is reasonably high, particularly in Area A & C. It is also likely that below tanks and pipelines containing free product are present in Area A.

7.12.4 Fuel contaminated material identified, should be excavated under the full-time supervision of the Engineer, who will be equipped with a portable PID instrument to assist with delineation.

7.12.5 Following excavation of the grossly contaminated ground, the Engineer will inspect and sample the resultant excavations.

7.12.6 A minimum of 5 verification samples should be taken from the excavation sidewalls and base. These samples should be tested for TOC, speciated PAH & speciated TPH. Analysis for other determinands, likely SVOC and VOCs in Area A, may be appropriate and will be requested by the Engineer as necessary.

7.12.7 In larger excavations, additional verification samples should be taken from the exposed excavation surfaces on a 10m grid.

7.12.8 The Engineer will instruct continued removal of soil/fill if verification samples yield concentrations in excess of the clean-up criteria outlined in Section 3.

7.12.9 Excavations should not be left open for longer than is necessary, and should be securely cordoned-off using 2m high Heras-type fencing, with appropriate warning signs whenever excavation works are suspended.

7.12.10 Excavated contaminated soils should either be treated or disposed of off-site; see Sections 7.23 and 7.24 respectively.

7.12.11 On completion of tank/soil removal, excavations are to be backfilled (see Section 7.17).

Groundwater monitoring during excavation of organic contamination

7.12.12 Areas of gross organic contamination are anticipated in **Area A** and within the **reservoir** in Area B. As both are likely to be in hydraulic connectivity with Blacup Beck via shallow groundwater, it is recommended that **groundwater monitoring** is periodically undertaken during the exaction of these areas.

7.12.13 Monitoring wells are already installed in BHs 502, 508 & 509 along the southern boundary between the Beck, Area A and the reservoir. During excavation of made ground, removal and treatment of source areas, these boreholes should be monitored for metals, VOC & sVOC at a minimum frequency of once a week. However, the monitoring frequency should reflect the excavation programme, more frequent monitoring could be required during periods of increased activity, particularly during excavation of the reservoir.

7.12.14 No compliance limits are proposed, monitoring is solely intended to consider trends in contaminant loading and provide an early indication of mobilisation of contaminants in the groundwater.

7.12.15 If an increase in contaminant loading in groundwater is identified, excavation works should stop, and the process be reviewed. This could include:

- reducing the width of excavation panels,
- over pumping groundwater in excavations to prevent flow through source areas.
- covering or backfilling some parts of the excavations to reduce infiltration.

7.12.16 Groundwater monitoring is not considered necessary during remediation and excavation of made ground across the wider site.

7.12.17 Once remediation of the reservoir and Area A is complete the three monitoring boreholes should be decommissioned (see Section 7.7).

7.13 Control of water

7.13.1 Surface water sampling, both up and down gradient has been undertaken on 3 occasions. No elevated concentrations of determinants were recorded during any sampling round, suggesting a low mobility of site contamination.

7.13.2 However, site preparatory earthworks and remediation can result in mobilisation of contamination either via groundwater flow or sediment discharge.

7.13.3 Groundwater is likely to be encountered, particularly following periods of high rainfall. Drawing 3043/15, included in Appendix A shows where excavations are most likely to encounter water.

7.13.4 Groundwater should be controlled in accordance with CIRIA report 113 "Control of Groundwater for Temporary Works".

7.13.5 Arrangements should be made to prevent ponding in any excavation "hollows"; the Contractor should ensure that ground levels are of sufficient gradient to enable the collection of surface water run-off in sumps or grips.

7.13.6 Pumping from over-excavated sumps may be required to maintain satisfactory working conditions.

7.13.7 The Contractor should make all necessary arrangements to prevent off-site migration of contaminated sediment via surface water run-off, and avoid any pollution of Blacup Beck. This will necessitate the installation of surface water grips, and removal, sealing-off, or diversion of all redundant former site drains (and any land drains).

7.13.8 A **Surface Water Management Plan** (SWMP) should be prepared with input with the Contractor, to describe the mitigation measures that will be put in place to intercept direct run-off from any disturbed areas, stockpiles etc, thereby preventing any potential impact of adjacent land and nearby watercourses. Surface water run-off will probably require treatment (as a minimum to allow settlement of fines) prior to consented discharge.

7.13.9 Site topography and the location of the beck at the lowest point on site will make management of surface water problematic. The SWMP should consider a phased method of mitigation along several plateaus, with separate collection points, rather than a single silt fence along the line of the beck, although this is also recommended.

7.13.10 It is quite likely that perched waters and shallow groundwater will also be encountered during the remediation earthworks; most commonly associated with redundant drains, buried structures and below groundwater resting levels (97mAOD to 95mAOD).

7.13.11 Some groundwater may be contaminated with hydrocarbons and\or VOCs, such as those encountered in the reservoir.

7.13.12 It should be noted that significantly elevated concentrations of hydrocarbons and heavy metals are often associated with sediment within the former drainage network below brownfield sites such as this, and that these, if released, pose potential risk to waters.

7.13.13 Any potentially contaminated water should not be allowed to escape to other areas until the results of the analysis are available and, if required, a suitable means of water treatment has been agreed.

7.13.14 Water collected water should be passed through a series of oil/water separators to remove any oily contamination. Oils trapped in the absorbent medium should be disposed of to a suitably licensed landfill site.

7.13.15 Treated water should then be tankered off-site, or be discharged to sewer, subject to analytical results and Yorkshire Water consent.

7.13.16 No active pumping or treatment of groundwater for contamination, beyond managing water in excavations, is recommended.

7.13.17 Dewatering associated with construction activities is no longer automatically exempt from the Water Abstraction and Impoundment (Exemptions) Regulations 2017 (WAIR 2017). A permit may be required if:

- The abstraction is continuous and extends over a 6 month period
- The abstraction could cause damage to a conservation site or protected species
- Water is not immediately discharged back to ground, or
- The volume of water pumped exceeds 100 cubic meters per day

7.13.18 If excavations cannot be programmed to coincide with lower groundwater levels, discussions may be needed with the Environment Agency to confirm WAIR 2017 does not apply or secure an exemption.

7.14 Removal of below ground obstructions

7.14.1 All foundations associated with existing buildings and other relict structures should be chased out and grubbed-up, in order to remove potential obstructions to new foundations and infrastructure.

7.14.2 Where relict structures are found to retain fluid contaminants, they should be drained first. The drained fluids should be stored in appropriate, sealed tanks/containers and analysed for a range of determinands to be agreed with the Engineer. Fluids may then be tankered off-site, or be discharged to sewer, subject to analytical results and local water treatment company consent.

7.14.3 Deep excavations for the removal of structures etc will be unstable in the short term and continuous side support will be necessary.

7.14.4 Where significantly deep foundations (e.g. piles) cannot be removed by conventional means, they are to be cut at a depth to be agreed with the Engineer and the position of the remaining lower section is to be accurately recorded by survey.

7.14.5 Suitable materials derived from grubbing-up should be stored in a location on site, to be agreed with the Engineer, prior to crushing (see Section 7.16). Any unsuitable materials should be removed to a suitably licensed landfill site (see Section 7.24).

7.14.6 It is anticipated that much of the grubbed-up concrete and brick arisings in Area A will be coated by contaminants. Consideration could be given to **steam-cleaning** of these arisings in order to generate material suitable for crushing and re-use, if they can be proven not to have been impregnated.

7.15 Management of stockpiles

7.15.1 Materials management across all 4 areas will be critical to secure successful remediation and earthworks. The physical and chemical properties of material generated from excavations will determine where this can be reused, and where / what depth material can be reused.

7.15.2 It is strongly recommended that separate stockpiles / storage areas are established for;

- Material physically suitable for crushing and reuse as engineered & non engineered fill (including consideration of impregnated contaminants)
- Crushed aggregate ready for placement
- Made ground that requires treatment for organic contamination.
- Made ground that meets controlled waters targets and can be placed at or below 97mAOD
- Made ground that meets health targets and can be placed within the upper 2m of the development formation (below garden cover)
- Topsoil / subsoil suitable for reuse
- Clean natural strata excavated for use as subsoil
- Material for off-site disposal

7.15.3 See also comments in Section 7.17 regarding sulphate-rich made ground in Area A.

7.15.4 Clean naturally occurring topsoil and subsoil should not be imported and stockpiled on site until these can be placed in a remediated location, away from ongoing earthworks to avoid the potential for cross contamination.

7.16 Crushing

7.16.1 Production of a selected granular fill should be possible if suitable materials (generated by demolition operations and grubbing-up of floor slabs, foundations and other relict structures) are crushed.

7.16.2 The crushed product should be screened to remove any unsuitable elements and stockpiled for re-use during the subsequent construction works. Generation of a Class 6 material as defined in the Highways Agency Specification (Series 600) should be possible.

7.16.3 **Tarmac** could be recycled and crushed to yield a 6F3 selected granular material, provided the recovered bitumen content is less than 10% (determined in accordance with BS598-1:2011). Alternatively, crushed tarmac could also be blended with crushed concrete etc to generate 6F2 graded material. 6F2 can contain up to 50% recycled tarmac/asphalt (provided it does not pose a contamination risk to controlled waters and, if the proportion of asphalt is greater than 20%, the recovered bitumen content is less than 2%).

7.16.4 The Engineer should check the suitability of crushed product for re-use, instruct the removal of any unsuitable material and schedule appropriate confirmatory geotechnical or chemical testing.

7.16.5 It should be possible to generate other secondary aggregates from crushed concrete provided it is subject to good sorting prior to crushing and thereby contains little ‘impurity’ (e.g. brick, breeze block, wood, re-bar etc). The Contractor should liaise with the Local Authority to obtain their views with respect to the use of Type 1 etc generated from recycled concrete.

7.16.6 A minimum of 3 samples (or 1 sample per 500m^3, whichever is the greater) should be taken from any stockpile of specific crushed product and sent to a UKAS accredited laboratory for analysis to assess whether the material conforms to requirements as defined in of the Highways Agency Specification for Highway Works; Series 600 (if 6F2 is anticipated), or Series 800 (if Type 1) and end of waste criteria for aggregates set out in the WRAP protocol.

7.16.7 See also comment in Section 7.14.6 above regarding oily coated materials.

7.17 Backfill of excavations

7.17.1 As discussed in Section 2.2, elevated concentrations of elemental sulphur were recorded in Area A. Sulphur will oxidise rapidly to sulphate and this can influence concrete mixes. The potential for particularly high sulphate concentrations should be anticipated in Made Ground excavated from Area A.

7.17.2 Ideally, Made Ground from **Area A** should be retained in this Area, not used across Area B, C or D to prevent the need for protective concrete mixes across the entire site. Where made ground cannot be retained in Area A, additional supplementary testing for sulphate should be undertaken prior to placement. In addition, the extent of any relocated arisings from Area A should be recorded by **survey**.

7.17.3 Excavations (to remove tanks, relict structures, contamination etc) should be backfilled as necessary to achieve the desired levels, with suitable materials and compacted in accordance with Lithos' Earthworks Specification (Report 3043/7).

7.17.4 Trenches for services including site drainage and water supply should be cut over size in order to isolate pipe materials from potential contaminants and to enable maintenance to be conducted in "clean" material.

7.17.5 The site surface should be left at levels to be agreed by Strata and the Remediation Contractor, taking account of requirements for:

- placement of soil cover in gardens
- placement of a piling mat
- Finished Floor Levels (with allowance for sub-floor voids)
- road construction

7.17.6 Excavated arisings will be inspected by the Engineer in areas of suspected contamination, and any suspicious material or material yielding evidence of significant contamination (based on visual\olfactory observations), will be placed in temporary stockpiles from which an adequate number of samples will be taken (typically a minimum of 6 samples). The samples will be scheduled for an appropriate suite of contaminants in order to characterise the material and decide its fate.

7.17.7 Any material considered unsuitable for use as backfill will either be treated on-site (see Section 7.23), or be exported from site (see Section 7.24).

7.18 "Clean" corridors

7.18.1 Along the line of proposed new sewers (and within the footprint of a proposed attenuation tank), made ground will be excavated to its full thickness, or at least 1.0m below deepest sewer invert whichever is the lesser, to a width agreed with Strata.

7.18.2 Consideration should be given to backfill of the resultant excavation (i.e. the use "clean" material). The nature of backfill should be agreed in advance of the works following liaison between Strata, the Remediation Contractor and the Groundworker.

7.19 Placement of a granular running layer & piling mat

7.19.1 A minimum 200mm thickness of suitable granular fill (i.e. a "blanket" of 6F2) could be placed along the line of proposed haul roads to provide a firm and stable running layer for the subsequent construction works.

7.19.2 Ground conditions at this site are considered likely to require provision of a piling mat (working platform) and further advice should be sought from the appointed specialist-piling contractor regarding the proposed plant loadings and resulting pressures. This data, together with a knowledge of the strength and variability of the near-surface ground conditions is required in order that design of a mat can be undertaken in accordance with guidance provided in the 2004 BRE document, "BR 470: Working platforms for tracked plant".

7.19.3 The design of working platforms for tracked plant is a geotechnical design process and should be carried out by a competent person. The following parties should have input into the design:

- Permanent works designer, to consider additional uses for platform material as part of the overall development
- Principal contractor, to define any other purposes for which the platform might be used
- Contractor or subcontractor, to specify requirements for the platform, including gradients, ramps and edges.

7.20 Highways

7.20.1 The Contractor should consult the adopting authority regarding preparation of the ground beneath new highways (as outlined below, or in any proposed alternative specification) in advance of the works. The Contractor should also agree acceptable performance criteria, with the Engineer and the adopting authority.

7.20.2 However, it is considered that the following options would be suitable to enable the construction of the highways.

7.20.3 Made ground should be excavated from beneath new highway footprints to a maximum of depth of 3.0m - from existing ground level or proposed highway formation, whichever is the lower. Highways should then be raised to formation level, either with:

- Suitable aggregate placed & compacted in accordance with The Highways Agency Specification for Highway Works (SHW) Series 600, or
- Suitable screened & selected site-won material, placed & compacted in accordance with SHW Series 600. Unsuitable materials include any soft or wet materials, biodegradables including topsoil, wood, scrap metal, frozen & oversize material.

7.20.4 Some refinement of the above advice might be possible after highways design (with consideration of the proposed formation level cf existing ground level), and via inspection (and usually CBR testing) of the proposed formation during site preparatory groundworks.

7.20.5 Any residual made ground materials in the base of the excavation (i.e. in areas where the thickness of made ground exceeds 3m) should be inspected and (where necessary) any soft spots removed and replaced with suitable engineered fill.

7.20.6 In the footprint of proposed highways, the contractor, under supervision, must ensure that relict obstructions are removed to a minimum of 500mm below deepest sewer invert. The resultant sub-formation should then be proof rolled, in accordance with the Specification for Highway Works.

7.20.7 If deep backfilled basements (Area A) and backfilled quarries (east of Area B & south of Area C) conflict with new highways, further advice should be sought from the Engineer responsible for detailed infrastructure design. However, where highways span the 'high-wall', the following precautions are recommended to protect infrastructure from damage due to differential settlement.

- The made ground should be excavated over the full width of the adoptable highway to at least 1.0m below deepest sewer invert
- The base of the excavation (1.5m below sewer invert) should be reinforced with two layers of Tensar Triax TX160 (or equivalent) geogrid sandwiched within at least 300mm of suitable aggregate (i.e. nominally 75mm aggregate, geogrid, 150mm aggregate, geogrid and then another 75mm aggregate).

7.20.8 A minimum length of 5m either side of the highwall should be treated to the above specification, although the final specification should be agreed with the adopting authority.

7.20.9 Crushing of demolition/hardstand/foundation arisings will generate aggregate, which (subject to confirmatory testing) should be suitable for use as unbound pavement materials within the highways.

7.20.10 The suitability of site-won material for placement as engineered fill should be confirmed by field trials and geotechnical laboratory testing, which will yield the following information:

- Number of passes with the compaction plant (to be used during subsequent earthworks)
- Maximum layer thickness (plant dependent)
- Acceptance criteria: minimum dry density & moisture content range

7.20.11 The engineered fill should achieve at least 95% maximum dry density, with air voids comprising less than 10%, as determined by 2.5kg laboratory compaction tests.

7.20.12 Where the made ground is re-engineered in accordance with the above specification, it is considered that a CBR value of 5% should be achievable; however, this should be verified by field trials.

7.20.13 The Contractor will arrange for the necessary compliance testing to be undertaken at formation level on road alignments, as required by the adopting authority and Engineer. As a minimum this should comprise plate load tests, carried out to determine the CBR at formation level, at approximate 25m intervals. Test locations should be staggered across the width of the highway to ensure the whole highway area is assessed.

7.21 Boundary issues

7.21.1 Strata's Designer should ensure that proposed levels tie in with the surrounding infrastructure, and ground levels of adjacent properties (after allowance for the placement of any required soil cover). It is understood the development incorporates a new retaining wall among the northern boundary of Area A.

7.21.2 Advice should be sought from the Engineer if mobile contamination or redundant drains/utilities are encountered close to the site's boundaries. This is likely to be particularly important on the northern boundary of Area A, where historic maps show the former chemical works extended to the north beyond the site boundary.

7.22 Surveying

7.22.1 The Contractor should arrange for the following survey work as directed by the Engineer:

- All setting out necessary to allow the works to proceed
- Recording of the depth and lateral extent of excavations to remove obstructions, contaminated soils etc
- Recording of the positions of any relict obstructions (i.e. piles) left in-situ
- Recording the depth & extent of each excavation panel during turnover of made ground, prior to backfilling
- Recording of natural ground levels, where natural ground encountered during the earthworks
- Recording the final location of potentially combustible, treated hydrocarbon-contaminated soils, and any Made Ground relocated from Area A
- Recording the locations and volumes of all stockpiles of suitable materials left on site for Strata 's use during the development works
- As-built survey of the finished surface on completion of the remediation contract

7.22.2 The Contractor should supply the results of this survey work (disc & hard copy) to the Engineer for inclusion in the Verification Report.

7.23 On-site treatment of contamination

7.23.1 Hydrocarbon contaminated material is considered likely to be suitable for treatment on site, although some export to landfill is anticipated (see Section 7.24).

7.23.2 Excavated soils should be screened, to remove oversize (concrete and brick), and the remaining fines hauled to a treatment area.

7.23.3 Within an impacted mass, contaminant concentrations are likely to vary significantly, and segregation of very heavily contaminated material from less contaminated material may not be practical. However, deliberate "overdig" of soil that has not been impacted, for mixing with contaminated soil, is not acceptable.

7.23.4 The treatment area, irrespective of treatment technique should be formed on an impermeable composite liner (clay with polythene membrane, or HDPE sheeting, or concrete hardstand) in an area of site agreed with the Engineer, ideally away from residential properties and in a location where it can remain undisturbed throughout the duration of site wide remediation.

7.23.5 A lined collection trench should be constructed along the width of the treatment area, within the bund, to collect rainwater runoff and leachate. This water should then be passed through the water treatment tanks prior to disposal to sewer (see Section 7.13).

7.23.6 Validation samples (including the use of vapour monitoring if adopted) should be taken at a minimum rate of 1 composite sample per 200m^3 of treated soil (with a minimum of 6 samples if the volume treated is less than 1,200m^3). Chemical analysis (and/or vapour monitoring) of these samples should be at a minimum of weekly intervals (although this frequency is highly dependent on the remediation technique adopted). Chemical analysis (and/or vapour monitoring) will enable determination of the average concentration of each contaminant of concern and must be used to demonstrate successful remediation before material is reused.

7.23.7 A windrow/stockpile will be deemed to have been successfully treated once two consecutive sampling rounds yield mean concentrations of all the contaminants of concern below agreed clean-up criteria (see Section 3 and Appendix C).

7.23.8 Treated soils should be placed in accordance with recommendations in the detail risk assessment as summarised in Section 3, with remediation depths also shown on Drawing 3043/15 (cross section of Areas A & B)

7.23.9 Retention and re-use of treated material on site must be undertaken in accordance with the principles of the CL:AIRE Code of Practice (v2, March 2011); i.e. the treated material must be suitable for use, at this site consideration must be given the suitability in respect f controlled waters and human health.

7.23.10 Once a decision on how the hydrocarbon contamination will be dealt with has been made (i.e. stabilisation/bioremediation or landfill), this should be set out in the Contractor's Method Statement, a copy of which should be kept on site and made available for inspection by regulators should they request.

7.24 Export to landfill

7.24.1 Excavation arisings that are unsuitable for retention and re-use on site should be placed in temporary stockpiles on hardstand or polythene sheeting and be suitably covered to minimise the potential for dust/odour nuisance, and prevent surface water run-off.

7.24.2 Any material exported from site to landfill should be hauled by a registered waste carrier in accordance with the requirements of the Waste Regulations 2011 and the Landfill (England & Wales) Regulations 2002.

7.24.3 A transfer note should be completed, signed and retained by the parties involved. The transfer note should include the volume of waste, the nature of the material and a statement of its chemical composition, details of the source and destination sites, and details of the haulier.

7.24.4 In order to protect the general public from dust and vapour emissions, wagons that are to be used for the haulage of the contaminated material from the site must be sheeted. In addition, the Contractor must ensure that no fluids seep from the wagons.

7.24.5 In order to provide the landfill facility with information regarding chemical composition of the waste, further analysis of any material that requires removal from site may be required.

Waste classification

7.24.6 Characterisation of stockpiled materials generated during the site preparatory works will be required if off-site disposal is proposed.

7.24.7 It should be noted that the classification and assessment of waste soils under the Environment Agency's Technical Guidance WM3[1], is a complex process and this is different to classification under a Waste Acceptance Criteria (WAC) test required by landfills.

7.24.8 It is critical if material is to be exported from site that this is allocated an appropriate waste code, following the steps within WM3. It is highly likely that material on this site will fall under various waste codes (not all material will fit the description 17 05 Soils and Stones), furthermore it is likely that a percentage of made ground could be classified as hazardous. As such careful material segregation is essential.

7.24.9 Waste carriers transporting, and sites accepting, this material should have a corresponding code within their permits. It is the responsibility of those generating the waste (i.e. the developer), to ensure that the waste is handled and disposed of appropriately.

[1] Technical Guidance WM3 – Guidance on the classification and assessment of waste. Environment Agency 2015

7.24.10 With respect to **asbestos**, waste soils will be classed hazardous if the soil mass contains more than 0.1% asbestos fibres that are free and dispersed. However, WM3 states that where the waste contains identifiable pieces of asbestos (i.e. any particle of a size that can be identified as potentially being asbestos by a competent person if examined by the naked eye), then the waste is hazardous if the concentration of asbestos in the pieces alone is 0.1%. If a stockpile of soil contained rare fragments of broken asbestos-cement sheeting, the whole stockpile would be classed as hazardous unless all the fragments could be picked-out (even though the concentration of asbestos in the soil mass might be orders of magnitude less than 0.1%).

7.24.11 Some localised areas of **tarmac** hardstand is present in Area D.

7.24.12 This tarmac could be recycled and crushed to yield a 6F3 selected granular material, provided the recovered bitumen content is less than 10% (determined in accordance with BS598-1:2011). Crushed tarmac could also be blended with crushed concrete etc to generate 6F2 graded material. 6F2 can contain up to 50% recycled tarmac/asphalt (provided it does not pose a contamination risk to controlled waters and, if the proportion of asphalt is greater than 20%, the recovered bitumen content is less than 2%).

7.24.13 However, if off-site disposal is anticipated, tarmac assessment is based on the amount of coal tar present, this will vary depending on the age of the tarmac. The assessment is based on the amount of benzo(a)pyrene, and has a concertation limit of 50mg/kg.

7.25 Placement of soil cover

7.25.1 Lithos' SI Report (Ref. 3043/2D) recommended a 1,000mm clean cover due to the presence of significantly elevated metal concentrations (in excess of 5 times Tier 1 Screening Values) in nearly 20% of the c. 80 samples tested as part of the site investigation. The most notable contaminants are arsenic and lead.

7.25.2 Reduction of the clean cover thickness to **600mm** is now proposed providing the uppermost **400mm** of underlying made ground can be proven to be "cleaner", i.e. **not** to contain significantly elevated metal concentrations.

7.25.3 A cover thickness of 600mm is subject to:

- the application of appropriate soil screening values to the uppermost 400mm of underlying made ground (see Tables below); and
- a robust sampling & testing regime of made ground placed in the uppermost 400mm immediately below the marker barrier

Inorganic Screening Values for uppermost 400mm of made ground

Inorganic contaminant	Screening Value mg/kg	Comments/notes
As	185	5 times relevant Tier 1 Screening Values (as referenced in Lithos' SI Report 3043/2D).
Cd	130	
Cr	20,000	Assumes Cr is CrIII
Pb	1,000	5 times relevant Tier 1 Screening Values (as referenced in Lithos' SI Report 3043/2D).
Ni	545	
Se	2,170	
Hg	995	
Vn	410	
B	290	These are LQM S4UL Screening Values. They have been derived using the CLEA model on the assumption that risks to human health are the primary concern; i.e. phytotoxic properties are not a concern (especially for soils placed at >600mm depth). Any proposed planting of trees will require consideration of the need for a greater thickness of soil with much lower concentrations of boron, copper & zinc.
Cu	2,400	
Zn	3,700	
Asbestos	<0.002%	No visible ACM fragments. Occasional positive asbestos ID results are considered acceptable provided quantification analysis confirms only trace concentrations (i.e. <0.002%). In the context of the works proposed here, occasional is defined as less than 1 positive for each 15 samples tested, and no more than 2 adjacent plots to yield a positive ID.

Organic Screening Values for uppermost 400mm of made ground

Organic contaminant	Screening Value mg/kg	Comments/notes
Benzene	4	Derived using the CLEA model, assuming a residential with gardens end use, placement of 600mm 'clean' cover in gardens. The 600mm cover removes risks from all pathways other than inhalation.
Naphthalene	5	
Methylphenol (cresol)	65,800	
Phenol	2,870	
TPH aliphatic C5-6	420	Derived using the CLEA model, assuming a residential with gardens end use, placement of 600mm 'clean' cover in gardens. The 600mm cover removes risks from all pathways other than inhalation. With respect to TPH, only volatile fractions are included in the health assessment (C_5 to C_{12}).
TPH aliphatic C6-8	420	
TPH aliphatic C8-10	23	
TPH aliphatic C10-12	23	
TPH aromatic C5-7	156	
TPH aromatic C7-8	9	
TPH aromatic C8-10	5	
TPH aromatic C10-12	243	

7.25.4 The key contaminants of concern (arsenic and lead) cannot be seen. Therefore, testing of made ground placed in the uppermost 400mm of made ground, immediately below the marker barrier needs to be robust. The following regime is proposed.

7.25.5 This regime relates to Strata's Planning Layout (Drawing 18-CL2-SEGB-WE-01, Rev. J, dated 29th March 2023). Any revision of the layout may require update of the proposed sampling & testing regime.

a) At least one sample will be recovered from the rear gardens of Plots 1 to 180.

b) Each sample's label will include reference to the plot from which it was taken.

c) Each sample will be analysed for pH, metals, asbestos ID (with quantification if positive).

d) One in 5 samples will also be analysed for naphthalene, benzene, methylphenol (cresol), phenol and speciated TPH. It is expected that the remediation works outlined in Sections 7.11, 7.12 & 7.23 will already have dealt with hydrocarbon contamination. This testing is simply to provide increased confidence.

e) The uppermost 400mm of made ground will be deemed suitable for retention beneath the proposed 600mm clean soil cover, with basal marker barrier if all determinands yield results below the soil screening values in the Tables above.

7.25.6 In addition to the above, the Contractor might choose to test made ground that has been excavated and stockpiled in the belief that it will provide a source of suitably "clean" material, prior to placement in garden areas. Such testing should reduce the likelihood of placing, and then having to remove, unsuitable made ground. However, for the avoidance of doubt, such testing does not remove the need to test one sample from the rear gardens of Plots 1 to 180.

7.25.7 In the event that laboratory results for any sample indicate that one or more determinant concentrations exceed the screening values in the Tables above, then the following will be necessary:

a) Either remove the uppermost 400mm of made ground from the entire rear garden of concern and replace with imported clean soil or suitable, "cleaner", site-won made ground (subject to testing);

b) Or recover and test a further 10 samples from the uppermost 400mm of made ground from the rear garden of concern and analyse each sample for the determinants of concern. The made ground can be considered suitable if:

- 3 or fewer of the 10 samples yield any result(s) of concern, and
- The true mean of all determinants lie below the critical concentrations (i.e. the screening values in Table 1 & 2) as determined using the statistical analysis guidance outlined by CL:AIRE[2].

7.25.8 If this further testing indicates that the made ground is not suitable, then it will be necessary to remove the uppermost 400mm of made ground from the entire rear garden of concern and replace with imported, clean soils or suitable, "cleaner", site-won made ground (subject to testing).

7.25.9 In summary, clean inert soil will be placed over the made ground in proposed garden and landscaped areas (but not beneath hardstanding) comprising:

- **Garden areas**:
  - 225mm of topsoil, over
  - 375mm of "clean" subsoil, over
  - a high visibility contaminated ground warning / marker barrier, such as Lotrak Alarm18, over
  - a minimum 400mm thickness of "cleaner" made ground
- **POS areas:** a minimum 600mm of "clean" subsoil and topsoil, underlain by a high visibility contaminated ground warning / marker barrier.

7.25.10 Some natural subsoil suitable for use as cover material might be sourced on site by excavation of the uppermost 500mm or so of natural soils beneath made ground during earthworks. However, over dig into natural strata to source suitable subsoil is constrained both by the presence of shallow bedrock (predominantly sandstone), and a need to ensure made ground used as backfill to 'borrow pits' is either placed above 97mAOD or contains contaminant concentrations below the site-specific controlled waters screening value.

7.25.11 Soil cover (375mm subsoil & 225mm topsoil) would be best placed during the construction phase; i.e. it should be left in stockpile(s) on completion of the site preparatory works, subject to the Engineer's approval.

7.25.12 Material imported for use within the **600mm cover** should be validated in accordance with Lithos' **Protocol for Soil Importation**, copied in Appendix B. This Protocol includes chemical assessment criteria which should not be exceeded.

7.25.13 **Drawing 3043/20** provides a cross-section of the proposed soil cover and 'constraints' on the underlying made ground.

[2] *CL:AIRE, 2020.Professional Guidance: Comparing Soil Contamination Data with a Critical Concentration.*

7.26 Hazardous gas protection

7.26.1 As discussed in Section 2.2, Lithos issued a Gas Risk Assessment (Report No. 3043/5A) in July 2023. Conclusions were:

- **Area A:** Data is heavily influenced by organic contamination but methane was only recorded in one location, at concentrations well below the Amber 2 threshold of 5% and therefore **Amber 1** measures are considered appropriate.

  However, remediation targets assume the membrane placed in all plots within Area A (and above the former reservoir) will also be **hydrocarbon resistant**.
- **Areas B, C & D:** Amber 1 measures required.

7.26.2 Based on the site characterisation (Traffic Light) discussed in Report No. 3043/5A, the proposed foundation solutions, and with reference to the gas protection "scoring" system outlined in BS8485:2015+A1:2019, Lithos consider that the following protective measures should be incorporated in new dwellings:

<table>
<tr><th rowspan="3">Traffic light classificn and "score" req'd by BS8485#</th><th rowspan="3">Floor slab
(BS8485 "score")</th><th colspan="2">Protective measures</th></tr>
<tr><th rowspan="2">Sub-floor ventilation
(BS8485 "score")</th><th>Membrane</th></tr>
<tr><th>Type
(BS8485 "score")</th></tr>
<tr><td rowspan="1">Areas B, C & D
(Plots 1 to 79, 111 to 119 & 135 to 180)*

Amber 1

3.5</td>
<td rowspan="2">Select one from:
i. Block & Beam – (0).
ii. Reinforced ground bearing slab – (0.5).
iii. Reinforced, cast in-situ suspended slab (with minimal and suitably sealed service penetrations & joints) – (1.5).
iv. Reinforced ground bearing raft (with limited service penetrations cast into slab). Note: the venting area through any downstand beam should be 3 times greater than that provided by the side ventilation (air bricks) – (1.5).</td>
<td rowspan="2">Select one from:
Passive sub-floor ventilation; venting layer could be:
i. A min. 150mm clear void (2.5), or
ii. A proprietary void former providing an equivalent clear void depth of 60mm; see Section B7 in BS8485 (2.5), or
iii. Min. 300mm thick blanket of min. 20mm single size gravel (1.0).

Min. ventilation = 1,500 mm^2/m run of external wall (via air bricks on each of 2 opposite sides), with 100mm pipes at 1.75m centres or honeycombing of any sub-floor sleeper walls.</td>
<td>Gas resistant membrane meeting all of the following criteria:
• sufficiently impervious to gases with a methane gas transmission rate <40.0 ml/day/m^2/atm (average) for sheet and joints (tested in accordance with BS ISO 15105-1 manometric method);
• sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions;
• sufficiently strong to withstand in-service stresses (e.g. settlement if placed below a floor slab);
• sufficiently strong to withstand the installation process and following trades until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, dropping tools, etc);
• capable, after installation, of providing a complete barrier to the entry of the relevant gas; and
• a minimum 0.4 mm thickness (1600g polyethylene) reinforced membrane (virgin polymer
• verified in accordance with CIRIA C735∞
(2.0)</td></tr>
<tr><td>Area A & former reservoir
(Plots 80 to 110 & 120 to 134)*

Amber 1

3.5</td>
<td>Hydrocarbon resistant membrane meeting
• all of the criteria specified for Amber 1 (above)
• including additional protection against organic hydrocarbon vapours
Advice should be sought from membrane manufacturer based on SI data (2.0)</td></tr>
</table>

Footnotes:

* Based on Planning Layout 18-CL2-SEGB-WE-01 Rev J, dated 29th March 2023

\# Scores are broadly based on those outlined in BS8485:2015+A1:2019 (for Characteristic Situations 2 & 3, and Building Type A).

∞ In accordance with CIRIA C735, a Verification Plan should be prepared which outlines the activities (inspection and testing), the relevant personnel, and the type of records to be collected. Gas membranes need to be visually inspected to establish possible damage. Whilst conflicts of interest in verification should be avoided, the Developer's staff on site could undertake inspection & verification on Amber 1 sites. In all circumstances, the verifier should be competent, experienced and suitably trained.

Note NHBC guidance only requires membranes to be fitted by a specialist contractor, and be fully certified, on Amber 2 sites. However, BS8485 is considered to 'outrank' NHBC guidance, and it would be prudent to comply with this Standard and CIRIA C735. Furthermore, (YALPAG) local authorities have issued guidance requiring a detailed verification method statement in advance of the construction phase. This should address how gas measures will be installed and what verification information will be provided to demonstrate that installation has been carried out in accordance with the appropriate guidance.

1. A combination of two or more of the three types of protection measures (slab, ventilation & membrane) should be used to achieve the BS8485 score.
2. The membrane should always be lapped and sealed in accordance with BRE\Environment Agency Report BR 414 (2001) – "*Protective Measures for housing on gas-contaminated land*". The membrane should be **continuous** across internal walls & the cavity, and there should be a **cavity tray** in external walls.
3. In all cases there should be minimum penetration of floor slab by **services**; any penetrations should be suitably sealed.
4. Integral **garages** with occupied rooms above, or direct access through a doorway from the garage to the house, should be provided with the same protective measures as the rest of the dwelling. Buildings with basement car parks (with ventilation in accordance with Building Regulations) may not require gas resistant membranes.

APPENDIX A
DRAWINGS

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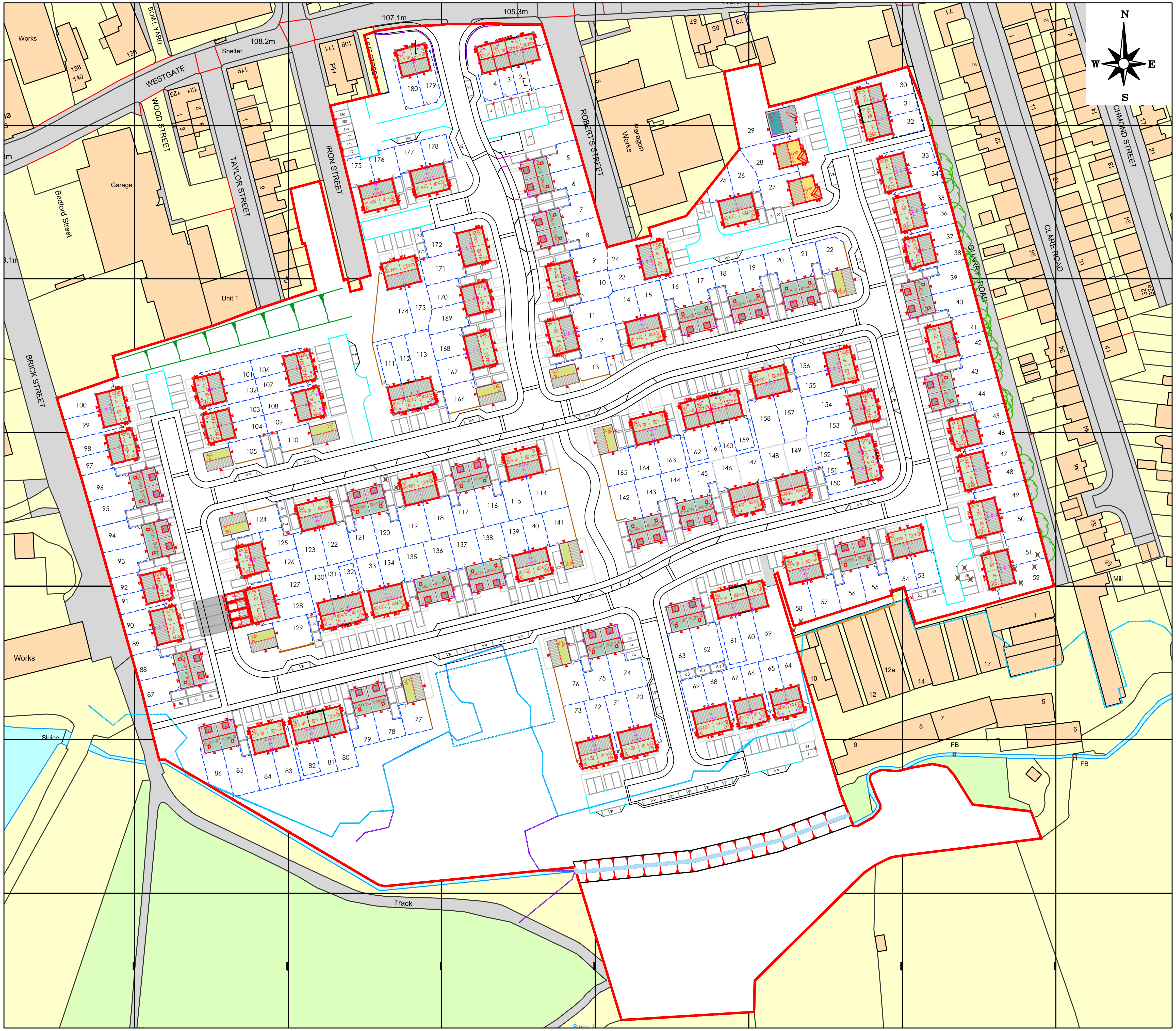
CLIENT	JOB TITLE	DRAWING TITLE	DRAWN	DATE
STRATA	WESTGATE, CLECKHEATON	SITE LOCATION PLAN	GLM	23/11/2020
			CHECKED: ASw	DATE: 23/11/2020

STATUS: FOR COMMENT ☐ FOR APPROVAL ☐ DRAFT ☐ FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
1:25,000	A4	3043/1	



NOTES

APPROXIMATE SITE BOUNDARY

REPRODUCED FROM STRATA HOMES' DRAWING 18-CL2-SEGB-WE-01 REV J, DATED 29 03 2023

REV.	DESCRIPTION	DATE
C	UPDATED WITH NEW CLIENT LAYOUT	26/07/23
B	UPDATED WITH NEW CLIENT LAYOUT	05/05/21
A	UPDATED WITH NEW CLIENT LAYOUT	23/02/21

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CLIENT

STRATA

JOB TITLE

WESTGATE, CLECKHEATON

DRAWING TITLE

PROPOSED SITE LAYOUT

DRAWN	DATE	STATUS
GLM	23/11/2020	FOR COMMENT ☐ FOR APPROVAL ☐
CHECKED	DATE	DRAFT ☐
REG	23/11/2020	FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
1:1,250	A3	3043/2	

Only PDF/ DWF Issues of this drawing are controlled. All other formats (eg. DWG AutoCAD FILES) are UN-controlled and are used at your own risk.

GENERAL NOTES

1. DO NOT USE THIS DRAWING IN ISOLATION. THIS DRAWING HAS BEEN PREPARED AS PART OF A SET AND MUST BE READ IN CONJUNCTION WITH ALL OTHER DRAWINGS. ANY DISCREPANCIES MUST BE REPORTED TO THE ENGINEER PRIOR TO THE COMMENCEMENT OF WORKS
2. MODELLING SHALL BE CHECKED AGAINST THE REMEDIATION STRATEGY
3. MODELS HAVE BEEN PRODUCED USING INFORMATION AVAILABLE AT THE TIME.
4. CUT AND FILL VOLUMES ADVISED ARE FOR GUIDANCE PURPOSES ONLY. THE GROUNDWORKS CONTRACTOR IS EXPECTED TO UNDERTAKE HIS OWN COMPUTATION OF MATERIAL FROM THE INFORMATION PROVIDED. ANY SIGNIFICANT DEVIATION BETWEEN THE QUANTITY OF MATERIAL RECOMMENDED AND THAT CALCULATED BY THE CONTRACTOR, IS TO BE QUALIFIED IN HIS TENDER QUOTATION.
5. ALL EARTHWORKS SHALL BE IN ACCORDANCE WITH THE ACCOMPANYING SPECIFICATION
6. THE CONTRACTOR IS EXPECTED TO CHECK ALL QUANTITIES AND REPORT ANY DIVINATION
7. THE CONTRACTOR IS EXPECTED TO PREPARE APPROPRIATE CONSTRUCTION METHOD STATEMENTS FOR ASPECTS OF APPOINTED WORKS. THIS SHOULD INCLUDE ANY TEMPORARY PROTECTION OR WORKS
8. STOCKPILE LOCATIONS ARE TO BE AGREED WITH DEVELOPER / ENGINEER
9. REFER TO DRAWING QD1776-070-02 FOR PLATFORM LEVELS
10. TOPOGRAPHICAL SURVEY CONTOURS REPRESENT EXISTING SITE LEVELS EXCLUDING EXISTING STOCKPILES

SITE CLEARANCE

1. SITE CLEARANCE MODEL HAS BEEN GENERATED BY REDUCING THE TOPOGRAPHIC SURVEY BASED ON THE ALLOWANCES SHOWN IN FIGURE A
2. ITS IS ASSUMED THAT MATERIAL GENERATED FROM HARD STANDING AND BUILDING SLABS WILL BE SUITABLE FOR SORTING/CRUSHING TO BE RE-USED AS 6F2 OR 6F3.
3. IT IS EXPECTED THAT A PORTION OF GENERAL CLEARANCE MATERIAL WILL NEED TO BE EXPORTED FROM SITE - SUBJECT TO TESTING
4. THE RESULTS OF THE SITE CLEARANCE EXCLUDE POSSIBLE BURIED OBSTRUCTIONS AND BUILDING FOUNDATIONS
5. AS DETAILED IN THE REMEDIATION STRATEGY THE CONTRACTOR MUST NOT MOVE GROSSLY CONTAMINATED MATERIAL FROM AREA A TO OTHER PARTS OF THE DEVELOPMENT THIS MATERIAL MUST BE ISOLATED
6. RESULTS PROVIDED ARE SUBJECT TO CONFIRMATION OF ARISING TREATMENT PROCESSES

POST REMEDIATION LEVELS

1. AN AVERAGE GROUND PROFILE HAS BEEN SET APPROXIMATELY 300mm BELOW SITE CLEARANCE LEVEL
2. THESE LEVELS PROVIDE A POST REMEDIATION PROFILE WHICH IS TO BE FORMED PRIOR TO THE PLACEMENT OF CLEAN CAPPING FORMING THE DEVELOPMENT FINISHED LEVELS
3. POST REMEDIATION LEVEL IS TO BE REVIEWED UPON COMPLETION OF REMEDIATION STRATEGY AND UPON SITE TURN OVER

PLATFORM LEVELS

1. PLATFORM LEVELS HAVE BEEN SET 1150mm BELOW FINISHED PLOT AND GARDEN LEVELS AND 650mm BELOW FINISHED CARRIAGEWAY LEVEL
2. PROPOSAL IS FOR GUIDANCE UNTIL REMEDIATION STRATEGY AND POST REMEDIATION LEVELS ARE AGREED

Rev.	Date	Revision Details	Drawn	Checked
A	16.08.23	PLATFORM UPDATED TO CURRENT SITE LAYOUT AND LEVEL DESIGN	ND	ND

QUEENSBERRY DESIGN
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Client
STRATA HOMES

Project
WESTGATE
CLECKHEATON

Title
DEVELOPMENT PLATFORM

Drawn	Checked	Date
ND	AL	17.11.2021

Drawing Number: QD1776-70-03

Drawing Status	Scale	Rev.
INFORMATION	1:500 - A1	A

NOTES

	EXISTING BUILDING
	CONCRETE HARDSTAND (FORMER BUILDING FOOTPRINT)
	EXTERNAL SURFACING (CONCRETE HARDSTAND/TARMAC/ ROUGH GROUND)

REV.	DESCRIPTION	DATE
A	UPDATE OF SITE FEATURES & CONDITION	23/11/2020

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CLIENT

STRATA

JOB TITLE

WESTGATE, CLECKHEATON

DRAWING TITLE

SITE FEATURES

DRAWN	DATE	STATUS
GLM	23/11/2020	FOR COMMENT ☐
		FOR APPROVAL ☐
CHECKED	DATE	DRAFT ☐
ASw	23/11/2020	FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
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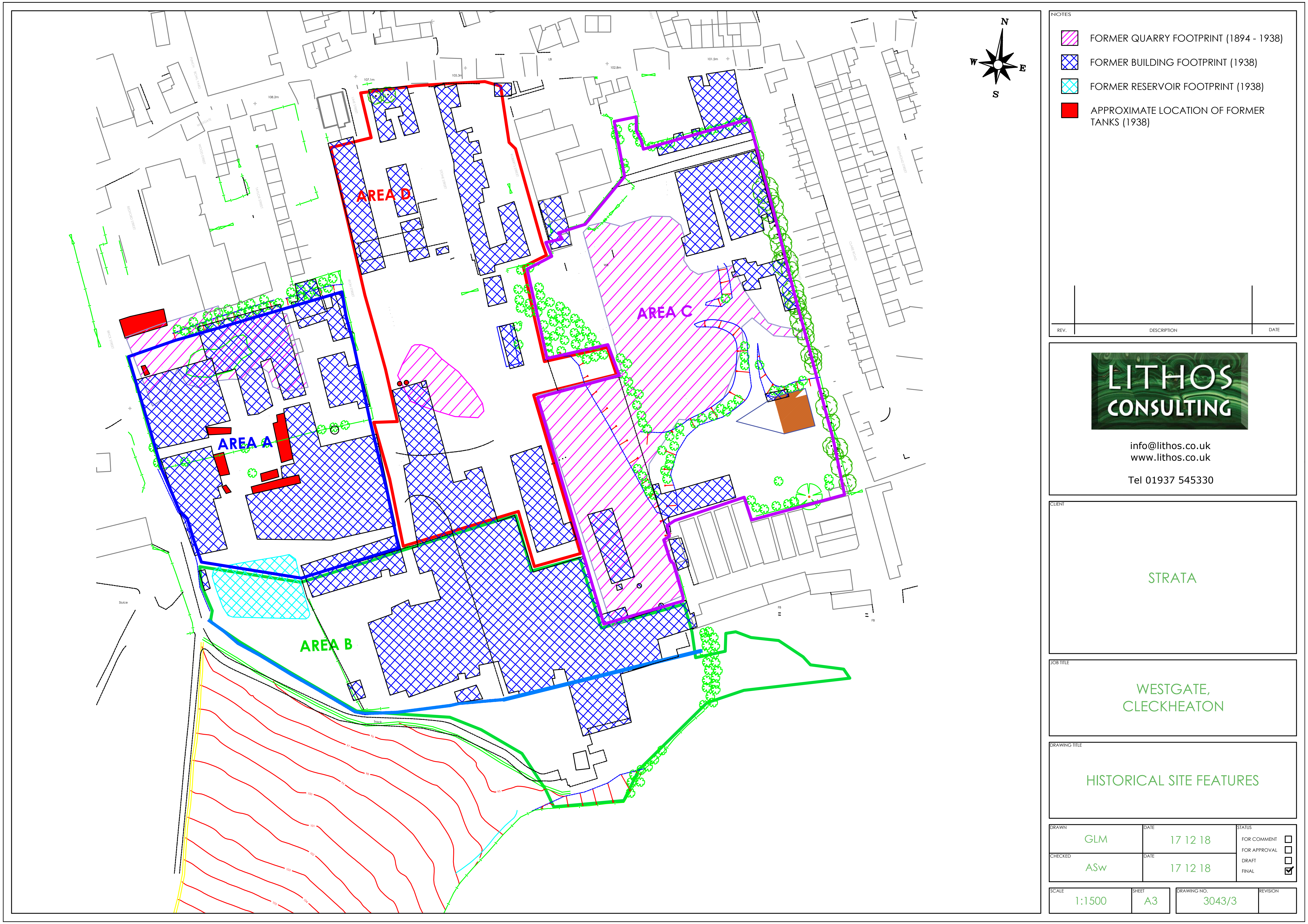
AREA A
AREA B
AREA C
AREA D
N
S
E
W
NOTES
FORMER QUARRY FOOTPRINT (1894 - 1938)
FORMER BUILDING FOOTPRINT (1938)
FORMER RESERVOIR FOOTPRINT (1938)
APPROXIMATE LOCATION OF FORMER TANKS (1938)
REV.
DESCRIPTION
DATE
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CLIENT
STRATA
JOB TITLE
WESTGATE, CLECKHEATON
DRAWING TITLE
HISTORICAL SITE FEATURES
DRAWN
GLM
DATE
17 12 18
CHECKED
ASw
DATE
17 12 18
STATUS
FOR COMMENT
FOR APPROVAL
DRAFT
FINAL
SCALE
1:1500
SHEET
A3
DRAWING NO.
3043/3
REVISION

NOTES

AIG INVESTIGATION (APRIL 2001)

- TRIAL PIT LOCATION (TPs 01 TO 33)
- BOREHOLE LOCATION (BHs 01 TO 05)
- PROBEHOLE LOCATION (PHs 01 TO 05)
- WINDOW SAMPLE LOCATION (WSs 01 TO 20)

ROGERS INVESTIGATION (2009)

- TRIAL PIT LOCATION (TPs 01 TO 16)
- BOREHOLE LOCATION (SAs 01 TO 03)
- PROBEHOLE LOCATION (RTs 01 TO 03)
- WINDOW SAMPLE LOCATION (WSs 01 TO 10)

ENCIA INVESTIGATION (2004)

- TRIAL PIT LOCATION (TPs 201 TO 215)
- PROBEHOLE LOCATION (PH 6 TO 13 & 8S)
- APPROXIMATE SITE BOUNDARY

REV.	DESCRIPTION	DATE

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CLIENT

M KIENLEN ESQ

JOB TITLE

WESTGATE, CLECKHEATON

DRAWING TITLE

THIRD PARTY EXPLORATORY HOLE LOCATIONS

DRAWN	DATE	STATUS
ASw	17 12 18	FOR COMMENT ☐
		FOR APPROVAL ☐
CHECKED	DATE	DRAFT ☐
REG	17 12 18	FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
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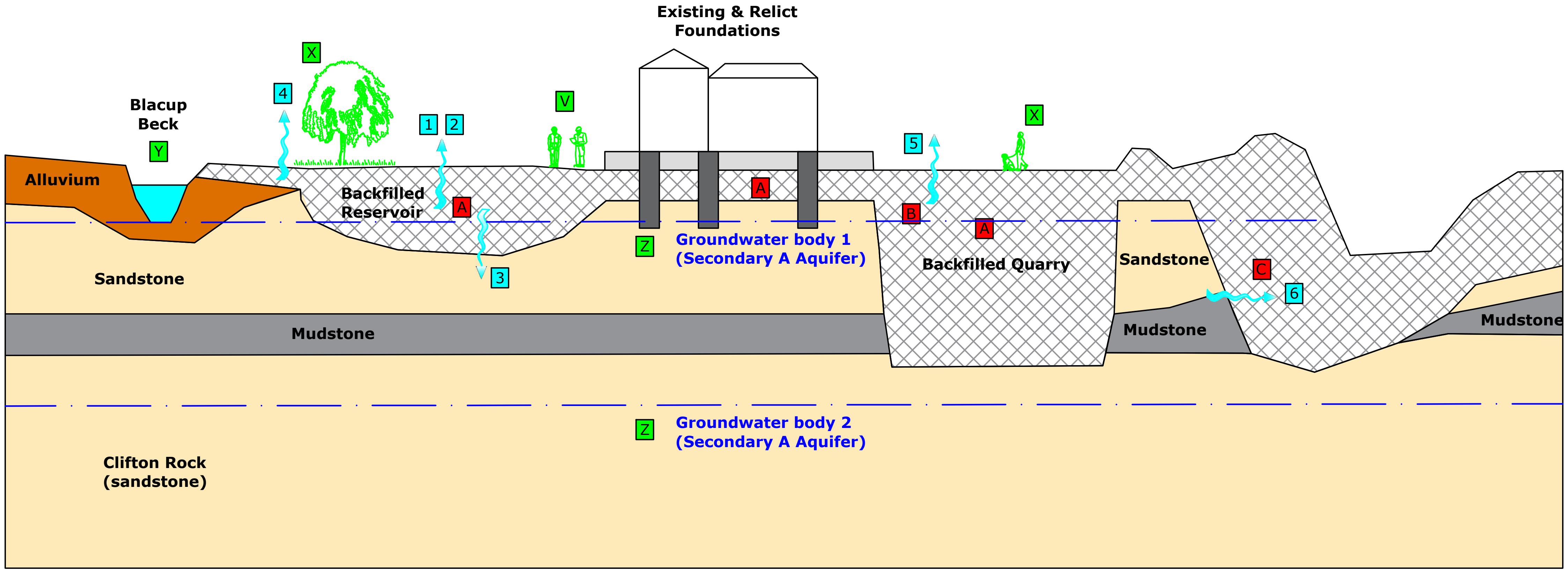

SOURCES	
A	MADE GROUND (ABESTOS & HEAVY METALS)
B	MADE GROUND (HYDROCARBONS)
C	DEEP MADE GROUND (HAZARDOUS GAS)

PATHWAYS	
1	DERMAL CONTACT
2	INGESTION/INHALATION
3	LEACHING OF CONTAMINANTS
4	UPTAKE BY PLANTS
5	VOLATILISATION
6	MIGRATION OF GAS

RECEPTORS	
X	END USERS (RESIDENTS)
Y	SURFACE WATERS
Z	GROUNDWATER
W	WORKERS
V	VEGETATION

NOTES

REV.	DESCRIPTION	DATE
A	REVISION OF SITE GEOLOGY & GROUNDWATER BODIES	17/12/2020

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CLIENT
STRATA

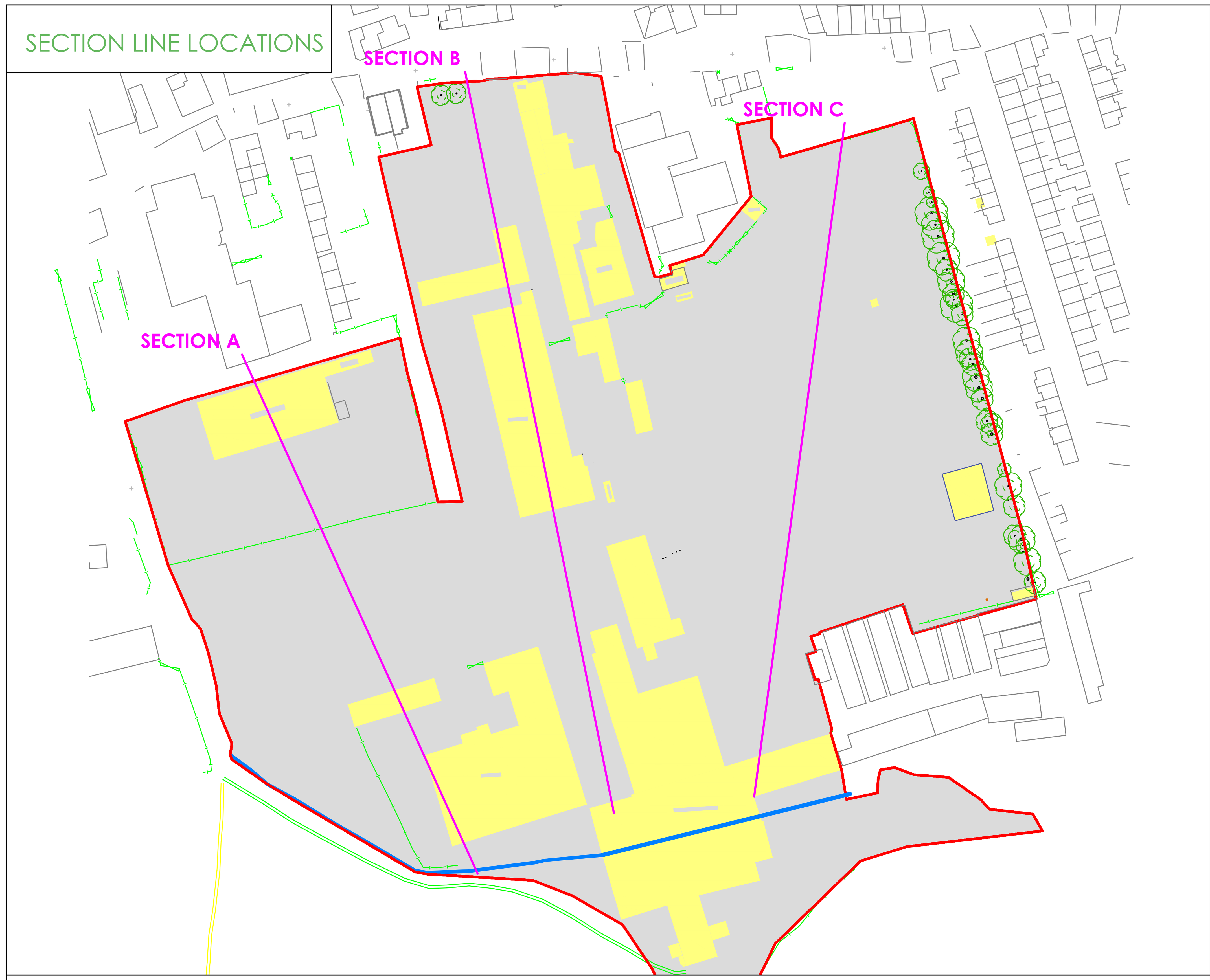
JOB TITLE
WESTGATE, CLECKHEATON

DRAWING TITLE
REVISED CONCEPTUAL SITE MODEL

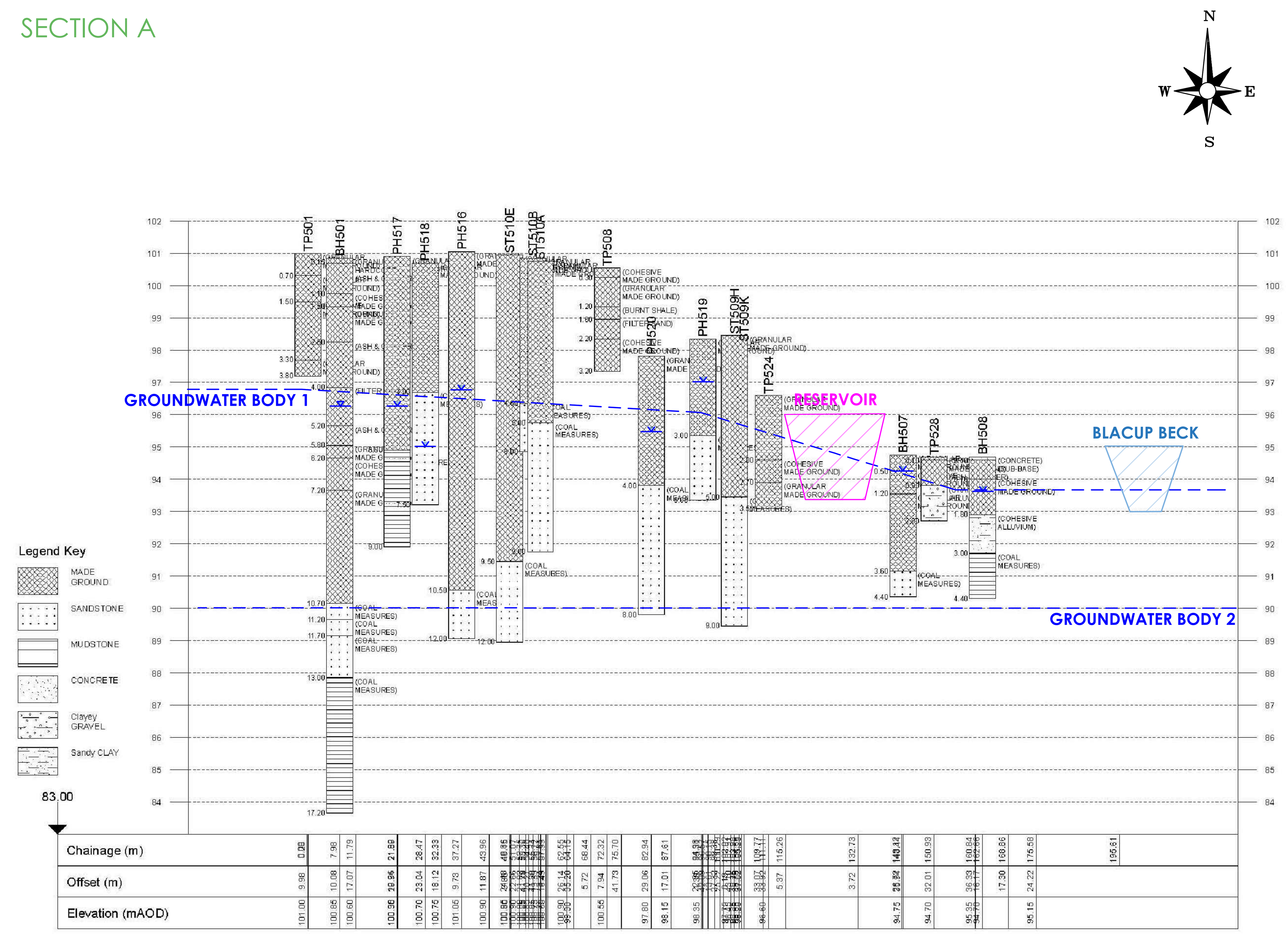
DRAWN	DATE	STATUS
GLM	17/12/2020	FOR COMMENT ☐ FOR APPROVAL ☐
CHECKED	DATE	DRAFT ☐
ASw	17/12/2020	FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
Not to scale	A3	3043/9	A

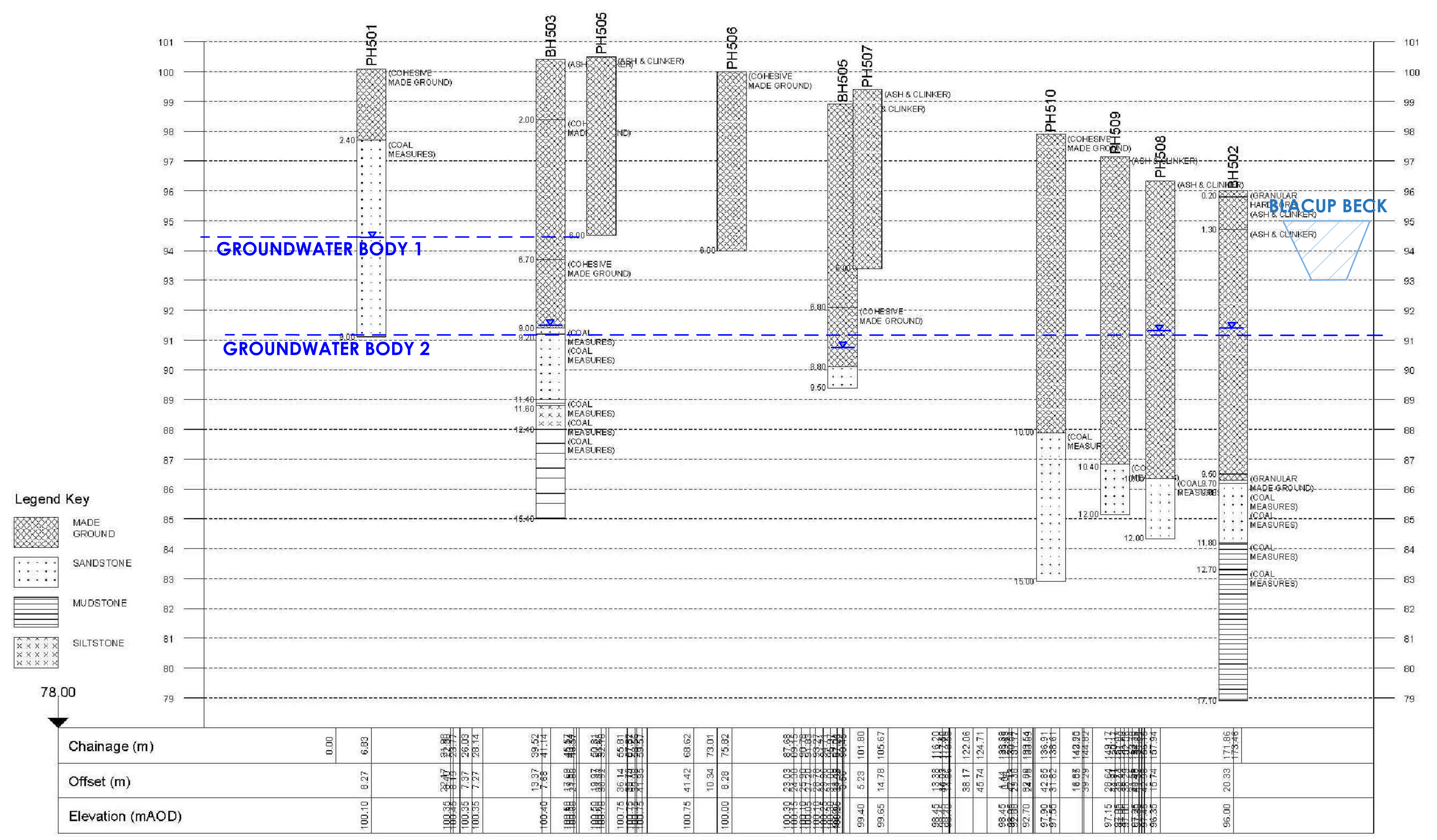
SECTION LINE LOCATIONS



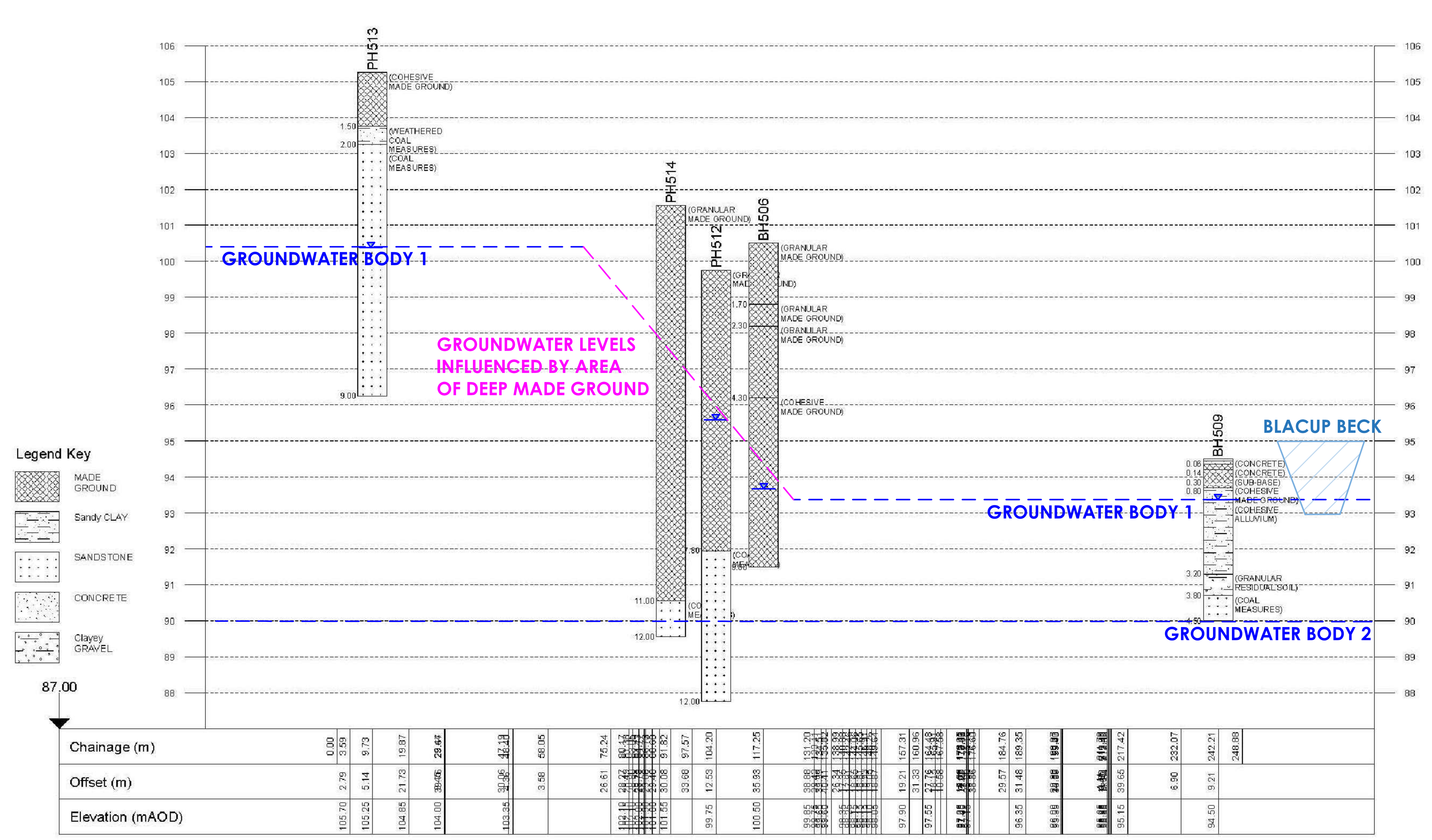
SECTION A



SECTION C



SECTION B



NOTES

- LINE OF CROSS SECTION
- APPROXIMATE SITE BOUNDARY
- GROUNDWATER LEVEL FROM MONITORING WELL DIPS
- GROUNDWATER LEVEL
- BACKFILLED RESERVOIR
- SUFACE WATERCOURSE

REV.	DESCRIPTION	DATE

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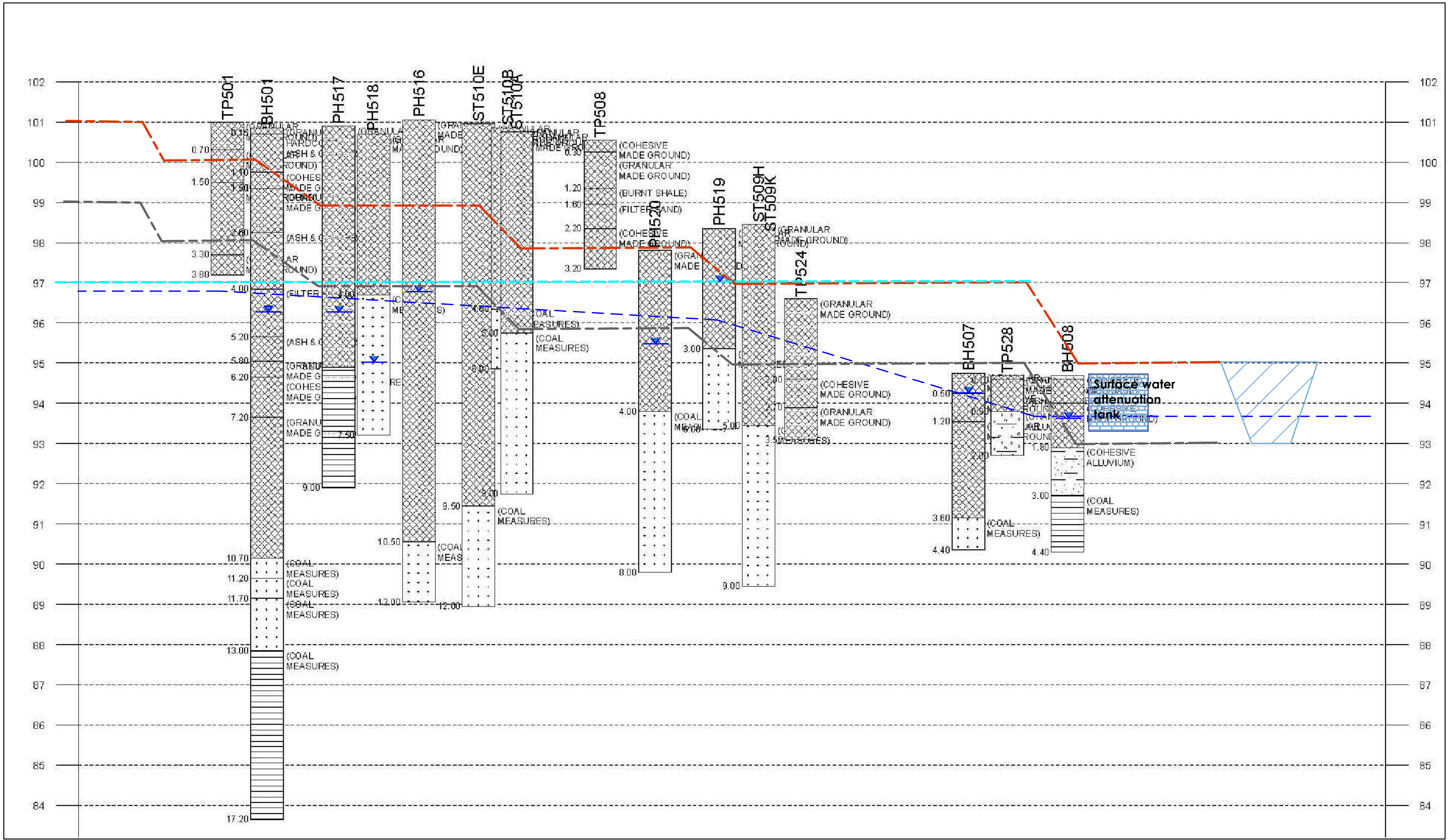
CLIENT: STRATA

JOB TITLE: WESTGATE, CLECKHEATON

DRAWING TITLE: HYDROGEOLOGICAL CROSS SECTIONS

DRAWN	DATE	STATUS
GLM	17/12/2020	FOR COMMENT ☐ FOR APPROVAL ☐ DRAFT ☐
CHECKED	DATE	
ASw	17/12/2020	FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
NOT TO SCALE	A1	3043/14	



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CLIENT	JOB TITLE	DRAWING TITLE
STRATA	WESTGATE, CLECKHEATON	REMEDIATION LEVELS AREAS A & B

NOTES

- Finished floor levels
- Material placed below this depth must meet waters target levels
- Material placed above this depth must meet health target levels

REV.	DESCRIPTION	DATE

STATUS: FOR COMMENT ☐ FOR APPROVAL ☐ DRAFT ☐ FINAL ☑

DRAWN	LH	DATE	23/03/21
APPROVED	REG	DATE	24/03/21
SCALE	As shown on drawing	SHEET	A3
DRAWING NO.	3043/I 5	REVISION	

APPENDIX B

LITHOS PROTOCOL FOR IMPORTATION & USE OF SOIL COVER (CAPPING)

1 INTRODUCTION

1.1 Isolation of made ground in garden and landscaped areas beneath a cover of "clean" subsoil, and topsoil is often recommended on residential developments; most notably when the made ground contains inorganic (and non-volatile organic) contaminants at concentrations above guidance threshold values. A cover solution is not appropriate for volatile or semi-volatile organic contaminants (fuels, solvents etc); removal or treatment will usually be required.

1.2 The thickness of cover is dependent on the nature and degree of contamination (and sometimes the Local Authority whose area the site lies within), but typically between 600mm and 1,000mm is required. Where contamination is more significant a granular hard-dig layer or geotextile marker membrane may also be required at the base of the cover.

1.3 If the made ground is essentially "clean", but contains materials generally considered undesirable as near-surface material in garden areas (e.g. oversize materials such as construction/demolition rubble) then, in accordance with NHBC Standards Chapter 9.2, a 300mm thick soil cover should be adequate. If the made ground is essentially "clean" and comprises reworked natural soil, the only cover likely to be required is topsoil.

1.4 The "clean" soil cover blocks potential linkages between the contaminated made ground and future residents. Soil cover is not required beneath drives, garages or houses.

1.5 The **CML initiative**, which came into force on 1st April 2003, requires housebuilders to submit to NHBC (or other warranty provider) a validation report confirming the thickness and quality (i.e. contaminant-free) of the placed soil cover. Validation reports should normally be prepared by independent geoenvironmental consultants.

1.6 Failure to submit cover validation reports promptly will delay issue of the cover note by the warranty provider, which will subsequently delay the release of mortgage funds and hence legal completion; i.e. the financial implications are significant. Consequently, it is essential that cover validation is requested at least 2 weeks prior to the anticipated finalling date.

1.7 Soil cover is usually placed many weeks after completion of the preparatory/remediation works, and issue of the associated Verification Report, typically at a relatively late stage in the construction programme.

1.8 Prior to placement of soil cover, the appointed remediation contractor and/or groundworker should ensure that ground levels are low enough to accommodate the required cover thickness, taking account of any boundary issues, and without compromising the DPC and any sub-floor ventilation.

1.9 Ideally soil **quality** should be determined by sampling of the **source** at least 7 working days before importation to the development site. Samples could be obtained from stockpiles on site, which may on occasion comprise surplus natural ground development arisings. Soil samples could be obtained from gardens after placement, but this is not recommended.

1.10 Clearly, if soil cover is imported and placed before confirmation of its suitability, no guarantee can be given that validation work will yield the desired results. It may therefore be necessary to excavate and export the placed soil cover and/or import further "clean" soil.

1.11 Where soils have been tested at source and temporarily stockpiled on site, stockpiles should be fenced-off and marked as containing certified topsoil/subsoil. The soil should be inspected prior to placement to confirm that it is the same material as previously tested, and that it has not been cross-contaminated with miscellaneous arisings generated during the construction works.

1.12 Soil **thickness** can only be checked after placement; this should be done before turfing / landscaping, but ideally after scaffolding has been dismantled.

1.13 ***Sampling Frequency (to check Soil Quality):*** The number of samples tested will be dependent on the nature of the source, and the quantity of material to be imported. However, in accordance with current YALPAG (Yorkshire & Lincolnshire Pollution Advisory Group) guidance[1], the testing frequency should be as follows:

Nature of source	Number of samples (from any single source material)	
	Up to 1,000m³	Per additional 1,000m³
Greenfield	At least 3, with at least 1 sample per 250m³	2
Brownfield	At least 6, with at least 1 sample per 100m³	2
Crushed product	At least 3, with at least 1 sample per 500m³	2

1.14 On a typical development with gardens comprising a total area of $100m^2$ (front and rear), and a soil cover thickness of 600mm including 100mm topsoil, for a brownfield source this testing frequency equates to approximately one topsoil sample per ten plots and one subsoil sample per two plots. Given the requirement to test a minimum number of samples from any one source, the testing frequency effectively increases for sites with only a small number of plots.

1.15 **Inspection Frequency (to check Soil Thickness):** The number of inspection pits excavated to check cover thickness (and collect samples, if testing at source has not been undertaken), should be dependent on the number of plots associated with the given development. The following frequencies are recommended:

No. plots within development	Frequency of inspection pits	Remarks
1 to 5	1 pit per plot	e.g. for 3 plots, dig 3 inspection pits
6 to 20	1 pit per 2 plots	e.g. for 9 plots, dig 5 inspection pits
21 to 30	1 pit per 3 plots	e.g. for 23 plots, dig 8 inspection pits
≥ 30	1 pit per 4 plots	e.g. for 39 plots, dig 10 inspection pits

1.16 Photographs should be taken of each inspection pit to show:

- The thickness of cover material present
- The presence of any geotextile marker or granular hard-dig layer (if required)
- The position of each inspection pit in relation to the plot

1.17 **Soil Material Suitability**: Inspection pits should be excavated through the entire thickness of any proposed in-situ source material, or cover material (if inspection is post-placement). Stockpiles should be assessed from both the surface and by digging into the "core", to ensure the material is reasonably homogenous.

[1] *Verification Requirements for Cover Systems: Technical Guidance for Developers, Landowners & Consultants; Version 3.4, November 2017.*

1.18 The soil material should comply with the following requirements:

- Be clean and free of foreign debris, building waste materials, glass sharps, and contaminants
- Topsoil should not have a gravel content of greater than 30% by dry weight and should generally have a maximum stone size of 50mm in any one direction
- Subsoil should generally have a maximum stone size of 150mm in any one direction
- Not have been sourced from an area within 7m laterally, or 3m vertically, of Japanese Knotweed plants, and not contain any Japanese Knotweed fragments (rhizomes, leaves, stems etc)

1.19 **Laboratory Analysis:** Whether samples are taken at source, from stockpiles on site, or from gardens after placement, they should be forwarded to an analytical laboratory for testing in accordance with one of the Schedules detailed in Table 1.

1.20 Imported topsoil should be subject to such testing, unless it is being sourced from a reputable commercial supplier able to provide robust certification (certificate date less than 2 months prior to import date). In addition, some analysis in accordance with BS3882 may occasionally be appropriate.

Table 1 – Test schedule

Source	Test schedule
Greenfield & Manufactured topsoil	pH, total metals (Cu, Ni, Zn, Cr III, Cr VI, As, Hg, Se, Cd & Pb), water soluble boron. TOC & speciated PAH Asbestos ID
Brownfield & Soil transfer stations	pH, total metals (Cu, Ni, Zn, Cr III, Cr VI, As, Hg, Se, Cd & Pb), water soluble boron. TOC, Speciated PAH & banded TPH* Asbestos ID
Crushed product	pH, total metals (Cu, Ni, Zn, Cr III, Cr VI, As, Hg, Se, Cd & Pb), water soluble boron. TOC & Speciated PAH Asbestos ID

Note: The schedules detailed above have been prepared in accordance with the Secondary Model Procedures. This document states that analysis should be relevant to potential sources and not merely a set list of parameters applied to each site.

* The YALPAG guidance recommends speciated TPH (TPH CWG) analysis for brownfield sources, but this should not be necessary unless the banded TPH analysis fails the assessment criteria detailed in Table 2 below.

Where crushed product is used at least 600mm below finished garden level, only asbestos analysis will be required.

1.21 Additional determinands may be scheduled dependent on the history of the source site, although if this is considered necessary it may suggest the material is unlikely to be suitable for use as clean cover in gardens.

1.22 Chemical assessment (Tier 1) criteria for imported soils are provided in Table 2, these reflect exposure and toxicological amendments proposed within the C4SL report. Where no revised toxicological value has been published the former CLEA value has been adopted.

Table 2 - Chemical assessment criteria for imported soils

Contaminant	Source	Tier 1 assessment criteria (mg/kg)	Comments/notes
pH	CLEA		
As	C4SL	37	
Cd	C4SL	26	
Cr (III)	C4SL	3,000	
Cr (VI)	C4SL	21	
Pb	C4SL	200	
Ni	C4SL	127	Assessment of human health risk only.
Se	C4SL	434	
Hg	C4SL	199	Assumes mercury present as an inorganic compound (cf elemental metal or within organic compound). See Science Report SC050021/Mercury SGV.
B	Lithos	5	Based on phytotoxic risks as plants are the more sensitive receptor (Cu is pH dependent).
Cu	DoE	80 to 200	
Zn	DoE	200	
Benzo(a)pyrene	C4SL	5	
Naphthalene	C4SL	12	
GRO	C4SL	45	Conservative value based on value for aromatic fraction C7 to C8 range, but assuming indoor inhalation pathway still relevant (it shouldn't be).
DRO	C4SL	219	Conservative value based on value for aliphatic fraction C10 to C12 range, but assuming indoor inhalation pathway still relevant (it shouldn't be).
LRO	C4SL	1,000	Calculated value above hazardous waste screen in WM3, there 1,000mg/kg adopted. This may be reviewed on a site specific basis depending on the source and nature of transfer.

2 VALIDATION REPORTS

2.1 The analytical testing will usually be undertaken on a 3 or 5-day turnaround and the Client/Contractor will be notified of the soil's suitability (or otherwise) immediately after receipt of the results.

2.2 Interim plot validation certificates should be issued to warranty providers on a plot by plot (or block by block) basis as development proceeds. Once the full development has been completed these should be pulled together into a final verification report, for submission to the Local Authority to satisfy planning conditions.

APPENDIX C

LITHOS TIER 1 VALUES

Soil screening values used by Lithos

In March 2002 DEFRA and the Environment Agency published a series of technical papers (R&D Publications CLR 7, 8, 9 and 10) outlining the UK approach to the assessment of risk to human health from land contamination. In 2008 CLR 7, 9 and 10 and all corresponding SGV and Tox reports were withdrawn and superseded by new guidance including:

- Guidance on Comparing Soil Contamination Data with a Critical Concentration - CL:AIRE and CIEH, May 2008
- Evaluation of models for predicting plant uptake of chemicals from soil - Science Report – SC050021/SR
- Human health toxicological assessment of contaminants in soil - Science Report: SC050021/SR2
- Updated technical background to the CLEA model - Science Report: SC050021/SR3
- CLEA Software Handbook (Version 1.071), Science report: SC050021/SR4
- Compilation of data for priority organic pollutants for derivation of Soil Guideline Values - Science Report: SC050021/SR7

The approach set out in these documents represents current scientific knowledge and thinking; and includes the Contaminated Land Exposure Model (CLEAv1.06). The Environment Agency are in the process of using this updated approach to regenerate a selection of Soil Guideline Values (SGVs).

CLEA SGVs were derived for standard land use scenarios predominantly in the context of Part IIA, using a conceptual site model (CSM) defined in SR3. Lithos have incorporated amendments to the CSM used to derive SGVs, that more accurately reflect redevelopment within the planning regime; consequently, Lithos have not adopted any published SGV as a screening value.

The CLEA conceptual site model assumes a source located in a sandy loam, with 6% soil organic matter (SOM) - equivalent to 3.5% total organic carbon (TOC). However, where the average TOC value for a particular soil type is significantly lower than the 3.5%, evaluation of Lithos Screening Values should be undertaken and a site specific risk assessment will usually be required. Other CLEA default characteristics adopted by Lithos are:

Sandy Loam characteristics (source)	Default values adopted
Total porosity (fraction)	0.53
Water filled porosity (fraction)	0.33
Air filled porosity (fraction)	0.2

Lithos have derived Screening Values for four different CSMs (scenarios); these are:

A - Residential with gardens, but no cover (or only up to 300mm)

B - Residential with gardens and 600mm 'clean' cover

C - Residential apartments with landscaping (i.e. no home grown produce)

D - Commercial/industrial with landscaping

E – Importation of soil cover

The **exposure** pathways considered for each scenario are detailed in the table below.

Scenario	Land use	Pathways	Justification
A	Residential with garden, but no cover (or only up to 300mm)	• Direct ingestion of soil • Dermal contact • Consumption of vegetables & soil attached to vegetables • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	Minimal cover – insufficient to break any pathways therefore all exposure pathways are relevant.
B	Residential with garden minimum 600mm cover	• Inhalation of indoor vapours • Inhalation of outdoor vapours	The 600mm cover removes the risk from all pathways other than inhalation.
C	Residential apartments with landscaped areas and minimum 300mm cover	• Direct ingestion of soil • Dermal contact • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	All pathways applicable due to possible exposure from landscaped areas. However consumption of home grown produce not included as unlikely to be grown in landscaped areas. Where vegetables are to be grown site specific QRA may be required.
D	Commercial/ industrial with landscaped areas no cover	• Direct ingestion of soil • Dermal contact • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	All pathways applicable due to possible exposure from landscaped areas. Assumed the commercial development consists of offices to provide a conservative assessment.
E	Importation of soil for cover in garden and landscaped areas	• Direct ingestion of soil • Dermal contact • Consumption of vegetables & soil attached to vegetables • Inhalation of outdoor vapours and dust	Material used as cover to break existing pathways therefore all direct and indirect pathways relevant; however cover is **not** placed below plots therefore indoor inhalation is not relevant.

Lithos have assumed the source of contamination is directly below the building foundations; i.e. a depth to source of 0.15m as opposed to the CLEA default of 0.65m. This assumption provides for a more conservative approach than the UK default. This adjustment has been included to account for sites where made ground is re-engineered to enable new buildings to be established on raft foundations. In such situations contamination may lie directly beneath the foundation.

The Soil Screening Values referred to in this document are **not** intended to be used when considering potential risks associated with:

- Existing land uses in the context of Part IIA of the Environment Protection Act 1990;
- End uses such as allotments, sports fields, children's playgrounds, care homes, hospitals etc; and
- Controlled waters

In December 2013 Defra published the results of research project SP1010 – Development of Category 4 Screening Levels (C4SLs) for Assessment of Land Affected by Contamination. The objective of this project was provide technical guidance in support of Defra's revised Statutory Guidance for Part 2A of the Environmental Protection Act 1990 (Part 2A). The revised Statutory Guidance, published in April 2012, introduced a new four-category system for classifying land under Part 2A where Category 1 includes land where the level of risk is clearly unacceptable, and Category 4 includes land where the level of risk posed is acceptably low. Project SP1010 aimed to deliver:

- A methodology for deriving C4SLs for four generic land-uses comprising residential, commercial, allotments and public open space; and
- Demonstration of the methodology, via derivation of C4SLs for 6 substances – arsenic, cadmium, chromium IV, lead, benzene & benzo(a)pyrene.

The methodology for deriving both the previous Soil Guideline Values and the new Category 4 Screening Levels is based on the Environment Agency's Contaminated Land Exposure Assessment (CLEA) methodology. Development of C4SLs has been achieved by modifying the toxicological and\or exposure parameters used within CLEA (while maintaining current exposure parameters).

The Part 2A Statutory Guidance was developed on the basis that C4SLs could be used under the planning regime. However, policy responsibility for the National Planning Policy Framework falls to the Department for Communities and Local Government. Defra anticipate that, where they exist, C4SLs will be used as generic screening criteria, and Lithos consider C4SLs to be suitable for use as Tier 1 Screening Values. Lithos have discussed this matter with both NHBC and YALPAG (collection of Yorkshire & Lincolnshire local authorities) and received confirmation that they are satisfied with this approach.

With respect to **inorganic** determinands, Lithos derived Tier 1 values for the five Scenarios A to E are presented below:

Inorganic contaminant	Tier 1 assessment criteria (mg/kg) for Scenarios A to E							Comments/notes
	SGV*	C4SL*	A	B	C	D	E	
As	32	37	37	Use (A) in SI Report for initial "screen" If >5 x A, then consider increase of cover to 1,000mm	40	640	37	C4SL adopted
Cd	10	26	26		149	410	26	C4SL adopted
Cr			3,000		3,000	30,000	3,000	Assumes Cr is CrIII
Pb	450	200	200		310	2,330	200	C4SL adopted
Ni	130		127		127	1,700	127	Assessment of health risk only
Se	350		350		595	13,000	434	
Hg	170		169		238	3,640	199	Assumes in an inorganic compound
B			5		5	5	5	Based on phytotoxic risks as plants are the more sensitive receptor (Cu is pH dependant)
Cu			80-200		80-200	80-200	80-200	
Zn			200		200	200	200	

With respect to **organic** determinands, Lithos derived Tier 1 values for the five Scenarios A to E are presented below:

Organic contaminant (all sourced via CLEA)	Tier 1 assessment criteria (mg/kg) for Scenarios A to E							Comments/notes
	SGV*	C4SL*	A	B	C	D	E	
Benzene	0.33	0.87	0.9	0.9	3.3	98	N/A	C4SL adopted
Toluene	610		600	3,000	2,700	5,000	N/A	Calculated value over 10,000
Ethyl Benzene	350		350	932	843	5,000	N/A	
Xylenes	240		246	327	321	5,000	N/A	
Phenol	420		412	2,400	519	5,000	N/A	
PCBs			2	8	2	38	N/A	Based on toxicity of EC7
Benzo(a)pyrene		5	5	25	5.3	76	5	C4SL adopted. Where source is not a coal tar
Naphthalene			8	9	9	1,000	12	
Gasoline Range Organics			30	34	34	5,000	45	See 3-step assessment of TPH below
Diesel Range Organics			151	156	154	5,000	219	
Lubricating Range Org			1,000	5,000	2,000	5,000	1,000	

* *For a residential end use*

The significance of PAHs can be determined by considering indicator compounds. In most cases benzo(a)pyrene (BaP) is adopted as an indicator due to the amount of toxicological data available and has been used by various authoritative bodies to assess the carcinogenic risk of PAHs in food. A surrogate marker approach can be used to estimate the toxicity of a mixture of PAHs in soil using toxicity data for individual indicator compounds within that mixture. Exposure to the surrogate marker is assumed to represent exposure to all PAHs in that matrix. The surrogate marker approach relies on a number of assumptions:

- Surrogate marker (bap) must be present in all soil samples
- Profile of the different PAH relative to bap should be similar in all samples
- PAH profile in the soil samples should be similar to that used in the pivotal toxicity study[1]

To assess the PAH profile in a soil sample, the ratio of the seven genotoxic PAHs (benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene and indeno[1,2,3-c,d]pyrene), relative to BaP, should be calculated. The ratio relative to BaP should lie within an order of magnitude above and below the mean ratio to BaP.

Naphthalene should also be considered separately against its generic screen. Whilst classed as a PAH, naphthalene is more volatile and mobile in the environment than most other PAHs. As such the significance of naphthalene cannot be considered within the surrogate marker approach.

Similarly, **TPH** cannot be assessed as a single "total" value, and reference has been made to the Environment Agency's document P5-080/TR3, "The UK approach for evaluating human health risks from petroleum hydrocarbons in soils". This document supports the assumptions and recommendations made by the US Total Petroleum Hydrocarbons Criteria Working Group (TPHCWG). The TPHCWG have broken down "TPH" into representative constituent fractions or "EC Bandings". The TPHCWG have derived a series of physiochemical and toxicological parameters for each of the bandings.

[1] SP1010 Appendix E, Provisional C4Sls for benzo(a)pyrene as a surrogate marker for PAHs, CL:AIRE 2013

The significance of speciated TPH results can be assessed by following the 3 steps outlined in the tables below.

Step	Result	Action
1. Consider indicator compounds: Are BTEX, naphthalene, benzo(a)pyrene above their respective Tier 1 values?	Yes	Remediation or dQRA required
	No	Proceed to Step 2
2. Consider individual TPH fractions: are they above respective screening values?	Yes	Remediation or dQRA required
	No	Proceed to Step 3
3. Assess Cumulative effects: Is the calculated Hazard Index for each source >1	Yes	Remediation or dQRA required
	No	TPH compounds pose no significant risk

Step 1 - Assessing indicator compounds

TPH fraction Indicator compound	End use specific screening value (mg/kg)			
	A: Residential no cover	B: Residential with 600mm cover	C: Residential no gardens	D: Commercial\ industrial
Benzene	0.9	0.9	3.3	98
Toluene	600	3,000	2,700	5,000
Ethyl Benzene	350	932	843	5,000
Xylenes	246	327	321	5,000
Naphthalene	8	9	9	1,000
Benzo(a)pyrene	5	25	5.3	76

Step 2 - Assessing individual TPH fractions

TPH fraction		End use specific screening value (mg/kg)			
		A: Residential no cover	B: Residential with 600mm cover	C: Residential with no gardens	D: Commercial/ industrial
Aliphatic 5-6	GRO	41	41	42	5,000^ per fraction
Aliphatic 6-8	GRO	125	125	125	
Aliphatic 8-10	GRO	31	31	32	
Aliphatic 10-12	DRO	151	156	154	
Aliphatic 12-16	DRO	500^	500^	500^	
Aliphatic 16-21	DRO	1,000^	5,000#	1,000^	
Aliphatic 21-35	LRO	1,000^	5,000#	1,000^	
Aromatic 5-7	GRO	100	123	122	
Aromatic 7-8	GRO	30	34	34	
Aromatic 8-10	GRO	47	50	50	
Aromatic 10-12	DRO	215	287	266	
Aromatic 12-16	DRO	689	1,000*	1,000*	
Aromatic 16-21	DRO	1,000^	5,000#	1,000^	
Aromatic 21-35	LRO	1,000^	5,000#	1,000^	

* Calculated Screening Value exceeded soil saturation limit and could indicate free product, therefore calculated soil saturation limit adopted as a target

^ Calculated Screening Value close to soil saturation limit, screening value selected by Lithos considering visual and olfactory impacts.

Five times the screening value for Scenario A.

Step 3 - Assessing Cumulative Effects

$$HI = \sum_{F_i=1}^{16} HQ\ F_i = \frac{Measured\ concentration\ F_i\ (mg\ kg^{-1})}{SGV\ F_i\ (mg\ kg^{-1})}$$

where HI = Hazard Index
HQ = Hazard Quotient
F_i = Fraction $_i$
SGV = Soil Guideline Value

Other screening values used by Lithos

Tier 1 risk assessment of **hazardous gas** is undertaken through reference to the following documents (and further information is presented in Generic Note No. 5 – Hazardous Gas):

- Approved Document C, Building Regulations 2000
- Boyle & Witherington (2007) – Guidance on evaluation on development proposals on sites where methane and carbon dioxide are present, incorporating "traffic lights". Report Ref. 10627-R01-(02), for NHBC
- CIRIA C665 (2007) – Assessing risks posed by hazardous ground gases to buildings
- BS 8485:2015 – Code of Practice for the characterisation & remediation from ground gas in affected developments

With respect to the assessment of potential **phytotoxic effects** of contaminants, Lithos refer to "The Soil Code" (MAFF, 1998) for copper and zinc. The CLEA SGV is adopted for nickel due to its human health effects.

The potential risk to **building materials** is considered through reference to relevant BRE Digests, with particular emphasis on BRE Special Digest 1, 'Concrete in aggressive ground', 2005.

With respect to the interpretation of the **calorific values**, at present there are no accepted methods to assess whether a sample is combustible and under what circumstances it might smoulder. Some guidance is given in ICRCL Note 61/84 "Notes on the fire hazards of contaminated land" which states that: *"In general … it seems likely that materials whose CV's exceed 10MJ/kg are almost certainly combustible, while those with values below 2MJ/kg are unlikely to burn".*

Tier 1 **groundwater** risk assessments are undertaken by comparing leachate or groundwater concentrations with the appropriate water quality standard. Tier 1 Screening Values have been discussed with the Environment Agency, and typically those in **bold** below are adopted.

Analyte	Source of Tier 1 Screening Value (μg/l)			
	Surface water (Abstraction for Drinking) 1996	Water Supply Regulations 2000	Water Framework Directive	EA Advice
Arsenic	50	10	**50**	
Selenium	10	**10**		
Cadmium	5	5	**1.5**	
Chromium	50	50	**32**	
Copper	50	2,000	**28**	
Lead	50	10	**7.2**	
Nickel		20	**20**	
Zinc	3,000		**125**	
Boron		**1,000**		
Mercury	1	1	**0.07**	
Petroleum Hydrocarbons				**10**
1,1,1-Trichloroethane			**100**	
1,1 Dichloroethane				**100**
1,2-Dichloroethane		3	**10**	
1,1-Dichloroethene				**100**
Benzene		1	**10**	
Ethylbenzene				**10**
Tetrachloroethene		10	**10**	
Toluene			**50**	
Trichloroethene		10	**10**	
Vinyl Chloride		**0.5**		
Trichloromethane			**2.5**	
Xylenes			**30**	
Chloroethane				**100**

Waste classification & WAC

In the context of waste soils generated by remediation and\or groundworks activities on brownfield sites, the following definitions (from the Landfill Regulations 2002) apply:

- Inert (e.g. uncontaminated 'natural' soil, bricks, concrete, tiles & ceramics)
- Non-Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances, but at concentrations below prescribed thresholds)
- Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances at concentrations above prescribed thresholds)

Dangerous substances include compounds containing a variety of determinants commonly found in contaminated soils on brownfield sites, for example arsenic, lead, chromium, benzene etc.

Landfill operators require Waste Acceptance Criteria (WAC) laboratory data, if soil waste is classified as **hazardous**, and such waste must have been subjected to pre-treatment. However, subject to WAC testing it may be possible to classify it as stable, non-reactive hazardous waste, which can be placed within a dedicated cell within the non-hazardous landfill.

Lithos typically only include WAC analysis in site investigation proposals and reports, if significant off-site disposal (of soil classified as hazardous waste) is anticipated, for example where redevelopment proposals include basement construction etc. If off-site disposal of soils classified as hazardous waste during redevelopment is anticipated, then WAC analysis should be scheduled at an early stage in the remediation programme. However, organic compounds (BTEX, TPH, PAH etc) are the most common contaminants that result in soils being classed as hazardous, and these contaminants can often be dealt with by alternative technologies (e.g. by bioremediation or stabilisation) and consequently retention on site is often possible.

It should be noted that **non-hazardous** soil waste can go to a non-hazardous landfill facility; no further testing (e.g. WAC) is required.

APPENDIX D

EA GUIDANCE: DECOMMISSIONING REDUNDANT BOREHOLES AND WELLS

Good practice for decommissioning redundant boreholes and wells

October 2012

What's the purpose of this guidance?

Redundant boreholes and wells must be dealt with appropriately to make them safe and secure, and also to ensure they don't cause groundwater pollution or loss of water supplies. This guidance focuses on groundwater protection aspects but there are many other important factors owners and developers need to consider when designing and carrying out decommissioning works. These will be site specific, depending on the situation and intended afteruse. For example, boreholes near landfills or other sources of soil gas may require an opening to the air to prevent the build-up of noxious, explosive or flammable gas. Therefore, you should seek expert site-specific advice.

Legal framework

The Environment Agency (EA) has a duty to promote the sustainable use of water and to ensure it is protected from pollution. The Environmental Permitting (England and Wales) Regulations 2010 require the EA to take all necessary measures to prevent input of so called hazardous substances (for example pesticides) and limit the input of other non-hazardous pollutants (such as nitrate) into groundwater*, including for example contaminated run-off directly entering groundwater via an uncapped borehole.

**Groundwater is defined as water that is below the surface of the ground in the saturated zone and is in direct contact with the ground or subsoil.*

Why is it important to decommission properly?

Boreholes and wells are constructed for a variety of purposes including water supply, de-watering excavations, collecting geological information, investigating or sampling soils and groundwater and, increasingly, for ground source heating and cooling and geothermal (non-carbon) energy production. Many old water wells and boreholes are redundant as most properties are now connected to a mains water supply.

Improperly abandoned boreholes and wells can provide preferential pathways for groundwater or contaminant movement. This may result in the contamination of groundwater, the mixing of groundwaters of variable quality from different aquifers, or contribute to the loss of aquifer yield and water pressure (referred to as the potentiometric or piezometric head) as groundwater flows out of the system. This can threaten the availability and quality of groundwater resources for other users and potentially have an impacts on wetlands. Abandoned boreholes and wells can also present a physical hazard to people and property.

Artesian boreholes (where groundwater at depth in a 'confined aquifer' is at sufficient pressure to cause water to discharge either at the ground surface or into another overlying aquifer without any pumping) can be particularly problematic. They require special attention to prevent uncontrolled discharge of groundwater or cross-contamination of different aquifer units.

Therefore, site owners need to ensure that redundant boreholes and wells are made both safe and structurally stable, and also backfilled or sealed to prevent groundwater pollution and flow of water between different aquifer units. This is particularly important where other potable groundwater supplies are at risk.

However, in certain circumstances they may be adapted for use as a groundwater monitoring facility. **You must not use wells or boreholes as soakaways for foul or surface water drainage** because they provide a direct discharge route into groundwater and, as such, pose a risk of groundwater pollution.
This is prohibited by the Environmental Permitting (England & Wales) Regulations 2010.

Firstly, what are the construction details?

When considering how best to backfill and seal a borehole or well, or whether it could be adapted for monitoring purposes – you should first obtain information on the geological strata encountered by the borehole and how it was constructed (including depth, diameter and casing details). These can usually be obtained from site records or the original driller's log; the British Geological Survey holds the national water well archive and other borehole databases.

Is the site suitable for groundwater monitoring?

There are many good reasons for collecting groundwater samples or measuring groundwater levels; the information can, for example, help to validate the success of any remedial works being undertaken on a contaminated land site. Therefore, before decommissioning a borehole you should consider whether you wish to retain it as a monitoring facility. If it is to fulfil part of a planning condition or other legal monitoring requirement you may wish to discuss the details of how you do this with the Environment Agency.

If not, it is still worth contacting us via our National Customer Contact Centre (NCCC) to check whether we would be interested in incorporating it into our strategic groundwater level or quality monitoring networks.

If the borehole is not going to be converted then it should be abandoned using the guidelines below and the British Geological Survey should be informed.

Decommissioning

Each situation is different in terms of its location, geological setting, borehole construction, dimensions, hazards and, very importantly, intended site afteruse. Therefore the most appropriate abandonment procedure will vary from site to site. It is strongly recommended that you engage the services of a proficient well contractor with a good knowledge of the local geology and well abandonment procedures. For large boreholes and wells you may need to seek engineering advice. (**Note that structural aspects are outside the scope of this guidance.**)

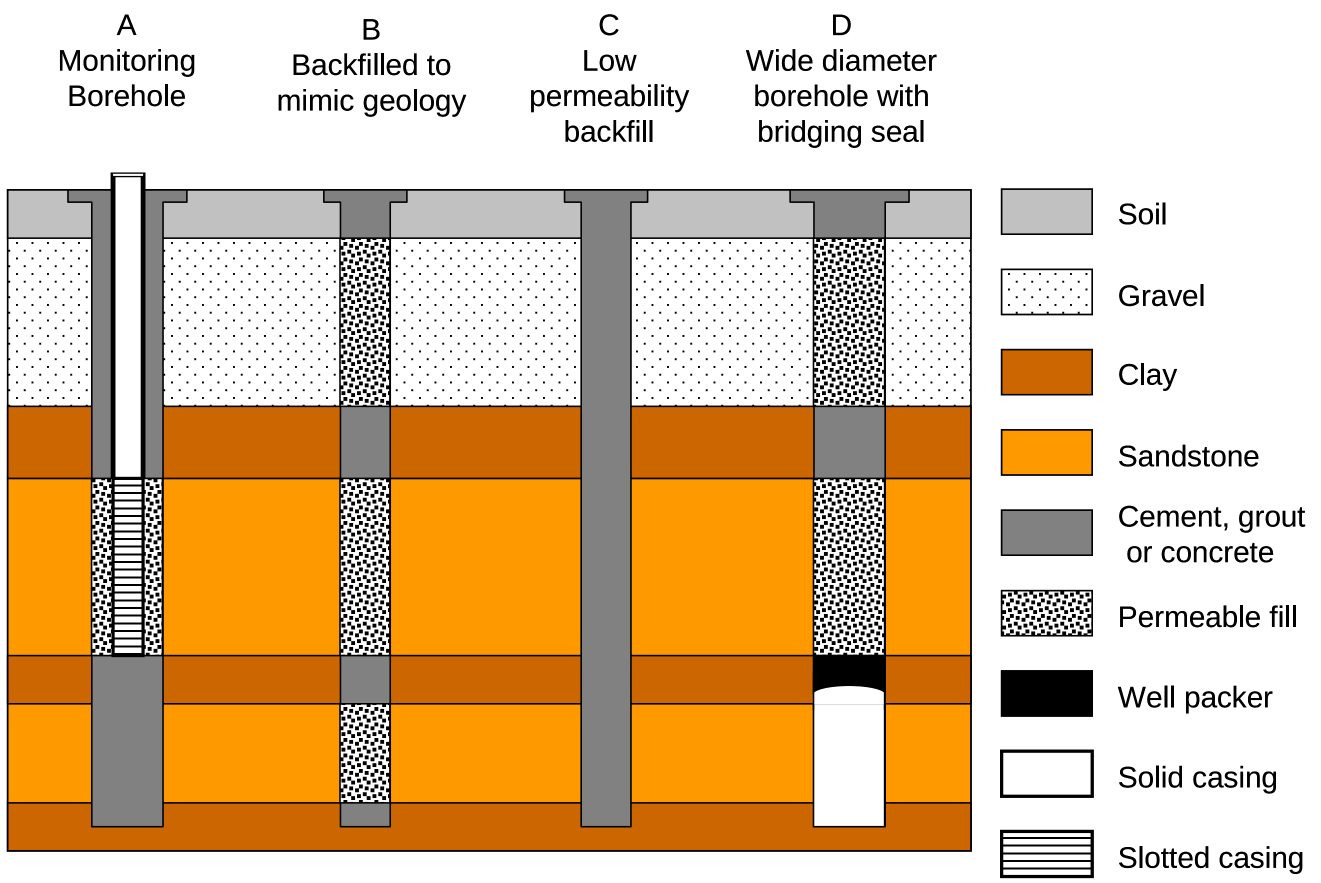

Figure 1: Schematic options (B–D) for decommissioning wells and boreholes

Step 1 - Defining the objectives

When planning the decommissioning works, in addition to any site specific afteruse considerations, the method should address the following objectives:

- Remove the hazard of an open hole (safety issues).
- Prevent the borehole acting as a conduit for contamination of groundwater.
- Prevent the mixing of contaminated and uncontaminated groundwater from different aquifers.
- Prevent the flow of groundwater from one geological horizon to another.
- Prevent the wastage of groundwater from the overflow of artesian boreholes.

Step 2 - Removing headworks and casing

It is crucial to ensure that the borehole or well is free from all obstructions that may interfere with the sealing of the hole. In particular, the pump and pipework should be removed, together with any other infrastructure (dip tubes etc).

The condition of any borehole casing and grout must be examined to ascertain whether its retention in the hole would prejudice any of the objectives of the abandonment. For many holes, examination of the casing from the ground surface will be adequate. However, deep boreholes may require the use of closed-circuit television (CCTV) to examine the casing at depth.

Where the casing has corroded or broken, or the grouting has failed, depending on the setting it may be necessary to remove those materials to prevent any flow of groundwater around the outside of the borehole. However, this is not without its own risks since removal of the well casing can result in collapse of the borehole walls (particularly in unconsolidated materials) and possible subsidence at ground level. If the well casing needs to be removed, a specialist well contractor can advise on appropriate techniques and associated risks.

Step 3 - Backfilling

General considerations

For most purposes the ground should be restored as closely as possible to its pre-drilled condition. The borehole or well should be backfilled with clean (washed), uncontaminated materials so that the permeability of the selected materials are similar to the properties of the geological strata against which they are placed. The backfilled borehole will then mimic the surrounding natural strata and groundwater flow and quality will be protected.

Restoration will require a variety of materials to be used so that permeable aggregates (for example pea gravel and sand) are positioned adjacent to aquifer horizons, whilst low permeability materials (usually clay, bentonite cement grout, or concrete) are positioned adjacent to low permeability horizons (see Fig. 1(B)). Alternatively, the entire borehole or well can be backfilled with low permeability materials that will prevent significant vertical or horizontal movement of groundwater through or along the borehole (see Fig. 1(C)).

The backfill materials must be clean, inert and non-polluting. Suitable materials include pea gravel, sand, shingle, concrete, bentonite, cement grout and uncontaminated rock. There are also a range of recycled products, like crushed glass, on the market that are designed for use in boreholes

IMPORTANT - Never use backfill materials that can cause pollution.

You should also consider the geochemical environment into which these materials will be placed, as the behaviour of materials may change under different environmental conditions (for example, iron-rich sands may contaminate the aquifer; phenol contamination may prevent bentonite grouts curing).

Aggregates (pea gravel, shingle, sand etc) should be selected such that they have a grain size that allows easy delivery into the borehole and should be introduced in a controlled manner to ensure that accidental 'bridging' does not occur within the borehole. Concrete and grouts that are introduced in a liquid form should be introduced through an appropriate delivery pipe (e.g. tremie pipe), to ensure that voids do not form. **Note**: It is good practice to monitor the volume of backfill material that is being emplaced, compared to that calculated at the design stage, to check if bridging within the borehole, or loss to the formation is occurring.

Boreholes that penetrate highly fissured aquifers, such as some limestones and gypsum bearing units, present additional problems. Liquid grouts (particularly those injected under pressure), or fine-grained aggregates (e.g. sand) may be transported out of the borehole into the body of the aquifer through fissures. Careful monitoring of the process is required if these techniques are used, and in these cases it may be more appropriate to use coarser aggregates such as gravel as a backfill.

Deep and large diameter boreholes/wells

When dealing with very deep or large diameter boreholes and wells (note, this does not apply to mine shafts), the volume of the hole may be considerable. In such circumstances it may be appropriate to adopt an alternative approach to completely backfilling the void, as long as this will not prejudice any of the design objectives.

Provided that the long-term structural stability of the borehole can be demonstrated, it may be possible to place a permanent bridging seal within the borehole and then to infill above this level using the approach summarised above (see Fig. 1(D)). The bridging seal should ideally be positioned below the lowest aquifer horizon. However, where this is not possible, it is important that the open borehole beneath the bridging seal penetrates no more than a single aquifer unit, thereby preventing the flow of groundwater between different aquifers.

The material commonly used as a bridging seal is cement, although a combination of a mechanical plug (packer) and cement can be used. Cement seals must be allowed to set (cure) in place before backfilling is continued and completed.

Again, this is a specialist area of work that requires high standards of design and workmanship to ensure an effective permanent seal is achieved.

Artesian boreholes

For artesian boreholes, the decommissioning process should aim to confine the groundwater to the aquifer from which it came – in order to prevent loss of confining pressure and the loss of water resources to the surface or other formations.

The first step is to control the artesian flow. There are a number of ways to accomplish this depending, in part, on the water pressure in the confined aquifer and the depth to which the water level must be lowered. These include:

- Pumping the borehole to produce the necessary drawdown.
- Pumping nearby boreholes.
- Extending the casing above ground level beyond the elevation to which water will rise in the borehole. (the potentiometric or piezometric surface).
- Introducing dense, non-polluting fluids into the borehole.
- Introducing a pre-cast plug at an appropriate level within the hole.
- Using an inflatable packer and pressure grouting the void space below it.

In aquifers that have large seasonal fluctuations in water level, decommissioning artesian boreholes is likely to be easiest in late summer, when groundwater levels and artesian flows are at their lowest.

The importance of the potential pathways in and around the casing should also be considered.

Decommissioning artesian boreholes is a specialist job and requires expert advice.

Step 4 - Sealing the top of the borehole

The backfilled borehole/well should be completed with an impermeable plug and cap to prevent entry of potentially contaminated surface run-off or other liquids. The top two metres should be filled with cement, concrete or bentonite grout. A concrete cap of suitable strength, with a diameter at least one metre greater than the width of the backfilled borehole (see Fig. 2), should then be installed. The exact finished depth of this cap will depend on the setting and planned afteruse of the site. It should be at least 2 metres below plough depth in agricultural areas and at least 1 metre below formation level for sites proposed for redevelopment. Never build structures directly onto well caps or linings.

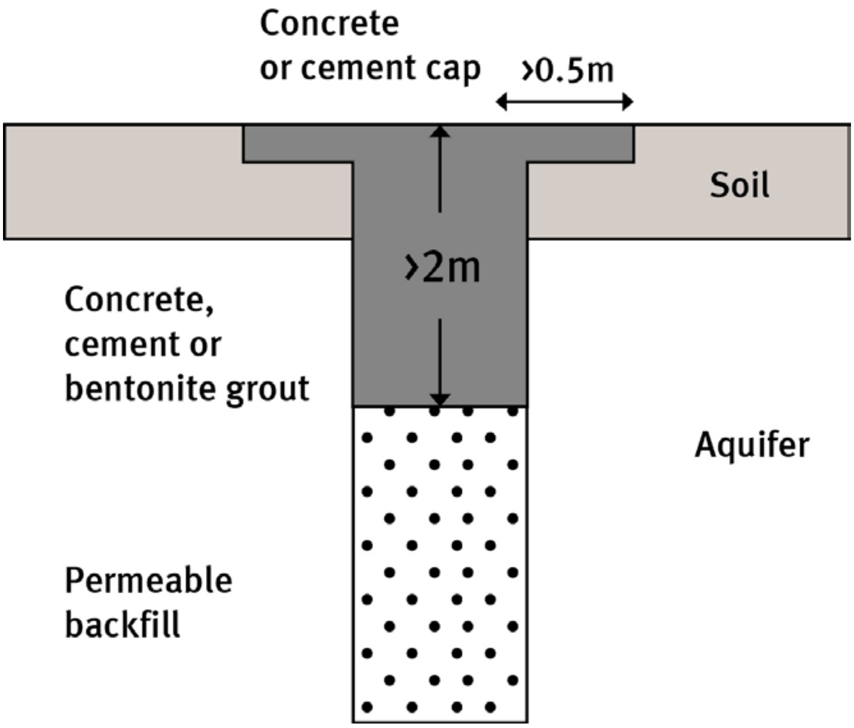

Figure 2: Schematic diagram for borehole seal and cap

Step 5 - Recording details and informing others

You should keep an accurate record of the abandonment details for future reference, including:

- The reasons for abandonment (for example water quality problems).
- Measurement of groundwater level prior to backfilling.
- The depth and position of each layer of backfilling and sealing materials.
- The type and quantity of backfilling and sealing materials used.
- Any changes made to the borehole/well during the abandonment (for example casing removal).
- Any problems encountered during the abandonment procedure.

The location of abandoned borehole and wells should be clearly marked on site records This is essential where any part of the well has not been filled.

It is also very good practice to mark or deeply inscribe well caps with the word "WELL”. Even if done crudely it can avoid considerable risk, delay or uncertainty in the event of the structure being discovered during excavation by others in the future, who may not otherwise know what the feature is.

Always notify the Environment Agency and British Geological Survey of the abandoned well location and structure.

Conversion to soakaways

Wells and boreholes should not be converted to soakaways, as these allow the direct discharge of pollutants into groundwater without any potential for attenuation, and will often result in groundwater pollution. The direct discharge of hazardous substances to groundwater, via a borehole, is effectively prohibited by the Environmental Permitting (England & Wales) Regulations 2010, and the pollution risk from any direct discharge of non-hazardous pollutants, such as sewage effluent, is so great as to make it highly unlikely to be acceptable.

Further advice and guidance

It is recommended that the advice of a specialist well contractor should always be sought, Details can be obtained from:

- **The British Drilling Association**. Wayside, London End, Upper Boddington, Daventry, Northamptonshire, NN11 6DP. Tel: 01327 264 622, email: office@britishdrillingassociation.co.uk

The Environment Agency cannot provide an advisory service on decommissioning individual boreholes and wells but your local Groundwater & Contaminated Land team may have some generic advice to help you; and would appreciate a copy of your abandonment details. They can be contacted via our National Customer Contact Centre (NCCC)

- **Environment Agency NCCC** Tel: 03708 506 506

The British Geological Survey are the national custodian of water well records in addition to other borehole records and geological information. They may have a record of the borehole or well you are dealing with, and will be interested in the abandonment details

- **British Geological Survey. National Geosciences Data Centre (NGDC)**, Keyworth, Nottingham, NG12 5GG. Tel: 0115 936 3143.

Useful references

- Environment Agency GP3 (Groundwater Protection Principles and Practice) http://www.environment-agency.gov.uk/research/library/publications/40741.aspx

- American Society for Test and Materials (ASTM) D5299 - 99(2005) Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities

- Driscoll, F.G., 1986. Groundwater and Wells. Second Edition, Johnson Division.

***Note:** This guidance supersedes the document ' Good practice for decommissioning redundant boreholes and wells' produced by our former National Groundwater and Contaminated Land Centre*

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