



SGN Commercial Services Limited

REMEDIATION SCHEME

Gas Holder No. 4, Reading





SGN Commercial Services Limited

REMEDIATION SCHEME

Gas Holder No. 4, Reading

TYPE OF DOCUMENT (VERSION) CONFIDENTIAL

PROJECT NO. 70070233

OUR REF. NO. 70070233_R01

DATE: NOVEMBER 2021

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QUALITY CONTROL

Issue/revision	First issue	Revision 1	Revision 2A	Revision 3	Revision 4	Revision 4a
Remarks	Draft	Final	Revised following DQRA updates	Revised to address EA comments	Final Issue	Final Issue Rev 4a
Date	15 Feb 2021	4 Mar 2021	9 Aug 2021	11 Nov 2021	18 Nov 2021	18 Nov 2021
Prepared by	S. Thorpe	S. Thorpe	S. Thorpe	S. Thorpe	R Gohel	R Gohel
Signature						 Gohel, Reena (UKRXG006) 2021.11.18 17:26:32
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Project number	70070233	70070233	70070233	70070233	70070233	70070233
Report number	70070233R01	70070233R01	70070233R01	70070233R01	70070233R01	70070233R01
File reference	\\uk.wspgroup.com\Central Data\Projects\700702xx\70070233 - Reading Gasholder Remediation\03 WIP\Remediation Strategy\ISSUE 18 NOVEMBER 2021					

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1 INTRODUCTION

1.1 TERMS OF REFERENCE

- 1.1.1. WSP UK Limited (WSP) was commissioned by SGN Commercial Services Ltd (SGN) (the Client) to prepare a Remediation Scheme, comprising of a remediation options appraisal and remediation strategy for Gas Holder No.4 Site, Reading (hereafter referred to as the 'Site'). The Site location is shown on Drawing 70070233-001 and the Site layout is shown on Drawing 70070233-002 contained within **Appendix A**. The work has been conducted with reference to WSP proposal, dated 10 December 2020 (SGN reference 2820003081).
- 1.1.2. This work has been undertaken in accordance with current United Kingdom best practice including government document 'Land Contamination: Risk Management' (LCRM) October 2020.

1.2 BACKGROUND

- 1.2.1. SGN are preparing to sell the Site for a residential end-use, for which the Local Planning Authority (Reading Borough Council) have granted full planning permission (ref. 190627) for the proposed development, and prior approval has been granted for the demolition of the gas holder and ancillary structures; demolition works are due to commence in September 2021. The proposed development comprises demolition of existing buildings and the gas holder and the erection of new buildings ranging between two and nine storeys in height, providing 130 residential units (Class C3) with associated access, car parking, landscaping, open space and two private gardens. The proposed development plan layouts are included in **Appendix A**.
- 1.2.2. Three phases of site investigation in 2015, April 2019 and September 2019, and subsequent generic and detailed quantitative risk assessment identified a number of contaminants, largely associated with the historical gasworks, above the adopted human health (residential) and Controlled Waters screening criteria. Contaminants of concern included metals, chlorinated solvents, ammoniacal nitrogen, cyanide, Total Petroleum Hydrocarbon (TPH), Poly Aromatic Hydrocarbon (PAH) compounds and asbestos.
- 1.2.3. A remediation scheme, including an appraisal of remediation options, is required for the development in addition to subsequent implementation to mitigate the identified risks and ensure the Site is suitable for the intended future use. This document is required to support the discharge of planning condition No. 18 which states:

No development, except demolition above slab level, shall take place, including demolition and any preparatory works, until a detailed remediation scheme to bring the site to a condition suitable for the intended use by removing unacceptable risks to human health, buildings and other property and the natural and historical environment has been submitted to and approved in writing by the Local Planning Authority. The scheme must include all works to be undertaken, proposed remediation objectives and remediation criteria, an appraisal of remedial options, and proposal of the preferred option(s), and a timetable of works and site management procedures and a validation plan providing details of the data that will be collected in order to demonstrate that the works set out in the remediation strategy are complete and identifying any requirements for longer-term monitoring of pollutant linkages, maintenance and arrangements for contingency action. The scheme must ensure that the site will not qualify as contaminated land under Part 2A of the Environmental Protection Act 1990 in relation to the intended use of the land after remediation.

- 1.2.4. In addition to the preparation of a detailed remediation scheme to discharge Condition 18, due to the risk to groundwater, this remediation scheme will also consider the requirements for Condition 6, however, a separate foundations works risk assessment (FWRA) will be required to be submitted by the developer in support of Condition 6 which states:

No piling using penetrative methods shall be carried out unless first approved in writing with the Local Planning Authority. The development shall only be carried out in accordance with the approved details. The piling approval is required to ensure that the proposed foundations do not harm groundwater resource in line with paragraph 170 of the National Planning Policy Framework and Policy EN16 of the Reading Local Plan 2019.

- 1.2.5. At this stage of the project, the foundation solution for the proposed redevelopment has not been designed by the developer. The risks of creating potential pathways and cross contamination between shallow and deep groundwater need to be carefully considered and should be the top priority in selecting the correct foundation solution. The use of pad foundations bearing in the River Terrace Gravels should be strongly considered and any penetration to depths beneath the Gravels needs to manage the risks and seek approval accordingly.

1.3 SCOPE & OBJECTIVES

- 1.3.1. The objective of this work is to prepare a detailed remediation scheme to address the identified risks and relevant contaminant linkages. The scheme comprises:

- Remediation Options Appraisal – which evaluates feasible remediation options to remove, reduce or control unacceptable risks and determines the plausible remediation options or combination of options for remediation;
- Remediation Strategy - which specifies the strategy to address all the relevant contaminant linkages and associated remediation criteria (if relevant); and
- Outline Implementation Plan – which provides details of how the works will be scheduled and managed, implemented and verified, and how health and safety and environmental impacts will be managed.

1.4 REPORT STRUCTURE

- 1.4.1. This report follows the following structure:

- **Section 2 – Site Setting and Assessment:**
 - Establishes key site characteristics and provides a summary of previous reports and assessments. Sets out the remedial objectives of the project.

- **Section 3 – Identification of Feasible Remediation Options:**

The evaluation of remediation options is progressed in a staged process as follows:

- **Stage 1** – Available techniques (options) are first introduced and assessed with respect to applicability for each relevant contaminant linkage (RCL) and associated contaminant(s) of concern (CoC);
- **Section 4 – Options Appraisal:**
 - **Stage 2** – The list of remaining techniques from Stage 1 is then qualitatively appraised against site specific characteristics and constraints. Feasible site-specific options are identified for more detailed examination;

- **Stage 3** – Provides a detailed evaluation of the identified feasible options, and recommendations of the preferred options.
- **Section 5 – Remediation Strategy:**
 - Details the proposed strategy to implement the identified remedial options; and
- **Section 6 – Verification & Implementation Plan:**
 - Presents the draft implementation and verification plan for the remediation works.

1.5 LIMITATIONS

- 1.5.1. This report is addressed to and may be relied upon by SGN. It may not be relied upon or transferred to any other parties without the express agreement of WSP UK Limited in writing. The report should be read and used in full. No responsibility will be accepted where this report is used, either in its entirety or in part, by any other party.
- 1.5.2. Third party information not directly commissioned by WSP UK Limited and used in the production of this report has been relied upon as being accurate. WSP UK Limited cannot and will not accept any liability for errors and/or omissions in data provided by others in these cases and cannot warrant that works. Report limitations are presented in **Appendix B**.

2 SITE SETTING AND ASSESSMENT

2.1 SITE REFERENCING INFORMATION

- 2.1.1. The Site is located off Alexander Turner Close and is situated approximately 70m north of the River Kennet. The land is owned by SGN and comprises of a decommissioned gas holder and a yard utilised by SGN as a manned depot, used for the storage of plant and equipment. The Site also contains a small electrical substation in the northwest corner. The Site location is shown on Drawing 70070233-001 and the Site layout is shown on Drawing 70070233-002 contained within **Appendix A**.
- 2.1.2. Site referencing information is summarised below in **Table 2-1** with more detailed site information provided in the reports listed in Section 2.3.

Table 2-1 – Site Information

Detail		Comment
Name and Address of Site		Gas Holder No. 4, Alexander Turner Close, Reading
National reference	Grid	472925, 173675
Area		Approximately 1.0 ha.
Site Description and Current Use		The Site is approximately triangular in shape and is classified as operational gas land, comprising a decommissioned gas holder (Gas Holder No.4) within a separate palisade fence compound in the west of the Site and an asphalt yard in the east of the Site which was until recently utilised by SGN as a manned storage depot. The Site is accessed via a new housing development to the west. Access to the former SGN depot yard is gained through a gate in the southwest corner. The palisade compound which houses the gas holder is accessed through the SGN depot yard via double gates in the palisade compound. Gas Holder No.4 is a 2,000,000 cubic foot (cu ft) capacity, oil filmed, column guided holder with an above ground tank which is decommissioned and has been purged to air. The holder is constructed on a raft foundation with cast concrete simplex piles. Demolition of the gas holder is due in 2022. The former yard has an asphalt surface cover and contains two portable offices which are located along the southern site boundary and a metal storage container. Signage, lights, barriers, and plant are stored within the yard area. A small palisade fenced compound area is located adjacent to the northern Site boundary (accessed through the yard) which contains a disused concrete water tower and seven metal storage containers. Two small single-storey brick buildings are present within the gas holder compound. These comprise: a former boiler house which is currently used to store red diesel, which is located in the northwest corner; and an equipment store to the west of the compound. The red diesel stored in the former of these buildings is used to fuel plant within a small substation present to the east of the building. Plant and equipment (including bowzers, traffic lights, gas pipes and barriers) are stored externally within the compound. The two buildings including associated fuel and equipment storage are due to be removed and demolished in 2022, prior to the start of the proposed remediation works set out in this remediation scheme.

Detail	Comment
Site Setting and Surrounding Area	The Site is located within a mixed residential and commercial area, east of Reading town centre, and approximately 1.3 km east of Reading Train Station. Notable trade directory entries include an active scrap yard 334 m west of the Site, which is classified as a car breakers and dismantlers, and a former photographic processors, Kodak Processing, located 370 m west of the Site. Other notable off-site notable industries include the former gasworks and a tin factory to the west of the Site.
Site History	The site formed part of Reading Gasworks which occupied land to the west (of the site). Historic information indicates that the site was first developed in 1899 as the gasworks expanded, with above ground liquor tank, purifiers, and sulphate of ammonia plant along the northern boundary. A gas holder that crossed the current western boundary of the site was constructed in 1901 with liquor mains shown crossing the Site and connecting with the liquor tank. Gas holder No.4, located in the centre of the western portion of the Site, is first shown on mapping from 1931 (liquor mains would have been removed when Gas Holder No.4 was constructed). Full site history is contained within previous reports (including Ref. 6) listed in Section 2.3.
Topography and Ground Cover	The Site is generally flat with levels slightly increasing to the west. A topographical survey plan (2019) is provided on Drawing 70070233-002 within Appendix A. Site levels are typically around 37 m above ordnance datum (AOD). The western half contains gas holder number 4 within a palisade fenced compound; this area is largely covered by concrete hardstanding and crushed stone (90%), with soft standing present in localised areas. The storage is covered by hardstanding comprising tarmac (75%) and concrete (25%).
Geological, Hydrogeological and Hydrological Setting	Made Ground is present across the Site to a maximum depth of 3.8 m below ground level (bgl) and an average thickness of 1.40 m. Superficial deposits at the Site comprise Alluvium overlying Kempton Park Gravel Member (River Terrace Gravels), comprising sand and gravel. The solid geology beneath the superficial deposits comprises the Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated). The superficial deposits are classified as a Secondary A aquifer, while the Chalk bedrock is classified as a Principal aquifer. The Site is within a groundwater Source Protection Zone (SPZ 3, Total Catchment). The River Kennet is present adjacent to the south of the Site and is a tributary of the River Thames converging approximately 200 m north, north east of the Site.
Boundaries	Railway lines bound the Site to the north. The River Kennet is present to the southeast of the Site with residential houses beyond. A newly constructed residential development is present beyond the western Site boundary.
Drainage & Flooding	Drainage is present across the Site as detailed on Drawing 70070233-003 contained within Appendix A .

Detail	Comment
	According to the 'Flood map for planning' ¹ , the southern boundary of the Site is adjacent to a Flood Zone 3. This zone relates to "Land having a 1 in 100 or greater annual probability of river flooding".
Embankments & Slopes	Embankments are present along the northern and south-eastern boundaries of the Site by the railway line and river respectively.
Trees & Vegetation (including invasive species)	Trees and vegetation bound the northern and south-eastern boundaries of the Site. An Arboricultural Method Statement and a Tree Protection Plan are required in line with Planning Condition 21, and a scheme for an Ecological Buffer Zone is required in line with Planning Condition 25. No invasive species have been noted by WSP during site investigation works.
Fauna	The potential for nesting birds (including a Peregrine Falcon) and bats have been identified on Site. A habitat enhancement scheme is required to be signed off prior to development (as detailed in Planning Condition 22) which is to include, as a minimum, a Peregrine Falcon platform, bird and bat boxes, and native wildlife friendly landscaping.

2.2 ENVIRONMENTAL SETTING

2.2.1. Details of the environmental Site setting are provided below in **Table 2-2**, with further information provided in the previous reports listed in Section 2.3.

Table 2-2 – Environmental Setting

GEOLOGY	The Site is underlain by Made Ground generally comprised of sandy gravelly clay, with occasional cobbles and with an average thickness of 1.40 m. Evidence of contamination within the Made Ground was identified across the Site, but mainly in the northern central areas of the Site where Made Ground was described as black clayey gravels and gravelly clays with pockets of tarry material and evidence of staining. A significant thickness of Made Ground was noted in BH302 (adjacent to former cross boundary gas holder) to ~8.00 m bgl (no recovery from 7.50-8.40 m bgl) where product was noted on core liners between 4.50-7.50 m bgl. The Made Ground directly overlaid the Chalk in this location. Numerous buried structures and unmarked services were exposed in several locations across the Site during previous phases of work. Alluvium deposits consisting of soft silt with sandy gravelly clay, peat bands and clayey sand layers underlay the Made Ground to approximately 4.00 m bgl). Generally, evidence of contamination within the Alluvium consisted of hydrocarbon odours with black staining notably within BH202 and BH203. The Alluvium is in turn underlain by the Kempton Park Gravel Member of the River Terrace Gravels (RTG), which consist of sandy gravel and gravelly sand deposits
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¹ <https://flood-map-for-planning.service.gov.uk/confirm-location?easting=472934&northing=173627&placeOrPostcode=RG1%203EA> (viewed 3 February 2021)

	approximately 5 m thick. Notable evidence of contamination was present within BH201, BH202 and BH301 as gravels were stained black, had a strong hydrocarbon odour and a sheen, with areas of visible product noted in BH301 between ~5.00-7.50 m bgl. Underlying the drift deposits the bedrock geology comprises the Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated). The upper boundary of the weathered Chalk was noted in the deep boreholes from 5.45 m bgl in BH303, to 8.25 m bgl in BH101. The Chalk comprised structureless white clayey gravelly sand or sandy gravelly clay/silt with Chalk and flint cobbles and gravels. Chalk was noted to the base of the deep boreholes to a maximum depth 20.6 m bgl (BH302). Hydrocarbon odours and visual staining were also observed in the Chalk within exploratory positions of BH101, BH202, BH301 and BH302 to the west of the Site, with globules of product noted in fractures at depth (~16.00 m bgl) in BH202, and product noted on drilling core liner between 14.50-16.00 m bgl within BH301 (adjacent to BH202).
HYDROGEOLOGY	The superficial deposits are classified as a Secondary A aquifer, while the Chalk bedrock is classified as a Principal aquifer. The Site is within a groundwater Source Protection Zone (SPZ 3, Total Catchment). The Environment Agency website identifies the SPZ to be associated with a potable groundwater abstraction located approximately 2 km south of the Site adjacent to Reading University operated by Thames Water. Four further groundwater abstractions are present within 1 km of the Site. Perched groundwater was encountered within the Made Ground between 1.28m and 1.36 m bgl. The relatively low permeability Alluvium deposits were thought to confine the underlying River Terrace Gravel and Chalk aquifers. However, this was not strictly the case as proven by BH302A where Made Ground was identified to directly overlay the Chalk, potentially providing a pathway to the underlying Chalk aquifer. The lack of confinement is likely related to the presence of numerous buried structures and services, and deep Made Ground. Groundwater data shows similar water levels within the River Terrace Gravels and Chalk aquifer, suggesting both aquifers are hydraulically connected. Review of hydrogeological mapping has confirmed regional groundwater flow to be in an approximate north easterly direction, however site investigation and monitoring data shows a localised area of groundwater mounding to the south east of gasholder number 4 which influences groundwater flow directions. The exact cause of this is not known, but groundwater, being relatively shallow (<2mbgl), may be influenced to by buried structures (such as the gasholder base), or potentially influenced by drainage along buried services. It is assumed that the groundwater flow beneath the Site is consistent with the general regional flow direction i.e., to the northeast towards the confluence of the River Thames and River Kennet.
HYDROLOGY	The Site is located within a Flood Zone 2 and historical mapping indicated the area to be 'liable to floods'. The River Kennet is situated adjacent to the southern Site boundary and flows in a west to east direction. The River Kennet is classified as a Primary River by the Environment Agency and is a tributary of the River Thames converging approximately 200 m north north-east of the Site. A dry drainage ditch is present adjacent to the Site's northern boundary with network rail land, for collection of surface water runoff. The River Kennet to the south of the Site is canalised adjacent to the Site boundary. This may impede shallow groundwater flow on Site.

2.3 PREVIOUS REPORTS

2.3.1. Previous reports and surveys which have been prepared for the site are listed below in **Table 2-3**.

Table 2-3 – Previous Reports

Ref	Title	Author	Produced for	Reference	Date
1	Kenavon Drive Reading, Desk Study	WS Atkins Consultants Ltd	South of England iDN	A71149 / GTG.97200/ R.011/ REV0/NJR	November 1997
2	Kenavon Drive Reading, Environmental Assessment Site Investigation, Final Interpretative Report	WS Atkins Consultants Ltd	South of England iDN	A7121 / TG97200/ R.020/ REV 1 /MG	October 1998
3	Factual Site Investigation Report, Gas Holder No. 4, Kenavon Drive, Reading	WSP Parsons Brinckerhoff Ltd	SGN	287642I	May 2016
4	Interpretative Site Investigation Report, Gas Holder No. 4, Kenavon Drive, Reading.	WSP Parsons Brinckerhoff Ltd	SGN	287642I	May 2016
5	Gas Holder Site Reading, Off-site Liability Assessment	WSP	Danescroft	70031882-001	July 2017
6	Gas Holder Site Reading, Geo-environmental Site Assessment	WSP	Danescroft	70031882-002	April 2019 (Submitted to Planning)
7	Gas Holder Site Reading, Supplementary Phase 2 Geo-environmental and Geotechnical Site Assessment	WSP	Danescroft	70031882-006	October 2019
8	Gas Holder Site Reading, Supplementary Site Investigation and Monitoring Report	WSP	Danescroft	70031882-011	March 2020
9	Gas Holder Site Reading, Controlled Waters Detailed Quantitative Risk Assessment	WSP	Danescroft	70031882-R3A	August 2021

2.4 SITE INVESTIGATION, MONITORING AND ASSESSMENT

SITE INVESTIGATION SUMMARY

- 2.4.1. Two phases of intrusive investigation have been undertaken at the Site by WSP (formerly WSP|Parsons Brinckerhoff) between November 2015 and May 2019 which comprised the excavation of trial pits (6 no.), trial trenches (2 no.), hand dug inspection pits (2 no.), vapour wells (3 no.), and deep and shallow boreholes (17 no.), some of which have been installed for groundwater monitoring and ground gas monitoring. A site investigation rationale is provided within the Supplementary Phase 2 Geo-environmental and Geotechnical Site Assessment [Ref 4.].
- 2.4.2. In September 2019 three additional boreholes (BH301-303) were drilled into the Chalk aquifer to further investigate the potential presence of Non-Aqueous Phase Liquid (NAPL) within the area where a coal tar derived product had previously been identified (within the Chalk at BH202A in the southwest of the Site).
- 2.4.3. A summary of the phases of Site work are listed in **Table 2-4** below. Drawing 70070233-004 shows the location of all site investigation locations.

Table 2-4 - Site Investigation Summary

DATE	SITE WORKS
November 2015	The principal aim of the Site investigation was to collect contemporary data to enable identify any sources of potential contamination and characterise ground and groundwater conditions on Site. Human health and Controlled Waters risks assessments to be undertaken for a continued commercial open space use. The rationale for the intrusive locations largely focused on the investigation of former gasworks structures and comprised the excavation of seven boreholes (three drilled to the Chalk) for groundwater and ground gas monitoring, seven trial pits/trial trenches, four hand pits and collection of soil samples. Geotechnical data was gathered during the site investigation. Two rounds of groundwater and surface water monitoring, and four rounds of ground gas monitoring were undertaken between November and December 2015. A small tank containing tar was discovered in the north of the Site (with a volume of circa 26m³). Pockets of visual and olfactory contamination (largely hydrocarbon, metals, and inorganics) were noted mainly in the west and north of the Site. Hydrocarbon odours were noted on groundwater from two locations, however no sheens were noted at any location. The base of the former gas holder cross-boundary was identified at 3.70 m bgl. Footings and bases of other former gasworks structures were also identified in the northern portion of the Site.
April 2019	Advancement of boreholes (4 no.), window samples (6 no.), vapour wells (3 no.) targeting non-investigated areas of the Site and the proposed residential development layout. Groundwater, gas and vapour monitoring programme to allow further assessment of Chalk and RTG aquifers, and to enable completion of ground gas and vapour risk assessment for the proposed development. Emulsified NAPL globules and water was identified in one location in the southwest of the Site (BH202) within the RTG and the Chalk.
September 2019	Advancement of additional boreholes (3 no., BH301 – 302) into Chalk aquifer in southwest corner of the Site to further evaluate presence of potential NAPL. One groundwater monitoring round, and two rounds of ground gas monitoring were undertaken following intrusive site investigation works. Additional Site works also included sampling of soils along southern site boundary adjacent to trees due to be retained and excavation of foundation pit adjacent to gas holder.

February 2020	Second round of groundwater monitoring on newly installed wells (300 series) to investigate presence of potential NAPL, and full round of groundwater sampling on all installed wells to monitor the chlorinated solvents degradation and potential increase of the daughter product concentrations, namely TCE, DCE and VC. One additional gas monitoring round undertaken to confirm seasonality trends and provide a robust data set.
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POTENTIAL NAPL

- 2.4.4. Strong hydrocarbon odours, staining and oily sheens were observed within the RTG at ~6.00 m bgl in BH202 at the base of the strata. Brown globules of potential product were noted within the fractures from depths between ~14.00-16.00 m bgl. Subsequently, emulsified product and water was noted in the purged groundwater in BH202 during well development. This had a very strong creosote / hydrocarbon odour. No measurable free phase product was measured with an oil/water interface probe.
- 2.4.5. Evidence of potential NAPL noted in 300 series wells in site investigation works in September 2019:
- BH301 (adjacent to BH202): between 5.05-7.40 m bgl, evidence of potential NAPL was noted within the River Terrace Gravels as sheens and globules. Potential NAPL staining was also noted on core liner from 14.50-16.00 m bgl.
 - BH302 (adjacent to cross-boundary gas holder): between 4.50-7.50 m bgl, evidence of potential product noted on drilling core liners. Potential NAPL staining was also noted on core liner from 14.50-16.00 m bgl.
 - BH303 (in proximity to southern Site boundary and River Kennet – assumed upgradient location): hydrocarbon sheen noted between 1.90-2.20 m bgl, and coal tar / gas works odour noted through Made Ground and River Terrace Gravels to 5.50 m bgl. No free product, or visual / olfactory evidence of contamination within the Chalk.
 - No NAPL identified during well development in any of the 300 series wells.
 - NAPL was not detected with the interface probe in any of the new wells.
 - A rare very small globule of product was noted during low flow sampling of BH302 in one of the two groundwater monitoring rounds – insufficient quantity for product sampling/analysis.

MONITORING AND ANALYSIS

- 2.4.6. Groundwater and surface water monitoring of on-site boreholes has been undertaken on five occasions since 2015.
- 2.4.7. Between 2015 and 2019 a total of nine gas monitoring rounds were completed at the Site.
- 2.4.8. Two rounds of vapour monitoring and sampling have been undertaken at the Site in 2019, with samples collected from the three dedicated vapour monitoring wells installed in April 2019.

HUMAN HEALTH RISK ASSESSMENT

- 2.4.9. The human health generic quantitative risk assessment (completed following site investigation works in April 2019 and contained within Ref. [4]) identified a number of contaminants (metals, ammoniacal nitrogen, cyanide, TPH, and PAH compounds), associated with the historical gasworks usage, with concentrations above the residential (without home grown produce) generic assessment criteria (GAC) together with positive identification of asbestos fibres in shallow Made Ground soils. A second tier of assessment for a residential scenario with plant uptake was undertaken for the proposed garden areas in the west of the Site. Concentrations of heavy metals (arsenic and lead), benzo(a)pyrene and

carbon disulphide were identified above the relevant GAC, and asbestos fibres in soil were also identified in this area.

GROUND GAS RISK ASSESSMENT

2.4.10. Potential risks posed by hazardous ground gases at the Site have been assessed following the guidance contained within CIRIA C665 Report. This method requires use of both gas concentrations (carbon dioxide and methane) and gas monitoring well flow rates to calculate a gas screening value (GSV). Between 2015 and 2019 a total of nine gas monitoring rounds were undertaken (all reported within the Supplementary Site Investigation & Monitoring Report, March 2020, Ref. [8]). Based on the calculated GSV, the Site has been characterised as low risk, Characteristic Situation 2 in line with BS 8576 and BS 8485 (NHBC equivalent classification of Green/Amber 1), whereby all new development requires gas protection measures to be installed, which would typically comprise the following protective measures:

- a) Reinforced concrete cast in-situ floor slab (suspended, non-suspended or raft) with at least 1,200 g DPM2 and underfloor venting.
- b) Beam and block or pre-cast concrete slab and minimum 2,000 g DPM/reinforced gas membrane.
- All joints and penetrations sealed.

2.4.11. Owing to the sporadic hydrocarbon contamination identified on Site, to ensure full protection from potential vapours, the DPM should also be hydrocarbon and vapour resistant.

CONTROLLED WATERS RISK ASSESSMENT

2.4.12. The Controlled Waters generic quantitative risk assessment (GQRA) was undertaken following the site investigation works in April 2019 (included within Ref. [4]) which identified exceedances of numerous water quality standards (WQSS) in water and leachate samples that could pose a risk to the identified receptors; groundwater (Secondary A and Principal Aquifer) and surface waters (River Thames). Laboratory analysis from the two additional rounds of groundwater monitoring (October 2019 and February 2020) were screened against the generic WQS and reported in the Supplementary Site Investigation and Monitoring Report (Ref. [6]).

2.4.13. Groundwater exceedances were mainly located within the superficial deposits. However, samples taken within the Chalk also recorded exceedances of ammoniacal nitrogen, PAH, TPH, benzene and chlorinated solvents. Generally, exceedances were located in the southwest area (BH202, BH301, BH302), northwest adjacent to the cross-boundary gas holder (WS206, BH101, BH201), north of the current gas holder (Gas Holder no. 4) and adjacent to the above ground liquor tank (BH102B, BH105) and north-eastern area of the Site, in proximity of the identified tank containing tar (BH103).

2.4.14. Minimal impact to groundwater was noted in the southeast areas of the Site with groundwater concentrations generally low or below the laboratory level of detection (LOD) in boreholes BH203C (RTG), BH204 (RTG), BH107 (Chalk).

DETAILED CONTROLLED WATERS RISK ASSESSMENT

2.4.15. A Controlled Waters Detailed Quantitative Risk Assessment (CW DQRA) (prepared in July 2019 and updated in March 2020 and August 2021 following additional rounds of monitoring and correspondence with the EA respectively), considered the surface water features of the River Thames and the underlying Chalk Formation aquifer as sensitive receptors.

- 2.4.16. Aquifers of the Alluvium/RTG deposits and the River Kennet were generally discounted from consideration following review of site-specific data (including review of groundwater flow, construction of the River Kennet and assessment of the sensitivity/future resource potential of the superficial aquifers).
- 2.4.17. Based on the model results the potential risks to the River Thames are driven by:
- TCE detected in the perched waters in the west of the Site and within the cross-boundary gas holder (WS206, BH101) (potential offsite source to west);
 - PCE in groundwater concentrations detected in BH101 and WS206 within the vicinity of the cross-boundary gas holder in the west of the Site (potential offsite source to west).
 - Free cyanide detected in two soil samples from BH102B and BH105, limited to the top 1m soil profile within the northern area of the Site, north of gas holder No. 4. Groundwater concentrations limited to BH102B, BH103A and BH201. The maximum soil and groundwater concentration both detected in BH102B; and
 - Aromatic EC8 – EC10 concentrations in groundwater detected in a single sample taken from BH102B in 2015. Subsequent monitoring at the same location and in the general area suggest there is no longer a risk. This is an isolated historic failure and considered trivial.
- 2.4.18. Risks to the Controlled Waters (future resource potential from the principal (Chalk) aquifer) were identified from:
- Ammoniacal nitrogen detected within all groundwater bodies throughout the Site and consistent with soil concentrations detected in Made Ground (throughout the Site); and
 - Chlorinated solvents (DCE and VC) detected in groundwater within the western area of the Site in proximity of the cross-boundary gas holder (WS206, BH101 and BH201).
- 2.4.19. The overall risk of the Site to Controlled Waters receptors is considered Low to Moderate. Risks to surface waters could potentially be reduced if dilution in the River Thames was factored into the assessment, however, dilution was not considered appropriate and such, was not accounted for.
- 2.4.20. Although there remains a theoretical risk to controlled waters, groundwater quality on site needs to be considered within the context of the wider groundwater quality - in particular groundwater quality upgradient of the site. Whilst the potential for on-site historic sources of soil and groundwater contamination cannot be discounted (such as tar/liquor storage), the main activities associated with the historic manufacture of gas took place across the wider gasworks upgradient of the site. Given the dense nature of contaminants associated with manufactured gas and the difficulties in remediating those contaminants in a dual porosity aquifer such as Chalk, it is highly likely that there will remain ongoing upgradient sources of dissolved phase organic and inorganic groundwater impacts. Additionally, the challenges faced by the presence of contaminants of concern in the structureless 'weathered', or 'putty' Chalk cannot be underestimated. It is worth noting the highest concentrations of contaminants of concern in groundwater, particularly in the Chalk, occur on the western (i.e. upgradient) boundary of the site.
- 2.4.21. Whilst upgradient sources of groundwater contamination remain untreated, the benefits of any active downgradient groundwater remediation that may be undertaken are likely to be short lived – unless treatment continues indefinitely. Given the impracticability of active groundwater remediation it is proposed that an agreement is sought with the regulators for a strategy that is proportionate to the risk. At this stage it is envisaged that such a strategy could comprise a programme of betterment

including removal of soil sources supported by groundwater monitoring to demonstrate a stable contaminant plume, as a proportionate approach to remediation in the context of the wider historic gas works and other off-site contaminant sources. In the interests of completeness an options appraisal for the remediation has been undertaken.

ASSESSMENT OF POTENTIAL RISKS TO PROPERTY

- 2.4.22. One sample of Alluvium, four samples of the River Terrace Gravels and three samples of the Upper Chalk were tested for buried concrete according to BRE Special Digest 1. The results of the testing indicated for each stratum buried concrete should be designed for Design Class 1 (DS-1), Aggressive Chemical Classification 1 (AC1). Identified sulphate concentrations within soils and groundwater would not pose a risk of chemical attack to concrete foundations.
- 2.4.23. A potential risk to drinking water supply pipes was identified from direct contact with contaminated Made Ground soils. Where Made Ground remains in-situ below the proposed development footprint, the use of chemically resistant materials for supply pipes may be required. This may also be required where hydrocarbon impact is present in the natural ground.

2.5 CONCEPTUAL SITE MODEL

- 2.5.1. Following the risk assessment, the conceptual site model (CSM) was established based on the future residential proposed site use. The key receptors are considered as:
- Human health; future residential site users and neighbouring residents.
 - Principal Aquifer (Chalk Formations).
 - Surface Water (River Thames).
- 2.5.2. Within the DQRA report the contaminant linkages are based on the receptors, and are referred to as Potential Contaminant Linkages (PCLs). For the purposes of this report and remedial options appraisal, the linkages have been determined by contaminant source and are referred to herein as Relevant Contaminant Linkages (RCLs).
- 2.5.3. The relevant contaminant linkages identified following an evaluation of the previous Site assessment works are detailed below in
- 2.5.4. **Table 2-5** with key contaminant source areas are shown on Drawing 70070223-006.

Table 2-5 - Relevant Contaminant Linkages

SOURCE	PATHWAYS	RECEPTORS	REF
Made Ground Contaminants within the upper strata of Made Ground within proposed garden areas in the west of the Site (and soft landscaping areas to be confirmed), including heavy metals (arsenic and lead), benzo(a)pyrene, carbon disulphide and asbestos.	Ingestion, inhalation and dermal contact with contaminated soil, dust and asbestos fibres.	Human Health: Future onsite residents and site users	RCL1
Tank Containing Tar A tank containing tar was discovered in the central northern area of the Site during the 2015 investigation, expected to be the concentrated liquor and sulphate tank. The volume is approximately 26 m ³ .	Vapour migration and inhalation Vertical and lateral migration of tar and residual contaminants to groundwater, and in groundwater to off-site surface waters.	Human Health: Future site residents Groundwater: Principal Aquifer (Seaford and	RCL2

SOURCE	PATHWAYS	RECEPTORS	REF
	Migration of contaminants in perched groundwater via overtopping, leaking or failure of the below ground structure.	Newhaven Chalk) Surface Water: River Thames	
Potential NAPL Globules of potential coal tar derived NAPL identified in Chalk fissures at depth (~16.00 m bgl) in BH202. Sheen noted in River Terrace Gravels (~5.00-7.50 m bgl) in BH301 and Made Ground (3.80-7.50 m bgl) in BH302A. Emulsified product and water noted in purged groundwater from BH202 when developing the well, however no measurable NAPL has been recorded. Globules of potential product noted in groundwater samples in the field from BH302A and noted by the laboratory in both BH301 and BH302A.	Dissolution of residual/immobile potential NAPL into groundwater representing potential source of dissolved phase contamination Vapour migration and inhalation	Groundwater: Principal Aquifer (Seaford Chalk Formation and Newhaven Chalk) Surface Water: River Thames Human Health: Future site residents	RCL3
CONTAMINATED GROUNDWATER:			RCL4
A - Chlorinated Solvents Chlorinated solvents detected in groundwater in boreholes installed in the Made Ground and River Terrace Gravels in the west of the Site in proximity to the cross boundary gas holder.	Vertical and lateral migration of leachable contaminants in soil to groundwater. Vertical and lateral migration of contaminants in groundwater to wider and/or more sensitive groundwater resources and surface waters. On-site migration of contaminants in groundwater from adjacent site	Groundwater: Principal Aquifer (Seaford Chalk Formation and Newhaven Chalk) Surface Water River Thames	RCL 4A
B - Ammoniacal Nitrogen Ammoniacal nitrogen has been detected within all groundwater bodies throughout the Site. Soil concentrations also detected in Made Ground across the Site.	Vertical and lateral migration of leachable contaminants in soil to groundwater and surface waters. Vertical and lateral migration of contaminants in groundwater to wider/more sensitive groundwater resources and surface waters. On-site migration of contaminants in groundwater from adjacent site	Surface Waters: River Thames	RCL4-B
C - Cyanide Free cyanide concentrations in shallow Made ground soils within the northern area of the site and corresponding elevated free cyanide within groundwater with maximum concentrations within BH102B.	Vertical and lateral migration of leachable contaminants in soil to groundwater and surface waters. Vertical and lateral migration of contaminants in groundwater to wider/more sensitive groundwater resources and surface waters.	Groundwater: Principal Aquifer (Seaford Chalk Formation and Newhaven Chalk)	RCL4-C
D – Hydrocarbons (TPH, Benzene) Isolated historic elevated concentrations of aromatic C8-C10 within BH102B in 2015 only and considered trivial, posing a low potential risk to groundwater.	Vertical and lateral migration of contaminants in groundwater to wider/more sensitive groundwater resources and surface waters.	Groundwater: Principal Aquifer (Seaford Chalk Formation and Newhaven Chalk)	RCL4-D

SOURCE	PATHWAYS	RECEPTORS	REF
Ground Gas The ground gas risk assessment categorised the Site as 'Characteristic Situation 2'. Selected gas protection membranes will need to be hydrocarbon and vapour resistant.	Accumulation and inhalation of ground gases	Human Health: Future site residents	RCL5*

* Any potential risks to the relevant receptors associated with these linkages will be inherently mitigated by measures incorporated into the design of the development by the developer (with cognisance of the potential risks identified within the risk assessment and associated recommendations). These linkages are therefore not taken forward for further assessment as part of the remediation options appraisal as detailed in Section 3.

2.6 REMEDIATION DRIVERS AND OBJECTIVES

2.6.1. The aim of the remediation strategy is to remove or suitably reduce or break the RPLs at the Site for the proposed development to a standard that does not present an unacceptable risk to the intended use and wider environment. To achieve this, the objectives for the remediation have been considered as follows:

- The Site will be rendered suitable for the intended residential end-use;
- Obligations under environmental laws and provisions are met (to a position of 'No Further Action' from a regulatory perspective).

3 APPRAISAL OF REMEDIATION OPTIONS

3.1 CONTEXT

- 3.1.1. The preliminary assessment of remediation options considers the general applicability of widely used remedial techniques, to either:
- Manage (remove, modify or immobilise) the source;
 - Interrupt the pathway; or
 - Modify the receptor or the behaviour of the receptor.
- 3.1.2. Source management may involve the removal, destruction, stabilisation, or transformation of the source. Pathway interruption may involve either the blocking of the pathway or the destruction or removal of contaminants moving along a pathway. Modifying the receptor is excluded from this appraisal and assumes the Site will be occupied in line with the proposed end use.
- 3.1.3. The above is such that the outstanding environmental liabilities are addressed as far as is reasonably practicable for the proposed residential use of the Site.
- 3.1.4. The preliminary evaluation considers applicability of the techniques to the RCLs identified in Section 2 and the objectives and constraints identified in Section 3.

3.2 ASSESSMENT OF REMEDIATION OPTIONS

- 3.2.1. The assessment of remediation options has been undertaken in the following stages:
- Stage 1 - Available techniques are first introduced and assessed for applicability with respect to each RCL media (i.e. soil or groundwater) and associated contaminants of concern (CoC);
 - Stage 2 - The list of remaining techniques from Stage 1 are then qualitatively appraised against site specific characteristics, constraints and objectives, detailed in sections 2 and 3.
 - Stage 3 - Remaining techniques are combined in order to formulate overall potential remediation strategies for the Site (i.e. to address all RCL's).

3.3 STAGE 1 - PRELIMINARY EVALUATION OF POTENTIAL REMEDIATION TECHNIQUES

- 3.3.1. An initial evaluation of groups of available remediation techniques specific to the identified sources at the Site are summarised in **Table 3-1** (RCL 5, ground gas, has not been included within the evaluation of remediation options below as gas protection measures will be required within the proposed development to be implemented by the developer).

Table 3-1 - Applicability of Remediation Techniques

REMEDICATION OPTION	Relevant Contaminant Linkages													
	1 Soil				2 Backfilled Tank	3 Groundwater	4 Groundwater				Soil			
	Heavy metals	PAH, carbon disulphide	asbestos fibres	Tar	Potential NAPL	Chlorinated solvents, ammoniacal nitrogen, free cyanide, TPH & benzene	Chlorinated solvents, ammoniacal nitrogen, free cyanide, TPH & benzene	Chlorinated solvents, ammoniacal nitrogen, free cyanide, TPH & benzene	Chlorinated solvents, ammoniacal nitrogen, free cyanide, TPH & benzene	Chlorinated solvents, ammoniacal nitrogen, free cyanide, TPH & benzene	Chlorinated solvents, ammoniacal nitrogen, free cyanide, TPH & benzene	Chlorinated solvents, ammoniacal nitrogen, free cyanide, TPH & benzene	Chlorinated solvents, ammoniacal nitrogen, free cyanide, TPH & benzene	Chlorinated solvents, ammoniacal nitrogen, free cyanide, TPH & benzene
Biological Methods (In-Situ)														
Natural Source Zone Depletion	x	x	x	x	x	✓/x	✓/x	✓/x	✓/x	✓/x	x	x	x	x
Natural Attenuation	x	x	x	x	x	✓/x	✓	✓	x	✓	x	x	x	x
Enhanced Natural Attenuation	x	x	x	x	x	✓/x	✓	✓	x	✓	x	x	x	x
Biopiles / windrow turning	x	✓/x	x	✓/x	x	x	x	x	x	x	✓	✓	x	✓
Biosparging / In-situ bioremediation	x	x	x	x	x	✓/x	✓	✓	x	✓	✓	✓/x	x	✓
Chemical Methods (In-Situ)														
Chemical oxidation / reduction	x	x	x	x	x	x	✓	x	x	✓	x	x	x	x
Surfactant Flushing	x	x	x	x	x	✓	✓	x	x	✓	x	x	x	x
Solvent extraction	x	x	x	x	x	✓	✓	x	x	✓	x	x	x	x
Physical Methods (In-Situ)														
Pump and treat	x	x	x	x	x	✓/x	✓	✓	x	✓	x	x	x	x
Skimming systems	x	x	x	x	x	✓	x	x	x	x	x	x	x	x
Soil vapour extraction / Dual phase	x	x	x	x	x	✓/x	✓	x	x	✓	✓	x	x	✓
Air sparging with vacuum recovery	x	x	x	x	x	x	✓	x	x	✓	x	x	x	x
Permeable reactive barriers (PRBs)*	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Civil Engineering Methods														
Source removal by excavation	✓	✓	✓	✓	✓	✓/x	x	x	x	x	✓	✓	✓	✓
Containment – cover systems	✓	✓	✓	✓	✓	x	x	x	x	x	x	x	x	x
Containment – in-ground barriers*	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Ex-Situ Treatment Techniques (For Treating Recovered Source Soils by Excavation)														
Stabilisation / solidification methods	✓	✓	x	✓	✓/x	x	x	x	x	x	✓	✓	✓	✓
Thermal techniques – desorption/thermopiles/vitrification	x	✓	x	x	✓/x	x	x	x	x	x	✓	✓	✓	✓

REMEDIATION OPTION	Relevant Contaminant Linkages													
	1				2	3	4							
	Soil				Backfilled Tank	Groundwater	Groundwater				Soil			
	Heavy metals	PAH _n	carbon disulphide	asbestos fibres	Tar	Potential NAPL	Chlorinated solvents,	ammoniacal nitrogen,	free cyanide,	TPH & benzene	Chlorinated solvents,	Ammoniacal nitrogen,	free cyanide,	TPH & benzene
Soil washing	✓	✓	✗	✓	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓
Off-site Disposal or Treatment Options (For Removal of Recovered Source Soils)														
Off-site disposal (landfill/STF)	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✓	✓	✓	✓
Off-site treatment (treatment centre / plant)	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✓	✓	✓	✓

✓ = generally applicable

✗ = generally not applicable

✓ / ✗ = limited applicability

*Note. The thickness of the aquifer preclude the use of Any kind of barrier system

- 3.3.2. In accordance with LCRM, technologies deemed not applicable due to technical and/or site constraints are excluded at the first stage of the options appraisal. Those technologies not excluded at the first pass have been subjected to a more detailed evaluation below.

3.4 SITE CONSTRAINTS

The distribution, nature and concentrations of contaminants of concern are a critical consideration for the selection of the correct remedial technology for the attainment of the remediation objectives. The prevalence of some recalcitrant contaminants may make a specific technology expensive or unviable in terms of treatability and/or cost. The selection of appropriate remedial techniques is further complicated by other considerations such as the geological and hydrogeological setting, extent of previous investigation/remediation works, the time available for implementation and treatment, site access and restrictions posed by ongoing development and cost.

- 3.4.1. Prior to the assessment of the applicable techniques identified above, site-specific factors and constraints have been identified that could affect the selection of feasible options, as detailed below in **Table 3-2**. Key constraints are detailed on Drawing 70070233-005 in **Appendix A**.

Table 3-2 – Site Constraints

SITE SETTING	The Site is located in a predominantly residential area. Noise, dust, vibration and odour considerations will be required for implementation of remediation options. Railway and River Kennet are present to the north and south. The Site is situated in an urban environment, with a history of off-site potentially contaminative sources (including former gasworks, kodak factory, biscuit tin factory, garages, railway). Therefore, off-site un-remediated sources may have the potential to re-pollute the Site following remediation. Remediation criteria and strategies will need to consider this potential.
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ENVIRONMENTAL SETTING	Made Ground and natural strata have varying degrees of cohesive and granular strata which may limit the treatable volume or application of techniques by some in-situ or ex-situ options. The dual porosity of the Chalk (fissured micro-porous aquifer) is complex and presents practical problems with many remediation options not realistically achievable, therefore limiting the choice of remediation. For example, groundwater within fractures and fissures can be remediated (either in-situ or ex-situ) in relatively short timeframes only for further diffusion of solvents from the micro-porous aquifer to occur during subsequent monitoring, often continuing in a cyclic nature with limited long term demonstrable net benefits to the aquifer achieved. Groundwater levels are relatively shallow (not much deeper than 1 m bgl in some areas of the Site), fluctuate to some degree across the Site and are responsive to seasonal conditions; these factors may limit or increase achievable remediation options. The River Kennet is located approximately adjacent to the southern site boundary. The close proximity of this sensitive receptor should be taken into consideration when evaluating in-situ remedial options. The Environmental Permitting (England and Wales) (Amendment) (EU Exit) Regulations 2019 require a permit to be contained for any activities which will take place on or within 8 meters of a main river. Further guidance can be found on environmental permitting online on the government website². According to the 'Flood map for planning'³, the southern Site boundary lies adjacent to a Flood Zone 3. This zone relates to "Land having a 1 in 100 or greater annual probability of river flooding". A 10 m wide buffer zone is required alongside the River Kennet as requested by the Environment Agency in Condition 25 of their planning consultation for the protection of wildlife and enhancement of biodiversity. The site adjacent to the western boundary was historically part of the wider gas works. It is understood that previous remediation at the adjacent site utilised a betterment approach for groundwater quality, resulting in likely continued elevated contamination concentrations within the groundwater. As laid out in Section 2.4 the presence of residual up-gradient sources of groundwater contamination will present an ongoing source of dissolved phase groundwater impact on site. When this is coupled with the extremely challenging geological setting options for active groundwater remediation become extremely limited.
SITE ACCESS AND RESTRICTIONS	The site has only one access point and will need to be maintained for the duration of the works. Access to the Site is highly constrained and is via one route on the western boundary through a residential housing estate with tight turns. Access on all other site boundaries are restricted due to the railway and the River Kennet. A traffic management plan will be required to manage traffic movements during the works. The Site area is relatively small with limited space for storing materials, stockpiling or processing soils.
SITE STRUCTURES AND GROUND CONSTRAINTS	Gas Holder No.4 is situated in the west of the Site within a palisade compound and is a 2,000,000 cubic foot (cu ft) capacity, oil filmed, column guided holder with an above ground tank which is decommissioned and has been purged to air. The holder is understood to be constructed on a raft foundation with cast concrete simplex piles. Demolition of the gas holder is due to start in 2022 with below ground structures being removed once regulatory acceptance of the Remediation strategy has been received.

² <https://www.gov.uk/guidance/flood-risk-activities-environmental-permits>

³ <https://flood-map-for-planning.service.gov.uk/confirm-location?easting=472934&northing=173627&placeOrPostcode=RG1%203EA> (viewed 3 February 2021)

	Two small single-storey brick buildings are present within the gas holder compound. These comprise: a former boiler house which is located in the northwest corner; and an equipment store in the west of the compound. These two buildings are due for demolition in September 2021. Adjacent to the boiler house is a small electrical substation contained within its own fenced perimeter. The yard to the east contains a portable office located along the southern site boundary. A small palisade fenced compound area is located adjacent to the northern Site boundary which contains a disused concrete water tower. The remediation works are planned following the demolition of these structures, including the gas holder, which are due to be demolished by March 2022. Significant thicknesses of concrete foundations and in-ground structures (gas holder tank, gas services and pipe work) have also been identified within the Made Ground from the Sites' previous development, which may impede some remediation techniques. Carbon disulphide has been identified within shallow soils and poses a potential risk associated with safe handling and safe systems of work. Due to its extreme volatility and low boiling point, appropriate working methodology will be required.
SERVICES	The location of known or potential services and utilities are shown on Drawing 70070233-003 in Appendix A. Low and medium pressure gas services (both live and decommissioned) run parallel to the southern site boundary. A live low pressure gas spur off and runs north-south between the two gas holders to the boiler house in the north of the Site. No gas mains serve either of the former gas holders on Site. Redundant gas mains serving the former holders on site will be present below ground. An electricity substation is present in the northwest corner of the Site. High voltage cables run from the eastern corner of the Site, around the south of the gas holder and up to the electrical substation. Further live low voltage electrical services are present on site which run parallel to the northern site boundary and from the electrical substation to the pumped foul sewer in the centre of the yard. Surface water drains are present in the yard area, which run to the south of the gas holder. BT services are present along the southern site boundary. Potable water supply enters the Site from the western site boundary and serves the portacabins on the southern site boundary, and also spur off to the centre of the Site. A foul water service crosses the Site from south east to north west, which passes through a pumped chamber in the centre of the Site. Clarification should be sought with the landowner/developer as to what services are to be retained post redevelopment. It is understood that some of the redundant services will be removed as part of the demolition works in September 2021, although details and extent of removal is yet to be confirmed at this stage. Safe excavation methods with appropriate stand-offs would need to be considered for any remediation options.
EXISTING BOREHOLES	There is a network of existing boreholes installed across the Site for vapour, gas and groundwater monitoring as shown on Drawing 70070233-004 contained within Appendix A. These may need to be retained for monitoring purposes depending on the remedial option, and the requirements of the LPA and EA.
ECOLOGY	The Site has limited vegetation cover, however several trees are present on-site, largely adjacent to the southern site boundary. An Arboricultural Method Statement and Tree Protection Plan is conditioned under planning. A small area in the south-west of the Site beyond palisade fencing is covered by scrub vegetation. In line with Planning Condition 21, no development shall commence, including demolition and any preparatory works, until details of a habitat enhancement scheme, to include as a minimum,

	a Peregrine Falcon platform, bird and bat boxes, and native wildlife friendly landscaping have been submitted to and approved in writing by the Reading Borough Council. The scheme is to include a programme for implementation and ongoing maintenance. The habitat enhancement scheme shall thereafter be implemented and adhered to in accordance with the agreed programme.
PROJECT TIMESCALES	Planning Condition 1 states that the development must be completed three years from the date of planning permission, which is dated 16th July 2021. A prior approval for the demolition of the gas holder has been granted. The remediation of the Site must be completed prior to the development commencing, and will begin following the demolition of the gas holder and structures on site. The project timescales for completion of remedial site works are anticipated to be 9-12 months from gas holder demolition, including all monitoring requirements.
LICENSES / PERMISSIONS AND REGULATORY ISSUES	■ Planning permission; ■ Remediation will need to be carried out under consultation with Environment Agency and the Reading Borough Council; ■ An Environmental Permit or Mobile Treatment License may be required for treatment activities as applicable; ■ Trade effluent consent would be required from the local provider for any discharges to foul sewer; ■ Removal or reuse of any materials will need to be undertaken under a materials management plan and site waste management plan; and ■ Works within 8 m of the water course will need a further permit from EA.
RELEVANT STAKEHOLDERS	The following relevant stakeholders include but are not exclusive to the following: ■ SGN; ■ Danescroft; ■ Utilities / services owners; ■ Site users (SGN staff, drivers of goods vehicles entering the Site); ■ Neighbouring residents; ■ Reading Borough Council; ■ Environment Agency; ■ Network Rail (proximity to rail land); ■ SSE.
SITE MANAGEMENT AND PR ISSUES	A public relations strategy may be required for the remediation works due to the proximity of the works to neighbouring residents.

3.5 RCL 1 – SHALLOW MADE GROUND SOILS

- 3.5.1. Potential risks from shallow Made Ground soils would be present in proposed garden areas following the Site redevelopment, as shown on Drawing 70070223-006, which cover an area of approximately 95 m². In addition, this area of the Site is likely to require raising with imported soils based on final site finished levels. Any areas of proposed soft landscaping would also be subject to the same mitigation measures.
- 3.5.2. The most feasible technique required to mitigate risks from shallow soil to human health receptors would be via pathway break (for example a cover system) which will be applicable to all the identified contaminants (other options would not sufficiently remediate the risks posed by asbestos fibres in soil). This would also require an element of source removal depending on final site levels which would require coupling with an ex-situ on-site treatment approach or off-site disposal / treatment to deal with the recovered source soils.

- 3.5.3. Off-site disposal to licensed landfill or appropriately permitted treatment facility is a feasible approach for source soils; however, soils may require pre-treatment and waste classification and acceptance may be limited by the presence of asbestos fibres. Off-site removal is not in line with sustainable remediation practices, where clear alternatives are available.
- 3.5.4. A cover system would be achievable in a short timeframe and suitable to implement on a Site with a small working area. The cover system would need to achieve a minimum risk-based depth of 0.70 m, comprising 0.60 m of clean imported soils, 0.10 m of a 'hard to dig' layer and a geomembrane at the bases and sides of the excavations to act as a warning / separation layer. It is unknown by what amount site levels are due to change at this stage, therefore Made Ground may need to be excavated to allow for the cover level depth to be imported to meet final site levels. Any cover system would need to be appropriately validated including recording of final development works such as placement of topsoil.
- 3.5.5. Re-use of soils on Site could also be considered but would be subject to the requirements of The Definition of Waste: Development Industry Code of Practice.
- 3.5.6. The remediation strategy to mitigate the risks posed by RCL1 are detailed within Section 5.
- 3.5.7. The remediation contractor will be responsible for the source removal (if required, based on final finished levels), and the developer will be responsible for the placement of a geomembrane and the clean cover system.

3.6 RCL 2 - TANK CONTAINING TAR

- 3.6.1. The tank/pit containing tar which was identified in the 2015 investigations comprises a 1.26 m deep concrete tank, with a volume of approximately 26 m³. Due to the size of the tank, and its location below the proposed structures, the most feasible technique will be to remove the tank contents and breakout the tank structure (if required).
- 3.6.2. Excavation and off-site disposal to licensed landfill or treatment facility is a feasible approach for tank contents; however, soils will require pre-treatment (either on or off-site) and waste classification.
- 3.6.3. Should gross contamination be identified, this may preclude destinations and acceptability for excavated material without pre-treatment.

3.7 RCL 3 – POTENTIAL NAPL

- 3.7.1. Due to the lack of measurable / recoverable product within the Chalk wells, it is unlikely that any remediation technology applicable to the removal of significant quantities of NAPL would be feasible from the Chalk on this Site. Additionally, the presence of 'weathered structureless Chalk and dual porosity competent Chalk severely restricts available remediation options (Ref. Section 2.4). The following paragraphs detail the potential NAPL evidence obtained during previous site investigation works.

Evidence of potential NAPL – BH202

- 3.7.2. Hydrocarbon odours were noted throughout BH202 from 1.50 m bgl. Dark brown globules (photograph contained within Supplementary Phase 2 Report Ref. [7]) was noted within the Chalk fissures 16.30-16.60 m bgl.

3.7.3. The borehole was installed with slotted pipe at the base of the well giving a response zone between 14.70-17.70 m bgl. The borehole was dipped with an oil water interface probe (IP), however no NAPL was detected with the IP either at the base of the well or on the surface of the water. The well was developed by purging groundwater following the drilling works to prepare the hole for sampling. During well development, potential NAPL was purged from the well which formed an emulsion with the purged water, estimated at 20 litres, which had a coal tar odour. The emulsified product and purged water did not settle out into a dense non-aqueous phase liquid (DNAPL). This may be as a result of the emulsification following the shearing effect of the well development pump or an indication that the viscosity of any NAPL is close to the viscosity of water and therefore was not detected with the IP and forms an emulsion with water. A sample of the purged water was taken. This sample contained high levels of TPH (21.5 mg/l), BTEX compounds (benzene 3.04 mg/l) and PAH concentrations (naphthalene 4.01 mg/l).

3.7.4. Prior to sampling BH202 one week after well development, the IP again did not detect product within the well. The well was sampled with low flow sampling techniques, however no NAPL was drawn up from the well. No product sample was obtained and therefore no tests on density or viscosity have been performed. This water sample showed naphthalene at concentrations close to the solubility limits.

Evidence of potential NAPL – 300 series wells

3.7.5. Three additional boreholes (BH301-BH303) were drilled to further investigate the area of potential NAPL impact around BH202.

3.7.6. BH301 (adjacent to BH202): between 5.05-7.40 m bgl, potential evidence of product was noted within the River Terrace Gravels. Potential product staining was also noted on core liner from 14.50-16.00 m bgl; however, no evidence was noted within the Chalk cores at this depth.

3.7.7. BH302 (adjacent to cross-boundary gas holder): between 4.50-7.50 m bgl, potential evidence of product noted on drilling core liners. Made Ground noted from to 7.50 m bgl in this location, potentially reworked Alluvium, with Chalk confirmed from 8.40 m bgl. Therefore, in this location Made Ground directly overlies the Chalk. Potential product staining was also noted on core liner from 14.50-16.00 m bgl; however, no evidence was noted within the chalk cores at this depth.

3.7.8. BH303 (in proximity to southern Site boundary and River Kennet – assumed upgradient location): hydrocarbon sheen noted between 1.90-2.20 m bgl, and coal tar / gas works odour noted through Made Ground and River Terrace Gravels to 5.50 m bgl. No free product, or visual / olfactory evidence of contamination within the Chalk.

3.7.9. Following well development (where no product was purged from any of the new 300 series wells), two rounds of groundwater monitoring were completed in October 2019 and February 2020. NAPL was not detected with the IP in any of the new wells. Low flow sampling was set up from the base of the well in an attempt to draw NAPL if there was any present within the well. Globules of product were noted during low flow sampling of BH302 on the first round of sampling in October. In addition, the laboratory noted 'oil inclusions' in samples from both BH301 and BH302A. Quantities were not significant enough to be sampled for analysis.

3.7.10. It must be noted that the Site formed only a small part of a much wider historical gas works and that the Chalk in the wider region is likely to be of poor quality and impacted with wider contaminant sources beyond the boundaries of this Site. The wider historical gas works and other industrial sites have been redeveloped through various schemes over the past 20 years or so. Available information

suggests that little to no groundwater remediation has taken place within the deeper RTG and Chalk groundwaters and where remediation work has been completed this has focussed on soil and perched/shallow groundwater betterment only. Anecdotal information suggests that remnant groundwater concentrations of 7 mg/l TPH and 1 mg/l PAH may exist in groundwater. Based on WSP's extensive remediation experience removal of the identified NAPL globules and sheen from the Chalk beneath the Site is not proportionate or practicable.

- 3.7.11. Although active recovery of NAPL is not considered feasible or practicable at this stage, the potential for encountering recoverable NAPL during earthworks, particularly during the removal of buried structures and redundant services, etc. cannot be discounted. Therefore, the developers will need to provide a watching brief whilst undertaking below ground activities to ensure that any recoverable NAPL is removed. At this stage it is envisaged that accumulations of NAPL in open excavations will be removed by skimming and/or during dewatering. Recovered NAPL and/or contaminated grossly contaminated water will require treatment (including NAPL and water separation) prior to discharge.
- 3.7.12. Additionally, ongoing monitoring of the groundwater monitoring wells will be required during development to confirm the absence, or otherwise of NAPL accumulation in wells. Given the dense nature of gasworks derived hydrocarbons and the depth of the Chalk aquifer, the accumulation of a measurable thickness of NAPL in the monitoring wells is considered unlikely. However, if NAPL accumulation does occur and if considered recoverable (criteria to be agreed with all stakeholders if required), it is likely that NAPL will be recovered either through skimming or low shear total fluids recovery.
- 3.7.13. It should be noted that it will be the developers responsibility to conduct a foundation works risk assessment (FWRA) and get approval from the regulators prior to commencing the construction works. The risks of creating potential pathways and cross contamination between shallow and deep groundwater need to be carefully considered and should be the top priority in selecting the correct foundation solution. The use of pad foundations bearing in the River Terrace Gravels should be strongly considered and any penetration to depths beneath the Gravels needs to manage the risks and seek approval accordingly.

3.8 RCL 4 – CONTAMINATED GROUNDWATER

- 3.8.1. The DQRA identified risks to Controlled Waters from the observed dissolved phase concentrations of chlorinated solvents, ammoniacal nitrogen, cyanide and hydrocarbons (aromatic C8-C10). The potential continued groundwater impact from the adjacent historical gas works site and unrecoverable NAPL present within the deeper River Terrace Gravels and Chalk have been considered in the remediation option assessment.
- 3.8.2. An appraisal of viable remediation options for RCL 4 (contaminated groundwater) are presented in the following section.

3.9 RCL 5 – GROUND GAS

- 3.9.1. Potential risks to human health and property associated with ground gas will be inherently mitigated by measures incorporated into the design of the development rather than soil and groundwater remediation measures. RCL 5 is therefore not taken forward for further assessment as part of the remediation options appraisal.

- 3.9.2. Based on the calculated GSV, the Site has been characterised as low risk, Characteristic Situation 2 in line with BS 8485 (NHBC equivalent classification of Green/Amber 1), whereby all new development requires gas protection measures to be installed, as detailed in Section 2.
- 3.9.3. Due to potential vapour risks from hydrocarbon impacted ground, hydrocarbon resistant membranes should be utilised in the proposed residential development.
- 3.9.4. The installation of the gas protection measures and protected services would need to be appropriately validated.

3.10 RCL'S CARRIED FORWARD FOR REMEDIAL OPTIONS APPRAISAL

- 3.10.1. Based on an initial evaluation of applicable technologies and site-specific constraints, remediation, and mitigation of some of the identified relevant contaminant linkages (RCLs) can be achieved by straightforward and established techniques. Therefore, a detailed evaluation of remediation options for the following RCLs (RCL1, RCL2 and RCL5) has not been carried out, and the established remediation techniques and mitigation strategies can be applied, as detailed above.
- 3.10.2. As discussed above, remediation technologies applicable to effectively remove potential residual NAPL are not considered practicable or proportionate in the context of the wider historic gas works. However, the presence of recoverable NAPL during the removal of below ground structures cannot be discounted. At this stage it is envisaged that NAPL accumulations associated with earthworks will be recovered by skimming/dewatering. At this stage the accumulation of NAPL in groundwater monitoring wells is considered unlikely, however, if this does occur the method of recovery will be confirmed in due course and will be subject to an assessment of physical characteristics, yield, stakeholder agreement, etc. Therefore, an appraisal of remedial technologies for RCL 3 (NAPL) has not been undertaken in the following section.
- 3.10.3. An appraisal of the short-listed remediation techniques for RCL 4 (contaminated groundwater) will be undertaken in the following section.

4 OPTIONS APPRAISAL

4.1 STAGE 2 – EVALUATION OF SHORTLISTED TECHNIQUES

- 4.1.1. Short-listed techniques of the remaining RCLs associated with contaminated groundwater (RCL 4A-D) from the preliminary assessment of remediation options are qualitatively appraised with cognisance of the site-specific characteristics, constraints and objectives as detailed below in Table 4-1.
- 4.1.2. Previous experience on similar sites, technical literature and information from remediation contractors were used to reject remediation options due to the timescales involved in application, economic considerations, and due to site constraints.

Table 4-1 – Evaluation of Applicable Groups of Remediation Techniques

GROUP OF TECHNIQUES	REMEDICATION OPTION	APPLICABLE RCLS	COMMENTS OF FEASIBILITY AND EVALUATION	KEY ADVANTAGES	KEY LIMITATIONS	CONSIDERED FOR FURTHER EVALUATION
Biological Methods	Natural Attenuation	RCL 4A RCL 4B RCL 4D	Natural attenuation has been demonstrated to be effective in treating chlorinated solvent impacted groundwater. a monitoring strategy could also work for other organic contaminants identified in groundwater and ammonia. It involves the long term sampling of groundwater monitoring points for primary, secondary, and tertiary characteristics that demonstrate the effective natural degradation of the contaminants.	- No generation of remediation wastes; and - It is relatively cost effective and requires low maintenance.	- Timescales for achieving remediation targets are in years depending on the nature of the contaminant and aquifer properties; - Requires detailed understanding of the geology and hydrogeology of the aquifer; - A contingency plan and funds should be available if the contaminants do not behave as predicted; - Potential recharge of contaminant concentrations from adjacent historical gas works site, leading to sustained concentrations that will take a longer timeframe to naturally attenuate; and - Not an effective strategy for dealing with cyanide contaminated groundwater (RCL 4C).	Yes
	In-Situ Bio-remediation (enhanced natural attenuation)	RCL 4A RCL 4B RCL 4D	These are in situ treatment methods through the addition of oxygen (electron acceptor) or hydrogen containing compounds to groundwater to increase the biological activity of microorganisms. The addition of cultured organisms can also enhance and accelerate the process. Enhanced aerobic treatments can include biosparging / bioventing / addition of proprietary oxygen releasing compounds. Enhanced anaerobic treatments can include injection into the saturated zone with proprietary hydrogen releasing compounds such as lactose, lactic acid, lactates, molasses and diary bi-products.	- Increased degradation rates of natural processes; - No waste generation and no resource/energy consumption - Simple technology; - Limited long term operational costs and maintenance; - Minimal site disturbance; and - Can be combined as a polishing step with other methods, such as in situ chemical oxidation.	- Sometimes the technique is difficult to validate; - It may alter and be inhibited by the geochemistry of the aquifer; - Most chlorinated hydrocarbons are recalcitrant to aerobic degradation; - Aerobic conditions may be required to complete mineralisation; - Slow remediation process; - More toxic and mobile intermediate breakdown products may be formed; - Stalling at daughter products can occur; and - Not an effective strategy for dealing with cyanide contaminated groundwater (RCL 4C).	Yes
Civil Engineering Methods (In Situ)	Containment: in-ground barriers	RCL 4A RCL 4B RCL 4C RCL 4D	This option will involve construction and operation of a containment barrier to manage the pathway to the surface water course. Containment barriers may also involve the use of pumping systems to extract contaminated groundwater, which is then treated and either returned to the ground or removed off-site. In ground barriers are typically impermeable 'cut-off walls' which seek to isolate the receptor by restricting or diverting groundwater flow.	Stops off-site migration of contaminants	- No reduction or removal of source contamination; - These options require a detailed understanding of local groundwater flow, which in this case is challenging; - Prolonged regulator consultation would likely be required, and as this method would not necessarily remove the contaminant source; - On-going operation, maintenance and monitoring is likely to be required; - Installation may be limited by below-ground constraints, in particular the former foundations on this site; - The infrastructure itself could potentially pose a constraint to future development. In addition, it can be difficult to achieve 'water-tight' barriers and impacts on groundwater flow and levels may be unpredictable leading to diversion of the impact or increasing the area of impact; and - This option would require large scale civil engineering works, which would cause disruption to the operation of the Site, involve disposal of excavated soils.	No
Physical Methods (in-Situ)	Soil Vapour Extraction Air sparging and vacuum extraction	RCL 4A	Vapour extraction from vadose zone. Groundwater may be artificially lowered to enhance extraction zone. With air sparging, typically air is injected into the saturated zone via vertical wells at a point below the target contamination and vapour is collected for surface treatment / disposal also encourages aerobic bacteria to breakdown dissolved phase contaminants.	- Relatively short timeframe for installation; - Not visually obtrusive; - Offers enhanced remediation rates compared with groundwater pump and treat systems; - Can be cost effective; and - Has minimal site disturbance.	- Is only applicable in unconfined aquifers where air can be injected easily into the aquifer and collected; - Careful air flow management is required to prevent spreading the plume; - Potential limitations due to depth to water table; - Forces volatiles into the unsaturated zone. Vapour collection would have to be robust; and - Requirement to install, maintain and operate infrastructure.	No

GROUP OF TECHNIQUES	REMEDIATION OPTION	APPLICABLE RCLS	COMMENTS OF FEASIBILITY AND EVALUATION	KEY ADVANTAGES	KEY LIMITATIONS	CONSIDERED FOR FURTHER EVALUATION
	Groundwater pump and treat	RCL 4A RCL 4B RCL 4D	Groundwater is pumped to the surface and passed through a filter (granulated activated carbon or similar) or chemically treated to remove the contaminants. Treated water is sometimes pumped back into the aquifer to encourage remobilisation of the contaminants so it can be further treated. Enhanced groundwater pump and treat methods can be applied to treat different sorts of contamination. For example, employment of zeolite filters (to treat ammonia), air stripping (to treat the volatile components), and biological treatments (to treat organic contamination).	- Short timeframe for installation; - Reduced local environment impact during installation and operation; and - Not visually obtrusive if well points used.	- Not always effective, especially in a dual porosity aquifer; - Often prone to rebound following cessation of treatment; - Requirement to maintain infrastructure and operational capacity throughout remediation programme; - Uncertainty in the length treatment time and uncertainties achieving end points; - Potential to draw contaminants from offsite onto the Site; - Treatment can be rate limited by contaminant desorption so will require a commitment to long term operation; and - Verification and regulatory uncertainty.	No* May be applicable during shallow dewatering during construction but not as a targeted remediation technique
Chemical Methods	<i>In-situ</i> chemical reduction or oxidation	RCL 4A RCL 4D	In situ chemical reduction or oxidation is an established remedial technology to degrade chemical contaminants, including chlorinated solvents. Involves the injection of liquid or gaseous oxidising or zero valent metal reducing agents to degrade organic contaminants.	- Reducing agents are available to degrade chlorinated solvents; - Short timeframe for installation; - Reduced impact to site during installation and operation; - Not visually obtrusive; - Fast treatment time. Can result in complete degradation of organic contaminants; and - Low cost reagents.	- The reagents are aggressive and may cause unintended reactions in the both the unsaturated and saturated zones i.e., alter soil pH; reduce soil nutrients; and some products can generate HCl or create more toxic breakdown products. Presence of potential NAPL and potential unidentified chlorinated solvent product has the potential to cause adverse reactions; - Large quantities of reagent may be required which can add to the overall cost of the scheme; - The application of the reagents in a fracture flow system may limit contact time; and - Regulatory acceptance may be problematic.	Yes
Ex-situ Treatment Techniques (For Treating Recovered Source Soils by Excavation)	Stabilisation / solidification methods Thermal techniques – desorption / thermopiles Soil washing Biological Techniques	RCL 4A RCL 4B RCL 4C RCL 4D	Where source soils have been identified in contributing to groundwater contamination, the viability of ex-situ treatment techniques have been considered. Ammoniacal nitrogen, cyanide and chlorinated solvent sources have been identified as soil sources. Soil stabilisation or solidification can be effective in immobilising or ‘encapsulating’ soil contamination within a bound soil matrix. Potentially feasible options to mitigate risks associated with source material containing metals (with the exception of thermal techniques and biological techniques), PAHs and TPH. Technique is not likely to be feasible for treating material containing asbestos fibres or ACM.	- Can be relatively low cost considering enabling works likely to be required; - Depending on the technique employed, could be cost effective (i.e., bioremediation); and - Stabilisation / Solidification can be effective at providing ground improvement but would be subject to pilot or field-scale trial.	- Would only be able to treat limited amount of source soils, technique is unlikely to be applicable to treating cyanide and ammonia contaminated soils; - Recalcitrant contaminants and potential for localised gross contamination may impinge effectiveness of ex-situ treatment methods; - Groundwater is very high on the Site; only source soils within the unsaturated zone could be treated simply; - There is limited space on site to carry out stabilisation and/or ex-situ treatment and in the event, this was considered it would require significant logistical planning; and - Difficult to implement in a short programme window and high risk of programme impact should treatment not prove effective.	No
Off-site Disposal or Treatment Options (For Removal of Recovered Source Soils)	Off-site disposal (landfill/STF)	RCL 4A RCL 4B RCL 4C RCL 4D	Excavation based technique to achieve source removal in the unsaturated zone. Where source soils have been identified in contributing to groundwater contamination, the viability of ex-situ treatment techniques have been considered. Ammoniacal nitrogen, cyanide and chlorinated solvent sources have been identified as soil sources. Off-site disposal to licensed landfill/STF is a feasible approach for source soils; however, soils would require pre-treatment and waste classification. Possibly some level of treatment may be required to meet waste acceptance criteria.	Excavation of source materials within the unsaturated zone would be a non-complex method and verification is easily demonstrable with no on-going monitoring or maintenance required.	- Off-site disposal of excavated material is not sustainable; and - Likely be expensive for large scale excavations due to landfill taxes and the landfill directive means it is difficult to dispose of some grossly impacted soils to landfill.	Yes
	Off-site treatment (treatment centre / plant)	RCL 4A RCL 4B RCL 4C	Excavation based technique to achieve source removal in the unsaturated zone. Soil treatment facilities may be a feasible option for source soils, although acceptance may be limited by the presence of	Excavation of source materials within the unsaturated zone would be a non-complex method and verification is easily demonstrable with no	- Soil treatment facilities could potentially be used as an alternative to landfill, although costs are still comparatively high compared to other options; and - Transport costs to appropriate disposal sites and the cost of imported material may also be very expensive.	Yes

GROUP OF TECHNIQUES	REMEDIATION OPTION	APPLICABLE RCLS	COMMENTS OF FEASIBILITY AND EVALUATION	KEY ADVANTAGES	KEY LIMITATIONS	CONSIDERED FOR FURTHER EVALUATION
		RCL 4D	asbestos. Treatment centre options for treatment of soils containing asbestos may be few.	on-going monitoring or maintenance required; ■ Sustainability and resource re-use benefits associated with treated materials; and ■ Reduces pressure on fixed point disposal locations.		

4.2 SHORTLIST OF FEASIBLE REMEDIATION OPTIONS FOR RCL 4: CONTAMINATED GROUNDWATER

- 4.2.1. Shortlisted options for RCL 4 (Contaminated Groundwater) have been reviewed in this section owing to the fact that established remediation and mitigation solutions have been identified for RCL 1 (Made Ground), RCL 2 (tank containing tar) and RCL 5 (Ground Gas), and that further active works on RCL 3 (potential NAPL) are not required.
- 4.2.2. The preliminary assessment of remediation options (which involved an evaluation of technical literature, previous experience, and information from specialist remediation contractors) has identified a number feasible options that are suitable to remove, reduce or control the relevant contaminant linkages associated with RCL 4. Feasible options were identified on the basis of cost, practicality, effectiveness, durability, and sustainability, and are identified below in Table 4-2.

Table 4-2 - Evaluation of Shortlisted Remediation Options for RCL 4

Category	Technique	RCL Applicability*	Comment
Feasible options for treating source soils, therefore reducing risk of ongoing groundwater contamination:			
Civil Engineering Off-site Disposal or Treatment Options	Source removal by excavation followed by Off-site disposal (landfill) Or Off-site treatment (treatment centre / plant)	RCL4A RCL4B RCL4C (RCL1) (RCL2)	• Already established as a feasible means of achieving source removal for RCL 1 (Made Ground in garden areas) and RCL 2 (tank containing tar). • Feasible for RCL 4A for removing the shallow chlorinated solvent source soils in the north west of the Site, identified in the vicinity of VW201A. • May also be applicable for removing hotspot contamination associated with RCL 4C (cyanide). • Ammoniacal nitrogen (RCL 4B) as a soil source has been identified across the Site. Unsustainable and uneconomic to apply this technique for RCL 4B, however by applying technique to other RCL's will provide an element of betterment. • Achievable in a short timeframe and suitable to implement on a Site with a small working area. • Possibility of combining with another ex-situ remediation technique (e.g., bioremediation) to reduce soil to landfill and improve sustainability. • Source removal approach meaning that associated linkages cannot be re-established in the future. No long-term obligations. • Verification is easily demonstrated. Commercially available. Does not requires specialist contractor for safe and effective implementation.

Feasible options for directly treating groundwater contamination:

Biological Methods	Natural Attenuation & Enhanced Natural Attenuation (in-situ bio-remediation)	RCL 4A RCL 4B RCL 4C RCL 4D	- Monitoring has demonstrated to be effective in treating chlorinated solvent impacted groundwater. A monitoring strategy may also be effective in proving stable conditions or betterment over time in RCL 4B (Ammoniacal Nitrogen) and RCL 4C (Cyanide). - To a certain extent, monitoring has already been proven to be an effective method in the treatment of chlorinated solvents on Site (natural decline between 2015-2020). - Combinations of anaerobic and aerobic biological degradation are known to degrade chlorinated solvents to low levels. Enhanced NA using techniques such as direct push or borehole injection of substrates is considered likely to be effective in treating chlorinated solvent impacted groundwater, with potential for increasing degradation rates compared to natural rates. - Physical delivery of an amendment to the contaminant in the weathered putty chalk or dual porosity competent chalk very problematic. Rebound in CoC concentrations from the primary porosity to be expected. - Given the low maintenance, relatively low cost of this treatment and its applicability to a deep, dual porosity aquifer, this method was deemed suitable for consideration. However, due to the ambiguity in timescales and potential interaction and conflict with other contaminants of concern this is not considered realistic for this Site.
Chemical Methods	In-situ chemical reduction or oxidation	RCL 4A (RCL 4C) RCL 4D	- Where dissolved phase chlorinated solvent contamination has been identified, chemical treatment is considered a viable option. - In-situ application relies on contact with the reducing or oxidising agents with the contaminant to physically destroy or breakdown the substance. This would normally be achieved by injection or infiltration or by in-situ mixing or augering where shallow contamination exists. - Similarly, physical delivery of an amendment to the contaminant in the weathered putty chalk or dual porosity competent chalk very problematic. Rebound in CoC concentrations from the primary porosity to be expected. - Chemical treatment is rapid and can achieve rapid reduction in contaminant mass providing that contact can be made and there is no preferential oxidant uptake with organic soils or NAPL globules or sheen – these will affect the efficiency and longevity of the scheme. Given the presence of potential NAPL sheens and globules and the high potential for wider contamination within the region (adjacent site), this is not likely to be a sustainable solution.
Physical Methods (In-Situ)	Groundwater pump and treat	RCL 4A RCL 4B RCL 4D	- This technology has a short timescale for installation and existing boreholes could potentially be utilised for this treatment technology. However, pump and treat systems require an ongoing operational timeframe and duration and effectiveness is ultimately governed by detailed understanding of hydrogeological regime and defined remediation targets or objectives. Traditional pump and treat technologies often prove ineffective at reaching defined remedial objectives. The potential impact from offsite to the west by the cross-boundary gas holder may also add to the uncertainty in treatment programme. - Pump and treat in Chalk problematic Contaminants are removed rapidly from secondary porosity (fractures), however, leaching of contaminants in primary porosity will result in CoC rebound once active treatment ceases.

			• There is, however, the option whereby a pump and treat system can support construction and dewatering during the enabling phase. Where shallow contamination exists, dewatering and treatment systems will be effective in managing perched and shallow groundwater and on the basis of the contamination identified to date, will be affected by contamination. • Dewatering and treatment is likely to be a construction requirement rather than a remediation requirement.
*The applicability of the technique to other RCLs is also included in brackets, if appropriate.			

4.3 REMEDIATION OPTIONS APPRAISAL CONCLUSIONS

4.3.1. Following the remediation options appraisal for RCL 4 (contaminated groundwater), the most feasible strategy to address the risks associated with contaminated groundwater are as follows:

- Removal of identified source soils by excavation;
- Removal of Made Ground (associated with RCL 1) and tank containing tar (RCL 2) will also reduce risk and provide betterment to the groundwater quality;
- The recovery of accumulated NAPL and/or grossly contaminated groundwater (if found to be present), during the removal of below ground structures, former service runs, and during general earthworks;
- A programme of groundwater monitoring to be implemented during below ground structure removal, earthworks, and development to determine effects of development on groundwater quality (to include a discovery, corrective action strategy); and,
- A period of monitoring to confirm stable groundwater conditions following the soil betterment works, to be completed over 6 months.

4.3.2. It should also be noted that infiltration rates will be reduced following Site redevelopment, therefore reducing the leaching potential of residual contaminants which will remain in the unsaturated zone.

5 REMEDIATION STRATEGY

5.1 BASIS OF THE STRATEGY

5.1.1. The remediation strategy is risk-based and has been developed in line with best practice procedures for the assessment of land contamination. The strategy has been prepared following a detailed review of existing Site information, utilising reasonable assumptions and previous experience. This remediation strategy does not represent a detailed method statement. A detailed method statement for undertaking the remediation will be undertaken (by others) once the strategy has been agreed with regulators.

5.1.2. The overriding objectives of the remediation work are:

- to render the Site safe to a standard at which it is suitable for a future residential end-use and does not pose an unacceptable risk to the environment, and;
- is not considered as contaminated land under Part 2A of the Environmental Protection Act 1990.

5.1.3. An appropriate reduction or removal of risks associated with the identified RCLs will be required to achieve the objectives. The location of the RCLs are presented on Drawing 70070223-006.

5.1.4. Following evaluation, a combination of strategies has been selected as the preferred remediation strategy, subject to agreement with the Reading Borough Council. Outline components of the strategy for each RCL are detailed in this section.

5.1.5. The outline strategy for the identified RCLs comprises:

■ RCL1	Shallow Made Ground Soils	➤ Cover System.
■ RCL2	Tank containing tar	➤ Source Removal.
■ RCL3	Potential NAPL	➤ No measurable NAPL has been recorded on the site and there is no targeted remediation required.
■ RCL4	Contaminated Groundwater	➤ Soil source removal. ➤ Removal of accumulated NAPL/grossly impacted groundwater during buried structure removal and earthworks ➤ Groundwater monitoring strategy during construction. ➤ Post construction groundwater monitoring strategy
■ RCL5	Ground Gas	➤ Gas protection measures.

5.1.6. In addition to the strategy outlined above, the above ground gas holder (gas holder No. 4) will be demolished between September 2021 and March 2022. This will include dewatering and the removal of any residual sludges within the tank, further reducing potential sources and risks. Historic evidence suggests the gas holder was founded on 600 pile foundations and experience of similar structures suggests that they are not a significant source of contamination on gas works sites. Therefore, no further investigation is proposed below the gas holder.

5.2 COMPONENTS OF THE STRATEGY FOR RCL 1: SHALLOW MADE GROUND SOILS

- 5.2.1. The most appropriate strategy for RCL1 (shallow Made Ground soils in proposed garden areas and areas of soft landscaping) to achieve the remediation objectives, given the Site's characteristics and constraints, comprises installation of a cover system to provide a pathway-break between source soils and receptors (future Site users). The strategy comprises the following principal elements:
- Removal of source soils within future soft-cover (landscaped / garden areas) to a minimum risk-based depth of 0.70 m (below final proposed development ground levels);
 - Placement of a geomembrane at the bases and sides of the excavations to act as a marker / separation layer;
 - Placement of 0.10 m hard to dig layer;
 - Placement of 0.60 m suitable imported sub soil and topsoil materials; and
 - Off-site disposal of excavated materials to a suitably licensed landfill or waste treatment centre (or re-use of soils on Site subject to the requirements of The Definition of Waste: Development Industry Code of Practice).

REMOVAL OF SOURCE SOILS & PLACEMENT OF COVER SYSTEM

- 5.2.2. Impacted source soils will be excavated to a minimum depth of 0.70 m below final proposed development ground level, or assuming site levels remain at current ground level. Where final site levels will require raising, and therefore less (or no) excavation may be required, so long as the 0.70 m cover layer is attained. The objective is to achieve full removal of soils to the stated risk-based depth based on finished site levels.
- 5.2.3. The remediation contractor will be responsible for the source removal (if required, based on final finished levels), and the developer will be responsible for the placement of a geomembrane and the clean cover system.

PLACEMENT OF GEOMEMBRANE

- 5.2.4. Prior to reinstatement a coloured geomembrane (e.g., Terram T1000 orange, or similar approved) will be placed over the bases of the excavations and lapped against the excavation sides. The membrane will also require lapping against the bases and sides of any tree pits excavated within future soft-cover areas. The geomembrane is placed as a marker for the base of the clean cover layer.

PLACEMENT OF IMPORTED MATERIALS

- 5.2.5. A minimum thickness of 0.70 m of imported materials shall be placed above the coloured geomembrane to final proposed development ground level to achieve suitable break in the pathway. Initially a 100mm hard to dig layer (such as Class 6F2) will be placed on top of the geomembrane for added protection. The remaining 0.60 m will comprise of a 0.30 m sub-soil and then a 0.30 m topsoil. The sub-soil will comprise of imported material compliant with the import criteria in **Appendix C**, to be protective of human health. Testing of imported materials should be carried out a frequency one test per 200 m³, and a minimum of three tests per source.
- 5.2.6. The topsoil must also meet the import criteria **Appendix C**, in addition to meeting the criteria for topsoil set out in BS 3882:2007 Specification for Topsoil. For this remediation strategy, it is proposed that the remediation contractor will place the 0.30 m of compliant sub-soil and the remaining 0.30 m topsoil will be placed by the future developer during construction phase. A separate Verification Report for

the 0.30 m of topsoil placed in soft cover areas should be produced by the developer and submitted to Reading Borough Council to fully discharge Planning Condition 19.

- 5.2.7. If an excavation to remove source material is deeper than the 0.70 m proposed cover layer system, the difference shall be made-up by increasing the thickness of sub-soil.
- 5.2.8. All imported materials are to be tested in line with the verification plan in Section 6.

OFF-SITE DISPOSAL / TREATMENT

- 5.2.9. Excavated materials will require testing and will either be subject to removal from Site to appropriately licensed recycling / disposal facilities or alternatively, soils may be re-used on Site, subject to the agreed reuse criteria and requirements of The Definition of Waste: Development Industry Code of Practice (DoW:CoP). Any material being re-used on site as either general fill or cover material will be subject to testing in line with the criteria set out in **Appendix C** at a rate of one test per 200 m³. Any material being removed from site will be subject to waste classification and if required waste acceptance testing. All material movements will be tracked and recorded with appropriate duty of care paperwork and verification reporting.

ANTICIPATED REMEDIATION EXTENTS AND QUANTITIES

- 5.2.10. Indicative remediation areas are shown on Drawing 70070233-007 and cover approximately 95 m² within proposed garden areas. Excavation quantities within garden areas are estimated at approximately 67 m³, assuming finished site levels are required to remain at current levels. It should be noted that the remediation extents have been based on the design proposals for garden areas only available at the time of writing. Additional cover systems will be required in areas of proposed soft landscaping. Should the extents of the future soft-cover areas change, then the remediation areas and volumes will require adjustment accordingly.

REMEDATION CRITERIA

- 5.2.11. The remediation criteria is based on achieving full removal of source soils within the specified areas to the risk-based depth of 0.70 m below final finish level and achieving an imported compliant placed break layer clean cover.
- 5.2.12. All imported material must comply with the criteria provided in **Appendix C**. In addition, topsoil must comply with standards set out in BS 3882:2007 Specification for Topsoil.

REMEDATION DURABILITY

- 5.2.13. The selected strategy is based on the creation of a pathway-break which will be a durable solution, provided the Site levels are maintained in the future.

5.3 COMPONENTS OF THE STRATEGY FOR RCL 2 –TANK CONTAINING TAR REMOVAL

- 5.3.1. The most appropriate strategy for RCL2 (tank containing tar) to achieve the remediation objectives, given the size of tank, the Site's characteristics and constraints comprises excavation of the contents of the tank. Excavated material to be disposed off-site (subject to waste classification and acceptance testing where appropriate). This will be undertaken by the remediation contractor.
- 5.3.2. If possible, the integrity of the tank structure should be assessment and removed if applicable.

PLACEMENT OF IMPORTED / SITE WON SOILS

- 5.3.3. Imported or site won soils (subject to meeting import/re-use criteria detailed in **Appendix C**) shall be placed within the excavation void and will be undertaken by the remediation contractor.

OFF-SITE DISPOSAL / TREATMENT

- 5.3.4. Excavated materials will require removal from Site to appropriately licensed recycling / disposal facilities. Materials will be tested and characterised prior to removal from Site. This would include residual liquids, tars and sludges that may be encountered. All material movements will be tracked and recorded with appropriate duty of care paperwork and verification reporting.

ANTICIPATED REMEDIATION EXTENTS AND QUANTITIES

- 5.3.5. Indicative remediation areas cover an area of approximately 21 m² (Ref. Drawing 70070233-007. From previous site investigations, the depth (from borehole excavation) and extents (from GPR survey), excavation quantities are estimated at approximately 26 m³, with the base of the tank being 1.26 m bgl.

REMEDIAION CRITERIA

- 5.3.6. The remediation criteria are based on achieving full removal of the tank structure and visual evidence of tars soils containing tar.

REMEDIAION DURABILITY

- 5.3.7. The selected strategy is based on complete source removal which will be a durable solution.

5.4 COMPONENTS OF THE STRATEGY FOR RCL 3 – NAPL

- 5.4.1. No measurable or recoverable NAPL has been recorded on the site to date, and so, on the basis of these previous observations, the need for targeted remediation of NAPL is not required. In addition, the removal of other identified sources from the site, such as the former tank and contents, will reduce the potential for further NAPL derived risks to groundwater and result in a degree of betterment.
- 5.4.2. However, the potential presence of as yet unidentified localised sources of LNAPL cannot be discounted. Therefore, during the removal of below ground structures, redundant services/service corridors runs and earthworks, a watching brief will be required to establish the presence of LNAPL and/or grossly contaminated soil and groundwater in open excavations and make the necessary arrangements for removal. The means by which NAPL/grossly contaminated water are removed will be determined by the developer but will be verified in accordance with the verification strategy as provided in Section 6.
- 5.4.3. In the event that NAPL recovery is required, the plant will need to comprise, as a minimum, the following main elements (subject to specific discharge consent conditions):
- Portable NAPL Skimmers and/or low shear total fluids pumps;
 - Solids separation/settlement;
 - Balancing tank(s);
 - Oil water separator;
 - Temporary NAPL storage tanks(s);
 - Means of removing dissolved phase organic and inorganic contaminants in accordance with the terms of discharge consent;

- Sufficient metering and instrumentation to determine volumes treated and volumes discharged;
- A programme of water/vapour performance monitoring; and,
- Sufficient secondary containment/preventative measures to prevent accidental discharges of untreated water to surface (including live surface water drainage protection)

5.4.4. In addition, should evidence of NAPL presence change, the remediation strategy will be revised to reflect the findings and verification strategy amended accordingly.

5.5 COMPONENTS OF THE STRATEGY FOR RCL 4 - GROUNDWATER

5.5.1. The strategy for RCL 4 (contaminated groundwater) comprises shallow source removal followed by a period of monitoring to demonstrate that groundwater conditions are not deteriorating and/or improving. This betterment approach will be subject to agreement with the regulatory authorities.

5.5.2. The overall risk of the Site to Controlled Waters receptors is considered Low to Moderate. However, given the context of the wider post-industrial setting, the complex dual porosity hydrogeological setting and the likely presence of upgradient source of groundwater impact associated with the former gasworks, the active remediation of groundwater to achieve specific targets is going to be both problematic and possibly disproportionate.

5.5.3. Agreement of a betterment strategy, including removal of soil sources followed by groundwater monitoring to demonstrate a stable contaminant plume is therefore considered the most appropriate approach.

5.5.4. The strategy for RCL 4 comprises the following principal elements to be undertaken by the remediation contractor:

- Removal and off-site treatment/disposal of identified source soils. Contamination identified as a soil source which are likely to be contributing to groundwater contamination have been identified as:
 - Chlorinated solvents – identified in Made Ground soils in the northeast of the site (within the vicinity of VW201A);
 - Cyanide – identified hotspot soil source within the Made Ground vicinity of in BH102B (where cyanide leachate exceeded the L3 SSAC for Controlled Waters) and thought to be associated with elevated concentrations in shallow groundwater in this location, associated with a historic localised source; and
 - Ammoniacal nitrogen – identified hotspot soil source in the north of the Site within the vicinity of TP104 and TP105 (associated with leachate exceedances the L3 SSAC for Controlled Waters). This is suspected to be associated with localised shallow source(s) around the former concentrated liquor plant.
- Implementation of a groundwater monitoring and sampling strategy to comprise the collection of additional groundwater elevation and data and groundwater quality data to monitor the effects of remediation and redevelopment on groundwater quality and demonstrate stable or decreasing trends in groundwater of the primary contaminants of concern to be monitored will be chlorinated solvents (RCL 4A), ammoniacal nitrogen (RCL 4B) and cyanide (RCL 4C). The strategy will include:
 - A single baseline monitoring baseline groundwater monitoring and sampling prior to the removal of slab and earthworks;

- Groundwater monitoring and sampling during soil remediation, earthworks, and construction; and,
- Groundwater monitoring and sampling following redevelopment

5.5.5. The indicative scope is provided in Section 5.6 below.

5.5.6. In addition, the removal of other shallow sources of soil impact, such as the tar tank (RCL 2), will also provide betterment and reduce contaminant sources on Site.

ANTICIPATED REMEDIATION EXTENTS AND QUANTITIES

5.5.7. Indicative contaminant source areas are shown on Drawing 70070233-006, and remediation areas are shown on Drawing 70070233-007. The remediation contractor will provide a detailed method statement for the works.

PLACEMENT OF IMPORTED / SITE WON SOILS

5.5.8. Imported or site won soils (subject to meeting import/re-use criteria detailed in **Appendix C**) shall be placed within the excavation void to tie in with final ground levels.

OFF-SITE DISPOSAL / TREATMENT

5.5.9. Excavated materials will require removal from Site to appropriately licensed recycling / disposal facilities. Materials will be tested and characterised prior to removal from Site. All material movements will be tracked and recorded with appropriate duty of care paperwork and verification reporting.

REMEDIATION CRITERIA (SOILS)

5.5.10. The remediation effort for this RCL, considering the urban setting and history of the Site and surrounding area, has been determined as localised source removal, resulting in betterment of the Site, supported by a groundwater monitoring strategy to demonstrate stable conditions. Source removal will focus on areas of high contaminant concentrations as determined from the previous site investigations to remove any localised gross contaminant sources.

5.5.11. Material imported onto the site to be used as general fill or as part of the cover layer will be compliant with the criteria in **Appendix C**. Material reused on site under DoW:CoP will comply with reuse criteria set out in **Appendix C**. Topsoil imported onto site must additionally be compliant with the standard within BS 3882:2007 Specification for Topsoil, likely to be placed by the developer at a later date.

5.6 GROUNDWATER MONITORING PROGRAMME - RCL4

5.6.1. A programme of groundwater monitoring will be required from monitoring wells installed within the Made Ground, River Terrace Gravels and Chalk before, during and after remediation, earthworks, and development.

5.6.2. Eight on-site wells have been selected for the groundwater monitoring strategy as summarised in

5.6.3. Table 5-1. The wells have been selected due to their proximity to the neighbouring historical gas works site to the west, proximity to River Kennet and general site wide groundwater condition.

The groundwater monitoring works which will be undertaken by the remediation contractor with the minimum requirements set out in Table 5-2.

Table 5-1 - Monitoring Programme Boreholes

Borehole ID	Screened Depth (m bgl)	Target Strata	Rationale
BH101	1.00 to 3.50	Made Ground	Within the backfill of gasholder No3 which straddles the site boundary. To confirm shallow ongoing groundwater quality in region of former gasholder.
BH104	1.50 to 4.50	River Terraces Gravels	To confirm groundwater quality in RTG along the southern site Boundary adjacent to River Kennet
BH105	8.50 to 10.50	Chalk	To confirm Groundwater quality in Chalk along the North western (downgradient) site boundary
BH106	9.00 to 10.50	Chalk	To confirm Groundwater quality in Chalk along the North eastern (downgradient) site boundary
BH201	5.00 to 7.00	River Terraces Gravels	To confirm groundwater quality with the RTG along the upgradient (western) site boundary.
BH204	5.00 to 7.00	River Terraces Gravels	To confirm groundwater quality with the RTG along on the downgradient side of the site.
BH302A	10.00 to 19.00	Chalk	To confirm groundwater quality in the chalk along the upgradient boundary
BH303	8.00 to 20.00	Chalk	To confirm groundwater quality in the chalk along the upgradient boundary

Table 5-2 – Groundwater Monitoring Scope

BH Ref	Frequency	Duration	Purpose	Suite
BH101, BH104, BH105, BH106, BH201, BH204, BH302A, BH303	Pre-remediation	Single event	Determine baseline groundwater contaminants of concern concentrations prior to remediation through shallow soil source removal.	- pH - PAH - TPH - VOC - Ammoniacal Nitrogen - Cyanide
BH101, BH104, BH105, BH106, BH201, BH204, BH302A, BH303	Monthly	During Remediation and earthworks remediation	Monitor groundwater for contaminants of concern. Observe potential impacts to groundwater quality from remediation and earthworks.	- pH - PAH - TPH - VOC - Ammoniacal Nitrogen - Cyanide
BH101, BH104, BH105, BH106, BH201, BH204, BH302A, BH303	Once every two months	During Construction / post remediation for 6 months	Verify groundwater quality following remediation.	- pH - PAH - TPH - VOC - Ammoniacal Nitrogen - Cyanide
BH101, BH104, BH105, BH106	Once every two months	6 months	Verify groundwater quality following completion of construction.	- pH - PAH - TPH - VOC

BH Ref	Frequency	Duration	Purpose	Suite
BH201, BH202, BH302A, WS206				- Ammoniacal Nitrogen - Cyanide

- 5.6.5. In addition to groundwater sampling, the following parameters must be measured including water level, base of well and presence of NAPL and thickness.
- 5.6.6. Wells required for the monitoring strategy that are lost through remediation will require replacement by the remediation contractor to ensure the long term monitoring is maintained. Wells not required within remediation excavation areas must be suitably decommissioned in line with Environment Agency guidelines.
- 5.6.7. Depending on the results of the monitoring, further monitoring may be required, following consultation with the regulators, to support the verification of the remediation.
- 5.6.8. In the event that notable increases in groundwater contamination occurs during the remediation or during the monitoring period post-remediation, the following will be implemented:
- Isolated increase in dissolved phase contamination – continue to monitor;
 - Significant, wider area increases in dissolved phase contaminants – increase frequency of monitoring and monitor additional wells available; and
 - Additional NAPL identified – stop works and increase monitoring and investigate in line with Discovery Strategy in Section 5.8.

5.7 COMPONENTS OF THE STRATEGY FOR RCL 5 – GROUND GAS AND VAPOUR

- 5.7.1. The Site has been characterised as a Characteristic Situation 2 (CS2) under the CIRIA risk definitions following the ground gas risk assessment. Therefore, to achieve the remediation objectives for RCL 5 (ground gas and vapour), installation of a gas protection measures in line with the requirements of CS2, including increasing the membranes to be protective of vapours, will be required by the developer during the development construction phase. The installed membrane will act as a pathway break for the ground gas and vapour with regards to human health.
- 5.7.2. In addition to the installation of gas protection measures, source removal of contaminants relating to other RCL's will be undertaken providing betterment and reducing gas and vapour potential.
- 5.7.3. This will be designed by the architects as part of the development designs, to be approved by the Reading Borough Council. The developer will provide a construction quality assurance (CQA) for verification purposes, to be contained within the developer verification report (the verification plan for this report is included in Section 6.7).

5.8 DISCOVERY STRATEGY

- 5.8.1. Although every effort has been made through the previous site investigations to characterise the site and associated ground and contamination risk and considered to be robust, it remains possible unexpected soil conditions may be encountered during the remediation works.
- 5.8.2. Should previously undiscovered contamination be encountered during the remediation works, changes to the remediation strategy may be required if the discovery is defined as a contamination

source which is distinct in its chemical or physical composition from the type of source material considered within the CSM.

- 5.8.3. On encountering unexpected contamination during the remediation, all works in this area will be halted and the remediation contractor site manager, WSP and the client will be informed. A WSP engineer will attend site to make observations and detail testing and risk assessment required to characterise the discovery.
- 5.8.4. An addendum to this remediation strategy will be prepared detailing how the contamination will be managed. Written agreement will be sought from the Reading Borough Council authority prior to implementation of any amendments to the agreed strategy in line with Planning Condition 20. Any such amendments will be fully documented within the Verification Report.

6 VERIFICATION PLAN

6.1 VERIFICATION PLAN

- 6.1.1. This verification plan sets out the requirements to ensure the remediation is completed in line with the remediation strategy and demonstrate the effectiveness of the remediation. This plan has been produced in accordance with the requirements of the Environment Agency document 'Verification of Remediation of Land Contamination' and sets out the process to be followed in order to demonstrate that the remediation has been successfully completed and the identified risks have been appropriately reduced or removed. The production of a verification plan and subsequent report is a requirement of Planning Condition no. 19.

6.2 RCL 1 - SHALLOW MADE GROUND SOILS

- 6.2.1. The strategy for the impacted Made Ground is presented in Section 5.2. Verification of the source excavation and placement of the cover layer will comprise of the following:
- Photographic record of the final excavation to 0.70m below final finished level of all the sides and bases;
 - Topographical survey of the excavation extents and depths, ensuring it is 0.70 m below final finished levels;
 - Photographic record of the placement of the geomembrane marker layer on the base and side of the excavation;
 - Material reuse to be tested and compliant with **Appendix C**, on a frequency of 1/200 m³; and
 - Imported materials tested and compliant with **Appendix C**, on a frequency of 1/200 m³ and at least 3 samples per source; and
 - The 0.30 m thickness of topsoil to be compliant with standards set out in BS 3882:2007 Specification for Topsoil and will likely be placed by the developer at a later date. A separate verification will be produced by the developer in this instance.

6.3 RCL 2 – TANK CONTAINING TAR REMOVAL

- 6.3.1. Upon completion of the remediation excavation, the remediation contractor, along with WSP will visually inspect the excavation and confirm all of the visual tar has been removed from the tank. The following validation recordings will be completed
- Photographic record of all faces and base;
 - Topographical survey of excavation extent and base; and
 - Imported materials tested and compliant with **Appendix C**, on a frequency of 1/200 m³ and at least 3 samples per source.

6.4 RCL 3 – POTENTIAL NAPL

- 6.4.1. No measurable NAPL has been recorded on the site and there is no targeted remediation required. The removal of other identified sources from the site, such as the tank containing tar, will limit the possibility of further potential NAPL sources and risks to groundwater, leading to betterment.
- 6.4.2. Should evidence of NAPL presence change, the remediation strategy will be revised to reflect the findings and verification strategy amended accordingly.

6.5 RCL 4 – CONTAMINATED GROUNDWATER

- 6.5.1. Groundwater remediation verification will be based on a lines of evidence approach. The removal of hotspot source contamination in shallow soils (chlorinated solvent, ammoniacal nitrogen and cyanide) at the site will reduce the impact to groundwater and facilitate betterment of the ground conditions.
- 6.5.2. Lines of evidence to show reduced risk and ongoing risk reduction from the RCL 4 (contaminated groundwater) will include:
- Evidence of soil source removal (soil volumes) associated with contaminants also identified in the groundwater; and
 - Groundwater monitoring as set out in Section 5.6 and reporting.

6.6 RCL 5 – GROUND GAS

- 6.6.1. During the development construction, a ground gas and vapour membrane will be installed to all proposed buildings on the Site. The membrane will be specifically engineers membranes for volatile contaminants, for example foil-faced reinforced polythene laminate vapour membrane.

All installed gas and vapour membranes will be independently validated and verified.

6.7 REMEDIATION CONTRACTOR VERIFICATION REPORT

- 6.7.1. Complete and accurate records of the works will be expected to be prepared and maintained throughout the remediation project for inclusion within the verification report. The verification report will be prepared on completion of the remediation works and submitted to the Reading Borough Council and Environment Agency to demonstrate completion of the remedial works.
- 6.7.2. Subject to consultation with the Reading Borough Council and the Environment Agency, the following information (though not exhaustive) is likely to be required to be incorporated within the report (where applicable):
- Details of all works completed;
 - Results of any laboratory analysis carried out, including validation testing;
 - Waste transfer consignment notes;
 - Imported material certification (if required);
 - Details of any environmental control measures, and whether they needed to be implemented (e.g., quenching water, pumping systems);
 - Details of post remediation monitoring (if required), including data and analysis results if applicable;
 - Details of audit trails;
 - Details of quality control procedures adopted;
 - Accurate details of any obstructions that remain in situ, including survey drawings showing their location and elevation to Ordnance Survey National Grid;
 - Appropriate scale drawings and photographs of remediation works; and
 - Summary of the outcome of the remediation works.

6.8 DEVELOPER VERIFICATION REPORT

- 6.8.1. On completion of the remediation by the appointed contractor, two outstanding actions will be completed by the follow on developer under the approved planning ref: 190627. The outstanding

works will be the placement of the topsoil for the cover layer system within soft cover areas (landscaping/ residential gardens) and the installation of the gas and vapour resistant membrane.

- 6.8.2. A separate verification report will be produced by the developer for these works, to be compliant with the strategy and verification requirements set out in this report. Full discharge of planning condition 19 can only be achieved once Reading Borough Council receive this final verification report.
- 6.8.3. Complete and accurate records of the works will be expected to be prepared and maintained throughout the developers works under this remediation strategy for inclusion within the verification report. The verification report will be prepared on completion of the remediation works and submitted to the Reading Borough Council and Environment Agency to demonstrate completion of the remedial works.
- 6.8.4. Subject to consultation with the Environment Agency and Reading Borough Council, the following information (though not exhaustive) is likely to be required to be incorporated within the report (where applicable):
- Details of all works completed;
 - Results of any laboratory analysis carried out, including validation testing;
 - Imported material certification;
 - Details of any environmental control measures;
 - Details of post remediation monitoring (if required), including data and analysis results if applicable;
 - Details of audit trails;
 - Details of quality control procedures adopted;
 - Topographical survey information and drawings;
 - Appropriate scale drawings and photographs of works; and
 - Summary of the outcome of the remediation works.

7 OUTLINE IMPLEMENTATION PLAN

7.1 OUTLINE IMPLEMENTATION PLAN

- 7.1.1. The objectives of this outline implementation plan are to outline the ways in which the planned remedial works will be undertaken, and procedures for how the work will be managed and controlled by the parties involved. The remediation works will be completed by an appointed remediation contractor who will produce a detailed remediation implementation plan.
- 7.1.2. The appointed remediation contractor will complete the remediation works after the demolition works and will be responsible as principal contractor during the remediation set out within the detailed implementation plan.

SITE PREPARATORY WORK

- 7.1.3. Live services (statutory and private) are known to cross the remediation areas. Liaison with the statutory service providers will be undertaken in advance of the remediation works to agree working methodologies and protection measures. Intrusive service verification, via hand digging or vacuum excavation techniques, will be undertaken to locate services which may present a constraint to the remediation. It will be necessary to maintain safe working distances (as advised by the relevant service owner) around these services during the works.
- 7.1.4. An area for the Site compound (comprising welfare, stores, and offices for the site staff) will be prepared and will be located within the Site.
- 7.1.5. Consideration will be given to the Site layout regarding vehicle movements for users of the car park, pedestrians and the goods vehicle drivers accessing the goods yard.

CONSTRAINTS AND LIMITATIONS TO REMEDIATION

- 7.1.6. Live and redundant services are present on site. A services investigation of the Site will be required to determine the location of on-site services which may be impacted by the works. These works will also include discussions with site owners and statutory service providers to agree working methods and practices in the vicinity of any live plant and equipment. Services and constraints are shown on Drawing 70070233-005 in **Appendix A**.

REMEDIATION TIMESCALES

- 7.1.7. Demolition works are due to be completed between September 2021 and March 2022 with remediation works commencing immediately after demolition works are complete. The anticipated timescales for the works is 9-12 months, however this will be dependent the combination of technologies employed, and will be subject to appointment of a contractor, client requirements and regulatory requirements (e.g., post works monitoring).

PERMITS / LICENSES

- 7.1.8. All material disposed of off-site will be carried out under full Duty of Care with appropriate documentation (e.g., borehole arisings). Receiving waste treatment / landfill sites and hauliers will be suitably licensed.

- 7.1.9. A discharge consent will be obtained from the appropriate water utility company if discharges to sewer are required. Relevant consents such as mobile plant permits and hazardous waste producer registration are to be obtained as required.

POTENTIAL ENVIRONMENTAL IMPACTS AND PRECAUTIONS

- 7.1.10. A construction phase environmental management plan will be prepared for the works by the appointed Contractor, and all workers will be made aware of the plan and its requirements.
- 7.1.11. Noise, odour, dust, and vibration during the works will be monitored, and restrictions will be in place on working hours. Mitigation measures will be operated if required to protect both site workers, site users and general public as applicable.

HEALTH & SAFETY RISKS AND PRECAUTIONS

- 7.1.12. A construction phase health and safety plan will be prepared for the works by the appointed contractor, and all workers will be made aware of the incident response plan, risk assessments and COSHH assessment.
- 7.1.13. Safe access will need to be maintained to the electrical substation at all times during the works.
- 7.1.14. The Site contains numerous live services both below and above ground. Unrecorded services may be present within the remediation areas, working methods will need to be adopted to minimise the risk of damaging services. Method statements for working procedures will be contained within the health and safety plan.
- 7.1.15. There is a potential for close contact with chemicals (depending on the proposed remediation technique) and contaminated materials. There are risks of physical harm resulting from the use of heavy plant and machinery. A site-specific risk assessment will be produced to address all risks associated with the remediation works, which will be included within the health and safety plan.
- 7.1.16. To minimise the above risks, PPE must be worn at all times, risk assessments will be undertaken to determine the most effective / efficient methods of working considering the work environment.
- 7.1.17. Pedestrian routes will need to be established to separate pedestrians and vehicles across the Site, as far as is practicable.

SITE MANAGEMENT AND PARTIES INVOLVED

- 7.1.18. SGN are the landowners commissioning the remediation works.
- 7.1.19. The Site management of the remediation works will be undertaken the contractor appointed to undertake the remediation who will act as Principal Contractor under the CDM 2015 Regulations.
- 7.1.20. The contractor will be responsible for site management and control of operations including site health and safety and environmental control responsibilities. All staff will be suitably trained and experienced in the roles they are to undertake.

SITE CONTROL MEASURES

- 7.1.21. The proposed site working hours are as follows:
- Mon - Fri 08:00 – 18:00 hrs.
- 7.1.22. No works are proposed for weekend or public holidays.

- 7.1.23. The contaminated land officer or any other officer at Reading Borough Council and officers from the Environment Agency are welcome to visit the site during the works.

Appendix A

DRAWINGS





KEY

— SITE BOUNDARY

Contains Ordnance Survey data ©Crown copyright and database right (2019)



Kings Orchard
1 Queen Street
Bristol BS2 0HQ

Tel: 44-(0)1179-306200

Client/Project

SCOTIA GAS NETWORKS (SGN)
GASHOLDER SITE AT ALEXANDER
TURNER CLOSE, READING

Title:

SITE LOCATION PLAN

Drawn: CEW

Checked: EW

Designed: EW

Approved:

Date: 09/07/2019

Scale: 1:20,000 A4 Sheet

Project Number:

Drawing Number:

Revision:

70070233

001

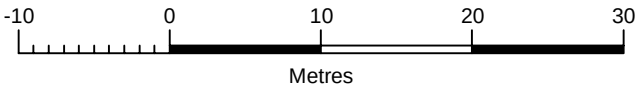
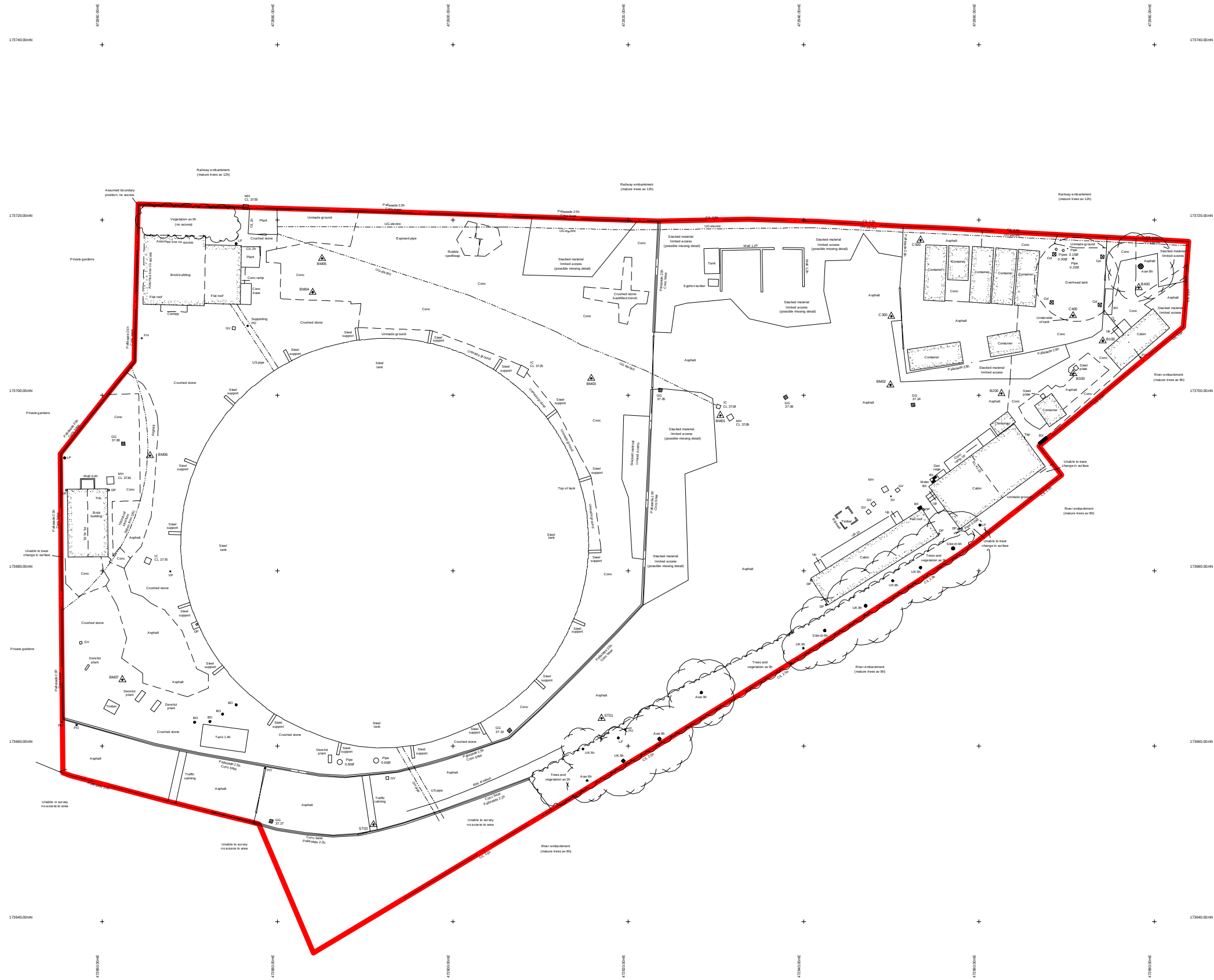
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Login: Watt, Chris
Plot Date: 10/07/2019 19:14:19
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KEY

— SITE BOUNDARY



Rev	Date	Description	By	Chk	App	Notes
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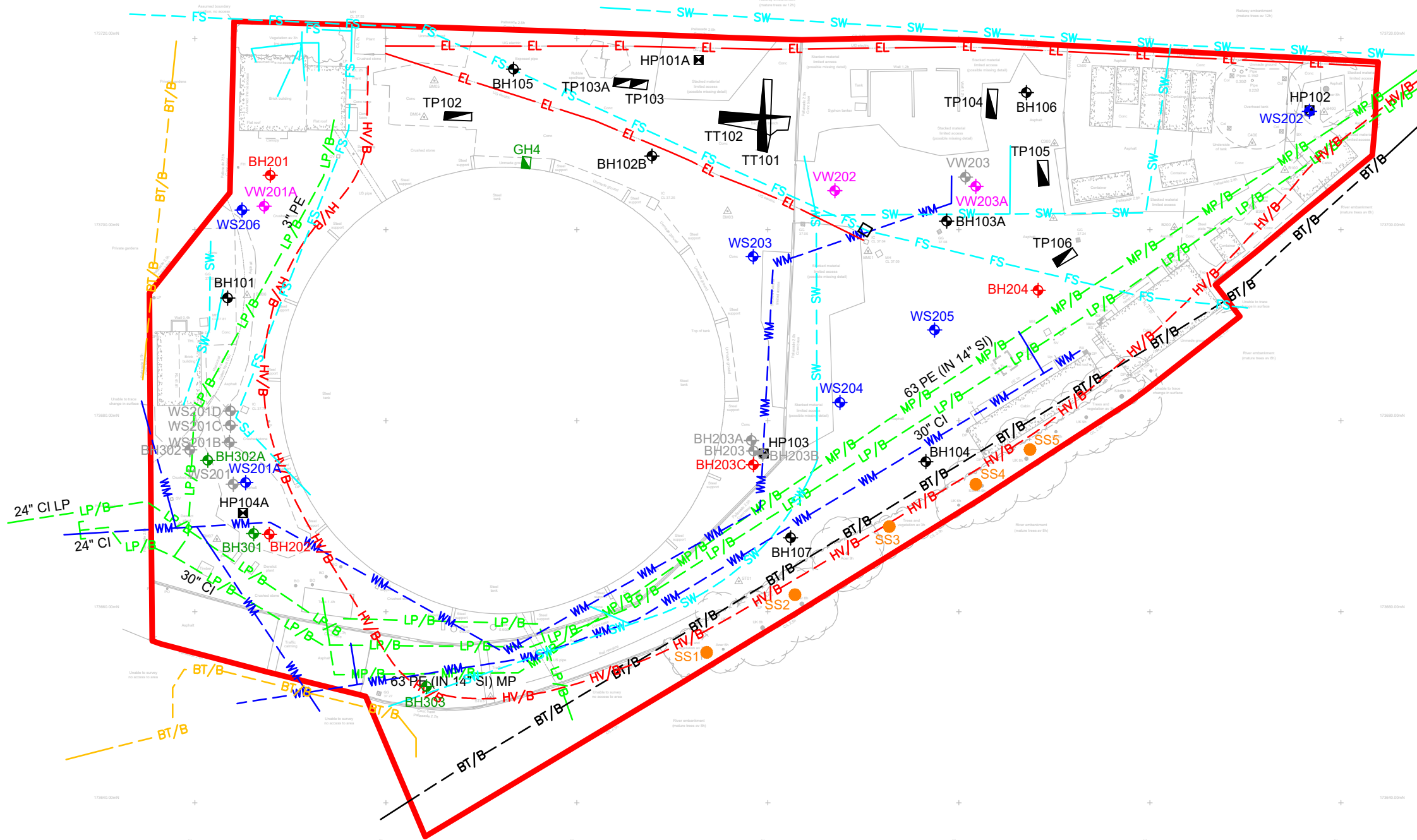
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SCOTIA GAS NETWORKS (SGN)

Project:
GASHOLDER SITE AT ALEXANDER
TURNER CLOSE, READING

Title:
SITE LAYOUT

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Designed: EW		Approved:	
Date: 22/05/2019	Scale: 1:500	A3	Sheet:
Project Number:		Drawing Number:	Revision:
70070233		002	
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File Name: C:\Users\INDT01667\Desktop\70070233\Working\70070233-ROA-003.dwg
Plot Date: 2/11/2021 11:58:19 AM
Login: Tyagi, Devendra



KEY

- SITE BOUNDARY
- BH BOREHOLE LOCATION (2019)
- BH SUPPLEMENTARY BOREHOLE (2019)
- GH4 SUPPLEMENTARY TRIAL PIT (2019)
- WS WINDOW SAMPLE LOCATION (2019)
- VW VAPOUR WELL LOCATION (2019)
- SS SOIL SAMPLE LOCATION (2019)
- BH, WS, VW EXPLORATORY HOLE REFUSAL (2019)

- BH HP TP TT
- 2015 EXPLORATORY HOLE LOCATIONS

KEY TO STATUTORY SERVICES

- HV/B— H.V. ELECTRIC (BELOW GROUND)
- LP/B— LP GAS MAIN (BELOW GROUND)
- MP/B— MP GAS MAIN (BELOW GROUND)
- BT/B— TELECOM (BELOW GROUND)

KEY TO SERVICES SHOWN IN PREVIOUS REPORT

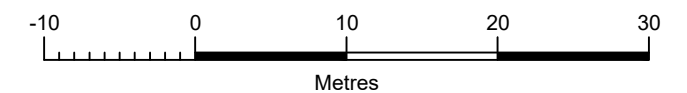
- BT/B— TELECOM
- WM— WATER

KEY TO PRIVATE SERVICES PROVIDED BY CLIENT

- FS— FOUL SEWER
- SW— SURFACE WATER SEWER

KEY TO ADDITIONAL SERVICES SURVEYED ON SITE

- EL— ELECTRIC CABLE



Rev	Date	Description	By	Chk	App	Notes
						1. SERVICE LOCATIONS ARE APPROXIMATE AND BASED ON THIRD PARTY INFORMATION. WSP TAKE NO RESPONSIBILITY FOR THE ACCURACY OF THIS INFORMATION. WHEN LOCATING SERVICES ON SITE REFER TO SERVICE PROVIDER PLANS.

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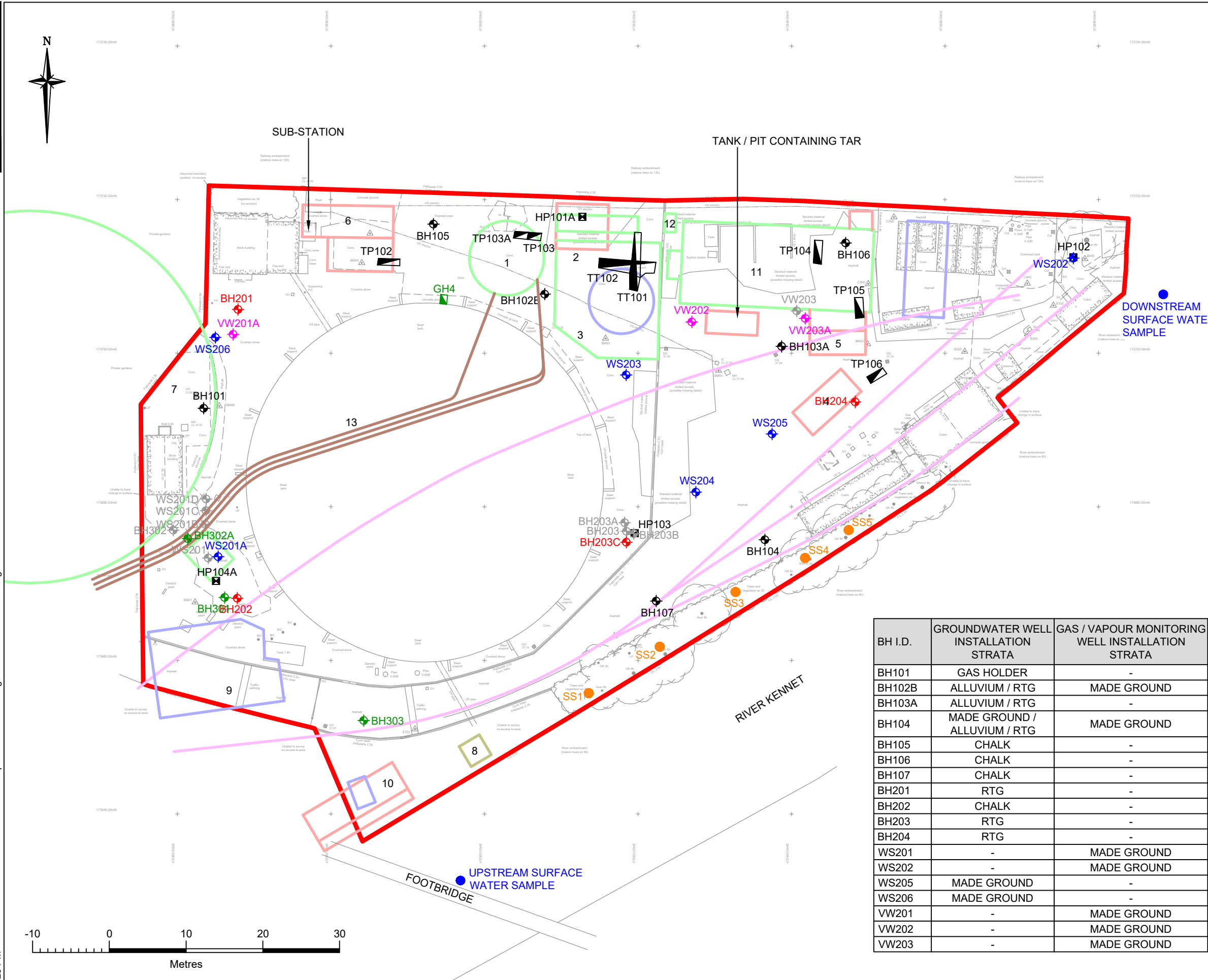
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Client:
**DANESCROFT (KENAVON DRIVE
PROJECT MANAGEMENT) LLP**

Project:
**GASHOLDER SITE AT ALEXANDER
TURNER CLOSE, READING**

Title:
**SITE LAYOUT WITH SERVICES
AND EXPLORATORY HOLE
LOCATIONS**

Drawn: CEW				Checked: EW		
Designed: EW				Approved:		
Date: 11/02/2021		Scale: 1:500		A3	Sheet:	
Project Number:				Drawing Number:		Revision:
70070233				003		
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KEY

- SITE BOUNDARY
- BH BOREHOLE LOCATION (2019)
- BH SUPPLEMENTARY BOREHOLE (2019)
- GH4 SUPPLEMENTARY TRIAL PIT (2019)
- WS WINDOW SAMPLE LOCATION (2019)
- VW VAPOUR WELL LOCATION (2019)
- SS SOIL SAMPLE LOCATION (2019)
- BH, WS, VW EXPLORATORY HOLE REFUSAL (2019)
- BH HP TP TT 2015 EXPLORATORY HOLE LOCATIONS

KEY TO HISTORICAL STRUCTURES

DATE FIRST APPEARS ON OS PLAN

- 1899 - 1930
- 1931 - 1970
- 1971 ONWARD
- HISTORICAL STRUCTURE (FROM ENGINEERING DRAWING)
- HISTORICAL RAIL LINE (CENTRELINE)
- HISTORICAL TAR MAINS

STRUCTURES

- LIQUOR TANK (PRESENT 1899-1938)
- PURIFIERS (PRESENT 1899-1933)
- SULPHATE OF AMMONIA WORKS (PRESENT 1899-1933)
- LIME STORE (PRESENT 1931-1938)
- OVERHEAD ACID TANKS, LATER CARPENTERS SHOP UNDER (PRESENT 1931-1972)
- SEPARATING PITS (PRESENT 1957)
- GASHOLDER (PRESENT 1912-1962)
- BOOSTER (DATE UNKNOWN)
- LPG AIR ENRICHMENT PLANT (PRESENT 1973)
- SCAFFOLD STORE (PRESENT 1957-1972)
- CONCENTRATED LIQUOR & SULPHATE PLANT (PRESENT 1899-1979)
- CHIMNEY (PRESENT 1899-1931)
- TAR MAINS

BH I.D.	GROUNDWATER WELL INSTALLATION STRATA	GAS / VAPOUR MONITORING WELL INSTALLATION STRATA
BH101	GAS HOLDER	-
BH102B	ALLUVIUM / RTG	MADE GROUND
BH103A	ALLUVIUM / RTG	-
BH104	MADE GROUND / ALLUVIUM / RTG	MADE GROUND
BH105	CHALK	-
BH106	CHALK	-
BH107	CHALK	-
BH201	RTG	-
BH202	CHALK	-
BH203	RTG	-
BH204	RTG	-
WS201	-	MADE GROUND
WS202	-	MADE GROUND
WS205	MADE GROUND	-
WS206	MADE GROUND	-
VW201	-	MADE GROUND
VW202	-	MADE GROUND
VW203	-	MADE GROUND

Rev	Date	Description	By	Chk	App	Notes
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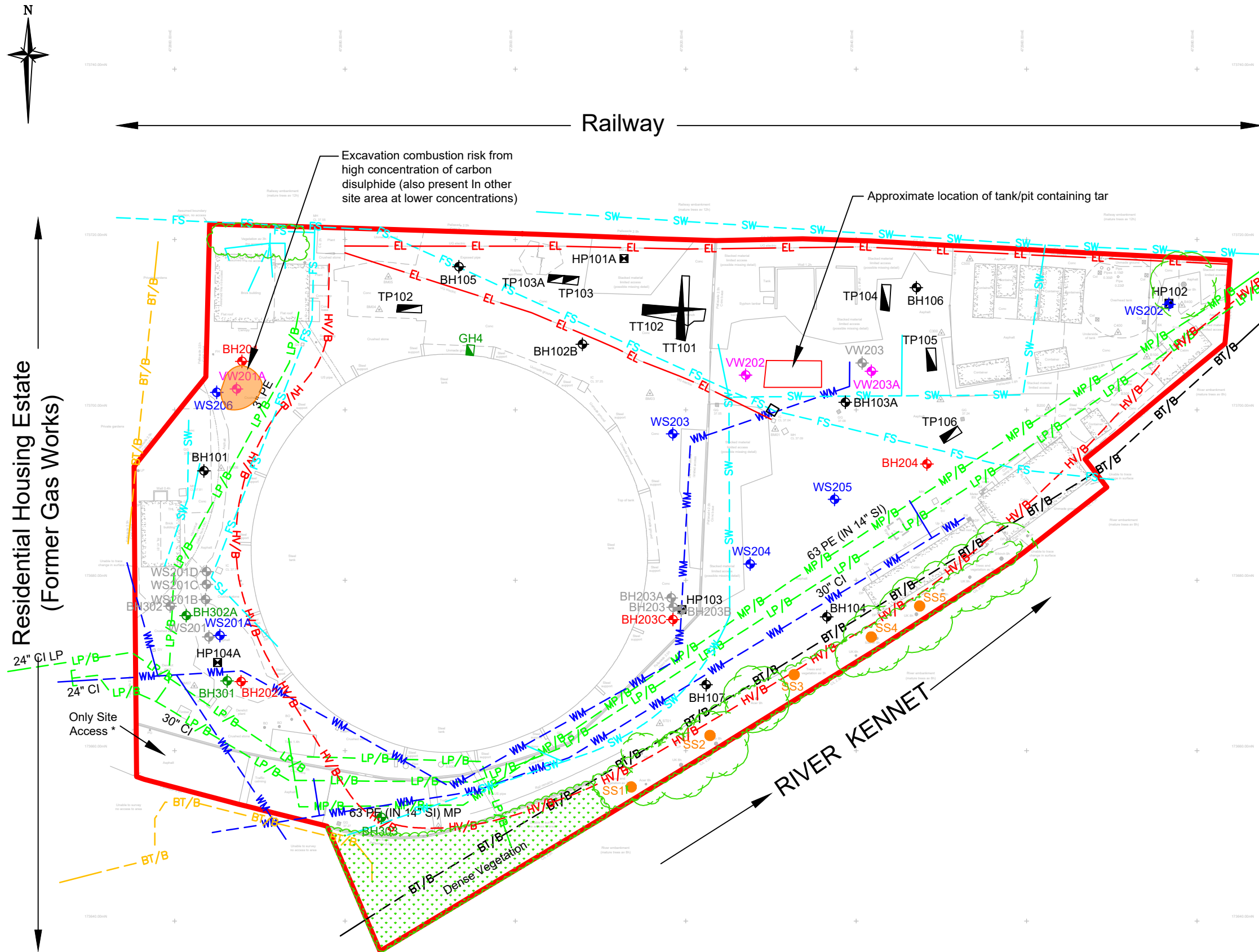
Client:
**DANESCROFT (KENAVON DRIVE
PROJECT MANAGEMENT) LLP**
Project:
**GASHOLDER SITE AT ALEXANDER
TURNER CLOSE, READING**

Title:
**PLAN SHOWING HISTORIC
SITE STRUCTURES AND
EXPLORATORY HOLE
LOCATIONS**

Drawn: CEW		Checked: EW		
Designed: EW		Approved:		
Date: 11/02/2021	Scale: 1:500	A3	Sheet:	
Project Number:		Drawing Number:		Revision:
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- KEY**
- SITE BOUNDARY
 - BH BOREHOLE LOCATION (2019)
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 - GH4 SUPPLEMENTARY TRIAL PIT (2019)
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- KEY TO SERVICES SHOWN IN PREVIOUS REPORT**
- BT/B TELECOM
 - WM WATER
- KEY TO PRIVATE SERVICES PROVIDED BY CLIENT**
- FS FOUL SEWER
 - SW SURFACE WATER SEWER
- KEY TO ADDITIONAL SERVICES SURVEYED ON SITE**
- EL ELECTRIC CABLE

* Access to site entrance is highly constrained through residential housing estate with tight turns

Rev	Date	Description	By	Chk	App	Notes
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1.		SERVICE LOCATIONS ARE APPROXIMATE AND BASED ON THIRD PARTY INFORMATION. WSP TAKE NO RESPONSIBILITY FOR THE ACCURACY OF THIS INFORMATION. WHEN LOCATING SERVICES ON SITE REFER TO SERVICE PROVIDER PLANS.				
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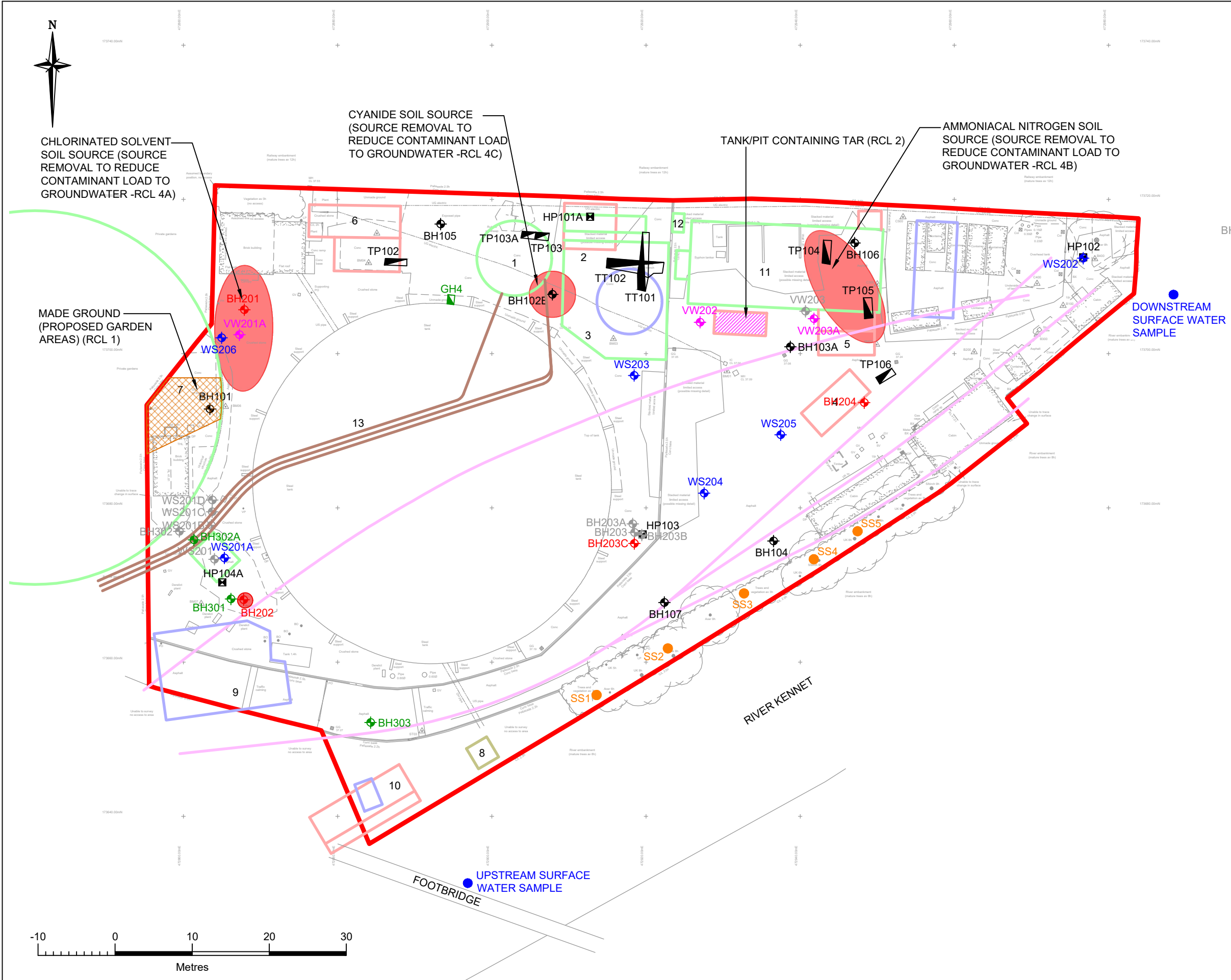


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Project: GASHOLDER SITE AT ALEXANDER TURNER CLOSE, READING

CONSTRAINTS PLAN

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Project Number:		Drawing Number:	
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		Revision	
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- KEY**
- SITE BOUNDARY
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- HISTORICAL STRUCTURE (FROM ENGINEERING DRAWING)
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 - CHIMNEY (PRESENT 1899-1931)
 - TAR MAINS

Rev	Date	Description	By	Chk	App	Notes

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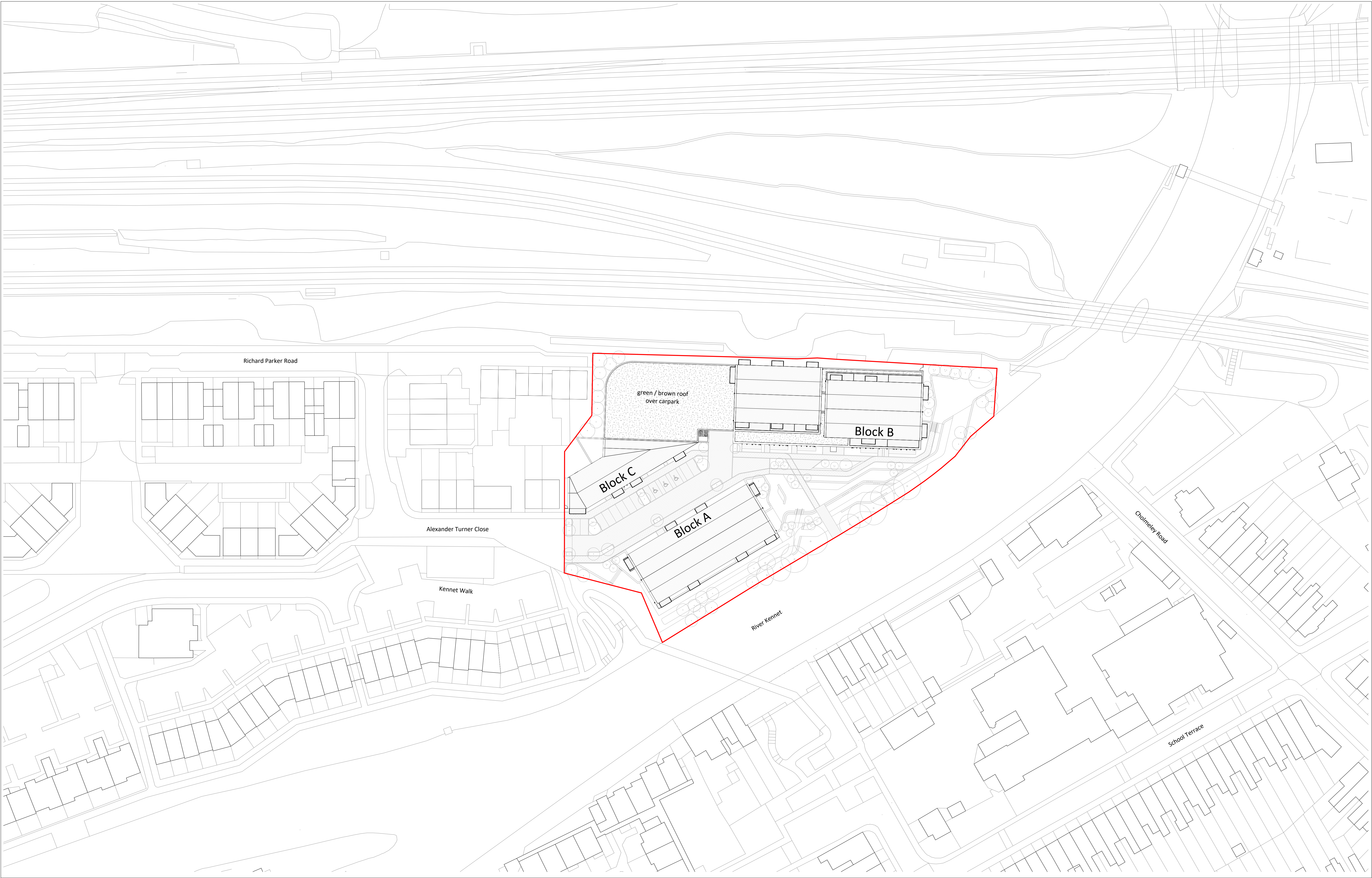
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**DANESCROFT (KENAVON DRIVE
PROJECT MANAGEMENT) LLP**

Project:
**GASHOLDER SITE AT ALEXANDER
TURNER CLOSE, READING**

Title:
REMEDIATION AREAS

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Designed: EW	Approved:
Date: 11/02/2021	Scale: 1:500 A3 Sheet:
Project Number: 70070233	Drawing Number: 008
Revision:	



NOTES

CONSULTANTS

- Refer to highways consultant's drawings for details
- Refer to landscape consultant's drawings for details
- Landscaping layout is indicative only

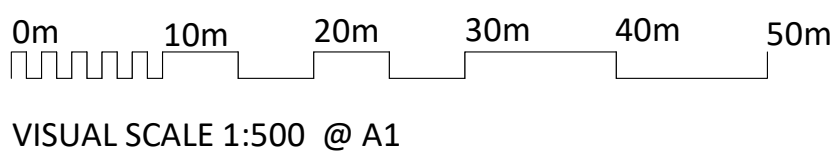
AREAS

- Refer to area schedule

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N

Rev	Notes	Date	By	Auth
P	Planning Application	28/03/19		
P1	Planning Amendments	23/09/19	LK	RC



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Date: 28/03/19
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Checked by: RC
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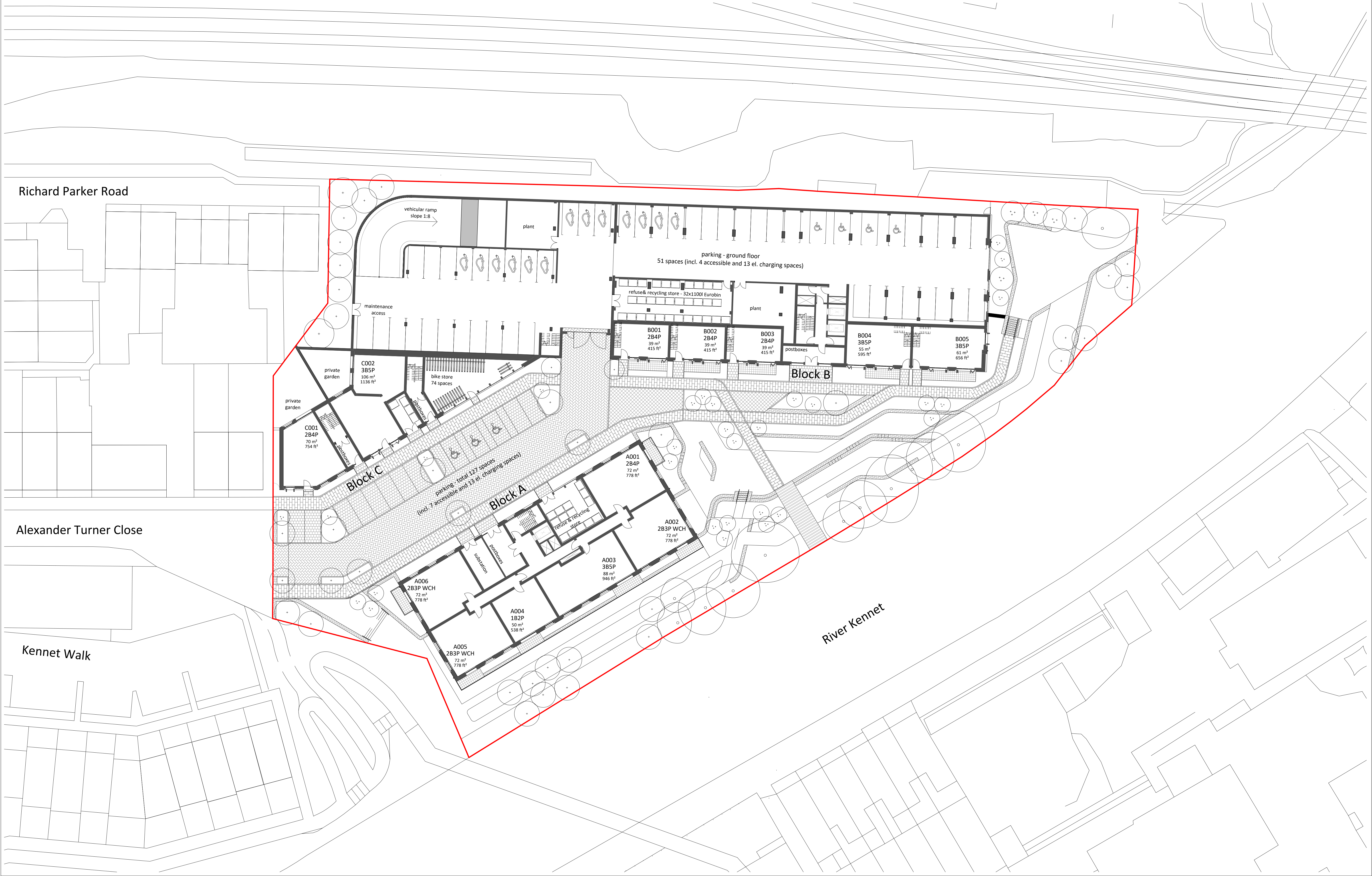
Danescroft (KDPM) LLP
Gas Holder, Reading
Proposed Site Plan

PLANNING
16035

P0-010

P1

Revision

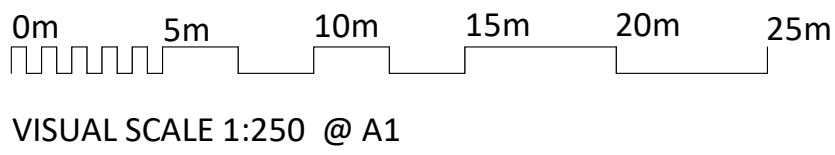


NOTES
CONSULTANTS
- Refer to highways consultant's drawings for details
- Refer to landscape consultant's drawings for details
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AREAS
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P1	Planning Amendments	23/09/19	LK	RC



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Checked by: RC
Scale @ A1: 1 : 250
Scale @ A3: 1 : 500
CAD File No:

Danescroft (KDPM) LLP
Gas Holder, Reading
Proposed Plan - Ground Floor

PLANNING
16035

P0-100

P1
Revision

Appendix B

LIMITATIONS



REPORT LIMITATIONS - GROUND RISK AND REMEDIATION

GENERAL

1. WSP UK Limited has prepared this report solely for the use of the Client and those parties with whom a warranty agreement has been executed, or with whom an assignment has been agreed and outlined in the body of the report.
2. Unless explicitly agreed otherwise, in writing, this report has been prepared under WSP UK Limited standard Terms and Conditions as included within our proposal to the Client.
3. Project specific appointment documents may be agreed at our discretion and a charge may be levied for both the time to review and finalise appointments documents and also for associated changes to the appointment terms. WSP UK Limited reserves the right to amend the fee should any changes to the appointment terms create an increase risk to WSP UK Limited.
4. The report needs to be considered in the light of the WSP UK Limited proposal and associated limitations of scope. The report needs to be read in full and isolated sections cannot be used without full reference to other elements of the report and any previous works referenced within the report.

PHASE 1 GEO ENVIRONMENTAL AND PRELIMINARY RISK ASSESSMENTS

Coverage: *This section covers reports with the following titles or combination of titles: phase 1; desk top study; geo environmental assessment; development appraisal; preliminary environmental risk assessment; constraints report; due diligence report; geotechnical development review; environmental statement; environmental chapter; project scope summary report (PSSR), program environmental impact report (PEIR), geotechnical development risk register; and, baseline environmental assessment.*

5. The works undertaken to prepare this report comprised a study of available and easily documented information from a variety of sources (including the Client), together with (where appropriate) a brief walk over inspection of the Site and correspondence with relevant authorities and other interested parties. Due to the short timescales associated with these projects responses may not have been received from all parties. WSP UK Limited cannot be held responsible for any disclosures that are provided post production of our report and will not automatically update our report.
6. The opinions given in this report have been dictated by the finite data on which they are based and are relevant only for the purpose for which the report was commissioned. The information reviewed should not be considered exhaustive and has been accepted in good faith as providing true and representative data pertaining to site conditions. Should additional information become available which may affect the opinions expressed in this report, WSP UK Limited reserves the right to review such information and, if warranted, to modify the opinions accordingly.
7. It should be noted that any risks identified in this report are perceived risks based on the information reviewed. Actual risks can only be assessed following intrusive investigations of the site.
8. WSP UK Limited does not warrant work / data undertaken / provided by others.

REPORT LIMITATIONS - GROUND RISK AND REMEDIATION

INTRUSIVE INVESTIGATION REPORTS

Coverage: *The following report titles (or combination) may cover this category of work: geo environmental site investigation; geotechnical assessment; GIR (Ground Investigation reports); preliminary environmental and geotechnical risk assessment; and, geotechnical risk register.*

9. The investigation has been undertaken to provide information concerning either:
 - i. The type and degree of contamination present at the site in order to allow a generic quantitative risk assessment to be undertaken; or
 - ii. Information on the soil properties present at the site to allow for geotechnical development constraints to be considered.
10. The scope of the investigation was selected on the basis of the specific development and land use scenario proposed by the Client and may be inappropriate to another form of development or scheme. If the development layout was not known at the time of the investigation the report findings may need revisiting once the development layout is confirmed.
11. For contamination purposes, the objectives of the investigation are limited to establishing the risks associated with potential contamination sources with the potential to cause harm to human health, building materials, the environment (including adjacent land), or controlled waters.
12. For geotechnical investigations the purpose is to broadly consider potential development constraints associated with the physical property of the soils underlying the site within the context of the proposed future or continued use of the site, as stated within the report.
13. The amount of exploratory work, soil property testing and chemical testing undertaken has necessarily been restricted by various factors which may include accessibility, the presence of services; existing buildings; current site usage or short timescales. The exploratory holes completed assess only a small percentage of the area in relation to the overall size of the Site, and as such can only provide a general indication of conditions.
14. The number of sampling points and the methods of sampling and testing do not preclude the possible existence of contamination where concentrations may be significantly higher than those actually encountered or ground conditions that vary from those identified. In addition, there may be exceptional ground conditions elsewhere on the site which have not been disclosed by this investigation and which have therefore not been taken into account in this report.
15. The inspection, testing and monitoring records relate specifically to the investigation points and the timeframe that the works were undertaken. They will also be limited by the techniques employed. As part of this assessment, WSP UK Limited has used reasonable skill and care to extrapolate conditions between these points based upon assumptions to develop our interpretation and conclusions. The assumption made in forming our conclusions is that the ground and groundwater conditions (both chemically and physically) are the same as have been encountered during the works undertaken at the specific points of investigation. Conditions can change between investigation points and these interpretations should be considered indicative.
16. The risk assessment and opinions provided are based on currently available guidance relating to acceptable contamination concentrations; no liability can be accepted for the retrospective effects of any future changes or amendments to these values. Specific assumptions associated

REPORT LIMITATIONS - GROUND RISK AND REMEDIATION

with the WSP UK Limited risk assessment process have been outlined within the body or associated appendix of the report.

17. Additional investigations may be required in order to satisfy relevant planning conditions or to resolve any engineering and environmental issues.
18. Where soil contamination concentrations recorded as part of this investigation are used for commentary on potential waste classification of soils for disposal purposes, these should be classed as indicative only. Due consideration should be given to the variability of contaminant concentrations taken from targeted samples versus bulk excavated soils and the potential variability of contaminant concentrations between sampling locations. Where major waste disposal operations are considered, targeted waste classification investigations should be designed.
19. The results of the asbestos testing are factually reported and interpretation given as to how this relates to the previous use of the site, the types of ground encountered and site conceptualisation. This does not however constitute a formal asbestos assessment. These results should be treated cautiously and should not be relied upon to provide detailed and representative information on the delineation, type and extent of bulk ACMs and / or trace loose asbestos fibres within the soil matrix at the site.
20. If costs have been included in relation to additional site works, and / or site remediation works these must be considered as indicative only and must be confirmed by a qualified quantity surveyor.

EUROCODE 7: GEOTECHNICAL DESIGN

21. On 1st April 2010, BS EN 1997-1:2004 (Eurocode 7: Geotechnical Design – Part 1) became the mandatory baseline standard for geotechnical ground investigations.
22. In terms of geotechnical design for foundations, slopes, retaining walls and earthworks, EC7 sets guidance on design procedures including specific guidance on the numbers and spacings of boreholes for geotechnical design, there are limits to methods of ground investigation and the quality of data obtained and there are also prescriptive methods of assessing soil strengths and methods of design. Unless otherwise explicitly stated, the work has not been undertaken in accordance with EC7. A standard geotechnical interpretative report will not meet the requirements of the Geotechnical Design Report (GDR) under Eurocode 7. The GDR can only be prepared following confirmation of all structural loads and serviceability requirements. The report is likely to represent a Ground Investigation Report (GIR) under the Eurocode 7 guidance.

DETAILED QUANTITATIVE RISK ASSESSMENTS AND REMEDIAL STRATEGY REPORTS

23. These reports build upon previous report versions and associated notes. The scope of the investigation, further testing and monitoring and associated risk assessments were selected on the basis of the specific development and land use scenario proposed by the Client and may not be appropriate to another form of development or scheme layout. The risk assessment and opinions provided are based on currently available approaches in the generation of Site Specific Assessment Criteria relating to contamination concentrations and are not considered to represent a risk in a specific land use scenario to a specific receptor. No liability can be accepted for the retrospective effects of any future changes or amendments to these values, associated models or associated guidance.



REPORT LIMITATIONS - GROUND RISK AND REMEDIATION

- 24. The outputs of the Detailed Quantitative Risk Assessments are based upon WSP UK Limited manipulation of standard risk assessment models. These are our interpretation of the risk assessment criteria.
- 25. Prior to adoption on site they will need discussing and agreeing with the Regulatory Authorities prior to adoption on site. The regulatory discussion and engagement process may result in an alternative interpretation being determined and agreed. The process and timescales associated with the Regulatory Authority engagement are not within the control of WSP UK Limited. All costs and programmes presented as a result of this process should be validated by a quantity surveyor and should be presumed to be indicative.

GEOTECHNICAL DESIGN REPORT (GDR)

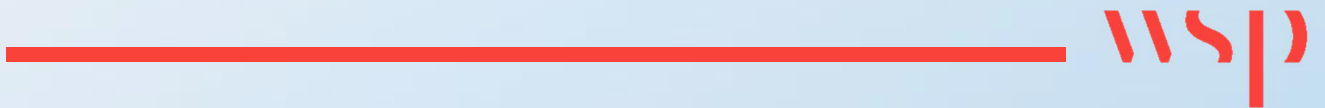
- 26. The GDR can only be prepared following confirmation of all structural loads and serviceability requirements. All the relevant information needs to be provided to allow for a GDR to be produced.

MONITORING (INCLUDING REMEDIATION MONITORING REPORTS)

- 27. These reports are factual in nature and comprise monitoring, normally groundwater and ground gas and data provided by contractors as part of an earthworks or remedial works.
- 28. The data is presented and will be compared with assessment criteria.

Appendix C

SITE SPECIFIC ASSESSMENT CRITERIA



SITE SPECIFIC ASSESSMENT CRITERIA

The following table presents the site specific import and reuse criteria for general fill materials and areas of soft standing (residential gardens and areas of soft landscaping) which are protective of human health. General fill material criteria are only applicable for the re-use of site material and cannot be used for any import.

In addition to the criteria set out below, topsoil imported onto site must additionally be compliant with the standard within BS 3882:2007 Specification for Topsoil.

Determinand	IMPORT / COVER MATERIAL (mg/kg) (to 0.7m in areas of soft standing)	GENERAL FILL MATERIAL (mg/kg) (re-use of material only)
Asbestos	Non-detect	<0.1%w/w (including no visible asbestos)
Arsenic	32	168
Barium	1,206	5,772
Cadmium	12	554
Chromium III	1,594	57,984
Hexavalent Chromium	< Limit of Detection	69
Copper	2,493	44,404
Mercury (Elemental)	0.23	25
Manganese	945	14,321
Molybdenum	0.63	2,886
Nickel	125	804
Lead	134	808
Antimony	293	3,294
Selenium	257	1,847
Tin	7,364	68,535
Zinc	3,862	173,204
Total TPH (applicable CWG band must also not be exceeded)	250 ⁽¹⁾	5,200 ⁽²⁾
Aliphatic C05-C06	42	N/A
Aliphatic C06-C08	103	N/A
Aliphatic C08-C10	26	N/A
Aliphatic C10-C12	131	N/A
Aliphatic C12-C16	N/A	N/A
Aliphatic C16-C35	N/A	N/A
Aromatic C05-C07	72	N/A
Aromatic C07-C08	130	N/A
Aromatic C08-C10	34	N/A

Determinand	IMPORT / COVER MATERIAL (mg/kg) (to 0.7m in areas of soft standing)	GENERAL FILL MATERIAL (mg/kg) (re-use of material only)
Aromatic C10-C12	74	N/A
Aromatic C12-C16	141	N/A
Aromatic C16-C21	248	N/A
Aromatic C21-C35	N/A	N/A
Total BTEX (applicable compound must also not be exceeded)	10 ⁽¹⁾	10 ⁽¹⁾
Benzene	0.09	10 ⁽¹⁾
Total PAH (applicable compound must also not be exceeded)	200 ⁽¹⁾	200 ⁽¹⁾
Benzo(a)pyrene	1	10 ⁽¹⁾
Naphthalene	2	2
Inorganic Cyanide	14	14
Thiocyanate	10	2,889

Unless otherwise stated the criteria have been derived from WSP generic acceptance criteria (GAC) for a 1% soil organic matter (SOM).

It should be noted that PID readings should be taken on all soils tested and no soils with visual / olfactory evidence of contamination should be re-used during the remediation works.

- (1) *Arbitrary standard to control quality of soils re-used on site or Imported on to site.*
- (2) *Based on 50% of CresT value (10,400mg/kg) to ensure no hydrocarbon saturated soils. Total hydrocarbon concentration must include separate fractions where stated.*



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