BROWNFIELD SOLUTIONS LTD

GEO-ENVIRONMENTAL ENGINEERING EXCELLENCE

BLUE PHOENIX

Tilbury Docks, Essex

Phase II Geo-Environmental Assessment Report – Part 2 Geotechnical Assessment

LN/C5441/12676

January 2024

EXECUTIVE SUMMARY	
Location and Brief Site Description	The site is located at the Tilbury Docks, Tilbury, RM18 7HA, centred on National Grid Reference 563067, 175910. It is 5.64 hectares in area and site comprises an existing Incinerator Bottom Ash (IBA) processing facility owned by Blue Phoenix in the west of the site, comprised predominantly aggregate storage, with a processing facility in the centre west of the site, and lagoons in the north-west and south-west. In the east and north-east of the site, a number of large warehouse style structures are present, predominantly in use for storage of plywood timber and paper products. Building 38A is a covered, open sided storage area. In the centre of the site is an open yard area. A small area of car parking, with container offices are present in the south of the site.
Ground Conditions	Generalised ground conditions from the ground investigation comprise (top down): • Made ground generally comprising asphalt / concrete over loose gravelly sand over organic clays from ground level to between 0.90m and 4.00m bgl. • Natural superficial deposits comprising very soft to firm damp organic clay, with subordinate bands of very loose slightly clayey gravelly sand, proven to depths between 1.20m and 12.00m bgl. This is interpreted to be Alluvium. • Spongy fibrous peat was encountered within CP01 between depths of 8.70m and 10.00m bgl. • Granular strata comprising medium dense to very dense sandy gravel and gravelly sand was encountered between 12.00m and 21.50m bgl. This is interpreted to be Thames Valley Gravels. • Solid geology comprising weak weathered Chalk proven to depths ranging between 21.50m and 21.80m bgl. This is interpreted to be Lewes Nodular Chalk Formation, Seaford Chalk Formation / Newhaven Chalk Formation. • Groundwater levels ranging between 1.00m and 13.50m bgl during site works. • Post site works monitoring groundwater levels ranging between 0.08m and 1.60m bgl.
Foundations and Floor Slabs	<u>General</u> It is understood that Stirling Maynard are considering shallow foundation solutions for the proposed plant with pad foundations constructed on the existing ground bearing slabs. These are discussed below together with other options to limit settlements. <u>Bearing Capacity</u> Bearing capacity of the underlying very soft soils is anticipated to be low and likely to be in the order of 10-20 kN/m^2 subject to foundation size and depth etc. Data is limited however, in particular inside the process plant building and further investigation is recommended. Punching shear of foundations through existing concrete slabs / asphalt is a concern as is bearing capacity failure and associated ground heave. BSL have undertaken the preliminary settlement calculations based on the anticipated loads provided by Stirling Maynard. The settlements discussed below are indicative only and cannot be relied upon or warrantied as the geotechnical data is limited. <u>Indication of Settlement</u> Preliminary calculations indicate that the floor slab of the process plant building could experience total settlements in the order of 300mm based on a 20 kPa loading. Concrete pads 2m x 2m constructed on the existing slab with column loads up to 75 kN (18.75 kPa) could experience total settlements in the order of 50-100mm. Pad foundations of the same size constructed below the existing floor slab on the natural very soft clay at a depth of 2.00m could experience settlements in the order of 25-75mm. With respect to the overhead conveyors with pairs of columns each with loads in the order of 75kN per column, based on 2.50m x 1.00m pads with an associated load of 60 kPa on the existing concrete ground slab, total settlements could be in the order of 200-400mm.

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	The IBA storage areas which will contain stacks in the order of 15m high are anticipated by Stirling Maynard to exert a ground pressure of 135 kPa. If these loads are transmitted to a reinforced concrete slab, bearing capacity failure is a significant risk together with excessive settlement (potentially in the order of 1500-2000mm). <u>Recommended Foundation Options</u> Foundation options for this site are considered to be a cost versus risk item, with the most robust solutions being of lowest risk but higher cost. The various options are discussed below: 1. Pad foundations constructed on the existing slabs – are deemed the most cost-effective solution but are likely to experience high settlements. Bearing pressures would need to be kept low to avoid punching of the foundation through the existing floor slab or bearing capacity failure. If large concrete pads are considered likely to represent obstructions to plant etc in the process building, consideration could be given to use of steel plates to spread the load. It would be prudent to allow for adjustment of columns to compensate for settlement. Pad foundations constructed below the existing floor slabs – settlements are anticipated to be high as indicated above. Should these be a concern, consideration could be given to the use of piled foundations, controlled modulus columns or dry soil mixing as detailed below. Bearing capacities for pad foundations of 10-20 kPa are anticipated at this stage subject to further investigation, in particular within the process building. 2. Piled foundations – where high settlement cannot be tolerated, consideration should be given to the use of a piled foundation solution to transfer foundation loads into the medium dense to very dense sandy gravel and gravelly sand which was encountered from 12.00m. Driven precast concrete piles are likely to be the most cost-effective solution, however reference should be made to a specialist piling contractor to design and warranty a suitable system. 3. Ground improvement using controlled modulus columns, dry soil mixing or other specialist techniques – these are considered potentially suitable to improve the soil stiffness of the very soft alluvial clays, increase bearing capacity and reduce settlements. These techniques may be specifically of use in the IBA storage areas where high loads and associated large settlements are anticipated. Specialist ground improvement contractors should be contacted to discuss these options if required. 4. The use of geotextiles with an associated granular layer could also be considered to redistribute settlements in particular the IBA storage areas. Data on the thickness and integrity of existing floor slabs is limited; as such it is recommended that coring and strength testing of the concrete is undertaken as required. In general, however, floor / ground bearing slabs should be suitably designed to resist cracking associated with settlement.
Concrete Classification	DS3 AC3 conditions prevail.
Highways Design	Equilibrium CBR values are likely to be <2% within the made ground for pavement design purposes. To achieve the required design CBR value, improvement works should be carried out in accordance with DMRB IAN 73/06 Rev 1 Chapter 5 and may include proof rolling, excavation and re-engineering / replacement of weaker soils, the inclusion of a geogrid or use of stabilisation techniques such as the addition of hydraulic binders (e.g. cement/lime).
Site Drainage	Given the site is underlain by low permeability clays, and is adjacent to the River Thames, it is unlikely that drainage to SuDS such as traditional soakaways will be suitable. It is considered that the existing drainage systems will likely be utilised on-site.
Further Work	The following further works will be required to progress to the construction phase: • Further investigation to confirm bearing capacities, in particular inside the process plant building.

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	• Coring and testing of the existing floor flabs. • Specialist flood risk advice should be sought.

This executive summary should be read in conjunction with the full report, reference LN/C5441/12676 and not as a standalone document. Report template version 4.4.

PROJECT QUALITY CONTROL DATA SHEET

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DRAWINGS

Drawing Number	Rev	Title
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C5441/01	-	Site Location Plan

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C5441/02	-	Site Features Plan
C5441/03	-	Exploratory Hole Location Plan

APPENDICIES	
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Appendix A	BSL Methodology and Guidance
Appendix B	Exploratory Hole Logs
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5.0 INTRODUCTION

1.1 Context

This report describes a Phase II Geo-Environmental Assessment carried out by Brownfield Solutions Limited (BSL) for Blue Phoenix as instructed by Stirling Maynard on a site at the Tilbury Docks, Tilbury and has been completed in general accordance with the following guidance:

- BS5930: 2015+A1:2020 Code of Practice for Ground Investigations.
- BS EN 1997-1:2004+A1:2013 Eurocode 7. Geotechnical design. General rules plus UK National Annex.
- BS EN 1997-2:2007 Eurocode 7 Geotechnical design. Ground investigation and testing plus UK National Annex.

Definitions of terms and acronyms used within this report is presented in Section 9.0.

At the request of the client, our reporting has been split into two, with Part 1 forming the environmental assessment, and Part 2 forming the geotechnical assessment. Part 1 is referenced in Section 1.3 below.

1.2 Proposed Development

The proposed development is for a continued industrial end-use, involving expansion of the existing Incinerator Bottom Ash (IBA) processing facility to enable an increase in processing capacity. The site is to be extended, with demolition of some of the existing buildings and structures, construction of a lagoon for surface water attenuation and process water storage, and construction of a new access and loading ramp. The proposed development is shown on the Schematic Layout, Drawing No. P22161-SMCE-ZZ-XX-DR-C-0100 Rev P02, provided to BSL by Stirling Maynard.

More specifically, the process plant will be contained mainly within the existing building in the north east of the site (which is currently used for bulk paper storage); this building is understood to be steel framed on piled foundations with an asphalt floor. Stirling Maynard consider that the existing floor potentially comprises 200mm of asphalt over 200mm of type 1. The new process plant will impose a general floor loading in the order of 20 kPa, with plant column loads of 30-75 kN. Concrete pads are proposed constructed on the existing floor.

Overhead conveyors are proposed externally from the south east corner of the process plant which are indicated to have pairs of columns each with loads in the order of 75kN per column, with columns spaced at approximately 1.50m transversely. An associated 2.50m x 1.00m base would apply a load of approximately 60 kPa to the existing concrete ground slab.

The attenuation lagoon is to comprise an approximately 46m x 35m concrete box excavated approximately 3m into the ground. When full (which is considered rare), it will exert a net zero bearing pressure on the ground.

IBA storage areas will contain stacks in the order of 15m high with a 30m wide base which could exert a ground pressure of 135 kPa. At least 1m of settlement has been observed in this area of the site in the last 12-13 years. Future settlement is acknowledged by Stirling Maynard. It is intended to build a new pavement on top of the existing comprising a minimum of 200mm reinforced concrete over 230mm sub-base.

1.3 Previous Reports

This report should be read in conjunction with BSL Desk Study Assessment Report, ref: JW/C5441/12238, issued in July 2023 as well as Part 1 of our Phase II reporting, our Phase II Geo-Environmental Assessment Report, ref: LN/C5441/12644 Rev A.

In addition, the following previous ground investigation report was supplied, undertaken for the construction of the existing process plant building: 'Report on Ground Investigation for New Shed Western Peninsula, Tilbury Free Port, London,' Geotechnical Developments, Report ref. E708/94, dated October 1994.

1.4 Objectives and Scope

The objectives of this report are to determine the ground conditions of the site, highlighting potential geotechnical hazards and risks and areas of concern that may govern the development under the current planning regime.

The factual and interpretive Phase II sections of this report are intended to fulfil the requirements of a Ground Investigation Report (GIR) as detailed in BS EN 1997-2:2007.

Following the Desk Study, an exploratory intrusive investigation was undertaken to confirm the ground conditions and meet any objectives that had not been satisfied. The exploratory investigation was undertaken using window sampling, laboratory geotechnical testing, with reporting on the findings.

1.5 Limitations

This assessment has been prepared in accordance with the relevant current legislative framework, guidance and risk assessment methodology as outlined in Appendix A. BSL is not liable for any subsequent changes in the guidance and legislation.

The findings and opinions conveyed via this report are based on information obtained from a number of sources as detailed within this report, BSL have assumed this information is correct and reliable. Nevertheless, BSL cannot and does not guarantee the authenticity or reliability of the information it has relied upon.

BSL have used reasonable skill, care and diligence for the investigation of the site and the production of this report. There may be other conditions prevailing on the site which are outside the scope of work and have not been highlighted by this assessment and therefore have not been considered by this report. Responsibility cannot be accepted for such site conditions not revealed by the assessment.

This report has been prepared for the sole use and reliance of the Client, Blue Phoenix. No other third parties may rely upon or reproduce the contents of this report without the written permission of Brownfield Solutions Ltd (BSL). If any unauthorised third party comes into possession of this report, they rely on it at their own risk and BSL do not owe them any Duty of Care. This report may not be relied upon by the client or submitted to a third party for their reliance for the purposes of valuation, mortgage, insurance and regulatory approval, until all invoices have been settled in full.

The investigation carried out on the site has been conducted to provide the best information on the ground conditions within site access and budgetary constraints. The inherent variation of ground conditions allows only for definition of the actual conditions at the locations and depths of exploratory locations at the time of the investigation. Different ground conditions may exist that have not been identified within this investigation.

The recommendations in this report assume that ground levels will remain as existing, unless stated otherwise within the report. If there is to be any re-profiling (e.g. to create development platforms or flood defences) then the recommendations may not apply.

The groundwater results described are only representative of the dates on which they were recorded, and levels may vary seasonally (e.g. due to changes in weather).

This assessment has been based on the proposed planning layouts provided. Any subsequent change to the planning layout may have an impact on the validity of recommendations made within this report. Furthermore, new information, changed practices or new legislation may necessitate revised interpretation of the report after the date of its submission.

Although every effort has been made to position exploratory holes in the least sensitive areas of the site, exploratory hole positions were located approximately as part of this investigation and no guarantee can be given as to their accuracy. Consideration should be given to the possibility that exploratory holes excavated as part of this investigation and indeed any previous ground investigation work by others may be encountered beneath or within the influence of individual foundations. BSL cannot be held responsible for structural failures caused by the location of foundations of any form of structure within the influence of exploratory holes.

Where it has not been possible to reasonably use an EC7 compliant investigation technique, a practical alternative has been adopted to obtain indicative soil parameters and any interpretation is based upon

Notwithstanding site observations concerning the presence or otherwise of archaeological issues, asbestos-containing materials (ACM) or invasive weeds (e.g. Japanese knotweed), this report does not constitute a formal survey of these potential issues.

Asbestos in structures was not covered in this report. It should be noted that an asbestos demolition survey will be required prior to any demolition of structures. If asbestos is present in soils, these will need to be dealt with in accordance with the Control of Asbestos Regulations (CAR) 2012.

The site plans enclosed in this report should not be scaled off. Any site boundary line depicted on plans does not imply legal ownership of land.

Any recommendations made in this report should be confirmed with the Regulatory Authorities prior to implementation to ensure compliance.

6.0 THE SITE

2.1 Location

The site is located at the Tilbury Docks, Tilbury, RM18 7HA, centred on National Grid Reference 563067, 175910 as shown on the Site Location Plan, Drawing No. C5441/01.

2.2 Site Description

The main site features and potential issues identified are detailed below and are shown on the Site Features Plan, Drawing No. C5441/02.

Feature	Description
Site Area	5.64 hectares.
Site Access	Access to the site is gained through the Tilbury Docks, which is accessed off St Andrew's Road (A1089) to the north-east of the site.
Current Land Use and Site Features	The site comprises an existing Incinerator Bottom Ash (IBA) processing facility owned by Blue Phoenix in the west of the site, comprised predominantly aggregate storage, with a processing facility in the centre west of the site, and lagoons in the north-west and south-west. In the east and north-east of the site, a number of large warehouse style structures are present, predominantly in use for storage of plywood timber and paper products. Building 38A is a covered, open sided storage area. In the centre of the site is an open yard area. A small area of car parking, with container offices are present in the south of the site. Several manhole covers are noted on-site, predominantly indicated to be for water, drainage and electricity. A small electrical sub-station is noted in the centre of the site, adjacent to the open yard area. The aggregate stockpiles in the north appeared to be unprocessed, with stockpiles appearing to comprise a mixture of ash, slag and clinker, alongside predominantly metal, with some plastic, paper and fabric. To the south of the processing facility, a number of large stockpiles, with signage noting the stockpiles to be Type 1, 6F2 and 6F4. Some smaller walled areas included ferrous and non-ferrous wastes.
Potential Sources of Gross Contamination	An unbunded above ground 10,000l diesel storage tank (AST) was noted in the centre west of the site. The diesel tank was situated on a concrete pad, and spill kits were available. A small area of indicated leakage appeared to be present. Adjacent to the diesel tank were a number of containers and IBCs. Two IBCs containing AdBlue were present, both on plastic spill trays. Two material storage cabinets were present with lockable roller shutter doors. These were not opened but are likely to contain chemicals or other potentially contaminative materials, as the cabinets included spill trays. Lockable cabinets for oxygen and gas containers were recorded in the east of the site, however the cabinets were empty at the time of the walkover.
Vegetation / Ecology	No formal areas of vegetation or soft landscaping are present. Some sparse patches of rough vegetation were observed.
Topography	Site levels range between approximately 3.50 and 5.50 mAOD. The western site of the site is flat, and the eastern boundary slopes gently toward the north-east.
Site Boundaries	The site boundaries are generally open to the adjacent docks to the north, east and south. To the west a the dock basin is present. The boundaries of the Blue Phoenix area to the north, east and south are formed of steel palisade fencing, and is open to the west. In the north and east, the boundaries are predominantly formed by the walls of the buildings on-site. A short section of the south-eastern boundary is formed of concrete panel wall.
Surrounding Area	The site is set within the commercial / industrial Tilbury Docks area, built upon one of the three main piers observable. Dock basins are present adjacent to the south-west, south and south-east, with other industry present to the north-west, north, north-east and east. The River Thames lies approximately 500 m to the south and east. Further afield, the port town of Tilbury is present to the north-east of the site.

7.0 SUMMARY OF PREVIOUS REPORTS

A summary of the relevant points from the previous Ground Investigation Report completed by Geotechnical Development (ref: E708/94) is presented below:

- The Tilbury Docks area was reclaimed from marshland site has remained open marshland and estuarine mud flats. Fill materials used to reclaim the area comprised ash, slag glass tiles etc
- 3 No. cable percussion boreholes were drilled to 30m in 1994 in the northeast of the site.
- Made Ground was encountered to depths of 1.90-3.30 m.
- The Made Ground comprised 0.60m-1.10 m of hard asphalt above dry mix concrete, sand and cement or concrete. This lay above variable very loose gravel sand with pockets of black silty organic clay and soft sandy silty clay with some gravel, brick, rubble wood and ceramic debris.
- SPT 'N' values in the Made Ground ranged from N=3 to N=8.
- Alluvial Deposits comprising alternating thinly bedded very soft to firm silty organic clays and firm clayey silty fibrous peat were encountered to depth of between 11.90 m and 13.30 m.
- Flood Plain Gravels were encountered directly beneath the Alluvial Deposits to depth of between 19.80m and 20.60m. These comprised medium dense to very dense gravels and gravelly sands with rare thin bands of firm to stiff sandy clay with some gravel and organic matter.
- SPT 'N' values in the Flood Plain Gravels ranged from N=15 to N=52.
- The Upper Chalk was encountered at depths between 19.80 m and 20.60 m and proved to 30m.
- Groundwater was encountered at depths of between 0.90 m and 2.10 m rising to standing water levels of between 0.90 m and 1.40 m.

A summary of the relevant points from the Desk Study completed by BSL (ref: JW/C5441/12238) is presented below:

- The site has remained open marshland, with railway lines bisecting the site, until the 1960s and 1970s, when expansion of the dockyard spread into the site boundary. Since then, the site developed into its current use for aggregate recycling, production and disposal, as well as storage of plywood and paper products.
- Historical land use in the surrounding area has been predominantly commercial / industrial, comprising additional dockyards.
- Geology comprises Alluvium (a Secondary Undifferentiated Aquifer) over the Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (a Principal Aquifer).
- No faults are within an influencing distance of the site.
- The site is outside the area of a designated coalfield or brine extraction area and no further consideration of coal mining/brine related risks is required.
- There are 4 No. current waste management sites recorded within 250m of the site, which fall under a total of 10 No. entries.
- The nearest watercourse is the Tilbury Docks (manmade) approximately 15m to the south-west of the site and River Thames approximately 500m south and west of the site.
- The site is located within both EA designated Zone 2 and Zone 3 floodplains.
- The risk to human health is considered to be low to moderate / low.
- There are no active or historic landfill sites recorded within 500m of the site.
- The risk from ground gas is considered to be moderate and the site is not located in an area requiring radon protection measures.
- The risk to controlled waters is low to moderate / low.
- The site is located in the UXO moderate risk zone.
- Recommendations were for an appropriate Phase II ground investigation to be carried out to confirm the identified risks and obtain information for preliminary design.

A summary of the relevant points from the Stage 1 Preliminary UXO Risk Assessment completed by Brimstone (reference: PRA 23-2176) is presented below:

- The site is situated within the WWII-era Urban District of Thurrock, which sustained 44.4 bombs / 1,000 acres, a moderate bombing density.
- Bomb census mapping does not record any bombing incidents within the site footprint, with the closest records circa 375m south-west of the site, however the information source is not comprehensive.
- Mapping records show a significant number of incidents occurring over the docks.
- A structure immediately south-east of the site is indicated to have been cleared between pre and post-WWII mapping, which is potentially indicative of bomb damage occurring.
- Tilbury Docks was identified as a primary Luftwaffe bombing target during WWII.
- Tilbury Docks was designated as an embarkation point and marshalling area during the preparations for D-Day. The docks were also involved when Operation Overlord occurred, used for the construction of Mulberry Harbours.
- On 19th August 2020, a bomb disposal squad was called to Tilbury Docks following the discovery of a UXB approximately 155m east of the site. An additional find is known to have occurred in 1991, however it's not known whether this occurred on-site.
- The ground cover historically present across the majority of the site (marshland, vegetation) is likely to have presented conditions unconducive to the visual detection of UXBs.
- Recommendations are for the completion of a Stage 2 Detailed Risk Assessment in order to further assess the risk to proposed works. In lieu of a Detailed UXO Assessment, on-site support for any planned ground works is recommended.

8.0 METHOD OF INVESTIGATION

8.0 Objectives

To confirm the risks to the identified receptors and confirm the ground conditions in respect to the identified geotechnical risks, an appropriate intrusive investigation was undertaken in accordance with the recommendations of the Phase I Desk Study Assessment.

The aim of the fieldwork was to:

- Investigate ground conditions on the site and the potential need for detailed investigation.
- Obtain geotechnical information on the ground conditions at the site for preliminary foundation design and preliminary pavement design purposes.

8.1 Site Works

The following site works have been undertaken as part of the intrusive investigation between the dates of 6th November and 7th November 2023.

Method	No.	Range Depths (m bgl)	Purpose
Window sample boreholes	8	0.90 – 5.00	Establish general ground conditions on site. Allow Standard Penetration Tests (SPTs) to be carried out and obtain samples for contamination and geotechnical and testing. Determine soil strengths/densities for preliminary foundation design. Installation of ground gas and water monitoring wells.
Cable percussive boreholes	1	21.80	Assess deeper ground conditions, carry out SPTs and obtain samples for contamination and geotechnical and testing. Determine soil strengths/densities for preliminary foundation design. Installation of ground gas and water monitoring wells.

As a specialist UXO preliminary risk assessment identified a potentially significant risk from UXO and order to minimise the risk to operatives during the ground investigation works, all exploratory locations were scanned with a hand-held magnetometer and works supervised by a specialist UXO surveyor.

No magnetic anomalies were noted.

WS07 was terminated at 0.90m bgl within the hand dug pit due to concrete obstructions which proved difficult to excavate. WS06 was terminated at 3.00m bgl depth due to the hole collapsing, therefore UXO magnetometer scanning could not be carried out below the 3.00m bgl depth. WS02 was terminated at 4.00m bgl due to SPT refusal.

The approximate locations of the exploratory holes are indicated on the Exploratory Hole Location Plan, Drawing No C5441/03. The exploratory hole logs are presented in Appendix B.

The exploratory holes were logged by an experienced geo-environmental engineer in general accordance with the following guidance:

- BS 5930:2015+A1:2020 Code of Practice for Site Investigations.
- BS EN 14688-1:2018 Geotechnical Investigation and Testing – Identification and classification of soil.
- BS EN ISO 14689:2018 Geotechnical investigation and testing – Identification and classification of rock.

8.2 Sampling Strategy

Representative samples were taken from exploratory holes at regular intervals to assist in the identification of the soils and to allow subsequent laboratory testing. They were stored and transported in general accordance with BS 10175:2011+A2:2017.

The type of sample was dependent upon the stratum and the purpose of analysis in accordance with current environmental and geotechnical guidance. The distribution of samples taken across the site is recorded on the exploratory logs.

Investigatory hole locations were determined by reference to the conditions identified in the preliminary risk assessment. Certain specific features such as diesel tanks, dockyards and electrical substation were targeted for specific investigation, but a reasonably even spacing was used for the remainder of the site. No specific sampling statistics or grid were utilised in this instance.

8.3 Laboratory Testing

Representative disturbed and undisturbed samples were obtained for all soil types encountered. Selected samples were scheduled for testing at an approved laboratory in accordance with BS 1377 'Method of Test for Soils for Civil Engineering Purposes' and BS EN ISO 17892- Parts 1-12:2018 'Geotechnical investigation and testing. Laboratory testing of soil'.

The following tests were scheduled for geotechnical purposes:

Description	No of Samples
Plasticity Index Analysis.	6
pH Value.	2
Water Soluble Sulphate Contents.	2
SD1 BRE Full Suite.	2
Determination of Undrained Shear Strength in Triaxial Compression.	1

The Geotechnical Laboratory Testing Results are presented in Appendix C.

9.0 GROUND CONDITIONS

9.1 Summary

A brief summary of the ground conditions encountered is presented in the table below:

Stratum	Range Depths - Top (m bgl)	Range Depths - Base (m bgl)	Range Thickness' (m)	Brief Description
Made Ground	0.00	0.90 – 1.95	0.90 – 1.95	Asphalt and concrete over loose gravelly sands with varying amounts of clay and gravel of chert, concrete, brick and rare clinker.
	0.50 – 1.50	1.20 – 4.00	0.65 – 2.55	Very soft to soft organic clays with varying amounts silts, peat and gravels of brick, coal, concrete and rare glass fragments.
Natural Superficial Strata - Alluvium	1.20 – 3.20	1.60 – 4.20	0.40 – 1.05	Very loose slightly clayey gravelly SAND.
	1.30 – 4.20	3.00 – 12.00	0.50 – 7.80	Very soft to firm, damp, organic CLAY with varying amounts of silt, gravels of chert, sands and fibrous peat.
	8.70	10.00	1.30	Spongy organic clayey fibrous PEAT
Natural Superficial Strata – Thames Valley Gravels	12.00	21.50	9.50	Medium dense to very dense sandy GRAVEL and gravelly SAND.
Solid Geology – Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation	21.50	21.80	0.30	Weak structureless weathered CHALK (Grade Dc).

Details are provided in the logs in Appendix B and the individual strata are described in the sections below.

9.2 Made Ground

Made Ground – General
Made ground was encountered within all the exploratory holes across the site and was observed from ground level to depths of between 0.90m and >4.00m bgl with the full thickness of made ground not proven within WS02, where made ground was found to be thickest.

Hardstanding surfacing of asphalt over concrete was present within WS01, WS02, WS03 and WS08 while only concrete surfacing was noted in CP01, WS04, WS05, WS06 and WS07. The thickness of the hardstanding surfacing was recorded between 0.21m and 0.46m.

The composition of the made ground was relatively consistent across the site and comprised loose yellowish brown gravelly sand below the hard standing, with gravels of chert, concrete, brick and rare clinker. Underlying this was generally very soft to firm dark grey and brown / black clays with varying proportions of silts, peat and gravels of chert, brick, concrete and rare glass fragments.

Soft grey mottled brown clay, suspected to be reworked natural clay was encountered locally in WS02 at depths ranging between 2.20m and 3.60m bgl. Below this, soft becoming firm black, organic very gravelly clay with ash was encountered where an SPT refused within this strata at 4.00m bgl.

9.3 Natural Superficial Strata

The superficial deposits were encountered in all the exploratory holes on the site, with the exception of WS02 and WS07. Soils interpreted to be Alluvium were observed below the made ground to depths of between 3.00m and 12.00m bgl. These soils generally comprised loose dark grey organic slightly clayey gravelly sand, very soft to firm dark grey and black clay with varying amounts of silt, sands, peat and gravel as minor constituents and, spongy organic clayey fibrous peat. SPT N-values were generally between 0 and 7.

Below the Alluvium strata, soils interpreted to be Thames Valley Gravels were encountered within CP01 from depths of 12.00m bgl up to depths of 21.50m bgl. These soils comprised medium dense to very dense dark grey to brown sandy gravel and gravelly sands. SPT N-values were generally between 1 and 38.

9.4 Solid Geology

Weak structureless weathered chalk bedrock (Grade Dc) was encountered within CP01 at 21.50m bgl and recovered as white and cream slightly sandy silty sub-angular to angular fine to coarse gravel of chalk and flint. This was proven to the base of the borehole at 21.80m bgl and is interpreted to represent the Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation.

9.5 Groundwater

The depths to groundwater and locations present during site works are shown in the table below:

Location	Depth During Site Works (m)	Comments
CP01	2.50	Slight seepage
	13.50, rising to 8.40	Moderate seepage
WS01	2.00	Slight seepage
WS02	3.00	Slight seepage
WS03	2.00	Slight seepage
WS04	1.50	Slight seepage
WS05	2.90	Slight seepage
WS06	1.00	Moderate seepage
WS07	NGW	-
WS08	2.00	Slight seepage

NGW – No Groundwater Encountered

9.6 Observations

Stability of Excavations/Boreholes
The borehole sidewalls were generally stable and window sampling progressed without the need to install casing. However, WS06 in the east was terminated due to the hole collapsing in the made ground. Casing was required to prevent collapse with the granular materials during drilling of the cable percussive borehole.

WS07 was terminated within the hand pit due to concrete obstructions at 0.90m bgl. Further concrete obstructions were observed within CP01 at depths of between 0.60m and 0.70m bgl, however drilling progressed through this obstruction.

10.0 TEST RESULTS

10.1 Geotechnical Laboratory Testing

Plasticity Index Analysis
Plasticity index results recorded in the Alluvium ranged between 34% and 80%, indicating to be of high to very high plasticity. Associated water contents ranged between 40.8% and 85.0%.

After modification of particle size in accordance with BRE 240 the modified plasticity indices are in the range 33% to 79% indicating the cohesive soils to be of medium to high volume change potential.

Undrained Shear Strength
The results of the tests are shown in the table below:

Location	Depth (m bgl)	Strata	Shear Strength (kPa)	Undrained Shear Strength to EC7
CP01	5.00-5.45	Alluvium	44	Medium

10.2 Aggressive Ground Conditions – Geotechnical Chemical Testing

The test results for the assessment of aggressive ground conditions are presented in Appendix C. The results are summarised and assessed within Section 7.6 of this report.

10.3 In Situ Geotechnical Testing

In Situ Standard Penetration Tests
Standard Penetration Tests (SPTs) were carried out within the window sample and cable percussive boreholes at regular 1.00m to 1.50m intervals. The results of the individual blows and the N-values are recorded on the Exploratory Hole Logs in Appendix B

All SPT N values are uncorrected. Density and strength descriptors are reported in accordance with the guidelines stated in BS 5930:2015+A1:2020, incorporating requirements of BS EN ISO 14688-1:2002, BS EN ISO 14688-2:2004 and BS EN ISO 14689-1:2003.

11.0 GEOTECHNICAL ASSESSMENT & RECOMMENDATIONS

11.1 Ground Model

The site currently comprises an existing Incinerator Bottom Ash (IBA) processing facility owned by Blue Phoenix in the west of the site, comprised predominantly aggregate storage, with a processing facility in the centre west of the site, and lagoons in the north-west and south-west.

The ground conditions can be summarised as below (top down):

- Made ground generally comprising asphalt / concrete over loose gravelly sand over organic clays from ground level to between 0.90m and 4.00m bgl.
- Natural superficial deposits comprising very soft to firm damp organic clay, with subordinate bands of very loose slightly clayey gravelly sand, proven to depths between 1.20m and 12.00m bgl. This is interpreted to be Alluvium.
- Spongy fibrous peat was encountered within CP01 between depths of 8.70m and 10.00m bgl.
- Granular strata comprising medium dense to very dense sandy gravel and gravelly sand was encountered between 12.00m and 21.50m bgl. This is interpreted to be Thames Valley Gravels.
- Solid geology comprising weak weathered Chalk proven to depths ranging between 21.50m and 21.80m bgl. This is interpreted to be Lewes Nodular Chalk Formation, Seaford Chalk Formation / Newhaven Chalk Formation.
- Groundwater levels ranging between 1.00m and 13.50m bgl during site works.
- Post site works monitoring groundwater levels ranging between 0.66m and 1.60m bgl.

Stage 1 Preliminary UXO Risk Assessment (REF: 23-2176) identified a potentially significant risk from UXO on site.

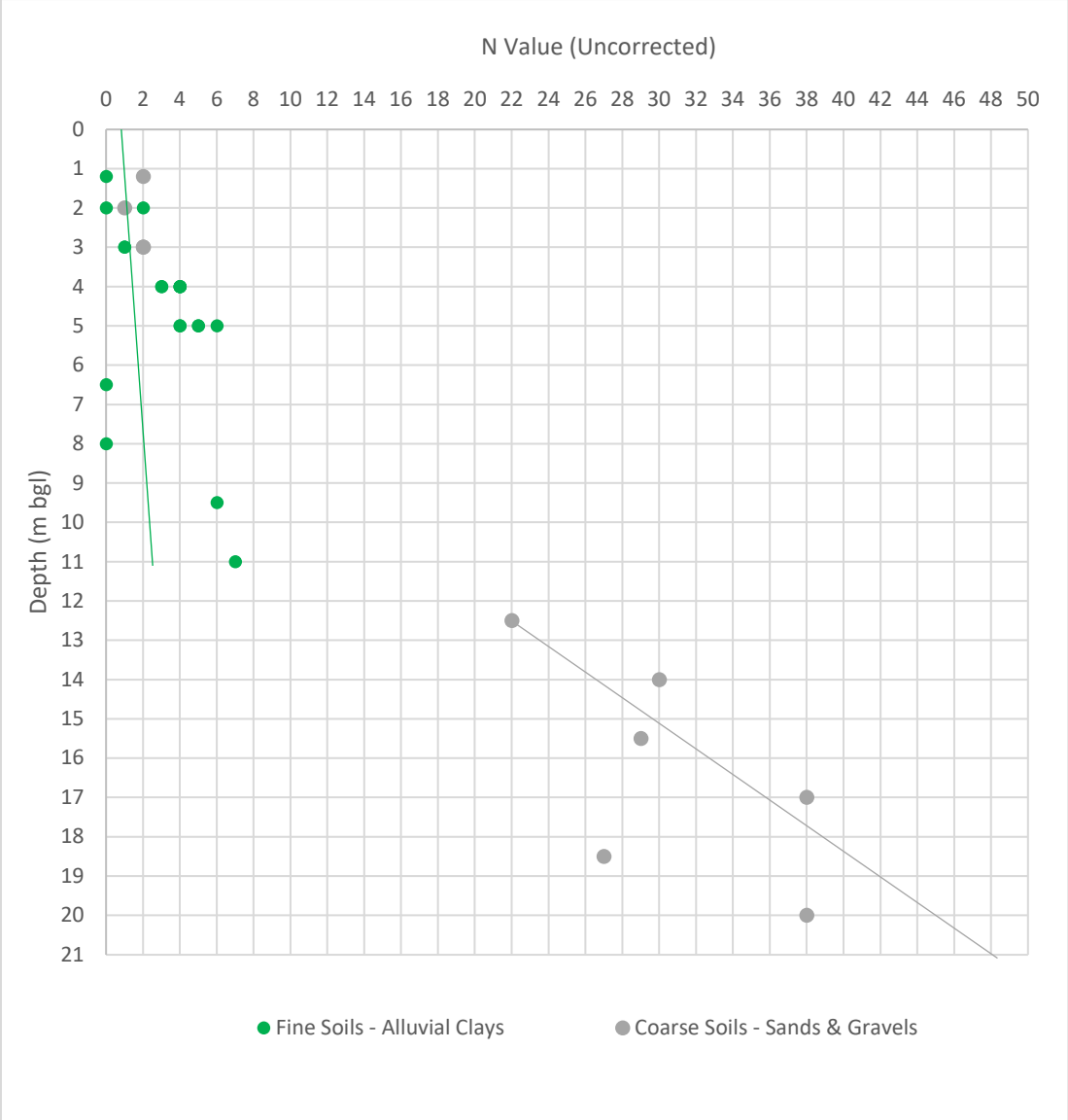
The site lies within Zone 2 and Zone 3 floodplains. Specialist flood risk advice should be sought, and this will require consideration when setting the finished levels for the site.

11.2 Design Soil Parameters

The relevant test results from the prior section have been evaluated to derive geotechnical soil parameters for the site.

For cohesive (fine) soils, the equivalent approximate undrained shear strengths (Cu) have been calculated from the recorded SPT N values, adopting f1 values based on the correlation of Stroud (1975) and the ‘average’ plasticity.

A depth (m bgl) vs SPT N value graph is also provided below to provide a profile of the granular and cohesive materials underlying the site.



The above graph shows the fine alluvial soils underlying the site to be of low soil strength (with SPT N values ranging from 0 to 7 with an average value of 2.2). The relative density of the granular soils encountered below 12.00m bgl generally increases with depth strength (with SPT N values ranging from 22 to 38 with an average value of 30.7).

Characteristic Values

Characterisation of the geotechnical parameters above has been undertaken to obtain characteristic values, which are a cautious estimate of the values affecting the occurrence of the limit state, taking into consideration typical minimum foundation depths for cohesive and granular soils.

Characteristic values for made ground are not presented due to the heterogeneity of the deposits and that they are not typically considered to be a suitable bearing stratum without some form of ground improvement.

The characteristic value for undrained shear strength (Cu) as determined from the depth vs Cu graph above for the cohesive Alluvium is 10kN/m^2 based on and average N value of 2.2.

The characteristic ϕ' value in the granular Thames Valley Gravels as determined from the depth vs ϕ' graph from 12.00m is interpreted to be 41° for Ultimate Limit State conditions.

Characteristic values are not presented for the chalk in this report as a deep piled foundation solution is not envisaged at this stage.

11.3 Foundations

General
With reference to Section 1.2, it is understood that Stirling Maynard are considering shallow foundation solutions for the proposed plant with pad foundations constructed on the existing ground bearing slabs. These are discussed below together with other options to limit settlements.

Bearing Capacity
Bearing capacity of the underlying very soft soils is anticipated to be low and likely to be in the order of 10-20 kN/m^2 subject to foundation size and depth etc. Data is limited however, in particular inside the process plant building and further investigation is recommended.

Punching shear of foundations through existing concrete slabs / asphalt is a concern as is bearing capacity failure and associated ground heave.

Indication of Settlement
BSL have undertaken the preliminary settlement calculations based on the anticipated loads provided by Stirling Maynard. The settlements discussed below are indicative only and cannot be relied upon or warrantied as the geotechnical data is limited.

Preliminary calculations indicate that the floor slab of the process plant building could experience total settlements in the order of 300mm based on a 20 kPa loading. Concrete pads 2m x 2m constructed on the existing slab with column loads up to 75 kN (18.75 kPa) could experience total settlements in the order of 50-100mm. Pads foundations of the same size constructed below the existing floor slab on the natural very soft clay at a depth of 2.00m could experience settlements in the order of 25-75mm.

With respect to the overhead conveyors with pairs of columns each with loads in the order of 75kN per column, based on 2.50m x 1.00m pads with an associated load of 60 kPa on the existing concrete ground slab, total settlements could be in the order of 200-400mm.

The IBA storage areas which will contain stacks in the order of 15m high are anticipated by Stirling Maynard to exert a ground pressure of 135 kPa. If these loads are transmitted to a reinforced concrete slab, bearing capacity failure is a significant risk together with excessive settlement (potentially in the order of 1500-2000mm).

Recommended Foundation Options
Foundation options for this site are considered to be a cost versus risk item, with the most robust solutions being of lowest risk but higher cost. The various options are discussed below:

1. Pad foundations constructed on the existing slabs – these are deemed the most cost-effective solution but are likely to experience high settlements. Bearing pressures would need to be kept low to avoid punching of the foundation through the existing floor slab or bearing capacity failure.

   If large concrete pads are considered likely to represent obstructions to plant etc in the process building, consideration could be given to use of steel plates to spread the load.

Pad foundations constructed below the existing floor slabs – settlements are anticipated to be high as indicated above. Should these be a concern, consideration could be given to the use of piled foundations, controlled modulus columns or dry soil mixing as detailed below.

Bearing capacities for pad foundations of 10-20 kPa are anticipated at this stage subject to further investigation in particular within the process building.

It would be prudent to allow for adjustment of columns to compensate for settlement.

2. Piled foundations – where high settlement cannot be tolerated, consideration should be given to the use of a piled foundation solution to transfer foundation loads into the medium dense to very dense sandy gravel and gravelly sand which was encountered from 12.00m. Driven precast concrete piles are likely to be the most cost effective solution, however, reference should be made to a specialist piling contractor to design and warranty a suitable system.

3. Ground improvement using controlled modulus columns, dry soil mixing or other specialist techniques. These are considered potentially suitable to improve the soil stiffness of the very soft alluvial clays, increase bearing capacity and reduce settlements. These techniques may be specifically of use in the IBA storage areas where high loads and associated large settlements are anticipated. Specialist ground improvement contractors should be contacted to discuss these options if required.

4. The use of geotextiles with an associated granular layer could also be considered to redistribute settlements in particular the IBA storage areas, however, total settlement is still likely to be in the order of those indicated above.

11.4 Floor Slabs & Ground Bearing Slabs

Data on the thickness and integrity of existing floor slabs is limited; as such it is recommended that coring and strength testing of the concrete is undertaken as required.

In general, however, floor / ground bearing slabs should be suitably designed to resist cracking associated with settlement.

Ground floor slabs should also be designed to incorporate any ground gas protections measures, where required.

11.5 Volume Change Potential

The clay soils on site are of medium to high volume change potential volume change potential. As such heave precautions should be incorporated in accordance with current guidance.

11.6 Site Preparation and Construction

Instability of excavations through the made ground and natural soils should be allowed for and reference made to CIRIA Report 97 ‘Trenching Practice’ and other appropriate guidance.

Recorded post site works groundwater levels ranged between 0.66m and 1.60m bgl and therefore will likely be encountered within likely excavation depths. As such, the contractor should allow for appropriate sump pumping / dewatering procedures.

11.7 Concrete Classification

The soluble sulphate and pH test results have been assessed in accordance with BRE Special Digest 1 "Concrete in aggressive ground" 2005. The Design Sulphate (DS) classification and the Aggressive Chemical Environment for Concrete (ACEC) classification are presented in the table below. For the purposes of this assessment, groundwater is considered to be mobile.

Stratum	No. Samples	Characteristic SO_4 (g/l)	Characteristic pH	DS Class	ACEC Class
Made Ground	5	1.515	7.60	DS-3	AC-3
Alluvium	5	1.825	7.70	DS-3	AC-3
Groundwater	3	1.59	7.10	DS-3	AC-3

Based on the above, the results of laboratory pH and sulphate content indicate that sulphate class DS-3 and ACEC Class AC-3 conditions prevail on the site in accordance with BRE Special Digest 1 "Concrete in aggressive ground" 2005.

11.8 Highways

Based on Table 5.1 from DMRB IAN 73/06 Rev 1 equilibrium CBR values are likely to be <2% within the made ground and natural very soft clays for pavement design purposes, unless proven otherwise by in-situ testing at formation level by a specialist geotechnical engineer.

Where the CBR is found to be less than 2%, the sub-grade is unlikely to be suitable for both the trafficking of site plant and as a permanent highway foundation without improvement of the soils.

To achieve the required design CBR value, improvement works should be carried out in accordance with DMRB IAN 73/06 Rev 1 Chapter 5 and may include proof rolling, excavation and re-engineering / replacement of weaker soils, the inclusion of a geogrid or use of stabilisation techniques such as the addition of hydraulic binders (e.g. cement/lime).

Where peat is encountered beneath proposed pavements it is recommended that this is removed to mitigate against settlement.

Based on the fines content of the soils, these are considered to be frost susceptible, therefore highway construction should be a minimum thickness of 450mm to mitigate against the risk.

Care should be taken to ensure the stratum at formation level is protected against inclement weather, as this is likely to lead to surface deterioration and a decrease in soils strengths.

11.9 Site Drainage

Given the site is underlain by low permeability clays with high groundwater, and is adjacent to the River Thames, it is unlikely that drainage to SuDS such as traditional soakaways will be suitable. It is considered that the existing drainage systems will likely be utilised on-site.

11.10 Further Work

The following further work is recommended:

- Further investigation to confirm bearing capacities, in particular inside the process plant building.
- Coring and testing of the existing floor flabs.
- Specialist flood risk advice should be sought.

9.0 ABBREVIATIONS AND DEFINITIONS

GLOSSARY	
Term / Abbreviation	**Definition**
AST	Above Ground Storage Tank.
B(a)P	Benzo (a) Pyrene.
BGS	British Geological Survey.
BRE	Building Research Establishment.
BS	British Standard.
BSL	Brownfield Solutions Ltd.
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes.
CBR	California Bearing Ratio (used in pavement/highways design).
CAR 2012	Control of Asbestos Regulations (2012).
CBCB	Cheshire Brine Compensation Board.
CBCD	Cheshire Brine Compensation District.
CBR	California Bearing Ratio.
CIEH	Chartered Institute of Environmental Health.
CIRIA	Construction Industry Research Association.
CL:AIRE	Contaminated Land: Applications in Real Environments.
CLEA	Contaminated Land Exposure Assessment.
CLO	Contaminated Land Officer.
COMAH	Control of Major Accident Hazards.
Contamination	Presence of a substance which is in, on or under land, and which has the potential to cause significant harm or to cause significant pollution of controlled water. There is no assumption in this definition that harm results from the presence of the contamination. Naturally enhanced concentrations of harmful substances can fall within this definition of contamination. Contamination may relate to soils, surface water, groundwater or ground gas.
Controlled Waters	Inland freshwater (any lake, pond or watercourse above the freshwater limit), water contained in underground strata and any coastal water between the limit of highest tide or the freshwater line to the three-mile limit of territorial waters.
CPT	Cone Penetration Test.
CSM	Conceptual Site Model. A schematic hypothesis of the nature and sources of contamination, potential migration pathways (including description of the ground and groundwater) and potential receptors, developed on the basis of the information from the preliminary investigation and refined during subsequent phases of investigation and which is an essential part of the risk assessment process. The conceptual site model is initially derived from the information obtained by the preliminary investigation (i.e. the Phase I Desk Study). This conceptual model is used to focus subsequent investigations, where these are considered to be necessary, in order to meet the objectives of the investigations and the risk assessment. The results of intrusive investigations can provide additional data that can be used to further refine the conceptual site model.
DCP	Dynamic Cone Penetrometer.
DNAPL	Dense Non-Aqueous Phase Liquid.
DoWCoP	Definition of Waste Code of Practice.
DWS	Drinking Water Standard.
EA	Environment Agency.
EHO	Environmental health Officer.
EQS	Environmental Quality Standard.

GLOSSARY	
Term / Abbreviation	**Definition**
GAC	Generic Assessment Criteria.
GDR	Geotechnical Design Report.
GFR	Geotechnical Feedback Report.
GIR	Ground Investigation Report.
GSV	Gas Screening Value.
Harm	Adverse effect on the health of living organisms, or other interference with ecological systems of which they form part, and, in the case of human health, including property/structures and water supply pipelines.
Hazard	Inherently dangerous quality of a substance, procedure or event.
HDPE	High Density Polyethylene.
HSV	Hand Shear Vane.
K	Modulus of Subgrade Reaction.
LCRM	Land Contamination: Risk Management (EA guidance).
LNAPL	Light Non-Aqueous Phase Liquid (petrol, diesel, kerosene).
LOD	Limit of Detection (for particular method adopted).
MMP	Materials Management Plan.
Mv	Modulus of Volume of Compressibility.
ND	Not Detected.
NHBC	National House Building Council.
NR	Not Recorded.
OS	Ordnance Survey.
PAH	Polycyclic Aromatic Hydrocarbon.
Pathway	Mechanism or route by which a contaminant comes into contact with, or otherwise affects, a receptor.
PCB	Poly-Chlorinated Biphenyl.
PCSM	Preliminary Conceptual Site Model.
pH	Scale used to specify how acidic or basic a water-based solution is.
PHC	Petroleum Hydrocarbons.
PID	Photo Ionisation Detector.
PNEC	Predicted No-Effect Concentration.
Precision	Level of agreement within a series of measurements of a parameter.
PSD	Particle Size Distribution.
PVC	Polyvinyl Chloride.
Receptor	Human health, living organisms, ecological systems, controlled waters (surface waters and groundwater within aquifers), atmosphere, structures and utilities that could potentially be adversely affected by contaminant(s).
Risk	Probability of the occurrence, magnitude and consequences of an unwanted adverse effect on a receptor.
Risk Assessment	Process of establishing, to the extent possible, the existence, nature and significance of risk.
Sampling	Methods and techniques used to obtain a representative sample of the material under investigation.
SOM	Soil Organic Matter.
Source	Location from which contamination is, or was, derived. This could possibly be the location of the highest soil, groundwater or gas concentration of the contaminant(s).
SPT	Standard Penetration Test.
SVOCs	Semi Volatile Organic Compounds.
TOC	Total Organic Carbon.

GLOSSARY	
Term / Abbreviation	**Definition**
TPH CWG	Total Petroleum Hydrocarbon (Criteria Working Group).
TVOCs	Total volatile organic compounds.
UCS	Unconfined Compressive Strength.
Uncertainty	Parameter, associated with the result of a measurement that characterises the dispersion of the values that could reasonably be attributed to the measurement.
UST	Underground Storage Tank.
UXO	Unexploded Ordnance.
VCCs	Vibro Concrete Columns.
VSCs	Vibro Stone Columns
VOCs	Volatile Organic Compounds.
WAC	Waste Assessment Criteria.
WFD (in waste context)	Waste Framework Directive.
WFD (in water context)	Water Framework Directive.
Units	**Definition**
°	Degrees
Φ	Phi angle (in degrees)
g/l	Grams per Litre
Km	Kilometres
kPa	Kilo Pascal (Equivalent to kN/m^2)
$KN/m^2/mm$	Kilo Newton per metered squared per millimeter
kN/m^2	Kilo Newtons per metre squared
kPa	Kilo Pascal (Equivalent to kN/m^2)
l/hr	Litres per hour
MJ/kg	Mega joule per kilogram
MN	Mega Newton
M^2/MN	Mega Newton per metre squared
M	Metres
m bgl	Metres Below Ground Level
m OD	Metres Ordnance Datum (sea level)
µg/l	Micrograms per Litre (parts per billion)
µm	Micrometre
mb	Millibars (atmospheric pressure)
mg/kg	Milligrams per kilogram (parts per million)
mg/m^3	Milligram per metre cubed
mm	Millimetre
ppb	Parts Per Billion
Ppm	Parts Per Million

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DRAWINGS

REV	DATE	DESCRIPTION	DRW	CHK
P01	12.12.22	Issued For Comment	SA	RME
P02	14.12.22	Updated to Clients comments	SA	RME

KEY

Site Boundary

Client
BLUE PHOENIX

Project Title
REDEVELOPMENT OF TILBURY DOCK SITE

Drawing Title
SCHEMATIC LAYOUT

Job No.	Originator	Zone	Level	Type	Role
P22161	SMCE	ZZ	XX	DR	C

Drawing No. 0100 — Revision P02

Drawn	Checked	Date	Scale	Size
SA	RME	06.12.22	1:1000	A1

Purpose Of Issue: FOR COMMENT — Status: S3

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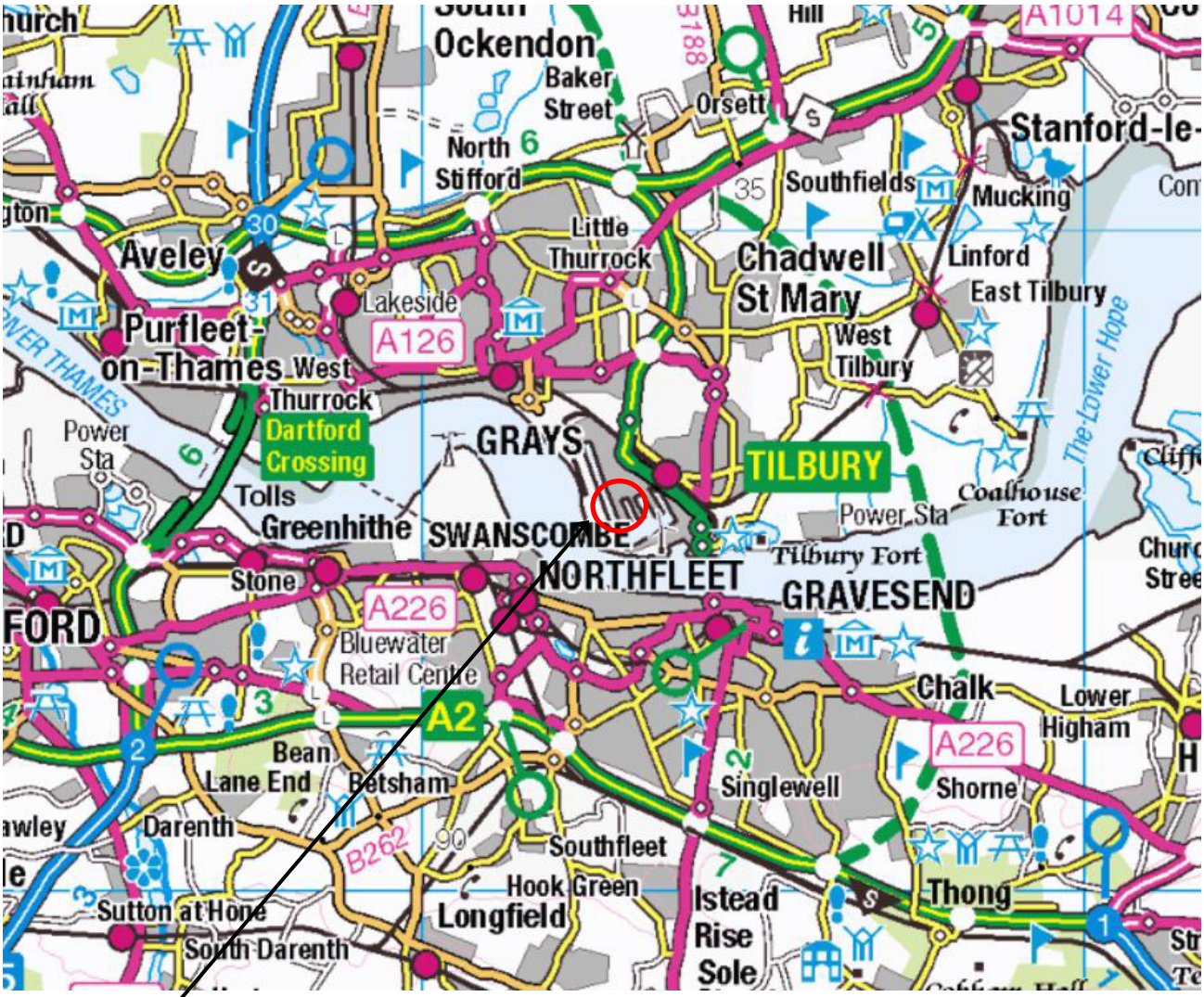
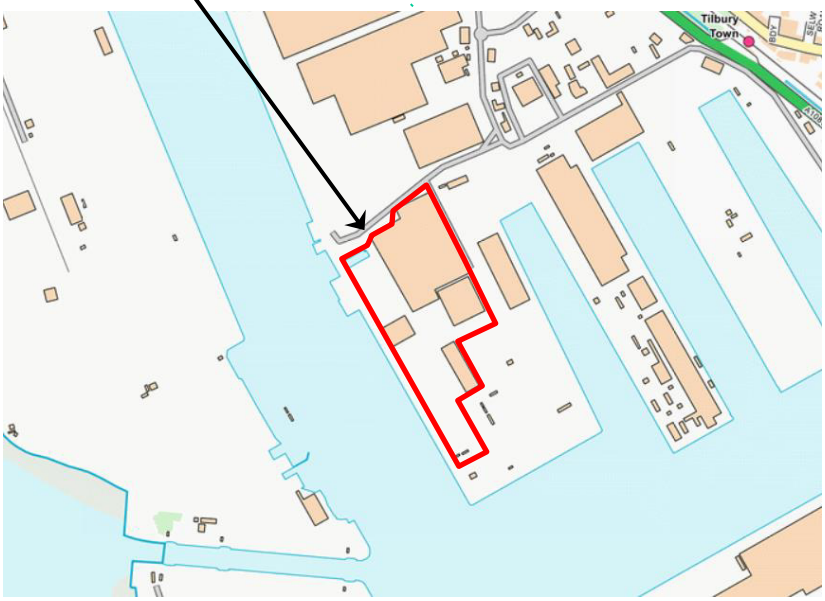


SITE LOCATION

NEAREST POSTCODE: RM18 7HA

SITE ENTRANCE WHAT3WORDS: ///BRIGHT.SIZES.LANES



REV	DATE	DESCRIPTION	BY	CKD

BROWNFIELD SOLUTIONS LTD
GEO-ENVIRONMENTAL ENGINEERING EXCELLENCE

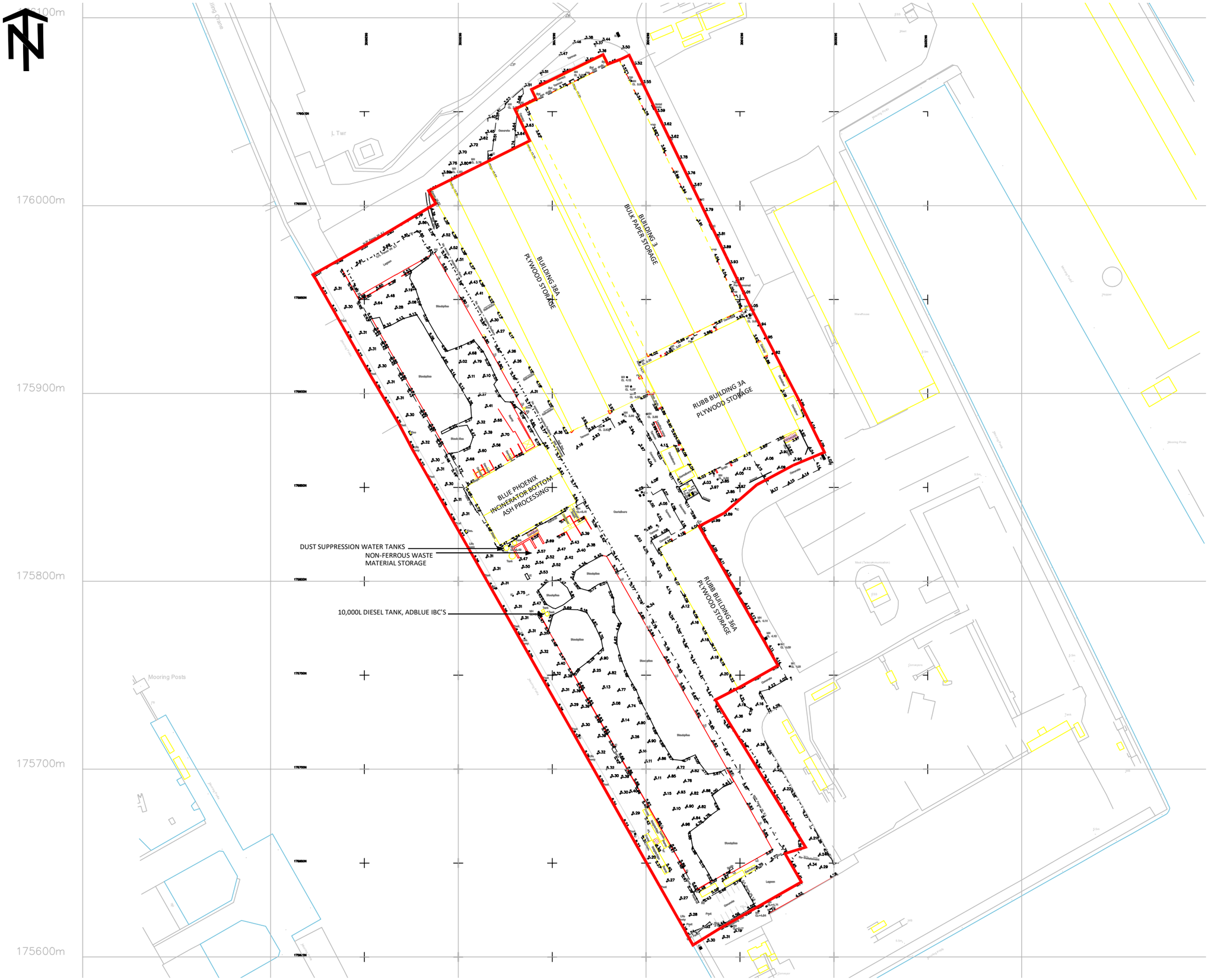
CLIENT
BLUE PHOENIX

PROJECT TITLE
TILBURY DOCKS, ESSEX

DRAWING TITLE
SITE LOCATION PLAN

DRAWING No.	REVISION	SCALE	DATE
C5441/01	-	NTS	04/07/23

DRAWN BY	CHECKED BY
SD	JW



KEY

APPROXIMATE SITE BOUNDARY

NOTES

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REV	DATE	DESCRIPTION	BY	CKD

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BLUE PHOENIX

PROJECT TITLE

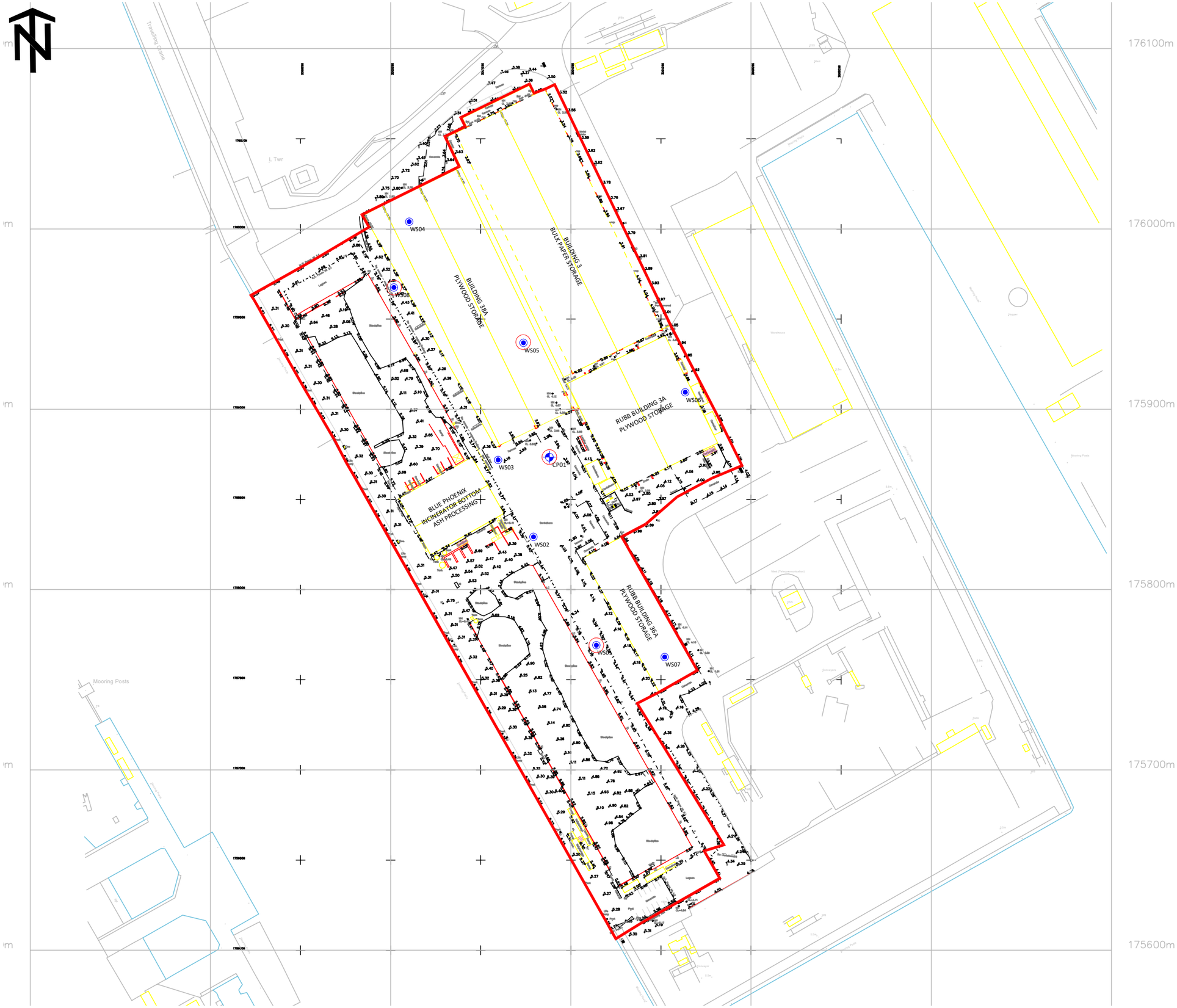
TILBURY DOCKS, ESSEX

DRAWING TITLE

SITE FEATURES PLAN

DRAWING No.	REVISION	SCALE	DATE
C5441/02	-	NTS	17/07/23

DRAWN BY	CHECKED BY
JW	XXX



KEY

- APPROXIMATE SITE BOUNDARY
- WSXX WINDOW SAMPLE BOREHOLE
- BHXX CABLE PERCUSSIVE BOREHOLE
- BOREHOLE INSTALLATION

NOTES

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REV	DATE	DESCRIPTION	BY	CKD

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CLIENT

BLUE PHOENIX

PROJECT TITLE

TILBURY DOCKS, ESSEX

DRAWING TITLE

EXPLORATORY HOLE LOCATION PLAN

DRAWING No.	REVISION	SCALE	DATE
C5441/03	-	NTS	08/11/23

DRAWN BY	CHECKED BY
LN	DRAFT

APPENDIX A

BSL Methodology and Guidance

BSL Phase I & II Geo-Environmental Assessment Reports - Methodology and Guidance

Background

This Appendix provides information on the approaches, methods and guidance used by Brownfield Solutions Ltd in the preparation of this report.

The term 'geo-environmental' is used to describe aspects relating to ground-related environmental issues (such as potential soils and groundwater contamination). The term 'geotechnical' is used to describe aspects relating to the physical nature of the site (such as foundation requirements). It should be noted that this is an integrated investigation and these two main aspects are related, unless otherwise specified within the report.

Phase I reports are written in general accordance with the description of a Preliminary Investigation as defined in BS10175:2011+A2:2017 and are also produced in general accordance with the recommendations for a Tier 1 Preliminary Risk Assessment as described in LCRM guidance.

The first stage of the investigation and assessment of a site is the Preliminary Investigation/Tier 1 Preliminary Risk Assessment, often referred to as a Phase 1 Desk Study, comprising a desk study and walk-over survey and collation of desk-based searches, which culminates in the Preliminary Risk Assessment and the development of a preliminary/initial **Conceptual Site Model (CSM)**. From this are identified any potential geotechnical and geo-environmental hazards and the qualitative degree of risk associated with them. In the case of the geotechnical hazard identification, this is referred to as the **Ground Model.**

From the geo-environmental perspective, the hazard Identification process uses professional judgement to evaluate all the hazards in terms of possible contaminant linkages (of source-pathway-receptor). Possible contaminant linkages are potentially unacceptable risks in terms of the current contaminated land regime legal framework and require either remediation or further assessment. These are normally addressed via intrusive ground investigation and generic risk assessment as part of Phase II investigations and reports.

The second stage is the Ground Investigation, Generic Risk Assessment and Geotechnical Interpretation. This represents the further assessment mentioned above. The Ground Investigation comprises field work and laboratory testing based on the findings of the Preliminary Risk Assessment, to reduce uncertainty in the geotechnical and geo-environmental hazard identification. This may include an exploratory, a detailed or/and supplementary Investigations as described in BS 10175:2011+A2:2017. Phase II Assessments are produced in general accordance with the recommendations for a Tier 2 Generic Quantitative Risk Assessment as described in LCRM guidance and are also intended to fulfil the requirements of a Ground Investigation Report (GIR) as detailed in BS EN 1997-2:2007.

Contaminated Land - Legislative Background

Land contamination can be addressed in several ways, e.g. during planning, under Part 2A, following an incident, during an investigation into environmental damages, or during the application of an environmental permit, or its surrender.

For the planning process the key test is **as a minimum the site cannot be determined as contaminated land**, e.g. there is not significant harm, significant possibility of significant harm to human health or that there is not significant harm to, or the significant possibility that the pollution of controlled waters will occur.

Environmental liabilities and risks have been evaluated in terms of a source -pathway - target relationship in accordance with the approach set out in:

- The 1995 Environment Act.
- The Contaminated Land Statutory Guidance, DEFRA – April 2012.
- The Contaminated Land (England) Regulations 2006.
- The Contaminated Land (England) Amendment Regulations 2012.
- Water Resources Act.
- Water Framework Directive.
- Environmental Damage Regulations.
- Environment Agency (EA) - Land Contamination Risk Management (LCRM) 2019.

Contaminated land is defined within the legislative framework as land which is in such condition by reason of substances in, on or under the land that:

1) Significant harm is being caused or there is a significant possibility of such harm being caused.
2) Significant pollution of controlled waters is being or is likely to be caused.

The potential for harm is based on the presence of three factors:

Source - substances that are potential contaminants or pollutants that may cause harm.
Pathway - a potential route by which contaminants can move from the source to the receptor, and the impact of that migration on the source e.g. attenuation.
Receptor - a receptor that may be harmed, for example the water environment, humans and water, considering the sensitivity of the receptor.

Where a source, pathway and target are all present a pollutant linkage exists and there is potential for harm to be caused.

Where any one of the “pollution linkages” between the above is absent there is deemed to be no risk.

The presence of a source does not automatically imply that a contamination problem exists, since contamination must be defined in terms of pollutant linkages and unacceptable risk of harm. The nature and importance of both pathways and receptors are site specific and will vary according to the intended end use of the site, its characteristics and its surroundings.

The key principle which supports the S-P-R approach is ‘suitable for use’ criteria. This requires remedial action only where contamination is considered to pose unacceptable actual or potential risks to health or the environment and, taking into account the proposed use of the site.

Relevant Guidance Documents
This report has been prepared in accordance with the list of guidance below, however the list is not exhaustive:

- DETR: Circular 02/2000: Environmental Protection Act 1990: Part IIA: Contaminated land. 2012.
- Environment Agency technical advice to third parties on Pollution of Controlled Waters for Part IIA of the EPA1990, May 2002.
- BS 10175:2011+A2:2017.
- Environment Agency (EA) - Land Contamination Risk Management (LCRM). 2019.
- Groundwater Protection https://www.gov.uk/government/collections/groundwater-protection
- UK Technical Advisory Group (UKTAG) - Water Framework Directive
- Incidents and their classification: the Common Incident Classification Scheme (CICS) – Used by the Environment Agency to classify pollution incidents.

Relevant Legislative Documents
The following is a non-exhaustive list of legislative framework documents that has been considered in the production of this report:

- The Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance (2012).
- The Environment Protection Act (1990).
- The Water Resources Act (1991).
- The Environment Act (1995).
- The Contaminated Land (England) Act (2000).
- The Pollution Prevention and Control (England and Wales) Regulations (2000).
- The Landfill Regulations (England and Wales) Regulations (2002).
- The Landfill (England and Wales) (Amendment) Regulations (2004).
- Contaminated Land (England) Regulations (2012).
- The Environmental Damage (Prevention and Remediation) Regulations (2009).
- Environmental Permitting Regulations (England and Wales) Regulations (2010).
- The Water Environment (Water Framework Directive) (England and Wales) Regulations (2017).
- Health and Safety at Work Act.
- National Planning Policy Framework (NPPF) – latest version.

Contaminated Land Risk Assessment Approach

Contaminated Land Risk Assessment is a technique that identifies and considers the associated risk, determines whether the risks are significant and whether action needs to be taken. The four main stages of risk assessment are:

LCRM outlines the framework to be followed for risk assessment in the UK. The framework is designed to be consistent with UK legislation and policies including planning. The starting point of the risk assessment is to identify the context of the problem and the objectives of the process. Under LCRM, three tiers of risk assessment exist – Stage/Tier Preliminary Risk Assessment, Stage 2 Generic Quantitative and Stage 3 Detailed Quantitative.

Further information can be found at the below site:
https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm

Formulating and developing a conceptual model for the site is an important requirement of risk assessment, this supports the identification and assessment of pollutant linkages. Development of the conceptual model forms the main part of preliminary risk assessment, and the model is subsequently refined or revised as more information and understanding is obtained through the risk assessment process.

Risk is a combination of the likelihood of an event occurring and the magnitude of its consequences. Therefore, both the likelihood and the consequences of an event must be taken into account when assessing risk.

The risk assessment process needs to take into account the degree of confidence required in decisions. Identification of uncertainties is an essential step in risk assessment.

The likelihood of an event is classified on a four-point system using the following terms and definitions from CIRIA C552, with reference to Incidents and their classification: the Common Incident Classification Scheme (CICS), Environmental Protection Act 1990: Part 2A – Contaminated Land Statutory Guidance 2012 and other guidance as appropriate which will be detailed within the main body of the report if applied.

The likelihood of a given receptor being impacted is related to a number of factors, e.g. the geology which could inhibit contaminant migration. For example, a site with a significant thickness of clay between it and a receptor may reduce migration of contamination via the subsurface, which will reduce the likelihood of a given receptor being impacted. The geology or drainage for example could offer a preferential pathway e.g. mines shafts/faults increasing the likelihood and potential magnitude of an impact. The depth of contamination will also affect the exposure pathway, for example petroleum hydrocarbons at depth are unlikely to reach a receptor via dermal contact but could via vapour pathways which will influence the likelihood of an impact being felt e.g. if there are no buildings on site.

The terms and definitions used for the assessment of the likelihood are provided below:

High likelihood: There is a pollution linkage and an event appears very likely in the short term and almost inevitable over the long term, or there is evidence at the receptor of harm or pollution.
Examples - Extensive areas with concentrations above saturation limits for mobile contamination e.g. petroleum hydrocarbons within the water table.

Likely: There is a pollution linkage and all the elements are present and in the right place, which means it is probable that an event will occur. Circumstances are such that the event is not inevitable, but possible in the short term and likely over the long term.
Examples – Localised areas of contaminants with concentrations above saturation limits for mobile contamination e.g. localised petroleum hydrocarbons within the water table; shallow contamination above relevant human health generic assessment criteria is present with little or no hardstanding,

Low likelihood: There is a pollution linkage and circumstances are possible under which an event could occur. However, it is by no means certain even over a longer period such event would take place, and is less likely in the short term.
Examples - A thickness/distance of low permeability deposits preventing contaminant migration to a receptor is present; a site is mostly covered hard standing preventing exposure to soil contamination.

Unlikely: There is a pollution linkage but circumstances are such that it is improbable the event would occur even in the long term.
Examples – A site is underlain by a substantial thickness of low permeability clays, between the source and potential receptors which will inhibit significantly, but not completely rule out migration to sensitive receptors.

The severity is also classified using a system based on CIRIA C552, with reference to Incidents and their classification: the Common Incident Classification Scheme (CICS), Environmental Protection Act 1990: Part 2A – Contaminated Land Statutory Guidance 2012 and other guidance as appropriate which will be detailed within the main body of the report, if applied. The terms and definitions are:

Severe: Short term (acute) risk to human health likely to result in 'significant harm' as defined by the Environment Protection Act 1990, Part IIA. Short-term risk of pollution of sensitive water resources. Catastrophic damage to buildings or property. A short-term risk to a particular ecosystem or organism forming part of that ecosystem (note definition of ecosystem in 'Draft Circular on Contaminated Land', DETR 2000);

Examples – High concentrations of contaminant on surface of recreation area, major spillage of contaminants from site into controlled waters, explosion causing building to collapse.

Medium: Chronic damage to human health ('significant harm' as defined in DETR 2000). Pollution of sensitive water resources. A significant change in a particular ecosystem or organism forming part of that ecosystem (note definition of ecosystem in 'Draft Circular on Contaminated Land', DETR 2000);
Examples - Concentrations of contaminants exceed the generic assessment criteria, leaching of contaminants from a site to a Principal or Secondary Aquifer, death of species within a designated nature reserve.

Mild: Pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services ('significant harm' as defined in 'Draft Circular on Contaminated Land', DETR 2000). Damage to sensitive buildings, structures, services or the environment.
Examples – Pollution of non-classified groundwater or damage to buildings rendering it unsafe to occupy.

Minor: harm, not necessarily significant harm, which may result in financial loss or expenditure to resolve. Non-permanent health effects to human health (easily prevented by use of personal protective clothing etc). Easily repairable effects of damage to buildings, structures and services.
Examples – Presence of contaminants at such concentrations PPE is required during site work, loss of plants in landscaping scheme or discolouration of concrete.

Once the likelihood and severity have been determined, a risk category can be assigned using the table below.

		Consequences			
		Severe	Medium	Mild	Minor
Probability	Highly likely	Very high	High	Moderate	Moderate/low
	Likely	High	Moderate	Moderate/low	Low
	Low likelihood	Moderate	Moderate/low	Low	Very low
	Unlikely	Moderate/low	Low	Very Low	Very low
	Negligible	Negligible Risk / No Linkage			

Definitions of the risk categories obtained from the above table are as follows together with an assessment of the further work that might be required:

Very high: There is a high probability that severe harm could arise to a designated receptor from an identified hazard or there is evidence that severe harm is currently happening. This risk, if realised, could result in substantial liability. Urgent investigation and remediation are likely to be required.

High: Harm is likely to arise to a designated receptor from an identified hazard. Realisation of the risk is likely to present a substantial liability. Urgent investigation is required and remedial works may be necessary in the short term and are likely over the longer term.

Moderate: It is possible that harm could arise to a designated receptor from an identified hazard. However, it is either relatively unlikely that any such harm would be severe, or if any harm were to occur it would be more likely to be relatively mild. Investigation is normally required to clarify the risk and determine the liability. Some remedial works may be required in the longer term.

Low: It is possible that harm could arise to a designated receptor from an identified hazard, but it is likely that this harm, if realised, would at worst normally be mild.

Very Low: There is a low possibility that harm could arise to a receptor. In the event of such harm being realised, it is not likely to be severe.

Some linkages may be identified which constitutes a theoretical connection between a source and a receptor, but professional judgement shows them not to be possible for some reason. These are labelled 'negligible risk' and 'no linkage' in the summary table, which give rise to an overall **negligible** risk category and no further action is required.

Contaminated Land Screening Values

In assessing the potential for contamination Brownfield Solutions Limited (BSL) follows UK guidance and current best practice.

General
The purpose of using generic Tier 1 screening levels is to have a simple means of assessing the potential contamination of a site and to inform decisions on whether further investigation is warranted or whether an option to undertake remedial action based on the data to hand is cost effective.

Human Health
Current UK guidance on risks to human health is provided by DEFRA and the Environment Agency (EA). Under the land use planning system where the aim is to demonstrate 'suitability for use' the key will usually be to confidently determine that the level of contamination of the land is low relative to some appropriate measure of risk at a particular critical connection.

Publications forming part of the guidance include the CLEA Model and toxicological reports collectively referred to as the CLEA Guidance. The CLEA Guidance has included a number of publications which have provided initial screening values or Generic Assessment Criteria (GACs) for soils contamination based on standard land uses and soil assumptions. The critical concentrations referred to above can be the relevant GAC.

CLEA guidance has gone through a number of revisions over time. Tier 1 generic S4UL values (or GACs) have been published using the CLEA 1.06 Model by CIEH/LQM. These are the third set of generic assessment criteria generated by CIEH and replace the previous two sets of GACs. The revised S4UL values are based on greater knowledge of relevant toxicology and further consideration of exposure frequencies.

C4SL values for six determinands including lead were published by DEFRA/CL:AIRE in December 2014. Additional determinands were added in 2021. They represent a low risk as opposed to minimal risk, however they are still strongly precautionary. These screening values were published by DEFRA for Part 2A use, although DEFRA have also confirmed acceptability for use under planning. However, S4ULs remain the first reference point for BSL due to the broader range of end uses scenarios and the availability of a wide array of determinands with various soil organic contents.

As part of Tier 1 assessments, the following data sources are used in the order of preference given below, unless further justification is provided to adopt less conservative criteria:

- CIEH S4UL values (derived by CIEH/LQM).
- DEFRA/CL:AIRE C4SL's https://www.claire.co.uk/projects-and-initiatives/category-4-screening-levels
- CL:AIRE GAC values.
- Guidance from other European countries.
- Guidance from the outside Europe.

Dependent on requirements, test results may be divided into representative data sets for assessment against the above referenced screening criteria, based on the conceptual model and taking into account such characteristics as variation in soil properties, historical, existing or proposed land uses. The soils in these areas are considered likely to form the ground cover in critical receptor areas (e.g. gardens, soft landscaping etc)

where pathways may exist. The critical part of the soil column is typically taken as the upper metre in terms of contact with end users of a development site for the purposes of initial assessment.

The screening criteria adopted by BSL are presented overleaf.

Further Assessment
When screening values are exceeded then further consideration is required. This could include further additional detailed investigation and assessment to further define the risk or to design appropriate remedial measures to either remove the source or break the pathway. In some cases, dependant on the Conceptual Site Model (CSM), no action may be required.

PAHs and B(a)P as a Surrogate Marker for Adoption of C4SLs
As stated above, S4ULs remain the first reference point as screening levels unless further justification is provided. In order to determine if the C4SL can be adopted, benzo(a)pyrene (B(a)P), the following guidance within SP1010 Appendix E for B(a)P and Public Heath England (PHE) may be adopted with our assessments where appropriate.

Guidance states that benzo(a)pyrene is considered to be one of the most potent PAHs, and it would be appropriate to assume the cancer risk in a mixture is proportional to the concentration of a surrogate marker PAH (benzo(a)pyrene) in the mixture. The ratio of PAHs within the mixture can be assessed to ensure that the profile is similar to that seen for the test material (coal tar mixtures) in the toxicological study by Culp et al. The International Programme on Chemical Safety (IPCS) considered that the PAH profile of the soil sample may deviate from the average profile by about an order of magnitude (up or down).

A more recent study by Bull et al (2013) which analysed PAH concentrations in soil samples from 274 sites, showed that the levels of PAH relative to B(a)P showed little variability and were similar to that recorded for the coal tar mix used in the Culp et al study. Given this, it was concluded that benzo(a)pyrene is a suitable surrogate marker to represent mixtures of PAH in soil.

In order to risk assess the PAH mixture for site specific soil samples using human health guideline values, notably the C4SLs, as detailed in SP10101 the ratio of the seven genotoxic PAHs as shown below, relative to B(a)P, should be calculated to ensure it is similar to the test material used in the Culp study (PHE 2010). To be considered sufficiently similar, the ratio relative to B(a)P should fit within the upper and lower limits (representing an order of magnitude above and below the mean ratio to B(a)P of test material used in the Culp et al study). In such cases B(a)P is considered an adequate surrogate marker and the Low Level of Toxicological concern (LLTC) for B(a)P (i.e., the C4SL) may be used in the risk assessment.

Statistical Analysis on Soils
Guidance on the use of statistics is taken from the CL:AIRE publication "Comparing Soil Contamination Data with a Critical Concentration" 2020, the basis of which in statistics is termed Central Limit Theorem (CLT), which says "*The distribution of sample means converges to a normal distribution as the sample size increases*".

If the critical concentrations have been exceeded, as part of a further assessment, statistical analysis may be undertaken on a dataset to demonstrate that the mean concentration on the site (or a particular area) is actually below the critical concentration. The true mean concentration of a contaminant is never known because all the site soil has not been tested. An estimation of the true mean can be obtained from the samples tested during the investigation. The greater the number of samples tested, the closer the mean of these values is to the true mean.

As discussed above, test results are typically divided into representative data sets for assessment and may be referred to as 'averaging areas' to which statistics can be applied, although several statements need to be satisfied before applying the guidance:

- Averaging areas have been defined based on the CSM.
- Sample locations – random/grid sampling adopted as opposed to targeted investigation.
- Samples are evenly spread and not clustered.

- Analysis do not suggest a hotspot/outlier or cluster established by histogram or other means.
- Samples are of same/similar depth and taken from one population (e.g. just topsoil).
- Analyses do not show a spatial trend or other spatial pattern across that zone.
- The number of samples has been shown to be sufficient for statistical analysis.

Once the above have been satisfied, when undertaking statistical analysis, the question "*are mean soil concentrations within the averaging area equal to, or greater than, the GAC*?" is being asked. Typically, outliers or "hotspots" are treated as separate zones or averaging areas. The sampling strategy and assessment should also take into account uncertainty (for example, spatial heterogeneity) in contaminant concentrations. There is the assumption that sampling was random or stratified and systematic (e.g. on a grid) and not targeted at specific sources; data from such targeted areas should be omitted from the statistical analysis. Data should be from one population (i.e. the same materials).

The statistical test that is carried out is used to demonstrate that there is a certain probability that the true mean falls below the critical concentration (typically the GAC in a screening exercise). The main tool used to draw conclusions based on the 2020 guidance is a comparison of a 2-way confidence interval with the critical concentration. A confidence interval consists of two sets of numbers; an interval i.e. a range of values plus a pre-determined level of confidence e.g. 80%. A common interpretation of a confidence interval of say 80% is that "*there is an 80% chance that the true mean concentration level of the contaminant in a sampling zone lies between X concentration and Y concentration*".

The current guidance for planning says that the site has to be "safe" which suggests we should use a large confidence interval such as 95% or higher to make a decision. This means that there is a 95% chance of the true mean concentration lying in this interval, there is also a 5% chance it lies outside this interval. One could then conclude that the requirements of planning have been met if the 95% confidence interval lies below the critical concentration.

The guidance recommends that at least two confidence levels are used such as 90% and 99% or 80% and 95%. By using two differing confidence intervals, we can use the smaller confidence interval (e.g. 80% confidence interval) to say "*we think the mean is most likely to be inside this range*" and the larger confidence interval (e.g. 95% confidence interval) to say "*we think the mean is most unlikely to be outside this range*".

If the confidence interval extends to above the critical concentration, then further action may be required.

Controlled Waters

The European Water Framework Directive (WFD) became UK law in December 2003. It was created to ensure that European countries manage their rivers, groundwater and lakes so that they stay healthy for people and for wildlife.

This is achieved by the use of chemical standards (Water Quality Targets – WQTs) for surface waters and groundwater. These values describe concentrations of chemicals that are not expected to cause harm to environmental organisms or human health, provided they are not exceeded. The same chemical may have several standards for different environmental regimes, and for different protection objectives.

Statutory Standards are set in legislation and if exceeded, this constitutes non-compliance with statutory obligations. European Directives are implemented in England and Wales by corresponding statutory instruments (i.e. regulations- The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 and The Private Water Supplies (England) Regulations 2016. SI 2016 / 618). In Scotland, the Public Water Supplies (Scotland) Regulations 2014 apply. The statutory instruments can be the exact same standards as they appear in the Directive or be more stringent.

A number of non-statutory standards also exist, these are set by various organisations (including the EA) for chemicals that are considered to be of concern, but are not covered by any specific legislation.

The chemical standards used in the UK to control impaction of contamination on controlled waters are Environmental Quality Standards (EQS). These cover a large number of compounds. EQS are available for inland surface waters (freshwater) and other surface waters (transitional and marine).

Several EQS are based on bioavailable metal proportions (i.e. copper, lead, manganese, nickel and zinc). A software tool (M-BAT) is available from the Water Framework Directive - UK TAG website for calculating the bioavailable fraction. Where this tool has been used, the bioavailability has been taken into account by calculating site-specific $PNEC_{dissolved}$ (Predicted No Effect Concentration) values. These enable the dissolved concentration data to be compared with the PNEC as if it were an EQS.

UK Drinking Water Standards (DWS) apply to waters abstracted for human consumption. Where no UK or EU drinking water standard exists, reference is made to the World Health Organisation criteria (2011).

The DWS apply to groundwater or to surface water used for abstraction and the EQS apply to surface water where the aquatic ecosystem is the receptor. Where the most appropriate water quality target cannot be determined with certainty, the lowest one is adopted in line with the precautionary principle.

In some instances, the laboratory detection limits (LODs) may be greater than the water quality target it is being screened against, but it should be noted that these comparisons are an initial screening assessment. It may be the case that lower LODs could be obtained using a more specialised technique, but it would be disproportionately expensive to adopt the more costly specialist technique for initial screening exercises.

The preference of BSL is to have testing carried out on actual samples of ground/surface water rather than theoretical values obtained from leachate testing, which is considered to often be highly conservative. Data from water samples obtained or from leachate analysis is then compared against the screening criteria adopted by BSL, which are presented overleaf.

When screening values are exceeded then further consideration is required. This could include further additional detailed investigation and detailed quantitative risk assessment (DQRA) to further define the risk or to design appropriate remedial measures to either remove the source or break the pathway.

Ground Gas Risk Assessment

BS8485:2015+A1:2019, BS 8576:2013, CL:AIRE RB17, and NHBC 'Hazardous Ground Gas - An essential guide for housebuilders' 2023, are the current guidance which gives up-to-date advice on all aspects of permanent ground gas risk. BS8576 alongside CIRIA C682 also provides guidance on assessment of hydrocarbon vapour intrusion.

The CL:AIRE publication 'Good Practice for Coal Mine Gas Emissions" 2021 provides guidance on the assessment of risks from mine gas sources.

The above all outline good practice in investigation, the collection of relevant data and monitoring programmes in a risk-based approach to ground gas contamination. The aim of the guidance is for a consistent approach to decision making, particularly relating to the scope of protective design measures on a site-specific basis.

Legislative Framework
BS8485:2015+A1:2019, BS 8576:2013 and CIRIA C665 provides technical guidance, however they also recognise the context into which the guidance has to be employed. Government policy is based upon a "suitable for use approach", which is relevant to both the current and proposed future use of land. When considering the current use of land, Part IIA of the Environment Protection Act 1990 provides the regulatory regime. The presence of hazardous ground gases could provide the "source" in a "pollutant linkage" which could lead the regulator to determine that considerable harm or there is a significant possibility of such harm being caused. Under such circumstances, the regulator would determine the land to be "contaminated land" under the provisions of the Act, setting out the process of remediation as described in the DETR Circular 02/2000 *Statutory guidance on contaminated land.*

Generation Potential of Sources

BS 8576:2013 Figure 6 provides a basis for assessing the generation potential from sources identified as part of the Phase I Assessment. These are summarised below:

Generation Potential	Typical Sources
Very Low	• Natural carbonate soil and strata, e.g. chalk and limestone. • Natural soil strata with a low degradable organic content, e.g. alluvium, peat. • In-filled pond less than 15 m diameter, in-filled before 1930s to 1940s. • Made ground with low degradable organic content (e.g. up to 5% organic material such as pieces of wood, pieces of paper, rags, etc. with a high proportion of ash and no food or other easily degradable waste). • Mine workings shallow or shaft (where there is clear evidence that they are flooded). • Inert landfill sites (and pre -1945 landfills).
Low	• Natural soil strata with a high degradable organic content (DOC). • Made ground with total organic carbon (TOC) up to 6% (e.g. dock silt, no food or other easily degradable waste). • Foundry sand (includes phenolic binders, rags and wood that decay, albeit at low rates). • Landfill 1945 to mid 1960s (see also Moderate below).
Moderate	• Sewage sludge. • Mine workings – unflooded, more than 50 years since last worked (gas is liberated from coal when mine workings are excavated; this continues for up to about 50 years). • Landfill 1945 to mid 1960s (this could also be “low” or, if disturbed, “high”).
High	• Landfill mid 1960s to early 1990s. • Mine workings – unflooded – less than 50 years since last worked.
Very High	• Municipal landfill sites. • Landfill early 1990s onward.

Frequency and Duration of Monitoring

BS8576 notes to determine where and how to monitor ground gases requires consideration of credible pathways of possible exposure of the receptors, taking into account what is known about the geology and hydrogeology, building construction and services layout, foreseeable events such as flooding, changes in groundwater level, climate change, extreme weather conditions, the closure of mines, and possible changes to the gas regime caused by future development.

The monitoring period for a specific site should cover the “worst case” scenario. A “worst case” scenario will typically occur during falling atmospheric pressure and, in particular, weather conditions such as rainfall, frost and dry weather.

The benefits of additional information and whether it is likely to change the scope of gas protection should be considered, as are the consequences of failing to characterise adequately pollutant linkages. Investigations concerned with ground gas are required to provide monitoring data sufficient to allow prediction of worst case conditions enabling the confident assessment of risk and subsequent design of appropriate gas protection schemes. Monitoring programmes should not be an academic exercise in data collection. CL:AIRE publication TB17 “Ground Gas Monitoring and ‘Worst-Case’ Conditions” provides further guidance.

Below are matrices that will aid in determining an appropriate number of gas monitoring visits and the length of monitoring period.

Typical/idealised periods of monitoring

		Generation of Potential Source				
		Very Low	Low	Moderate	High	Very High
Sensitivity of Development	Low (Commercial)	1 month	2 months	3 months	6 months	12 months
	Moderate (Apartments)	2 months	3 months	6 months	12 months	24 months
	High (Low rise Residential)	3 months	6 months	6 months	12 months	24 months

Typical/idealised frequency of monitoring/Number of Visits Required

		Gas Generation of Potential Source				
		Very Low	Low	Moderate	High	Very High
Sensitivity of Development	Low (Commercial)	4	6	6	12	12
	Moderate (Apartments)	6	6	9	12	24
	High (Low rise Residential)	6	9	12	24	24

Notes

1 Generation potential of sources based on descriptions within BS 8576:2013.

2 At least two sets of readings should be at low and falling atmospheric pressure (but not restricted to periods below <1000 mb) known as worst case conditions. Historical data can be used as part of the data set (Table 5.5b).

It is recommended that newly installed monitoring wells are left for 24 hours to allow the soil gas to reach equilibrium. It should be recognised, however, that some soil gas regimes could take considerably longer (up to seven days). Interpretation of any initial readings should take this equilibrium process into account.

Gas Risk Assessment

Within BS8485:2015+A1:2019 a semi-quantitative method is set out for the assessment of risk.

This method (Modified Wilson and Card) uses the concept of Gas Screening Values (GSVs) and typical threshold concentrations of carbon dioxide and methane to identify levels of risk. Sites are then classified into a 'Characteristic Situation' or 'CS' from CS1 where no mitigation is required and CS2 increasing up to CS6 where protection measures are required.

The NHBC guide 'Hazardous Ground Gas - An essential guide for housebuilders' 2023 provides further assessment tools for ground gas monitoring data, including the use of ternary plots to determine ground gas sources.

A separate approach to assessment without monitoring data is discussed under the RB17 header further below.

CIRIA C682 and BS 8576:2013 provide guidance on assessment of VOC intrusion risk.

Ground Gas Mitigation

Where a risk is determined to be present by assessment, BS8485:2015+A1:2019 provides guidance for the design of protection systems based on a points scoring system depending on the characteristic situation, structure type, structural barrier types, ventilation and a gas resistant membrane. Source removal can also be considered.

The design requires the structures to be categorised into one of four building types: Type A, Type B, Type C or Type D, related to the construction and end use of the building, together with the control of future structural changes and maintenance.

CIRIA C748 provides advice on the use of membranes as VOC vapour barriers.

CIRIA C735 sets out the approach for verification of installed mitigation measures. Note that if a membrane is installed it must be verified in accordance with CIRIA C735 or it will score zero points and assumed to not afford any protection.

RB17 Approach
CL:AIRE RB17 (Card et al 2012) is a pragmatic approach to ground gas risk assessment and was developed because gas concentration, pressure and flow rate measured in a well headspace may not be representative of the conditions in the surrounding formation.

In these low-risk situations, the approach is to use the conceptual site model and the estimation of the likely gas generation from a source to identify where or if gas monitoring is required to better define the risks.

Under this approach, for sites with natural soils only with no credible methane source, then no action is required (no monitoring or gas protection measures) as this represents Characteristic Situation 1 (CS1).

Radon
Advice on radon protection in England is provided by the UK Health Security Agency, https://www.ukradon.org/information/ukmaps and by the BRE (BR 211 (Scivyer 2023).

Areas of the country can be categorised according to the percentage of existing homes where radon is present above the Action Level:

- 0-1% lower probability.
- 1-3% and 3-10% intermediate probability.
- >10% higher probability.

Basic radon protection measures are required in new buildings and extensions in areas of England and Wales where 3-10% of properties exceed the Action Level and full radon protection measures where >10% exceed the Action Level.

Unexploded Ordnance (UXO) Guidance

Clients have a legal duty under the CDM 2015 Regulations to provide designers and contractors with project-specific health and safety information needed to identify hazards and risks. This includes the possibility of unexploded ordnance (UXO) being encountered on the site. Further details are given in CIRIA report C681.

BSL carry out non-specialist UXO screening exercises by considering any evidence of UK defence activities on or near the site evident from gathered desk study information and the unexploded aerial delivered bomb (UXB) online risk maps produced by Zetica. Other data sources are available, but as a first stage screening exercise the freely available online Zetica maps have been used. The level of risk stated is that determined by Zetica, a company experienced and considered competent in the assessment of UXO.

Geotechnical Guidance

A preliminary risk assessment of geotechnical hazards is carried out at the desk study stage and confirmed (or amended) at the ground investigation stage.

The CD 622 'Managing Geotechnical Risk' guidance document defines the technical approval and certification procedures to be used to ensure that the risk associated with the geotechnical activities are appropriately managed.

The desk-based stage may also include the requirements for a Coal Mining Risk Assessment (CMRA) which specifically assesses the risks from mining induced instability and related issues in high risk development areas: https://www.gov.uk/guidance/planning-applications-coal-mining-risk-assessments.

In order to establish the requirements of a project, the Geotechnical Category which is based on a consideration of project complexity, proposed geotechnical activities, presence of geo-hazards and severity of geotechnical risks, shall also be considered. These range from Category 1 (small/simple structures) to Category 3 (very large, unusual or complex activities/structures, such as tunnels). It is envisaged most projects typically fall into Category 2, including conventional types of geotechnical structures, earthworks and activities.

In the case of the geotechnical hazard identification at the intrusive investigation stage, this is referred to as the **ground model**.

The geotechnical sections of the report contain the factual information on the geology and relevant site data, including both in situ and laboratory testing, with a geotechnical evaluation of the information stating the assumptions made in the interpretation of the data.

Derived values of geotechnical parameters are obtained from test results by theory (book values), correlation or empiricism in general accordance with BS EN 1997-2:2007 (EC7).

Where derived geotechnical parameters are to be used in designs in accordance with EC7, the selection of characteristic values for geotechnical parameters using the derived values is carried out by well-established experience.

The characteristic value is a cautious estimate of the value affecting the occurrence of the limit state. For any particular material type there may be more than one characteristic value for each parameter because there may be more than one limit state.

The second stage is the selection of design values. The design values are either derived from the characteristic value by applying the relevant partial factors or assessed directly. Similarly, there can be several design values for the same material type.

In the event that geotechnical designs are included in this report, selection of the characteristic and design values is included. Otherwise, it is the duty of the geotechnical designer to determine these within a separate design report (a GDR).

Where it has not been possible to reasonably use an EC7 compliant technique, a practical alternative has been adopted to obtain indicative soil parameters and any interpretation is based upon engineering experience, local precedent where applicable and relevant published information.

In addition to the above:

- Assessments for highways designs are based on CD 622 Managing Geotechnical Risk.
- The assessment of sustainable drainage is based on BRE365 and CIRIA C753 'The SuDS Manual'.
- Earthworks Assessments are based on SHW Series 600 and BS6031.
- Risks from mining (both at the desk based and intrusive stages) are assessed adopting guidance from CIRIA C758.

Re-Use of Waste Soils Guidance

Definition of Waste
The Environment Agency considers waste to be "*...any material that is discarded, or intended to be discarded...*" this includes any soil from drainage trenches, foundation arisings, site strips etc. It is no longer required in its original location, therefore it is considered to be waste. Without an appropriate materials management plan, permit or exemption in place, by law this material is defined as "illegally deposited waste".

Landfill tax rules allow HM Revenue & Customs (HMRC) to recover landfill tax on illegally deposited waste on construction sites. This could lead to excessive costs without the correct documentation in place. In addition, a

person who makes, knowingly causes or knowingly facilitates a disposal to be made at an unauthorised site is also liable to pay Landfill Tax.

CL:AIRE: Code of Practice
Where materials are excavated for construction purposes, wherever possible these should be retained on site for engineering purposes if they are suitable for use. This can be implemented under the CL:AIRE "Development Industry Code of Practice for the Definition of Waste" (CL:AIRE DoWCoP), also commonly referred to as a "Materials Management Plan".

https://www.claire.co.uk/projects-and-initiatives/dow-cop

Developers and contractors are advised to complete all works under the DoWCoP where applicable.

To implement the DoWCoP (for Route A), there is a requirement to notify the Environment Agency and Local Authority of the intention to use the code of practice in principle, after which there is a 21-day notice period for their response.

In order to re-use soils under the DoWCoP, there are four key criteria that need to be met:

- The aims and objectives of the project meet the requirements of the Waste Framework Directive (does not harm human health or the environment).
- The soils can be demonstrated to be suitable for use (backed up by chemical/geotechnical testing and assessment).
- There is certainty of use (planning consents are in place alongside materials tracking, which should be in place as part of good site practice in any case).
- Quantity (the quantity of materials used should be known).

Potential scenarios where soils may be able to be re-used:

- Material capable of being used in another place on the same site without treatment.
- Material capable of being used in another place on the same site following ex-situ treatment on site.
- Material capable of being used in another development site without treatment (Direct Transfer).
- Material capable of being used in another development site following ex-situ treatment on another site e.g. Hub site.

In order to satisfy these requirements, the following are required:

i) Consultation/approval with Local Authority & Environment Agency to confirm they have no objections to the proposed re-use of waste soils, or the risk assessments for the site.
ii) Risk Assessments to demonstrate that the site does not present an Environmental Hazard.
iii) Remediation Strategy for contaminated sites (or Design Statement for non-contaminated sites).
iv) Materials Management Plan (MMP) which details material generated stockpiles and the end use.
v) Volume calculations.
vi) Planning permission for the development.
vii) Contractual details to be clear, regarding who steps in is a contractor goes into administration/liquidation.

The use of the CoP is effectively industry regulated, there is a requirement to appoint an independent Qualified Person (QP) who checks all the requirements have been met and registers the documentation with the Environment Agency. This person must not have had any involvement with the preparing of the risk assessments or remedial strategy on the site.

Soils which require treatment on site (e.g. bioremediation, stabilisation etc) may require an Environmental Permit for treatment, together with justification and validation to prove, once treated, this material is suitable for use.

Construction activities carried out on uncontaminated soils solely for the purpose of improving geotechnical properties are not generally regarded as waste treatment operations and do not require a permit.

Site management procedures need to be in place to ensure that material is tracked through from excavation stockpiling, treatment and remediation processes. Should the process of material tracking be considered non-robust, or not adhered to, this may fail the test whether excavated materials may be considered non-waste.

Any declared MMP should be amended as new import sources are added.

Regardless of implementing re-use under the code of practice or not, all sites should have some form of materials tracking in place in compliance with current legislation. Any re-use scheme should also be designed to minimise disposal costs. Note that for re-use of landfilled materials or mining wastes, the DoWCoP may not apply and a Waste Recovery Permit (or others) may be required. Liaison with the Environment Agency would be needed on a case by case basis to determine the best option.

Once the project is complete, a verification report detailing soils re-use/import will need to be produced and submitted to CL:AIRE, which may be subject to a random audit process. Sites found to be non-complaint with the CoP can be referred to the EA for further investigation.

Soils Re-use under Exemptions and Permits
Other potential options to allow the re-use and/or import of soils and aggregates on site are provided in the table below. Applies to England/Wales only – Scotland differs.

Re-use Mechanism	Description
U1 Exemption	Can be applied to re-use/import of soils and stones, but only up to 1000 tonnes or for brick and concrete up to 5000 tonnes. This is usually an efficient way to re-use small volumes of waste materials. However, only one U1 can be filled in per site in any 3-year period. Quick and free via online registration.
WRAP Quality Protocols	Describes how processed demolition arisings can be removed from regulatory waste regime. Requires a demonstration of appropriateness by: • Factory Production Control Manual. • Facility Permit (or Exemption). • Grading Analysis.
Waste Framework Directive (WFD) exclusion	In regard to "clean" naturally occurring soils only that are to be re-used on their site of origin, these are covered by a Waste Framework Directive (WFD) exclusion which is an EA regulatory position statement. So long as the project can prove the four criteria listed above for the DoWCoP, then permits or the DoWCoP are not required. However, many projects still use the CoP to ensure compliance.
T5 Screening and blending of waste	The T5 exemption allows you to temporarily treat waste on a small scale to produce aggregate or soil at a particular location, such as a construction or demolition site. The limit is 5,000 tonnes. This applies to: • Screening soil on a demolition site to remove wood and rubble. • Blending soil and compost that has been produced under an exemption on a construction site to produce better soil for landscaping on that site (e.g. peaty deposits). • Crushing waste (except bricks, tiles and concrete) before screening or blending • Grading waste concrete after it has been crushed to produce a certain type of aggregate.
T7 Exemption	The T7 allows treatment of waste bricks, tiles and concrete by crushing, grinding or reducing in size. This needs to be registered with the Local Authority.
Other Permitting Routes	Other options include use under an Environmental Permit (Standard or Bespoke Rules), however these may be a time consuming and costly route, where use of the other above options (if applicable) are likely to be more feasible in construction.

There are also potential non-enforcement positions for re-use e.g. a site has a large volume waste illegally deposited on it (not by landowner). The new owner is keen to re-use waste where possible to reprofile the site (planning condition granted). The DoWCoP could not be used as materials already excavated and deposited as a waste (illegally). The EA may agree that although the DoWCoP not applicable, they would take a non-enforcement position if the works were completed in accordance with the DoWCoP – this would need to be agreed in advance.

Waste Classification and Disposal Guidance for Soils

Introduction
As described in the 'Waste Duty of Care Code of Practice (2016)' any substance or object that the holder discards, intends to discard or is required to discard is a waste. Waste producers have a duty of care to classify the waste they are producing:

- Before it is collected, disposed of or recovered.
- To identify the controls that apply to the movement of the waste.
- To complete waste documents and records.
- To identify suitably authorised waste management options.
- To prevent harm to people and the environment.

The most sustainable and economic method of dealing with waste soil is usually the retention and re-use on site. Where this is not possible there are three main options for the disposal of soils:

1. Disposal to a permitted waste recycling facility.
2. Re-use on another site (subject to the suitability).
3. Disposal to a landfill site.

The disposal to a permitted facility will be subject to the **specific conditions of the permits for each individual facility** and will vary dependent on location and environmental sensitivity of the receiving site. Re-use on another site will also be subject to the acceptability criteria of that site.

The guidance below relates to disposal to **landfill sites only**.

Background for Landfill Disposal
The Landfill Directive places controls on waste disposal. These controls include requirements to follow the waste acceptance procedures and criteria that have been agreed by the Council of the European Union and are laid out in Council Decision 2003/33/EC.

Before a waste can be accepted at a landfill site, the landfill **operator** must be satisfied that the waste meets permit conditions, the waste acceptance procedures (WAP) and waste acceptance criteria (WAC).

If disposal to landfill is the best management option for the waste soils, these procedures **must** be followed or the operator may refuse to accept the waste.

Key Points:

- Not all waste can be landfilled.
- Landfills are classified according to whether they can accept hazardous, non-hazardous or inert wastes.
- Wastes can only be accepted at a landfill if they meet the waste acceptance criteria (WAC) for that class of landfill.
- Most wastes must be treated before you can send them to landfill.
- There are formal processes for identifying and checking wastes that must be followed before wastes can be accepted at a landfill site.

Classification

Wastes are listed in the European Waste Catalogue and grouped according to generic industry, process or waste types. Wastes within the EWC are either hazardous or non-hazardous. Some of these wastes are hazardous without further assessment (absolute entries) or are 'mirror' entries that require further assessment of their hazardous properties in order to determine whether they are hazardous waste.

Waste soil has mirror entries on the EWC and as such the first phase of the waste classification process is that of determining if the waste is hazardous or not i.e. the hazard assessment. The most common EWC waste codes related to soil are:

17 05	Soil (including excavated soil from contaminated sites), stones and dredging spoil
17 05 03*	soil and stones containing dangerous substances
17 05 04	soil and stones other than those mentioned in 17 05 03

Soils may contain certain contaminants (e.g. asbestos, oil,) which have prescribed concentration thresholds, that if breached will render the material hazardous waste. These are based on specific "hazardous properties" which include hazards such as carcinogenicity, flammability and toxicity.

In the first instance the concentrations of plausible contaminants within the soil should be identified and wastes should be **classified based on their total concentrations** and classified as either hazardous or non-hazardous waste. WAC analysis must not be used for waste classification.

Waste Definitions

Inert	• Will not undergo any significant physical, chemical or biological transformations. • Will not dissolve. • Will not burn. • Will not physically or chemically react. • Will not biodegrade. • Will not adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm to human health. • Has insignificant total leachability and pollutant content. • Produces a leachate with an ecotoxicity that is insignificant (if it produces leachate).
Non-Hazardous	Is not inert (see above). Is not hazardous (see below).
Hazardous	Soil has hazardous properties as defined in WM3 (Guidance on the classification and assessment of waste (1st edition 2015)- Technical Guidance).
Stable Non-reactive hazardous waste#	Hazardous waste, the leaching behaviour of which will not change adversely in the long-term, under landfill design conditions or foreseeable accidents either: in the waste alone (for example, by biodegradation), under the impact of long-term ambient conditions (for example, water, air, temperature or mechanical constraints) or by the impact of other wastes (including waste products such as leachate and gas).

This option allows hazardous waste that is stable and thus has a low leaching potential to be deposited in cells with a standard of containment consistent with non-hazardous wastes.

WAC Testing

The purpose of WAC analysis is to confirm that the waste complies with the relevant WAC for the receiving landfill. If the waste has any disposal route other than a landfill site (e.g. recycling facility, incineration etc) then WAC is not relevant. Furthermore, the WAC limits **cannot** be used to make an assessment of whether a waste is hazardous. WAC testing does however define if a non-hazardous waste is suitable for an inert landfill.

Classification based on Total Concentrations[1]	Non-Hazardous Waste		Hazardous Waste	
WAC testing	Below inert WAC limit values:	Above inert WAC limit values:	Below hazardous WAC limit values	> WAC limit values

Landfill requirements	INERT landfill	NON-HAZARDOUS landfill[2]	HAZARDOUS landfill	PRE-TREATMENT[3]

1 Total concentrations are defined as tests results on solids as opposed to leachate (i.e. a liquid).
2 Individual sites may have certain limit values pre-determined in their licence.
3 After pre-treatment the material characteristics may have changed to an extent that allow the soil to be re-classified.
4 Possibility that wastes could be classified as stable Nonreactive HAZARDOUS waste in non-hazardous Landfill (e.g. soils containing low concentrations of asbestos, gypsum or sulphate bearing soils).

Waste classified as non-hazardous can be accepted into a non-hazardous landfill without having to pass any numerical WAC.

Soils above hazardous WAC limit values require pre-treatment prior to disposal. The effective pre-treatment, typically involving separation, sorting and screening, can offer cost savings through reducing the hazardous nature and volumes of soil. Costs for disposal of non-hazardous/hazardous soils are significant compared to the disposal of inert material.

Greenfield Sites and Inert Waste
The possibility of automatic inert classification naturally occurring "clean" soils should be explored in accordance with the requirements of paragraph 10 (wastes acceptable without testing at landfills for inert waste) of the Landfill (England and Wales) (Amendment) Regulations (2005). This is the case if:

- They are single stream waste of a single waste type (although different waste types from the list may be accepted together if they are from a single source); and
- There is no suspicion of material or substances such as metals, asbestos, plastics, chemicals, etc to an extent which increases the risk associated with the waste sufficiently to justify contamination and they do not contain other classes of landfill (e.g. the waste producer can characterise the waste based on visual assessment and written description with supporting evidence such as a desk study, subject to agreement by the landfill operator).

Hydrocarbons in Soils
WM3 uses the term Oil or Waste Oil to cover hydrocarbons products such as fuel oil, petrol or diesel. These are defined by WM3 as hazardous under an absolute entry in the List of Wastes. However, hydrocarbons in soils are a mixture rather than a pure product and are therefore not absolute entries.

Known Oils
The simplest scenario is where the identity of the contaminating oil is known or can be identified. If the oil is known the manufacturer's or supplier's REACH compliant safety data sheet for the specific oil can be obtained and the hazard statement codes on that Safety Data Sheet can be used for the hazardous waste assessment.

Where the identity of the oil can only be identified down to a petroleum group level (i.e. the contaminating oil is known to be diesel, but the specific type/brand is unknown), then the classification of that petroleum group should be used in the assessment. The marker compounds associated with that petroleum group may be used to confirm carcinogenicity.

Oils may contain a range of hydrocarbons, so the presence of for instance Diesel Range Organics (DRO) does not enable the assessor to conclude that diesel is present. These hydrocarbons may have arisen from other oils, the laboratory needs to provide an interpretation of the chromatograph to determine if it is consistent with diesel or weathered diesel as a whole.

The concentration of known oils should be determined using a method that as a minimum spans the range in which the carbon numbers for that known oil fall.

Unknown Oils
Where hydrocarbons are contaminating soils, it is likely that the oil will be unknown or cannot be determined.

WM3 states that:

> For contaminated land specific consideration must be given to the following before proceeding:
>
> - The presence of other organic contaminants, for example solvents or coal tar that could be detected as hydrocarbons. Coal Tar is not an oil and is considered separately in WM3 example 2. Where the site history or investigation indicates the presence of hydrocarbons from oil and other sources (e.g. coal tar), and the origin of the hydrocarbons cannot reliably be assigned to either, then a worst case approach of considering the hydrocarbons both as waste oil (in accordance with this example) and from other sources, for example coal tar should be taken.
> - The presence of diesel, or weathered diesel, should be specifically considered by the laboratory and where this is confirmed by the hydrocarbon profile the oil should be assessed as a known or identified oil (diesel).

The use of marker compounds is optional; however, it is recommended that where possible the marker compounds should be used. WM3 states:

> If the identity of the oil is unknown, and the petroleum group cannot be established, then the oil contaminating the waste can be classified as non-carcinogenic/mutagenic due to the presence of oil if all three of the following criteria are met:
>
> - The waste contains benzo[a]pyrene (BaP) at a concentration of less than 0.01% (1/10,000th) of the TPH concentration (This is the carcinogenic limit specified in table 3.1 of the CLP for BaP)
> - This has been determined by an appropriate and representative sampling approach in accordance with the principles set out in Appendix D of WM3, and
> - The analysis clearly demonstrates, for example by carbon bands or chromatograph, and the laboratory has reasonably concluded that the hydrocarbons present have not arisen from petrol or diesel.

For example:

TPH Concentration (mg/kg)	Petrol or Diesel	BaP (mg/kg)	Classification
10,000	No	0.9	Non- Hazardous
1,000	No	Not available	Hazardous
1,000	Yes	Not relevant	Hazardous

References

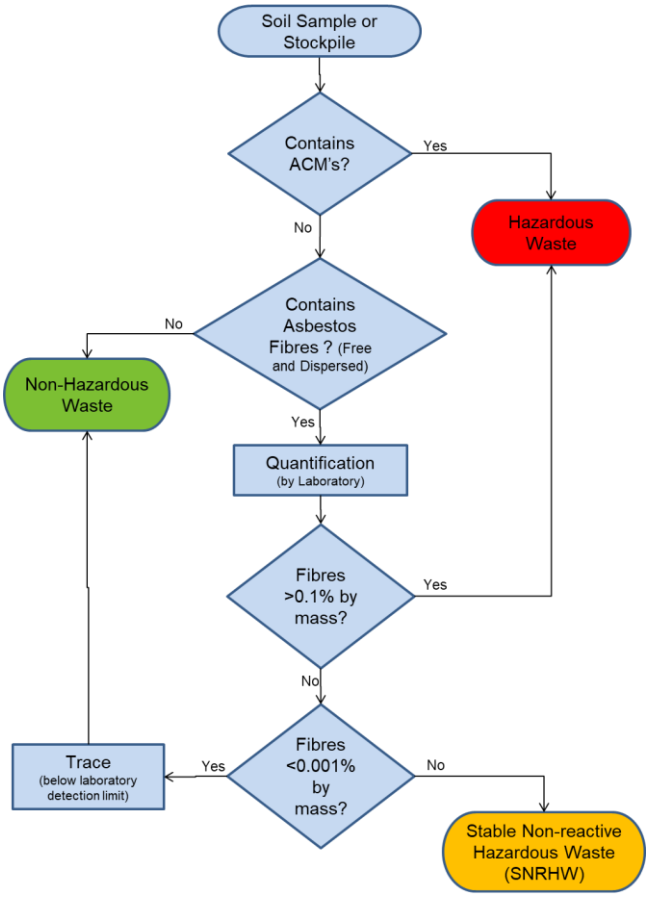
1. Environmental Permitting (England and Wales) Regulations 2010 (as amended) (EP Regulations), the Landfill Directive (1999/31/EC) and the subsequent Council Decisions.
2. Environment Agency Environmental Permitting Regulations: "Inert Waste Guidance- Standards and Measures for the Deposit of Inert Waste on Land" 2009.
3. Environment Agency "Waste acceptance at landfills - Guidance on waste acceptance procedures and criteria" Nov 2010.
4. Environment Agency "Guidance on the classification and assessment of waste (Technical Guidance WM3)".
5. Classification, Labelling and Packaging of Substances Regulation (EC 1272/2008) (CLP).
6. Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives.
7. 2014/955/EU: Commission Decision of 18 December 2014 amending Decision 2000/532/EC on the list of waste pursuant to Directive 2008/98/EC of the European Parliament.
8. Environmental Permitting Guidance The Landfill Directive For the Environmental Permitting (England and Wales) Regulations 2010 Updated March 2010 Version 3.1.
9. Classification, Labelling and Packaging of Substances Regulation (EC 1272/2008) (CLP).

Waste Containing Asbestos

The assessment of asbestos containing waste is dependent on whether the asbestos is present as:

- Fibres that are free and dispersed, or
- Identifiable pieces of asbestos containing materials (ACM's).

Identifiable pieces of asbestos are any particle of a size that can be identified as potentially being asbestos by a competent person if examined by the naked eye. The result is that commonly soils with visible ACM's are sorted and the ACM's removed by hand picking and separate disposal.



Should soils contain asbestos, the concentration and type of asbestos identified, in addition to the chemical composition (i.e. hazardous or non-hazardous detailed above), will determine which waste code is applicable to the soils and which landfill will accept it as summarised below:

Waste	Conc. by Weight (%)	EWC 2002 Catalogue Entry Code	Waste Disposal Route
Non-hazardous containing asbestos fibres	<0.001 - <0.1%	17 05 04 (soil and stones other than those mentioned in 17 05 03*)	Non-hazardous landfill subject to achieving Waste Acceptance Criteria (WAC) for a stable non-reactive hazardous landfill site.
Hazardous containing asbestos fibres	<0.001 - <0.1%	17 05 03* (soil and stones containing dangerous substances)	Hazardous landfill subject to achieving Waste Acceptance Criteria (WAC) for a hazardous landfill site.
Non-hazardous soils containing asbestos fibres	>0.1%	17 05 03* (soil and stones containing dangerous substances)	Hazardous landfill authorised to receive asbestos, or in a stable non-reactive hazardous waste cell at a non-hazardous landfill authorised to receive asbestos.

Waste	Conc. by Weight (%)	EWC 2002 Catalogue Entry Code	Waste Disposal Route
Non-hazardous Soils containing ACM (Mechanically separable)	>0.1%	17 06 05 (construction material containing asbestos) 17 05 04 (soil and stones other than those mentioned in 17 05 03*)	ACMs disposed of at a hazardous landfill authorised to receive asbestos, or in a stable non-reactive hazardous waste cell at a non-hazardous landfill authorised to receive asbestos. Soils should be disposed of at a non-hazardous landfill subject to achieving Waste Acceptance Criteria (WAC) for a stable non-reactive hazardous landfill site.
Hazardous soils containing ACM	>0.1%	17 05 03* (soil and stones containing dangerous substances)	Hazardous landfill subject to achieving Waste Acceptance Criteria (WAC) for a hazardous landfill site.

Asbestos concentrations below 0.001% by mass are below standard laboratory detection limits and are not currently regarded as containing asbestos for the purposes of disposal and may be disposed of to an inert landfill site[1]. These levels are often termed "trace" by laboratories.

Asbestos concentrations between 0.001% and 0.1% are stable non-reactive hazardous waste (SNRHW)[1]. Waste transfer stations where soil recycling takes place may be able to take SNRHW, but are unlikely to take soils containing asbestos above trace concentrations.

The following codes should be assigned to the asbestos waste as appropriate:

17 06	Insulation materials and asbestos-containing construction materials
17 06 01	Insulation materials containing asbestos
17 06 03	Other insulation materials consisting of or containing hazardous substances
17 06 04	Insulation materials other than those mentioned in 17 06 01 and 17 06 03
17 06 05	Construction material containing asbestos

WM3 indicates that 17 06 05 would normally be used in preference to 17 06 01 for the asbestos in asbestos contaminated soil and stones.

Construction materials containing asbestos and "*other suitable materials*" may be landfilled at landfills for non-hazardous waste in accordance with the Landfill Directive without testing.

This means that wastes that are only hazardous because of their asbestos content can be disposed of at landfills for non-hazardous waste in separate landfill cells that only accept asbestos wastes and other suitable materials. The Landfill Directive requires that stable non-reactive hazardous waste shall not be deposited with biodegradable waste (for example organic material, household waste, paper etc..) and must meet the waste acceptance criteria set out in accordance with Annex II.

Construction

Health and Safety Executive (HSE) guidance on asbestos is not directly related to soil and much of the guidance focuses on the removal of asbestos from buildings. The overarching legislation is the Control of Asbestos Regulation (CAR 2012). However, where work involves (or is likely to involve) contact with asbestos then CAR 2012 requires a risk assessment including whether the work is licensed or notifiable non-licensed work and may require an Asbestos Management Plan. Work becomes notifiable if it is considered that the control limit could be exceeded.

Brownfield sites frequently have soils that contain asbestos and the presence of asbestos needs to be considered within the context of construction, particularly in relation to groundworks. The exposure of soils and the use of excavators and plant to move soil around increases the possibility of fibres becoming airborne. However, it is good site practice to not generate dusts and to employ dust suppression on all sites regardless of the presence of asbestos.

The legal control limit for asbestos is 0.1f/ml over a continuous four-hour period. The control limit is not a '*safe*' level and exposure from work activities involving asbestos must be reduced to as far below the control limit as possible.

Clearly the higher the concentrations in the soil the greater potential there is for fibres to be released, however IOM publication TM/88/14 "the release of dispersed asbestos fibres from soil" 1988 concludes that:

- Mixtures of asbestos in dry soils with asbestos content as low as 0.001% can produce airborne respirable asbestos concentrations greater than 0.1f/ml in dust clouds where the respirable dust concentrations are less than 5mg/m3.
- An action limit is recommended of no higher than 0.001% asbestos in soils above which steps should be taken to minimise exposure to airborne fibres (e.g. by wetting).
- The addition of relatively small quantities (10%) of water can reduce the airborne fibre concentrations by an order of magnitude.

Where asbestos has been identified at concentrations above 0.001% as free and dispersed fibres in the soil precautions need to be adopted. Concentrations below this are considered to be normal background, although good site practice dictates that the generation of dusts should be avoided and therefore any fugitive fibre release from minor concentrations should be kept to a practical minimum.

End Use
The use of materials containing asbestos and material containing asbestos is prohibited under EU legislation.

Asbestos containing materials can remain in situ under a suitable cover system which may be hard surfacing or soft landscaping (with or without hard dig layers and markers).

There is a risk that future maintenance may compromise such systems and details of the presence of asbestos should be kept in the Health and Safety File.

Publications from the JIWG provide guides for decision making in relation to construction.

The re-use of waste soils should be undertaken in accordance with the CL:AIRE Code of Practice and is subject to suitable risk assessments demonstrating low risk. There is nothing that specifically excludes the re-use of soils containing asbestos as fill to raise levels. However, the movement of materials increases the risk of fibres becoming airborne and suitable precautions will be required. Re-use of soils containing asbestos should be as per CARSOILS.

The re-use of soils containing asbestos at concentrations above hazardous waste levels may be met with regulatory opposition. Assuming a suitable strategy could be agreed this would take a considerable amount of time and is only likely to be feasible where there is a long program for implementation.

Asbestos in Soil as Free Fibres

Concentration (by weight)	Waste Disposal				Construction Issues	End Use	
	Recycle	Inert	SNR	Haz		Suitable for re-use on site	Precautions
Not detected	√	√			No precautions necessary, however on a brownfield site asbestos not previously identified may be found during works and a statement within the contractor's method statement for how they will deal with this unforeseen asbestos would be good practice to ensure compliance with CAR2012.	Yes.	None.
Trace (<0.001%)		√ [2]			Precautions are unlikely to be required, however a detailed method statement may be required to ensure compliance with CAR2012. Basic asbestos management good practice will be required. Typically precautions would include: • Ensuring soils do not dry out to become dusty. • Site personnel have the risk communicated at induction stage.	Yes Soils can be re-used under CL:AIRE CoP with the correct precautions in place.	Generally clean cover or hardstanding cover required.
0.001% – 0.099%			√		Contractor needs to produce an Asbestos Management Plan in accordance with CAR2012 as part of their method statement. Typical precautions would include: • Site personnel have the risk communicated at induction stage. • Ensuring personnel have suitable training. • Task monitoring to inform PPE requirements. • Ensuring soils do not dry out to become dusty and that misting is available during groundworks. • Separate stockpiling. • Clean haulage routes.	Possibly. Soils may be able to be re-used under CL:AIRE CoP, subject to a satisfactory Risk Assessment and regulatory agreement with the correct precautions in place.	Clean cover with hard dig/demarcation layer or hardstanding cover required.
0.1+%				√	Contractor needs to produce an Asbestos Management Plan in accordance with CAR2012 as part of their method statement. Typical precautions would include: • Site personnel have the risk communicated at induction stage. • Ensuring personnel have suitable training. • Task monitoring to inform PPE requirements. • Site wide and or perimeter monitoring. • Ensuring soils do not dry out to become dusty and that misting is available during groundworks. • Separate stockpiling.	Unlikely [3] Re-use of soils containing asbestos within an earthworks scheme will involve significant engineering and the risk for generating dusts will be significantly	Clean cover and a hard dig / demarcation layer. A plan should be in place for future excavations as part of the Health and Safety File.

Concentration (by weight)	Waste Disposal				Construction Issues	End Use	
	Recycle	Inert	SNR	Haz		Suitable for re-use on site	Precautions
					• Clean haulage routes. • Decontamination unit	increased with repeated handling and compaction.	

1. The standard laboratory detection limit is normally 0.001%. Below 0.001% is trace and currently regarded as not containing asbestos for the purposes of disposal off site. However the waste producer has a duty to fully classify the waste and the presence of trace asbestos should be declared. Consequently it is unlikely that a waste treatment site will take this soil and an inert landfill may make a commercial decision to only take it under some circumstances.

2 The re-use of soils containing asbestos at concentrations above hazardous waste is likely to meet with regulatory opposition. Assuming a suitable strategy could be agreed this would take a considerable amount of time and is only likely to be warranted where there a long program for implementation.

APPENDIX B

Exploratory Hole Logs

BROWNFIELD SOLUTIONS LTD

Borehole Log

Borehole No.
CP01
Sheet 1 of 3

PROJECT NO:	C5441	**CO-ORDS:**	**Hole Type** CP
PROJECT NAME:	TILBURY DOCKS, ESSEX	**LEVEL:**	**Scale** 1:50
CLIENT:	BLUE PHOENIX	**DATES:**	06/11/23 - 07/11/23

Logged	Checked
LN	JW

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m OD)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.26	-0.26		MADE GROUND: Concrete reinforced with crossing metal rebar.
		0.50	ES		0.60	-0.60		MADE GROUND: Loose brown gravelly sand. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to coarse of chert, brick and concrete.
					0.70	-0.70		MADE GROUND: Concrete.
		1.00	ES					MADE GROUND: Loose brown slightly clayey gravelly sand. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to coarse of chert, brick and concrete with rare glass fragments.
		1.20	SPT	N=4 (1,1/1,1,1,1)	1.50	-1.50		MADE GROUND: Very soft dark brown slightly gravelly silty clay. Gravel is sub-angular to sub-rounded fine to medium of chert and concrete.
		2.00	D					
	▼		SPT	N=1 (1,0/0,1,0,0)				*Slight groundwater seepage encountered at 2.50m bgl, no rise after 20 minutes.*
		3.00	SPT	N=2 (1,0/0,1,0,1)	3.20	-3.20		Very loose dark grey organic slightly clayey gravelly SAND. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to medium of chert.
		4.00	D					
			SPT	N=4 (1,0/1,1,1,1)	4.20	-4.20		Soft to firm dark grey, damp, organic silty CLAY.
		5.00-5.45	U					*50 blows recorded.*
					5.80	-5.80		Very soft dark grey and black, organic fibrous peaty CLAY.
		6.00	D					
		6.50	SPT	N=0 (0,0/0,0,0,0)				
		8.00	D		8.00	-8.00		Very soft, dark grey, damp slightly sandy CLAY.
	▼		SPT	N=0 (0,0/0,0,0,0)				
					8.70	-8.70		Spongy dark grey and black organic clayey PEAT.
		9.50	SPT	N=6 (1,1/2,1,1,2)				
		10.00	D		10.00	-10.00		

1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0

Remarks

1. Clearance of services using GPR techniques and CAT and Genny prior to concrete coring.
2. Hand-dug inspection pit excavated to 1.20m bgl.
3. Slight groundwater seepage encountered at 2.5m bgl. No rise after 20 minutes and sealed at 5.0m bgl.
4. Groundwater seepage encountered again at 13.5m bgl and rose to 8.4m bgl after 20 minutes.
5. Monitoring well installed following completion of drilling. 0.00m to 3.50m bgl plain pipe. 3.50m to 9.50m slotted pipe. Bentonite seal between 9.50m to 10.50m bgl. 10.50m to 21.50m bgl backfilled with arisings.

ES = Environmental Sample
D = Disturbed Sample
B = Bulk Sample
LB = Large Bulk Sample
U = Undisturbed Sample
UT = Undisturbed Thin Wall Sample
SPT = Standard Penetration Test
PID = Photoionization Detector (ppm)
PPM = Part Per Million
HSV = Hand Shear Vane

BROWNFIELD SOLUTIONS LTD

Borehole Log

Borehole No. CP01

Sheet 2 of 3

PROJECT NO:	C5441	**CO-ORDS:**	
PROJECT NAME:	TILBURY DOCKS, ESSEX	**LEVEL:**	
CLIENT:	BLUE PHOENIX	**DATES:**	06/11/23 - 07/11/23

Hole Type: CP

Scale: 1:50

Logged	Checked
LN	JW

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m OD)	Legend	Stratum Description
		Depth (m)	Type	Results				
								Soft dark grey sandy CLAY. Sand is fine.
		11.00	SPT	N=7 (1,1/1,2,2,2)				
		12.00	D		12.00	-12.00		
		12.50	SPT	N=22 (2,2/4,5,8,5)				Medium dense dark grey slightly clayey sandy GRAVEL. Sand is fine to coarse. Gravel is sub-angular to sub-rounded fine to coarse of chert.
								Groundwater encountered at 13.50m bgl, rising to 8.40m bgl after 20 minutes.
		14.00	D SPT	N=30 (3,4/5,5,9,11)				
		15.50-16.00 15.50	B SPT	N=29 (3,4/4,6,9,10)				
		17.00-17.50 17.00	B SPT	N=38 (3,4/5,6,12,15)	17.00	-17.00		Dense brown gravelly SAND. Sand is fine to coarse. Gravel is sub-angular to angular fine to coarse of chert.
		18.50-19.00 18.50	B SPT	N=27 (2,4/5,8,6,8)				
		20.00-20.50 20.00	B SPT	N=38 (3,5/8,8,9,13)	20.00	-20.00		

Remarks

1. Clearance of services using GPR techniques and CAT and Genny prior to concrete coring.
2. Hand-dug inspection pit excavated to 1.20m bgl.
3. Slight groundwater seepage encountered at 2.5m bgl. No rise after 20 minutes and sealed at 5.0m bgl.
4. Groundwater seepage encountered again at 13.5m bgl and rose to 8.4m bgl after 20 minutes.
5. Monitoring well installed following completion of drilling. 0.00m to 3.50m bgl plain pipe. 3.50m to 9.50m slotted pipe. Bentonite seal between 9.50m to 10.50m bgl. 10.50m to 21.50m bgl backfilled with arisings.

ES = Environmental Sample
D = Disturbed Sample
B = Bulk Sample
LB = Large Bulk Sample
U = Undisturbed Sample
UT = Undisturbed Thin Wall Sample
SPT = Standard Penetration Test
PID = Photoionization Detector (ppm)
PPM = Part Per Million
HSV = Hand Shear Vane

BROWNFIELD SOLUTIONS LTD

Borehole Log

Borehole No. CP01

Sheet 3 of 3

PROJECT NO:	C5441	**CO-ORDS:**	**Hole Type** CP
PROJECT NAME:	TILBURY DOCKS, ESSEX	**LEVEL:**	**Scale** 1:50
CLIENT:	BLUE PHOENIX	**DATES:** 06/11/23 - 07/11/23	**Logged** LN / **Checked** JW

Well	Water Strikes	Sample and In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m OD)	Legend	Stratum Description
		21.00-21.50	B					Very dense brown gravelly SAND. Sand is fine to coarse. Gravel is sub-angular to angular fine to coarse of chert and chalk.
		21.50	B SPT	N=21 (2,2/3,5,5,8)	21.50 21.80	-21.50 -21.80		Weak structureless, weathered CHALK recovered as white and cream slightly sandy silty GRAVEL. Sand is fine to coarse. Gravel is sub-angular to angular fine to coarse of chalk and flint. End of Borehole at 21.80m

21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0

Remarks

1. Clearance of services using GPR techniques and CAT and Genny prior to concrete coring.
2. Hand-dug inspection pit excavated to 1.20m bgl.
3. Slight groundwater seepage encountered at 2.5m bgl. No rise after 20 minutes and sealed at 5.0m bgl.
4. Groundwater seepage encountered again at 13.5m bgl and rose to 8.4m bgl after 20 minutes.
5. Monitoring well installed following completion of drilling. 0.00m to 3.50m bgl plain pipe. 3.50m to 9.50m slotted pipe. Bentonite seal between 9.50m to 10.50m bgl. 10.50m to 21.50m bgl backfilled with arisings.

ES = Environmental Sample
D = Disturbed Sample
B = Bulk Sample
LB = Large Bulk Sample
U = Undisturbed Sample
UT = Undisturbed Thin Wall Sample
SPT = Standard Penetration Test
PID = Photoionization Detector (ppm)
PPM = Part Per Million
HSV = Hand Shear Vane

BROWNFIELD SOLUTIONS LTD

Borehole Log

Window Sampler No.
WS01
Sheet 1 of 1

PROJECT NO:	C5441	**CO-ORDS:**	**Hole Type** WS
PROJECT NAME:	TILBURY DOCKS, ESSEX	**LEVEL:**	**Scale** 1:30
CLIENT:	BLUE PHOENIX	**DATES:**	06/11/23

Logged	Checked
LN	JW

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m OD)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.04	-0.04		MADE GROUND: Asphalt. MADE GROUND: Concrete reinforced with crossing metal rebar.
		0.30	ES		0.29	-0.29		MADE GROUND: Loose slightly clayey gravelly sand. Sand is fine to coarse. Gravel is sub-angular to sub-rounded fine to coarse of chert, concrete and brick with rare glass fragments.
		0.55	ES		0.51	-0.51		MADE GROUND: Very soft greyish black slightly gravelly fibrous peaty clay. Gravel is angular to sub-angular of chert and brick. Slight hydrocarbon odour.
		1.20	SPT	N=2 (0,0/1,0,1,0)	1.30	-1.30		MADE GROUND: Very loose yellowish brown slightly clayey gravelly sand. Sand is fine to coarse. Gravel is sub-angular to sub-rounded fine to coarse of chert and brick with rare glass fragments.
		1.50	D ES		1.60	-1.60		Very soft dark grey and black, damp, organic fibrous peaty CLAY.
	▼	2.00	D SPT	N=1 (0,1/0,0,1,0)				*Slight groundwater seepage encountered at 2.00m bgl.*
								Becomes sandy at 2.60m bgl.
		3.00	SPT	N=2 (1,0/1,0,1,0)	3.00	-3.00		Very soft dark grey slightly gravelly silty CLAY with pockets of fibrous peat. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to medium of chert.
		3.50	D					
		4.00	SPT	N=4 (1,1/1,1,1,1)				
		4.50	D		4.40	-4.40		Soft black, organic slightly gravelly peaty CLAY. Gravel is sub-angular to sub-rounded fine to coarse of chert.
		5.00	SPT	N=5 (1,2/1,2,1,1)	5.00	-5.00		End of Borehole at 5.00m

1.0 2.0 3.0 4.0 5.0 6.0

Remarks

1. Clearance of services using GPR techniques and CAT and Genny prior to concrete coring.
2. Hand-dug inspection pit excavated to 1.20m bgl.
3. Slight groundwater encountered at 2.00m bgl.
4. Monitoring well installed following completion of drilling. 0.00m to 2.00m bgl plain pipe. 2.00m to 5.00m bgl slotted pipe.

ES = Environmental Sample
D = Disturbed Sample
B = Bulk Sample
LB = Large Bulk Sample
U = Undisturbed Sample
UT = Undisturbed Thin Wall Sample
SPT = Standard Penetration Test
PID = Photoionization Detector (ppm)
PPM = Part Per Million
HSV = Hand Shear Vane

BROWNFIELD SOLUTIONS LTD

Borehole Log

Window Sampler No.
WS02
Sheet 1 of 1

PROJECT NO:	C5441	**CO-ORDS:**	**Hole Type** WS
PROJECT NAME:	TILBURY DOCKS, ESSEX	**LEVEL:**	**Scale** 1:30
CLIENT:	BLUE PHOENIX	**DATES:**	06/11/23

Logged	Checked
LN	JW

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m OD)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.20	-0.20		MADE GROUND: Asphalt.
					0.46	-0.46		MADE GROUND: Concrete reinforced with crossing metal rebar.
		0.50	ES					MADE GROUND: Loose yellowish brown gravelly sand. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to coarse of chert, brick and concrete.
		0.85	ES		0.81	-0.81		MADE GROUND: Loose dark brown and black, slightly clayey gravelly sand with ash. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to coarse of chert and brick.
		1.20	ES SPT	N=2 (0,0/1,0,0,1)	1.25	-1.25		MADE GROUND: Loose yellowish brown slightly clayey gravelly sand. Sand is fine to coarse. Gravel is sub-angular to sub-rounded fine to coarse of chert, brick and concrete.
					1.45	-1.45		MADE GROUND: Soft to firm, dark grey, damp, organic slightly gravelly fibrous peaty clay. Gravel is sub-angular to sub-rounded fine to medium of chert.
		1.80	ES					
		2.00	SPT	N=2 (0,0/1,0,1,0)				
					2.20	-2.20		MADE GROUND: Soft grey mottled brown clay. (Suspect reworked natural).
	▼	3.00	SPT	N=3 (1,0/1,1,0,1)				*Slight groundwater seepage encountered at 3.00m bgl.*
		3.40	D ES					
					3.60	-3.60		MADE GROUND: Soft becoming firm black, wet, organic very gravelly clay with ash. Gravel is angular to sub-angular fine to coarse of chert and coal.
		4.00	D ES SPT	N≥50 (53 for 90mm/0 for 0mm)	4.00	-4.00		*Hole terminated at 4.00m bgl due to refusal.* End of Borehole at 4.00m

1.0 2.0 3.0 4.0 5.0 6.0

Remarks

1. Clearance of services using GPR techniques and CAT and Genny prior to concrete coring.
2. Hand-dug inspection pit excavated to 1.20m bgl.
3. Slight groundwater encountered at 3.00m bgl.
4. Hole terminated at 4.00m bgl due to refusal.
5. Hole backfilled with arisings upon completion.

ES = Environmental Sample
D = Disturbed Sample
B = Bulk Sample
LB = Large Bulk Sample
U = Undisturbed Sample
UT = Undisturbed Thin Wall Sample
SPT = Standard Penetration Test
PID = Photoionization Detector (ppm)
PPM = Part Per Million
HSV = Hand Shear Vane

BROWNFIELD SOLUTIONS LTD

Borehole Log

Window Sampler No.
WS03
Sheet 1 of 1

PROJECT NO:	C5441	**CO-ORDS:**	**Hole Type** WS
PROJECT NAME:	TILBURY DOCKS, ESSEX	**LEVEL:**	**Scale** 1:30
CLIENT:	BLUE PHOENIX	**DATES:**	07/11/23

Logged	Checked
LN	JW

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m OD)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.04	-0.04		MADE GROUND: Asphalt. MADE GROUND: Concrete reinforced with crossing metal rebar.
		0.40	ES		0.35 0.46	-0.35 -0.46		MADE GROUND: Loose yellowish brown gravelly sand. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to coarse of chert, brick and concrete. MADE GROUND: Very soft dark brown slightly gravelly silty clay. Gravel is sub-angular to sub-rounded fine to medium of chert, brick and concrete with rare glass fragments.
		1.00	ES					1.0
		1.20	SPT	N=2 (0,0/1,0,1,0)	1.30	-1.30		MADE GROUND: Very soft dark brown and black, damp, organic gravelly clay. Gravel is sub-angular to sub-rounded fine to medium of chert and brick.
		1.50	ES					
		1.80	ES		1.72	-1.72		MADE GROUND: Very loose dark brown slightly clayey gravelly sand. Sand is fine to coarse. Gravel is sub-angular to sub-rounded fine to coarse of chert and brick.
	▼	2.00	D SPT	N=1 (0,0/1,0,0,0)	1.95	-1.95		Very loose dark grey, damp, organic slightly clayey gravelly SAND with pockets of fibrous peat. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to medium of flint. *Slight groundwater seepage encountered at 2.00m bgl.*
								2.0
		3.00	SPT	N=2 (1,0/1,0,1,0)	3.00	-3.00		Soft black, organic slightly gravelly peaty CLAY. Gravel is sub-angular to sub-rounded fine to coarse of chert.
		3.50	D					
		4.00	SPT	N=4 (1,1/1,1,1,1)				*Becoming firm at 4.30m bgl.*
								4.0
		5.00	SPT	N=4 (1,1/1,1,1,1)	5.00	-5.00		End of Borehole at 5.00m
								5.0
								6.0

Remarks

1. Clearance of services using GPR techniques and CAT and Genny prior to concrete coring.
2. Hand-dug inspection pit excavated to 1.20m bgl.
3. Slight groundwater encountered at 2.00m bgl.
4. Hole backfilled with arisings upon completion.

ES = Environmental Sample
D = Disturbed Sample
B = Bulk Sample
LB = Large Bulk Sample
U = Undisturbed Sample
UT = Undisturbed Thin Wall Sample
SPT = Standard Penetration Test
PID = Photoionization Detector (ppm)
PPM = Part Per Million
HSV = Hand Shear Vane

BROWNFIELD SOLUTIONS LTD

Borehole Log

Window Sampler No.
WS04
Sheet 1 of 1

PROJECT NO:	C5441	**CO-ORDS:**	**Hole Type** WS
PROJECT NAME:	TILBURY DOCKS, ESSEX	**LEVEL:**	**Scale** 1:30
CLIENT:	BLUE PHOENIX	**DATES:** 07/11/23	**Logged** LN / **Checked** JW

Well	Water Strikes	Sample and In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m OD)	Legend	Stratum Description
					0.21	-0.21		MADE GROUND: Concrete reinforced with crossing metal rebar.
		0.50	ES		0.50	-0.50		MADE GROUND: Loose yellowish brown gravelly sand. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to coarse of chert, brick and concrete.
		0.80	ES					MADE GROUND: Very soft dark brown slightly gravelly silty clay. Gravel is sub-angular to sub-rounded fine to medium of chert, brick and concrete with rare glass fragments.
		1.20	SPT	N=1 (1,0/0,0,0,1)				*Becomes wet between 1.20m and 2.00m bgl.*
	▼	1.50	D ES					*Becomes gravelly between 1.30m and 2.00m bgl.* *Slight groundwater seepage encountered at 1.50m bgl.*
		2.00	SPT	N=1 (0,1/0,0,1,0)	2.00	-2.00		Very soft dark grey and black, damp, slightly gravelly sandy CLAY with pockets of fibrous peat. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to medium of chert.
		2.50	D ES					
		3.00	SPT	N=1 (1,0/0,0,0,1)	3.00	-3.00		Soft black, damp, organic slightly gravelly fibrous peaty CLAY. Gravel is sub-angular to sub-rounded fine to coarse of chert.
		4.00	SPT	N=3 (1,0/1,0,1,1)				
		4.50	D					*Becoming firm at 4.50m bgl.*
		5.00	SPT	N=4 (1,1/1,1,1,1)	5.00	-5.00		End of Borehole at 5.00m

1.0 2.0 3.0 4.0 5.0 6.0

Remarks

1. Clearance of services using GPR techniques and CAT and Genny prior to concrete coring.
2. Hand-dug inspection pit excavated to 1.20m bgl.
3. Slight groundwater encountered at 1.50m bgl.
4. Hole backfilled with arisings upon completion.

ES = Environmental Sample
D = Disturbed Sample
B = Bulk Sample
LB = Large Bulk Sample
U = Undisturbed Sample
UT = Undisturbed Thin Wall Sample
SPT = Standard Penetration Test
PID = Photoionization Detector (ppm)
PPM = Part Per Million
HSV = Hand Shear Vane

BROWNFIELD SOLUTIONS LTD

Borehole Log

Window Sampler No.
WS05
Sheet 1 of 1

PROJECT NO:	C5441	**CO-ORDS:**	**Hole Type** WS
PROJECT NAME:	TILBURY DOCKS, ESSEX	**LEVEL:**	**Scale** 1:30
CLIENT:	BLUE PHOENIX	**DATES:**	07/11/23

Logged	Checked
LN	JW

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m OD)	Legend	Stratum Description
		Depth (m)	Type	Results				
								MADE GROUND: Concrete reinforced with crossing metal rebar.
					0.37	-0.37		
		0.60	ES		0.55	-0.55		MADE GROUND: Loose dark brown gravelly sand. Sand is fine to coarse. Gravel is sub-angular to sub-rounded fine to coarse of chert, concrete and brick.
		0.85	ES		0.80	-0.80		MADE GROUND: Very soft dark brown slightly gravelly silty clay. Gravel is sub-angular to sub-rounded fine to medium of chert, brick and concrete with rare glass fragments.
								MADE GROUND: Soft dark grey silty clay.
		1.20	SPT	N=2 (0,0/1,0,1,0)	1.20	-1.20		Very loose dark grey, organic slightly clayey gravelly SAND with pockets of fibrous peat. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to medium of chert.
		1.40	ES					
		1.50	D					
					1.60	-1.60		Very soft dark grey slightly gravelly sandy CLAY. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to medium of chert.
		2.00	D SPT	N=0 (0,0/0,0,0,0)				
		2.50	ES		2.50	-2.50		Very soft dark grey and black, damp, organic fibrous peaty CLAY. Slight putrid odour.
	▼							*Slight groundwater seepage encountered at 2.90m bgl.*
		3.00	D SPT	N=1 (0,1/0,0,1,0)				
		4.00	SPT	N=3 (1,1/1,1,1,0)				*Becomes firm and slightly gravelly at 4.00m bgl.*
		4.50	D					
		5.00	SPT	N=5 (1,2/1,2,1,1)	5.00	-5.00		End of Borehole at 5.00m

1.0 2.0 3.0 4.0 5.0 6.0

Remarks

1. Clearance of services using GPR techniques and CAT and Genny prior to concrete coring.
2. Hand-dug inspection pit excavated to 1.20m bgl.
3. Slight groundwater encountered at 2.90m bgl.
4. Hole collapsed up to 4.00m bgl.
5. Monitoring well installed following completion of drilling. 0.00m to 2.00m bgl plain pipe. 2.00m to 4.00m bgl slotted pipe.

ES = Environmental Sample
D = Disturbed Sample
B = Bulk Sample
LB = Large Bulk Sample
U = Undisturbed Sample
UT = Undisturbed Thin Wall Sample
SPT = Standard Penetration Test
PID = Photoionization Detector (ppm)
PPM = Part Per Million
HSV = Hand Shear Vane

BROWNFIELD SOLUTIONS LTD

Borehole Log

Window Sampler No.
WS06
Sheet 1 of 1

PROJECT NO:	C5441	**CO-ORDS:**	**Hole Type** WS
PROJECT NAME:	TILBURY DOCKS, ESSEX	**LEVEL:**	**Scale** 1:30
CLIENT:	BLUE PHOENIX	**DATES:** 07/11/23	**Logged** LN / **Checked** JW

Well	Water Strikes	Sample and In Situ Testing: Depth (m)	Type	Results	Depth (m)	Level (m OD)	Legend	Stratum Description
		0.30	ES		0.25	-0.25		MADE GROUND: Concrete reinforced with crossing metal rebar.
		0.80	ES		0.70	-0.70		MADE GROUND: Loose brown gravelly sand. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to coarse of chert, brick and concrete.
	▼	1.00	ES					MADE GROUND: Loose brown slightly clayey gravelly sand. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to coarse of chert, brick and concrete.
		1.20	SPT	N=2 (4,3/1,0,1,0)				*Moderate groundwater seepage encountered at 1.00m bgl.*
		1.50	D		1.50	-1.50		MADE GROUND: Very soft dark brown, slightly gravelly silty clay. Gravel is sub-angular to sub-rounded fine to medium of chert, brick and concrete.
		2.00	ES SPT	N=1 (1,0/0,0,1,0)				
		2.70	D		2.50	-2.50		Soft black, damp, organic slightly gravelly peaty CLAY. Gravel is sub-angular to sub-rounded fine to coarse of chert.
					3.00	-3.00		*Hole terminated at 3.00m bgl due to hole collapses.* End of Borehole at 3.00m

1.0 2.0 3.0 4.0 5.0 6.0

Remarks

1. Clearance of services using GPR techniques and CAT and Genny prior to concrete coring.
2. Hand-dug inspection pit excavated to 1.20m bgl.
3. Moderate groundwater encountered at 1.00m bgl.
4. Hole terminated at 3.00m bgl due to hole collapses.
5. Hole backfilled with arisings upon completion.

ES = Environmental Sample
D = Disturbed Sample
B = Bulk Sample
LB = Large Bulk Sample
U = Undisturbed Sample
UT = Undisturbed Thin Wall Sample
SPT = Standard Penetration Test
PID = Photoionization Detector (ppm)
PPM = Part Per Million
HSV = Hand Shear Vane

BROWNFIELD SOLUTIONS LTD

Borehole Log

Window Sampler No.
WS07
Sheet 1 of 1

PROJECT NO:	C5441	**CO-ORDS:**	**Hole Type** WS
PROJECT NAME:	TILBURY DOCKS, ESSEX	**LEVEL:**	**Scale** 1:30
CLIENT:	BLUE PHOENIX	**DATES:**	07/11/23

Logged	Checked
LN	JW

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m OD)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.40	-0.40		MADE GROUND: Concrete reinforced with crossing metal rebar.
		0.50	ES		0.60	-0.60		MADE GROUND: Loose dark brown slightly clayey gravelly sand. Sand is fine to coarse. Gravel is sub-angular to sub-rounded fine to coarse of chert, concrete and brick.
		0.90	ES		0.90	-0.90		MADE GROUND: Loose yellowish brown gravelly sand. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to coarse of chert, brick and concrete.
								Hole terminated at 0.90m bgl due to concrete obstruction.
								End of Borehole at 0.90m

1.0
2.0
3.0
4.0
5.0
6.0

Remarks

1. Clearance of services using GPR techniques and CAT and Genny prior to concrete coring.
2. Hand-dug inspection pit excavated to 0.90m bgl.
3. No groundwater encountered.
4. Hole terminated at 3.00m bgl due to concrete obstruction.
5. Hole backfilled with arisings upon completion.

ES = Environmental Sample
D = Disturbed Sample
B = Bulk Sample
LB = Large Bulk Sample
U = Undisturbed Sample
UT = Undisturbed Thin Wall Sample
SPT = Standard Penetration Test
PID = Photoionization Detector (ppm)
PPM = Part Per Million
HSV = Hand Shear Vane

BROWNFIELD SOLUTIONS LTD

Borehole Log

Window Sampler No.
WS08
Sheet 1 of 1

PROJECT NO:	C5441	**CO-ORDS:**	**Hole Type** WS
PROJECT NAME:	TILBURY DOCKS, ESSEX	**LEVEL:**	**Scale** 1:30
CLIENT:	BLUE PHOENIX	**DATES:**	07/11/23

Logged	Checked
LN	JW

Well	Water Strikes	Sample and In Situ Testing			Depth (m)	Level (m OD)	Legend	Stratum Description
		Depth (m)	Type	Results				
					0.08	-0.08		MADE GROUND: Asphalt.
								MADE GROUND: Concrete reinforced with crossing metal rebar.
					0.35	-0.35		MADE GROUND: Loose brown gravelly sand. Sand is fine to coarse. Gravel is sub-angular to sub-rounded fine to coarse of chert, brick, concrete and clinker.
		0.50	ES					
					0.65	-0.65		MADE GROUND: Very soft greyish black slightly gravelly fibrous peaty clay. Gravel is angular to sub-angular fine to coarse of chert and brick.
		1.00	ES					
		1.20	SPT	N=0 (0,0/0,0,0,0)				
					1.30	-1.30		Very soft dark grey and black, damp, organic fibrous peaty CLAY.
		1.50	D ES					
	▼	2.00	SPT	N=2 (0,1/1,0,0,1)				*Slight groundwater seepage encountered at 2.00m bgl.*
								Becomes gravelly and sandy between 2.50m and 2.70m bgl.
		2.80	D					
		3.00	SPT	N=2 (1,0/0,1,0,1)	3.00	-3.00		Very loose dark grey, slightly clayey gravelly SAND with pockets of fibrous peat. Sand is fine to medium. Gravel is sub-angular to sub-rounded fine to medium of chert.
		3.20	D					
					3.50	-3.50		Soft black, damp, organic slightly gravelly fibrous peaty CLAY. Gravel is sub-angular to sub-rounded fine to coarse of chert.
		4.00	SPT	N=4 (1,1/1,1,1,1)				
		4.50	D					*Becomes firm at 4.80m bgl.*
		5.00	SPT	N=6 (1,2/2,1,2,1)	5.00	-5.00		End of Borehole at 5.00m

1.0 2.0 3.0 4.0 5.0 6.0

Remarks

1. Clearance of services using GPR techniques and CAT and Genny prior to concrete coring.
2. Hand-dug inspection pit excavated to 1.20m bgl.
3. Slight groundwater encountered at 2.00m bgl.
4. Hole collapsed up to 2.50m bgl.
5. Monitoring well installed following completion of drilling. 0.00m to 1.50m bgl plain pipe. 1.50m to 2.50m bgl slotted pipe.

ES = Environmental Sample
D = Disturbed Sample
B = Bulk Sample
LB = Large Bulk Sample
U = Undisturbed Sample
UT = Undisturbed Thin Wall Sample
SPT = Standard Penetration Test
PID = Photoionization Detector (ppm)
PPM = Part Per Million
HSV = Hand Shear Vane

APPENDIX C

Geotechnical Testing Results

TEST CERTIFICATE

DETERMINATION OF LIQUID AND PLASTIC LIMITS

Tested in Accordance with: BS EN ISO 17892-12:2018+A2:2022, cl 5.3.14, 5.5, Fall Cone Method, 1 Pt Test, BS 1377-2:2022, cl 5.3, 6

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

4041

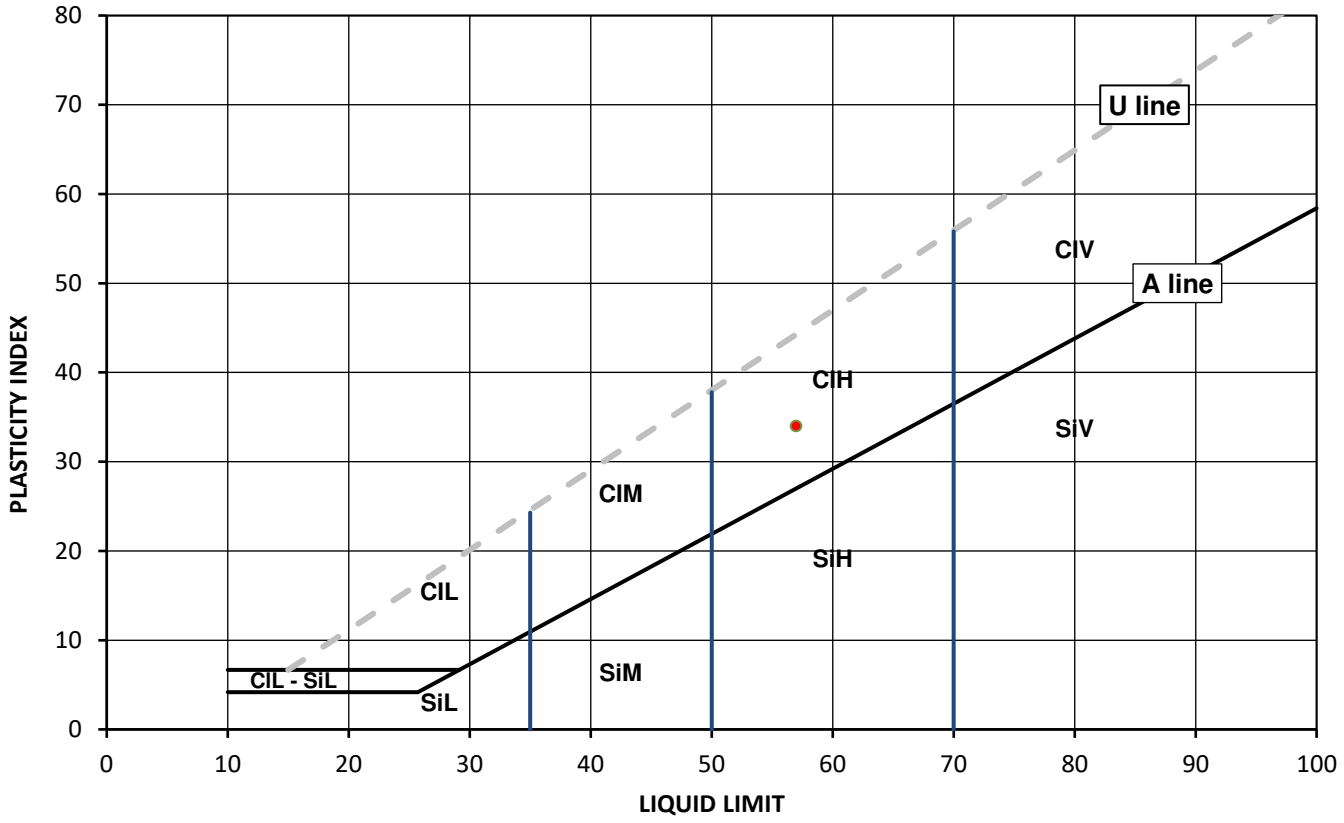
Client:	Brownfield Solutions Ltd	Client Reference:	C5441
Client Address:	William Smith House, 173 - 183 Witton Street, Northwich, Cheshire, CW9 5LP	Job Number:	23-68014-1
		Date Sampled:	06/11/2023
		Date Received:	09/11/2023
Contact:	Leroy Nyamayaro	Date Tested:	14/11/2023
Site Address:	Tilbury Docks, Essex	Sampled By:	Client - LN

Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Test Results:

Laboratory Reference:	2873933	Depth Top [m]:	3.50
Hole No.:	WS01	Depth Base [m]:	Not Given
Sample Reference:	Not Given	Sample Type:	D
Sample Description:	Grey slightly gravelly slightly sandy CLAY		
Sample Preparation:	Tested after >0.425 mm removed by hand;		
Cone Type:	80g/30deg		

As Received Water Content [W] %	Corrected Liquid Limit [WL] %	Correlation Factor	Plastic Limit [Wp] %	Plasticity Index [Ip] %	Liquidity index [IL] % #	Consistency index [IC] % #	% Passing 425µm BS Test Sieve
40.8	57	1.036	23	34	0.53	0.47	96



Legend, based on BS EN ISO 14688 2:2018 Geotechnical investigation and testing – Identification and classification of soil

		Plasticity		Liquid Limit
Cl	Clay	L	Low	below 35
Si	Silt	M	Medium	35 to 50
		H	High	50 to 70
		V	Very high	exceeding 70
		O	Organic	append to classification for organic material (eg ClHO)

Note: Water Content by BS EN 17892-1: 2014; Correlation Factor by Clayton C.R.I and Jukes A.W (1978); # Non accredited

Remarks:

Signed: Katarzyna Koziel

Katarzyna Koziel
Senior Reporting Specialist
for and on behalf of i2 Analytical Ltd

Date Reported: 27/11/2023

GF 360.12

TEST CERTIFICATE

DETERMINATION OF LIQUID AND PLASTIC LIMITS

Tested in Accordance with: BS EN ISO 17892-12:2018+A2:2022, cl 5.3.14, 5.5, Fall Cone Method, 1 Pt Test, BS 1377-2:2022, cl 5.3, 6

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

4041

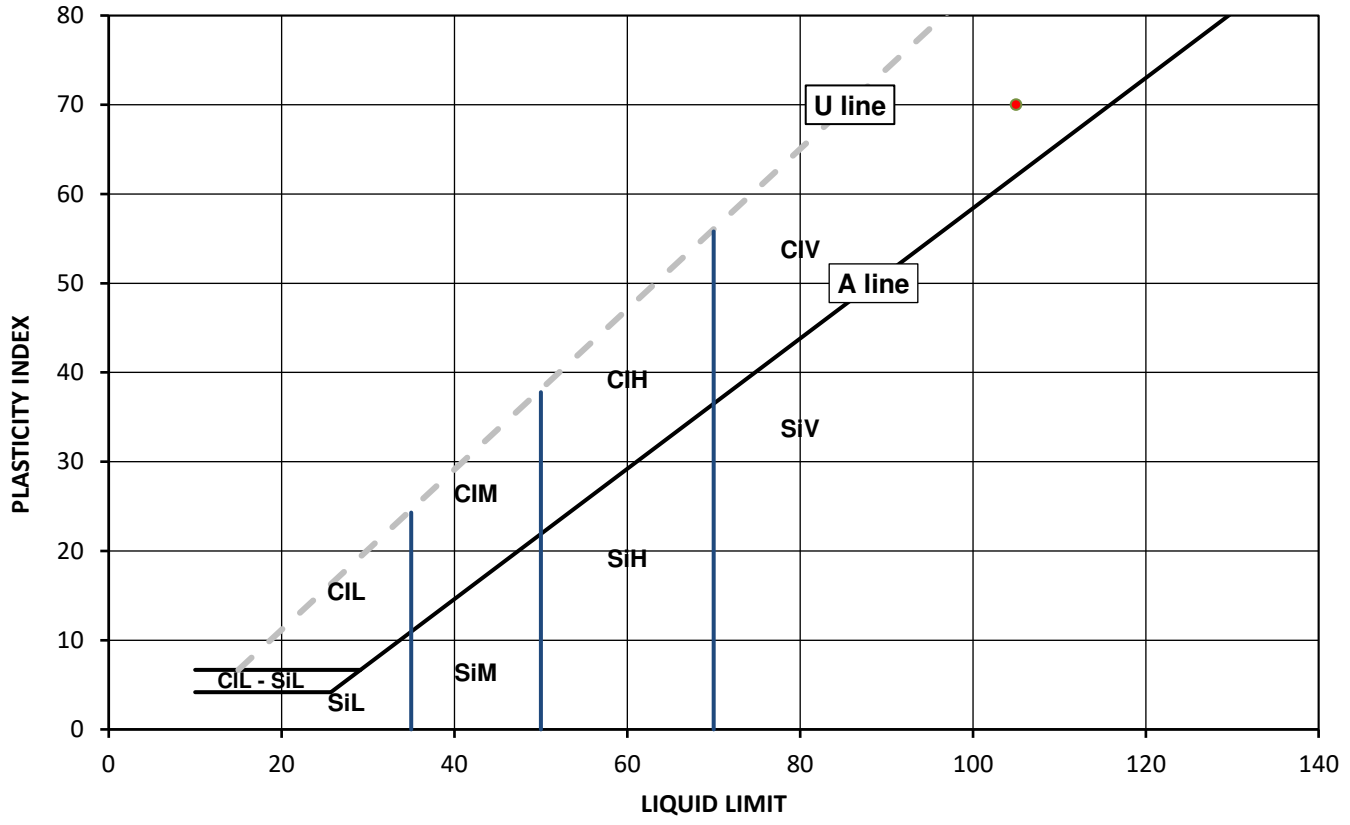
Client:	Brownfield Solutions Ltd	Client Reference:	C5441
Client Address:	William Smith House, 173 - 183 Witton Street, Northwich, Cheshire, CW9 5LP	Job Number:	23-68014-1
		Date Sampled:	07/11/2023
		Date Received:	09/11/2023
Contact:	Leroy Nyamayaro	Date Tested:	14/11/2023
Site Address:	Tilbury Docks, Essex	Sampled By:	Client - LN

Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Test Results:

Laboratory Reference:	2873934	Depth Top [m]:	3.50
Hole No.:	WS03	Depth Base [m]:	Not Given
Sample Reference:	Not Given	Sample Type:	D
Sample Description:	Grey slightly gravelly slightly organic CLAY		
Sample Preparation:	Tested after >0.425 mm removed by hand;		
Cone Type:	80g/30deg		

As Received Water Content [W] %	Corrected Liquid Limit [WL] %	Correlation Factor	Plastic Limit [Wp] %	Plasticity Index [Ip] %	Liquidity index [IL] % #	Consistency index [IC] % #	% Passing 425µm BS Test Sieve
85.0	105	1.018	35	70	0.71	0.29	96



Legend, based on BS EN ISO 14688 2:2018 Geotechnical investigation and testing – Identification and classification of soil

		Plasticity		Liquid Limit
Cl	Clay	L	Low	below 35
Si	Silt	M	Medium	35 to 50
		H	High	50 to 70
		V	Very high	exceeding 70
		O	Organic	append to classification for organic material (eg ClHO)

Note: Water Content by BS EN 17892-1: 2014; Correlation Factor by Clayton C.R.I and Jukes A.W (1978); # Non accredited

Remarks:

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Katarzyna Koziel
Senior Reporting Specialist
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Date Reported: 27/11/2023

GF 360.12

TEST CERTIFICATE

DETERMINATION OF LIQUID AND PLASTIC LIMITS

Tested in Accordance with: BS EN ISO 17892-12:2018+A2:2022, cl 5.3.14, 5.5, Fall Cone Method, 1 Pt Test, BS 1377-2:2022, cl 5.3, 6

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Brackmills Industrial Estate
Northampton NN4 7EB

4041

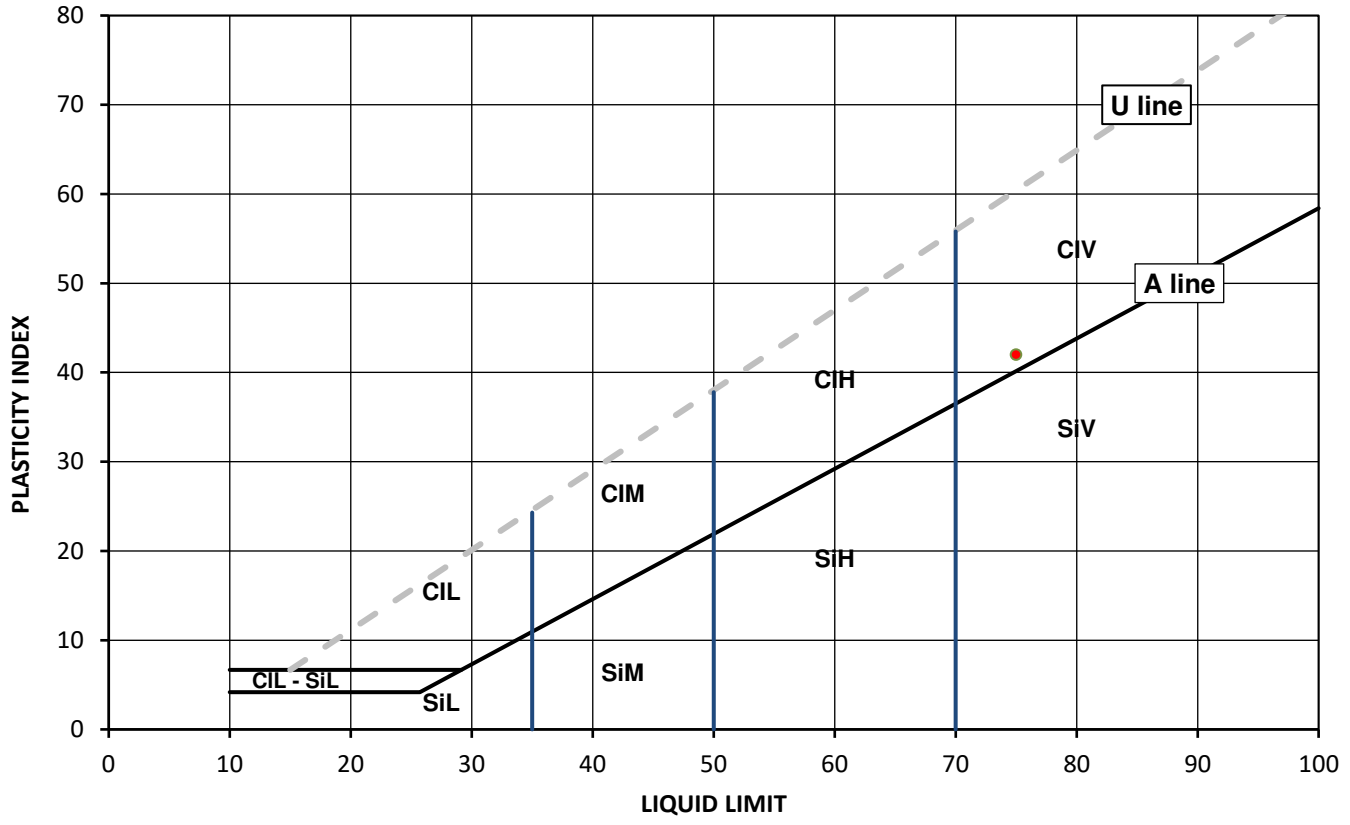
Client:	Brownfield Solutions Ltd	Client Reference:	C5441
Client Address:	William Smith House, 173 - 183 Witton Street, Northwich, Cheshire, CW9 5LP	Job Number:	23-68014-1
		Date Sampled:	07/11/2023
		Date Received:	09/11/2023
Contact:	Leroy Nyamayaro	Date Tested:	14/11/2023
Site Address:	Tilbury Docks, Essex	Sampled By:	Client - LN

Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Test Results:

Laboratory Reference:	2873935	Depth Top [m]:	2.50
Hole No.:	WS04	Depth Base [m]:	Not Given
Sample Reference:	Not Given	Sample Type:	D
Sample Description:	Brownish grey slightly gravelly slightly organic CLAY		
Sample Preparation:	Tested after >0.425 mm removed by hand;		
Cone Type:	80g/30deg		

As Received Water Content [W] %	Corrected Liquid Limit [WL] %	Correlation Factor	Plastic Limit [Wp] %	Plasticity Index [Ip] %	Liquidity index [IL] % #	Consistency index [IC] % #	% Passing 425µm BS Test Sieve
52.3	75	1.035	33	42	0.45	0.55	97



Legend, based on BS EN ISO 14688 2:2018 Geotechnical investigation and testing – Identification and classification of soil

		Plasticity		Liquid Limit
Cl	Clay	L	Low	below 35
Si	Silt	M	Medium	35 to 50
		H	High	50 to 70
		V	Very high	exceeding 70
		O	Organic	append to classification for organic material (eg ClHO)

Note: Water Content by BS EN 17892-1: 2014; Correlation Factor by Clayton C.R.I and Jukes A.W (1978); # Non accredited

Remarks:

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Senior Reporting Specialist
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Date Reported: 27/11/2023

GF 360.12

TEST CERTIFICATE

DETERMINATION OF LIQUID AND PLASTIC LIMITS

Tested in Accordance with: BS EN ISO 17892-12:2018+A2:2022, cl 5.3.14, 5.5, Fall Cone Method, 1 Pt Test, BS 1377-2:2022, cl 5.3, 6

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

4041

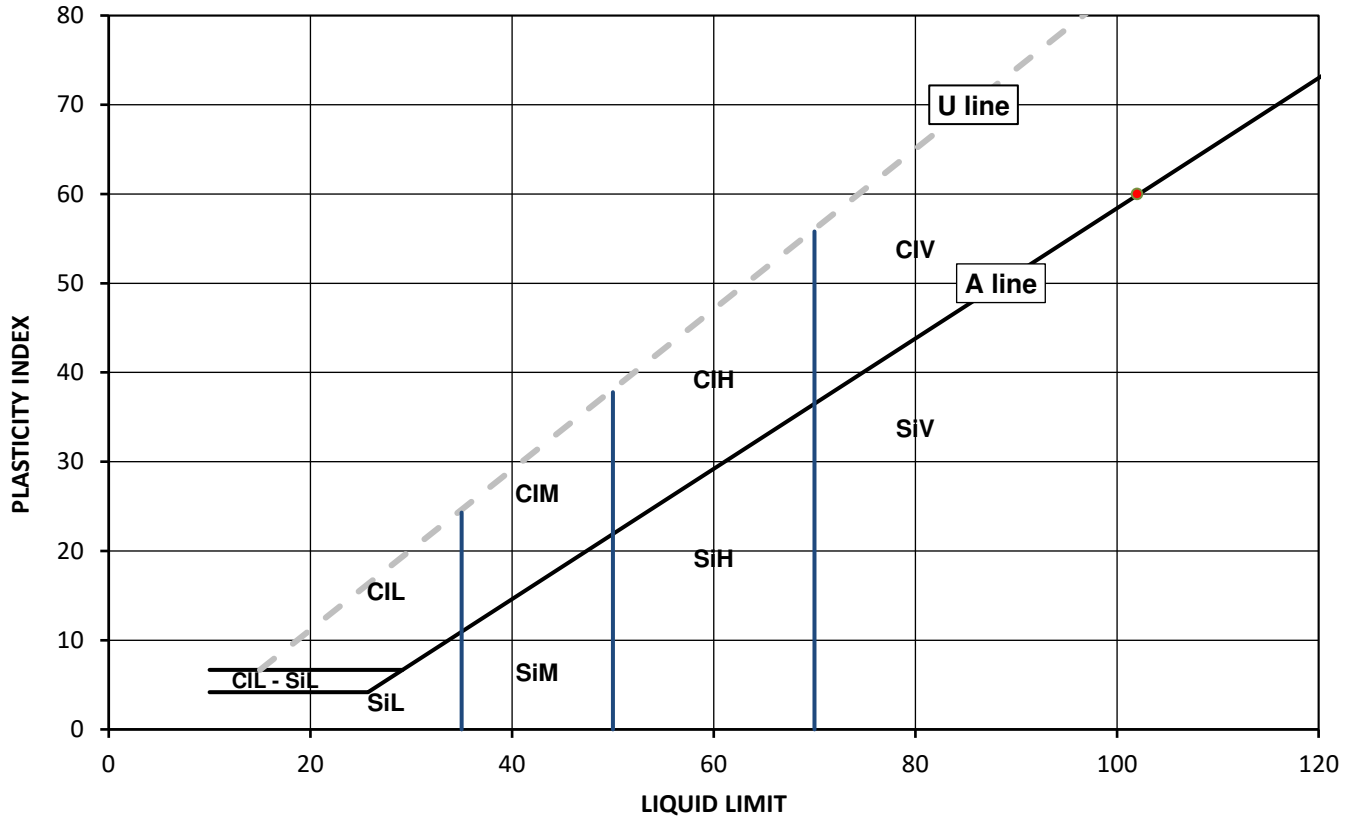
Client:	Brownfield Solutions Ltd	Client Reference:	C5441
Client Address:	William Smith House, 173 - 183 Witton Street, Northwich, Cheshire, CW9 5LP	Job Number:	23-68014-1
		Date Sampled:	07/11/2023
		Date Received:	09/11/2023
Contact:	Leroy Nyamayaro	Date Tested:	14/11/2023
Site Address:	Tilbury Docks, Essex	Sampled By:	Client - LN

Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Test Results:

Laboratory Reference:	2873936	Depth Top [m]:	2.00
Hole No.:	WS05	Depth Base [m]:	Not Given
Sample Reference:	Not Given	Sample Type:	D
Sample Description:	Dark grey slightly gravelly silty CLAY		
Sample Preparation:	Tested after >0.425 mm removed by hand;		
Cone Type:	80g/30deg		

As Received Water Content [W] %	Corrected Liquid Limit [WL] %	Correlation Factor	Plastic Limit [Wp] %	Plasticity Index [Ip] %	Liquidity index [IL] % #	Consistency index [IC] % #	% Passing 425µm BS Test Sieve
56.0	102	1.018	42	60	0.23	0.77	97



Legend, based on BS EN ISO 14688 2:2018 Geotechnical investigation and testing – Identification and classification of soil

		Plasticity		Liquid Limit
Cl	Clay	L	Low	below 35
Si	Silt	M	Medium	35 to 50
		H	High	50 to 70
		V	Very high	exceeding 70
		O	Organic	append to classification for organic material (eg ClHO)

Note: Water Content by BS EN 17892-1: 2014; Correlation Factor by Clayton C.R.I and Jukes A.W (1978); # Non accredited

Remarks:

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Date Reported: 27/11/2023

GF 360.12

TEST CERTIFICATE

DETERMINATION OF LIQUID AND PLASTIC LIMITS

Tested in Accordance with: BS EN ISO 17892-12:2018+A2:2022, cl 5.3.14, 5.5, Fall Cone Method, 1 Pt Test, BS 1377-2:2022, cl 5.3, 6

i2 Analytical Ltd
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Brackmills Industrial Estate
Northampton NN4 7EB

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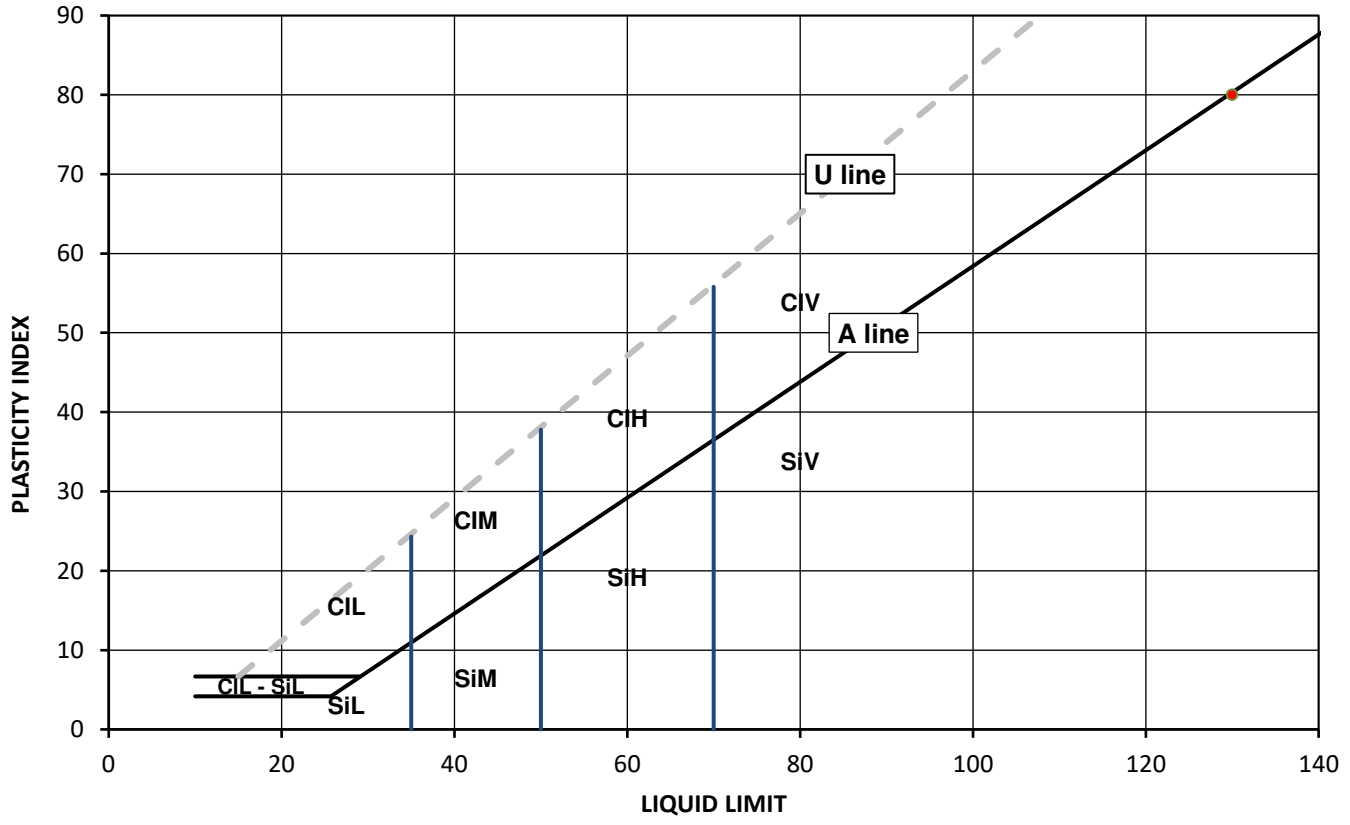
Client:	Brownfield Solutions Ltd	Client Reference:	C5441
Client Address:	William Smith House, 173 - 183 Witton Street, Northwich, Cheshire, CW9 5LP	Job Number:	23-68014-1
		Date Sampled:	07/11/2023
		Date Received:	09/11/2023
Contact:	Leroy Nyamayaro	Date Tested:	14/11/2023
Site Address:	Tilbury Docks, Essex	Sampled By:	Client - LN

Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Test Results:

Laboratory Reference:	2873937	Depth Top [m]:	2.70
Hole No.:	WS06	Depth Base [m]:	Not Given
Sample Reference:	Not Given	Sample Type:	D
Sample Description:	Dark grey slightly gravelly slightly organic CLAY		
Sample Preparation:	Tested after >0.425 mm removed by hand;		
Cone Type:	80g/30deg		

As Received Water Content [W] %	Corrected Liquid Limit [WL] %	Correlation Factor	Plastic Limit [Wp] %	Plasticity Index [Ip] %	Liquidity index [IL] % #	Consistency index [IC] % #	% Passing 425µm BS Test Sieve
82.8	130	0.967	50	80	0.41	0.59	99



Legend, based on BS EN ISO 14688 2:2018 Geotechnical investigation and testing – Identification and classification of soil

		Plasticity		Liquid Limit
Cl	Clay	L	Low	below 35
Si	Silt	M	Medium	35 to 50
		H	High	50 to 70
		V	Very high	exceeding 70
		O	Organic	append to classification for organic material (eg ClHO)

Note: Water Content by BS EN 17892-1: 2014; Correlation Factor by Clayton C.R.I and Jukes A.W (1978); # Non accredited

Remarks:

Signed: Katarzyna Koziel

Katarzyna Koziel
Senior Reporting Specialist
for and on behalf of i2 Analytical Ltd

Date Reported: 27/11/2023

GF 360.12

TEST CERTIFICATE

DETERMINATION OF LIQUID AND PLASTIC LIMITS

Tested in Accordance with: BS EN ISO 17892-12:2018+A2:2022, cl 5.3.14, 5.5, Fall Cone Method, 1 Pt Test, BS 1377-2:2022, cl 5.3, 6

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

4041

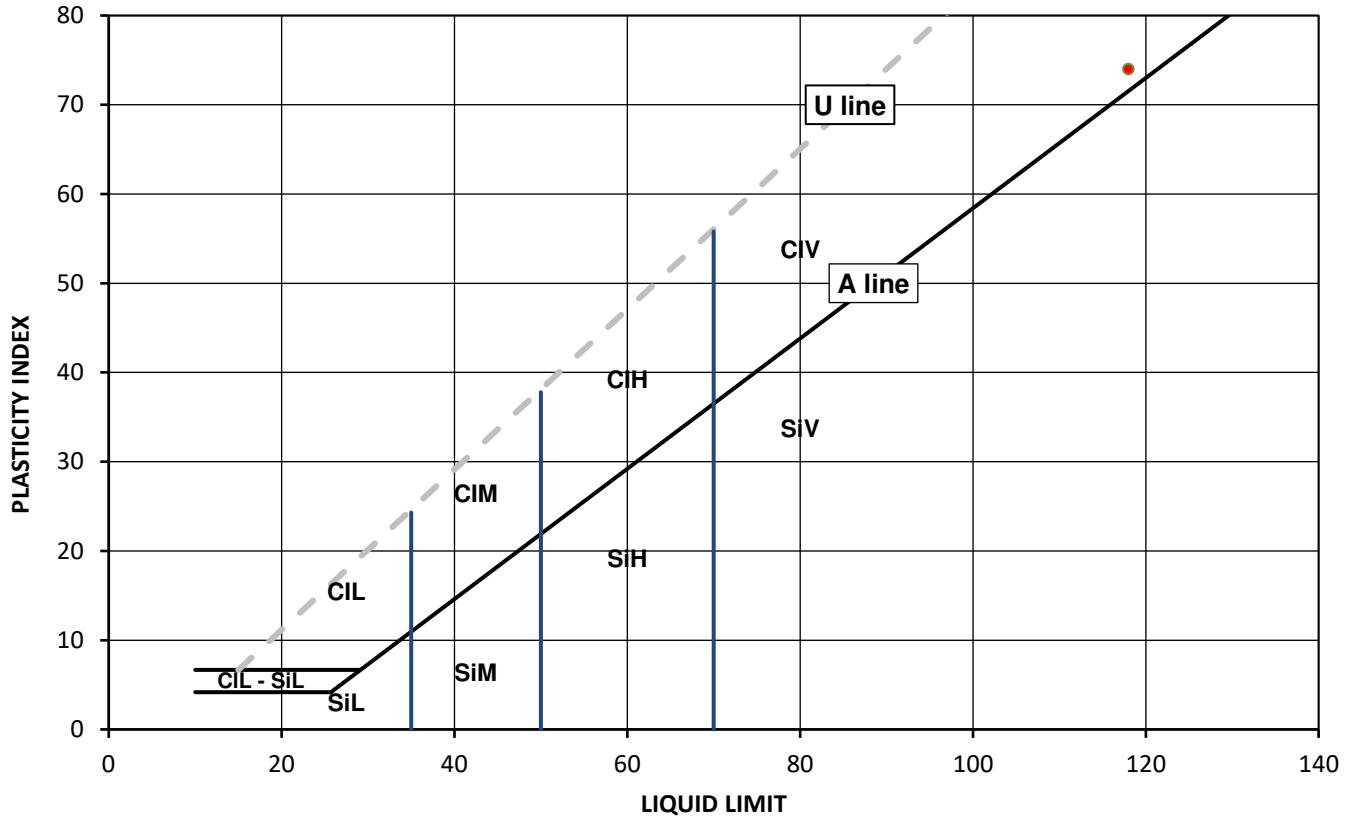
Client:	Brownfield Solutions Ltd	Client Reference:	C5441
Client Address:	William Smith House, 173 - 183 Witton Street, Northwich, Cheshire, CW9 5LP	Job Number:	23-68014-1
		Date Sampled:	07/11/2023
		Date Received:	09/11/2023
Contact:	Leroy Nyamayaro	Date Tested:	14/11/2023
Site Address:	Tilbury Docks, Essex	Sampled By:	Client - LN

Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Test Results:

Laboratory Reference:	2873938	Depth Top [m]:	1.50
Hole No.:	WS08	Depth Base [m]:	Not Given
Sample Reference:	Not Given	Sample Type:	D
Sample Description:	Dark grey slightly gravelly slightly organic CLAY		
Sample Preparation:	Tested after >0.425 mm removed by hand;		
Cone Type:	80g/30deg		

As Received Water Content [W] %	Corrected Liquid Limit [WL] %	Correlation Factor	Plastic Limit [Wp] %	Plasticity Index [Ip] %	Liquidity index [IL] % #	Consistency index [IC] % #	% Passing 425µm BS Test Sieve
80.7	118	0.984	44	74	0.50	0.50	99



Legend, based on BS EN ISO 14688 2:2018 Geotechnical investigation and testing – Identification and classification of soil

		Plasticity		Liquid Limit
Cl	Clay	L	Low	below 35
Si	Silt	M	Medium	35 to 50
		H	High	50 to 70
		V	Very high	exceeding 70
		O	Organic	append to classification for organic material (eg ClHO)

Note: Water Content by BS EN 17892-1: 2014; Correlation Factor by Clayton C.R.I and Jukes A.W (1978); # Non accredited

Remarks:

Signed: Katarzyna Koziel

Katarzyna Koziel
Senior Reporting Specialist
for and on behalf of i2 Analytical Ltd

Date Reported: 27/11/2023

GF 360.12

SUMMARY REPORT

SUMMARY OF CLASSIFICATION TEST RESULTS

Tested in Accordance with:

W by BS EN 17892-1: 2014; Liquid and Plastic Limit by BS EN ISO 17892-12:2018+A1:2021: Clause 5.3 (4 Point Test), Clause 5.3.14 (1 Point Test) and 5.5; Correlation Factor by Clayton C.R.I and Jukes A.W (1978)

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

4041

Client: Brownfield Solutions Ltd

Client Address: William Smith House, 173 - 183 Witton Street,
Northwich, Cheshire, CW9 5LP

Contact: Leroy Nyamayaro

Site Address: Tilbury Docks, Essex

Client Reference: C5441
Job Number: 23-68014-1
Date Sampled: 06/11 - 07/11/2023
Date Received: 11/09/2023
Date Tested: 14/11/2023
Sampled By: Client - LN

Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Test results

Laboratory Reference	Hole No.	Sample				Description	Remarks	W	Liquid & Plastic Limit							Density		
		Reference	Depth Top m	Depth Base m	Type			%	% Passing 425um %	WL* %	Correlation Factor	Wp %	Ip %	Cone type	Sample Preparation	bulk Mg/m3	dry Mg/m3	PD Mg/m3
2873933	WS01	Not Given	3.50	Not Given	D	Grey slightly gravelly slightly sandy CLAY	Atterberg 1 Point	40.8	96	57	1.036	23	34	80g/30 deg	R			
2873934	WS03	Not Given	3.50	Not Given	D	Grey slightly gravelly slightly organic CLAY	Atterberg 1 Point	85.0	96	105	1.018	35	70	80g/30 deg	R			
2873935	WS04	Not Given	2.50	Not Given	D	Brownish grey slightly gravelly slightly organic CLAY	Atterberg 1 Point	52.3	97	75	1.035	33	42	80g/30 deg	R			
2873936	WS05	Not Given	2.00	Not Given	D	Dark grey slightly gravelly silty CLAY	Atterberg 1 Point	56.0	97	102	1.018	42	60	80g/30 deg	R			
2873937	WS06	Not Given	2.70	Not Given	D	Dark grey slightly gravelly slightly organic CLAY	Atterberg 1 Point	82.8	99	130	0.967	50	80	80g/30 deg	R			
2873938	WS08	Not Given	1.50	Not Given	D	Dark grey slightly gravelly slightly organic CLAY	Atterberg 1 Point	80.7	99	118	0.984	44	74	80g/30 deg	R			

Note: # Non accredited; NP - Non plastic; N - Tested in natural condition, R - Tested after >0.425mm removed by hand, W - Tested after washing to remove >425mm; * - One point liquid limit corrected as per the report Correlation Factor by Clayton C.R.I and Jukes A.W (1978)

Comments:

Signed:

Katarzyna Koziel
Senior Reporting Specialist
for and on behalf of i2 Analytical Ltd

Date Reported: 27/11/2023 **GF 361.12**

SUMMARY REPORT

DETERMINATION OF WATER CONTENT

Tested in Accordance with: BS 1377-2: 1990: Clause 3.2

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

4041

Client: Brownfield Solutions Ltd

Client Address: William Smith House, 173 - 183 Witton Street,
Northwich, Cheshire,
CW9 5LP

Contact: Leroy Nyamayaro

Site Address: Tilbury Docks, Essex

Client Reference: C5441
Job Number: 23-68014-1
Date Sampled: 06/11 - 07/11/2023
Date Received: 09/11/2023
Date Tested: 14/11/2023
Sampled By: Client - LN

Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Test results

Laboratory Reference	Hole No.	Sample				Description	Remarks	WC	Sample preparation / Oven temperature at the time of testing			
		Reference	Depth Top m	Depth Base m	Type			%				
2873933	WS01	Not Given	3.50	Not Given	D	Grey slightly gravelly slightly sandy CLAY		41	Sample was quartered, oven dried at 106.7 °C			
2873934	WS03	Not Given	3.50	Not Given	D	Grey slightly gravelly slightly organic CLAY		85	Sample was quartered, oven dried at 106.7 °C			
2873935	WS04	Not Given	2.50	Not Given	D	Brownish grey slightly gravelly slightly organic CLAY		52	Sample was quartered, oven dried at 106.7 °C			
2873936	WS05	Not Given	2.00	Not Given	D	Dark grey slightly gravelly silty CLAY		56	Sample was quartered, oven dried at 106.7 °C			
2873937	WS06	Not Given	2.70	Not Given	D	Dark grey slightly gravelly slightly organic CLAY		83	Sample was quartered, oven dried at 106.7 °C			
2873938	WS08	Not Given	1.50	Not Given	D	Dark grey slightly gravelly slightly organic CLAY		81	Sample was quartered, oven dried at 106.7 °C			

Comments:

Signed:

Katarzyna Koziel
Senior Reporting Specialist
for and on behalf of i2 Analytical Ltd

Date Reported: 27/11/2023

GF 099.17

TEST CERTIFICATE

DETERMINATION OF THE UNDRAINED SHEAR STRENGTH IN TRIAXIAL COMPRESSION WITHOUT MEASUREMENT OF PORE PRESSURE

i2 Analytical Ltd
Unit 8 Harrowden Road
Brackmills Industrial Estate
Northampton NN4 7EB

4041

Tested in Accordance with: BS 1377-7: 1990: Clause 8

Client:	Brownfield Solutions Ltd	Client Reference:	C5441
Client Address:	William Smith House, 173 - 183 Witton Street, Northwich, Cheshire, CW9 5LP	Job Number:	23-68014-1
		Date Sampled:	06/11/2023
		Date Received:	09/11/2023
Contact:	Leroy Nyamayaro	Date Tested:	16/11/2023
Site Address:	Tilbury Docks, Essex	Sampled By:	Client - LN

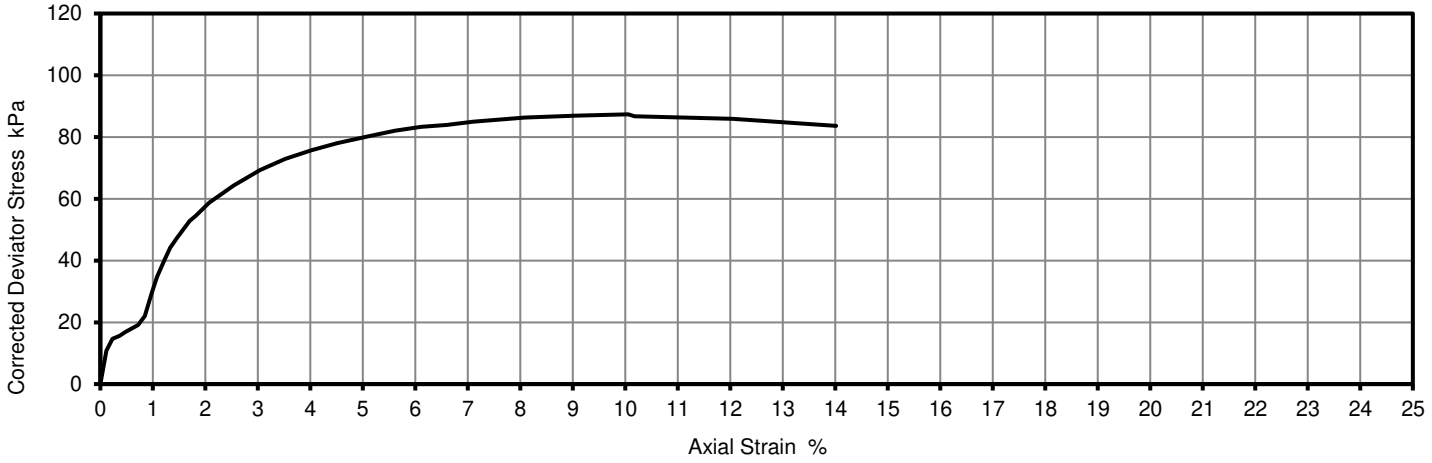
Testing carried out at i2 Analytical Limited, ul. Pionierow, 41-711 Ruda Slaska, Poland

Test Results:

Laboratory Reference:	2873932	Depth Top [m]:	5.00
Hole No.:	CP01	Depth Base [m]:	5.45
Sample Reference:	Not Given	Sample Type:	U
Sample Description:	Dark grey CLAY		
Sample Preparation:	Sample prepared in accordance with BS 1377-1:2016 Clause 9.1.1.		

Test Number	1		Rate of Strain	1.50	%/min
Length	205.64	mm	Cell Pressure	100	kPa
Diameter	102.58	mm	Axial Strain at failure	10.1	%
Bulk Density	1.72	Mg/m3	Deviator Stress, (σ1 - σ3)f	87	kPa
Moisture Content	52	%	Undrained Shear Strength, cu	44	kPa ½(σ1 - σ3)f
Dry Density	1.13	Mg/m3	Mode of Failure	Compound	
Membrane Correction	0.59	kPa	Latex membrane thickness	0.27	mm

Deviator Stress v Axial Strain



Mohr Circles

Position within sample

Note: Deviator stress corrected for area change and membrane effects. Mohr circles and their interpretation is not covered by BS1377. This is provided for information only.

Remarks: Duration of test fell below time specified in BS 1377-7.

Signed:

Katarzyna Koziel
Senior Reporting Specialist
for and on behalf of i2 Analytical Ltd

Date Reported: 27/11/2023

GF 184.14

Leroy Nyamayaro
Brownfield Solutions Ltd
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Analytical Report Number : 23-68015

Project / Site name:	Tilbury Docks, Essex	**Samples received on:**	09/11/2023
Your job number:	C5441	**Samples instructed on/ Analysis started on:**	10/11/2023
Your order number:	C5441 4746 LN	**Analysis completed by:**	23/11/2023
Report Issue Number:	1	**Report issued on:**	23/11/2023
Samples Analysed:	4 soil samples		

Signed:

Joanna Wawrzeczko
Senior Reporting Specialist
For & on behalf of i2 Analytical Ltd.

Standard Geotechnical, Asbestos and Chemical Testing Laboratory located at: ul. Pionierów 39, 41-711 Ruda Śląska, Poland.

Accredited tests are defined within the report, opinions and interpretations expressed herein are outside the scope of accreditation.

Standard sample disposal times, unless otherwise agreed with the laboratory, are :

soils - 4 weeks from reporting
leachates - 2 weeks from reporting
waters - 2 weeks from reporting
asbestos - 6 months from reporting

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Any assessments of compliance with specifications are based on actual analytical results with no contribution from uncertainty of measurement.
Application of uncertainty of measurement would provide a range within which the true result lies.
An estimate of measurement uncertainty can be provided on request.

Analytical Report Number: 23-68015
Project / Site name: Tilbury Docks, Essex
Your Order No: C5441 4746 LN

Lab Sample Number				2873939	2873940	2873941	2873942
Sample Reference				CP01	CP01	WS01	WS08
Sample Number				None Supplied	None Supplied	None Supplied	None Supplied
Depth (m)				4.00	6.00	2.00	2.60
Date Sampled				06/11/2023	06/11/2023	06/11/2023	07/11/2023
Time Taken				None Supplied	None Supplied	None Supplied	None Supplied
Analytical Parameter (Soil Analysis)	**Units**	**Limit of detection**	**Accreditation Status**				
Stone Content	%	0.1	NONE	< 0.1	< 0.1	< 0.1	< 0.1
Moisture Content	%	0.01	NONE	27	45	43	44
Total mass of sample received	kg	0.001	NONE	0.5	0.5	0.5	0.5

General Inorganics

pH - Automated	pH Units	N/A	MCERTS	8.4	7.7	8	8.2
Total Sulphate as SO4	%	0.005	MCERTS	0.199	-	-	0.199
Water Soluble Sulphate as SO4 16hr extraction (2:1)	mg/kg	2.5	MCERTS	-	1900	3400	-
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	g/l	0.00125	MCERTS	0.4	0.97	1.7	1.03
Water Soluble SO4 16hr extraction (2:1 Leachate Equivalent)	mg/l	1.25	MCERTS	-	970	1700	-
Water Soluble Chloride (2:1) (leachate equivalent)	mg/l	0.5	MCERTS	590	-	-	650
Total Sulphur	%	0.005	MCERTS	0.494	-	-	1.42
Water Soluble Nitrate (2:1) as N (leachate equivalent)	mg/l	2	NONE	< 2.0	-	-	< 2.0

Heavy Metals / Metalloids

Magnesium (water soluble)	mg/kg	5	NONE	32	-	-	190
Magnesium (leachate equivalent)	mg/l	2.5	NONE	16	-	-	96

U/S = Unsuitable Sample I/S = Insufficient Sample ND = Not detected

Analytical Report Number : 23-68015
Project / Site name: Tilbury Docks, Essex

* These descriptions are only intended to act as a cross check if sample identities are questioned. The major constituent of the sample is intended to act with respect to MCERTS validation. The laboratory is accredited for sand, clay and loam (MCERTS) soil types. Data for unaccredited types of solid should be interpreted with care.

Stone content of a sample is calculated as the % weight of the stones not passing a 10 mm sieve. Results are not corrected for stone content.

Lab Sample Number	Sample Reference	Sample Number	Depth (m)	Sample Description *
2873939	CP01	None Supplied	4	Brown clay and sand with gravel.
2873940	CP01	None Supplied	6	Brown clay and sand with gravel.
2873941	WS01	None Supplied	2	Brown clay and sand with gravel.
2873942	WS08	None Supplied	2.6	Brown clay and sand with vegetation.

Analytical Report Number : 23-68015
Project / Site name: Tilbury Docks, Essex

Water matrix abbreviations:
Surface Water (SW) Potable Water (PW) Ground Water (GW) Process Waters (PrW) Final Sewage Effluent (FSE) Landfill Leachate (LL)

Analytical Test Name	Analytical Method Description	Analytical Method Reference	Method number	Wet / Dry Analysis	Accreditation Status
Sulphate, water soluble, in soil (16hr extraction)	Determination of water soluble sulphate by ICP-OES. Results reported directly (leachate equivalent) and corrected for extraction ratio (soil equivalent).	In house method.	L038-PL	D	MCERTS
Magnesium, water soluble, in soil	Determination of water soluble magnesium by extraction with water followed by ICP-OES.	In-house method based on TRL 447	L038-PL	D	NONE
Moisture Content	Moisture content, determined gravimetrically. (30 oC)	In house method.	L019-UK/PL	W	NONE
pH in soil (automated)	Determination of pH in soil by addition of water followed by automated electrometric measurement.	In house method.	L099-PL	D	MCERTS
Stones content of soil	Standard preparation for all samples unless otherwise detailed. Gravimetric determination of stone > 10 mm as % dry weight.	In-house method based on British Standard Methods and MCERTS requirements.	L019-UK/PL	D	NONE
Total Sulphate in soil as %	Determination of total sulphate in soil by extraction with 10% HCl followed by ICP-OES.	In house method.	L038-PL	D	MCERTS
Total Sulphur in soil as %	Determination of total sulphur in soil by extraction with aqua-regia, potassium bromide/bromate followed by ICP-OES.	In house method.	L038-PL	D	MCERTS
Water Soluble Nitrate (2:1) as N in soil	Determination of nitrate by reaction with sodium salicylate and colorimetry.	In-house method based on Examination of Water and Wastewatern & Polish Standard Method PN-82/C-04579.08, 2:1 extraction.	L078-PL	W	NONE
Chloride, water soluble, in soil	Determination of Chloride colorimetrically by discrete analyser.	In house method.	L082-PL	D	MCERTS
Sulphate, water soluble, in soil	Determination of water soluble sulphate by ICP-OES. Results reported directly (leachate equivalent) and corrected for extraction ratio (soil equivalent).	In house method.	L038-PL	D	MCERTS

For method numbers ending in 'UK or A' analysis have been carried out in our laboratory in the United Kingdom (WATFORD).
For method numbers ending in 'F' analysis have been carried out in our laboratory in the United Kingdom (East Kilbride).
For method numbers ending in 'PL or B' analysis have been carried out in our laboratory in Poland.
Soil analytical results are expressed on a dry weight basis. Where analysis is carried out on as-received the results obtained are multiplied by a moisture correction factor that is determined gravimetrically using the moisture content which is carried out at a maximum of 30oC.
Unless otherwise indicated, site information, order number, project number, sampling date, time, sample reference and depth are provided by the client. The instructed on date indicates the date on which this information was provided to the laboratory.

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