KINGSNORTH POWER STATION

Site Wide Remediation Strategy

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Site Wide Remediation
Strategy

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Prepared by:

RPS

Graham Moore

Principal Consultant

20 Western Avenue
Milton Park
Abingdon, Oxfordshire OX14 4SH

T +44 1235 821 888

E graham.moore@rpsgroup.com

Prepared for:

Uniper Energy

Matthew Brown

UK Environmental Manager

Compton House, 2300 The Crescent

Birmingham Business Park, B37 7YE

T +44 121 3294366

E matthew.brown@uniper.energy

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1 INTRODUCTION

1.1 Background

1.1.1 RPS Consulting Services Ltd (RPS) has been commissioned by Uniper Energy Ltd (Uniper) to develop a site wide remediation strategy in relation to contamination identified at the Kingsnorth Power Station site in Kent.

1.1.2 RPS has undertaken three phases of ground investigation *(RPS, 2014a, 2014c and 2015)* at Kingsnorth Power Station to support a decommissioning, permit variation and surrender process alongside establishing potential contaminated land liabilities under Part IIa of the Environmental Protection Act (1990) and the Environmental Damage Regulations (2009).

1.1.3 These ground investigations generally identified low levels of contaminants across the majority of the power station site with respect to future commercial use, based upon the risk-based screening criteria available at the time that these assessments were undertaken. In addition, following a review of information supplied by Uniper (formerly E.ON UK plc), various site inspections and the ground investigations, it was concluded that Site Condition within specific areas of the power station site had been impacted by site operations during the lifetime of the site Environmental Permit (CP3237SJ, issued March 2007) *(RPS, 2014b, 2014d and 2016a)*. To support surrender of the Environmental Permit (EP), it was therefore considered that remediation would be required in the areas where Site Condition had been impacted. To support the EP surrender process, RPS has previously developed a Remedial Options Appraisal (Document Ref. 160913 JER5486 GM Kingsnorth Remediation Options Appraisal Draft v1) *(RPS,2016a)* and Remediation Strategy (Document Reference 170228RJER5486 GM Kingsnorth Remediation Strategy) (*RPS, 2017*), both of which have been agreed with the Environment Agency.

1.1.4 Uniper is currently looking at options for redevelopment of Kingsnorth Power Station for potential future commercial / industrial uses. At this stage there are no site wide redevelopment proposals or planning applications for site development, however a site wide Remediation Strategy is required to provide an outline framework for redevelopment of the power station site for future commercial / industrial use. This Remediation Strategy is required to support the proposed redevelopment of the power station site and also to include remediation requirements to assist with EP surrender.

1.1.5 Once the masterplan has been developed and development proposals are known, each parcel of land being redeveloped will require a separate remediation strategy, in line with this site wide Remediation Strategy, to support planning applications for each proposed development.

1.1.6 Furthermore, the human health screening criteria utilised in the risk assessments undertaken for the Assessment Site *(RPS, 2014b, 2014d and 2016a)* have been superseded. There is therefore a requirement to re-evaluate potential risks to human health for a commercial redevelopment scenario, utilising the most up to date screening criteria.

1.2 Objectives

1.2.1 This site wide Remediation Strategy has been developed to achieve a number of objectives in relation to the proposed redevelopment of the power station site, namely:

- To re-evaluate contamination risks to human health utilising appropriate up to date screening criteria based on a commercial redevelopment scenario;
- To identify the requirement for remediation to address contamination risks with regard to a commercial redevelopment scenario and Part 2A environmental liabilities and to assist with EP surrender;
- To develop a Remedial Options Appraisal to determine the most feasible remedial techniques in relation to any contamination identified;

- To develop a Remediation Implementation Plan that sets out the remediation goals and objectives for any contamination identified; and
- To develop a Remediation Verification Plan that sets out the 'lines of evidence' that are required to be gathered to sufficiently demonstrate that the remedial objectives have been successfully achieved.

1.3 Report Structure

1.3.1 The remainder of this report is structured as follows:

Section 2: Overview of Site Setting;

Section 3: Human Health Risk Assessment;

Section 4: Remediation Options Appraisal;

Section 5: Remediation Clean Up Criteria;

Section 6: Remediation Plan;

Section 7: Conclusions.

2 OVERVIEW OF SITE SETTING

2.1 Site Location and Description

Site Location

2.1.1 Kingsnorth Power Station is located approximately 2.5 km east of the village of Hoo St Werburgh on the Hoo Peninsular, and approximately 7.5 km north east of Rochester, Kent. The Power Station Site covers an area of approximately 162 Ha and is identified on *Drawing JFR7105-SI-001*. Further details regarding the site location and setting can be found in the Desk Study and Preliminary Risk Assessment (*RPS, 2013a*).

Site Description and Site Zones

2.1.2 Kingsnorth Power Station has been split into 11 zones as per *Table 1*. The zones have been defined either spatially or by common use as detailed below.

Table 1: Site Zones

Zone	Zone Name
1	Main Plant Area
2	Coal Stockyard
3	Tank Farm
4	Ash Lagoons
5	National Grid Substation
6	Western Storage Area
7	Area Proposed for Units 5 and 6
8	Former Waste Tip
9	Northern Laydown Area
10	Long Reach Jetty
11	Oakham Ness Jetty

2.1.3 Of the areas detailed in the table above, this Remediation Strategy has been developed to include Zones 1, 2, 3, 6, 7 and 9. The extent of these zones is shown on *Drawing JFR7105-SI-001* and is hereafter referred to as the 'Assessment Site'. Zone 5 has been excluded from this assessment and Remediation Strategy as this area is under the control of National Grid. Zone 4 is also excluded from this Remediation Strategy as this area was restored in 2015. The assessment of human health risks from soil contaminants has been updated for Zone 8 within this document, however it is understood that currently there are no plans to redevelop this area and therefore this zone has not been included within the Remediation Strategy.

2.2 Geology

2.2.1 The geological sequence underlying the Assessment Site has been proven during various phases of ground investigation. A summary of the shallow geology, as encountered the various phases of ground investigation is provided in *Table 2* below.

Table 2: Summary of Generalised Geological Sequence

Geology	General Description	General Range of Thickness of Stratum (m)	Base Depth mbgl (mAOD)
Made Ground	Variable soil & present across the Assessment Site including clay, gravelly and sandy clays, sandy gravel and gravelly sand. Gravel is typically flint, brick, concrete and occasional ash. Variable waste materials present within Zone 8 associated with the former tip area.	0.3 – 6.7	0.3 – 6.7 (3.73 - <1.33)
Alluvium	Green grey brown silt, brown gravelly clay, sandy clay or clay with peat inclusions in places. Gravel is typically flint.	1.7 – 7.7	0.8 – 11.1 (0.99 - -3.81)
River Terrace Deposits	Orange brown sand and gravel. Gravel is flint.	2 – 8.7	5.8 - >15.0 (-0.66 - -9.66)
London Clay	Firm to stiff brown grey clay.	Max. proven thickness of 1.4 m	Not proven

2.2.2 Further details of the geological sequence are included in the ground investigation reports listed in Section 2.5.

2.3 Hydrogeology

2.3.1 Groundwater is present within the Made Ground / upper layers of Alluvium as perched groundwater and a second separate groundwater body has been encountered within the underlying River Terrace Deposits. Based upon groundwater monitoring data at the Assessment Site, it is not considered that the two groundwater bodies are hydraulically connected.

2.3.2 The groundwater data has not provided conclusive evidence of the direction of groundwater flow within the perched groundwater and it is considered likely that shallow groundwater flow would be severely inhibited and affected by the presence of substantial buried substructures and drainage infrastructure, particularly within Zones 1 and 3.

2.3.3 Despite the lack of an obvious flow direction, piezometric levels were noted to be consistently higher within Zone 6 and Zone 8 i.e. within the most northerly parts of the Assessment Site, suggesting the possibility of a southerly groundwater flow. This correlates with the most likely discharge points for shallow perched groundwater to be the River Medway and Damhead Creek, given the proximity of these surface water bodies to the Assessment Site. Perched groundwater is also likely to discharge into the drainage ditches present in the northern and western parts of the Assessment Site, ultimately discharging into the River Medway.

2.3.4 Groundwater monitoring data has also indicated that groundwater within the River Terrace Deposits is tidally influenced by the adjacent Medway Estuary, thereby indicating a degree of hydraulic connectivity.

2.4 Hydrology

2.4.1 Several water features are present within the Assessment Site, most notably a shallow drainage ditch that defines the northern boundary of Zone 1 and ultimately discharges into the River Medway to the west of the Assessment Site. A shallow surface water ditch is also present in the eastern part of Zone 3 and is believed to ultimately discharge into the River Medway.

2.4.2 The tidal River Medway defines the southern boundary of the Assessment Site and Damhead Creek, a tidal water body linked to the Medway Estuary, is present along the northern boundary of Zone 3.

2.4.3 Damhead Creek is a manmade feature consisting of a sheet piled perimeter wall that was the receiving body for the discharge of cooling water from the former power station.

2.5 Summary of Ground Investigations

Introduction

2.5.1 RPS has undertaken 3 phases of ground investigation at the Assessment Site since 2013. An initial Desk Top Study and Preliminary Risk Assessment *(RPS, 2013a)* identified a number of Contaminant Source Locations (CSL) to be present across the Assessment Site, based upon the presence of potential contamination sources associated with the operational use of the site prior to and during the lifetime of the Environmental Permit. A Ground Investigation Plan *(RPS, 2013b)* was developed to outline an investigation strategy for each of the CSLs identified. These CSLs were subsequently subject to ground investigation as detailed in the sections below and reference should be made to the following reports for more detailed information:

- RPS Planning & Development. JER5486 Ground Investigation Factual Report (Main Site), Kingsnorth Power Station. *(RPS, 2014a)*;
- RPS Planning & Development. JER5486 Ground Investigation Interpretative Report (Main Site), Kingsnorth Power Station. *(RPS, 2014b)*;
- RPS Planning & Development. JER5486 Supplementary Ground Investigation Factual Report, Kingsnorth Power Station. *(RPS, 2014c)*;
- RPS Planning & Development. JER5486 Supplementary Ground Investigation Interpretative Report, Kingsnorth Power Station. *(RPS, 2014d)*;
- RPS Planning & Development. JER5486 Supplementary Ground Investigation Factual Report, Kingsnorth Power Station. *(RPS, 2015)*; and
- RPS Planning & Development. JER5486 Supplementary Ground Investigation Interpretative Report, Kingsnorth Power Station. *(RPS, 2016a).*

2.5.2 The human health risk assessments included within these reports were undertaken on the basis of an ongoing commercial / industrial use in a Part IIA context.

Ground Investigation, Main Site – 2013

2.5.3 An intrusive ground investigation was undertaken within Zones 1, 2, 3, 6 and 8 of the Assessment Site (*RPS 2014a, 2014b*) in 2013 in line with the Ground Investigation Plan. The investigation comprised the drilling of 14 cable percussive boreholes, drilling of 50 window sample boreholes, installation of gas and groundwater monitoring wells within a total of 34 boreholes, excavation of 28 hand dug pits and excavation of 27 machine excavated trial pits. Following completion of the investigation, 3 rounds of gas and groundwater monitoring and sampling were undertaken at the Assessment Site at approximate monthly intervals.

2.5.4 The risk assessments undertaken upon completion of the investigation works incorporated all relevant data from previous phases of ground investigation at the Assessment Site and identified that soil and groundwater contamination was not widespread across the Assessment Site. The assessments however identified the following:

- Localised areas of TPH and benzo(a)pyrene contamination within Zones 1 and 3 that were considered to pose a potentially unacceptable risk to human health under the Part IIA regime for a commercial use;

- Asbestos containing materials and asbestos fibres within the soil matrix at a number of locations within Zone 6 and 8 that were considered to pose a potentially unacceptable risk to human health under the Part IIA regime for a commercial use;

- Concentrations of inorganic and PAH contaminants within the groundwater were considered to pose a low risk to controlled waters under the Part IIA regime;

- Localised concentrations of TPH contaminants within the groundwater were noted to be more persistent and consistent with high soil TPH concentrations and were considered to pose a risk to surface water i.e. River Medway and Damhead Creek, under the Part IIA regime; and

- In order to assist with surrender of the environmental permit, a site condition assessment was undertaken and determined that 5 CSLs had deteriorated under environmental permit and 13 CSLs were likely to have deteriorated under environmental permit.

2.5.5 It was recommended that additional ground investigation was undertaken to further define areas of known contamination or within areas that were not accessible during the investigation, to inform the requirement for remedial action at these locations.

Supplementary Ground Investigation, Main Site – 2014

2.5.6 Following on from the findings of the ground investigation undertaken at the Assessment Site in 2013 and additional ground condition information supplied by E.ON (now Uniper), a supplementary ground investigation was undertaken at the Assessment Site (*RPS, 2014c, RPS 2014d*). The main objectives of this investigation were to delineate the extent of hydrocarbon contamination within the soils at a total of 8 CSLs within Zone 1 and 3, where additional investigation was deemed necessary to assist with environmental permit surrender, and to provide additional information to allow a groundwater Detailed Quantitative Risk Assessment (DQRA) to be undertaken.

2.5.7 The investigation comprised the drilling of 30 window sample boreholes and the installation of a total of 19 groundwater monitoring wells. Following completion of the investigation, a single round of groundwater monitoring and sampling was undertaken.

2.5.8 The risk assessments undertaken upon completion of the ground investigation identified the following:

- A single elevated TPH concentration within Zone 3 (borehole WS-Z3-51), considered to be associated with the presence of Heavy Fuel Oil (HFO) within the shallow soils adjacent to the HFO storage tanks, requiring remedial action under the Part IIA regime and as part of environmental permit surrender;

- Of the 8 contaminant source locations subject to the supplementary ground investigation, a total of 7 (Z1.12, Z1.17, Z1.25, Z3.1, Z3.3, Z3.7 and Z3.17) were considered to have been or likely to have been impacted by site operations under environmental permit. The eighth location was considered unlikely to have been impacted under environmental permit, based upon the investigation findings;

- The groundwater DQRA concluded that residual organic contaminants within the soil were generally not presenting unacceptable impacts to the River Medway or Damhead Creek; and

- The groundwater also DQRA concluded that there may be a low risk to surface waters from the localised presence of TPH and xylenes in soils within Zone 1 and PAH, benzene and TPH within soils in Zone 3.

2.5.9 It was recommended that additional ground investigation was undertaken within Z3.1 (location of known diesel spill) to further delineate the extent of hydrocarbon contamination in this area to

discharge potential Part IIA liabilities and as part of environmental permit surrender. Remedial action was also recommended to be undertaken within a total of 7 contaminant source locations that were the subject of this investigation (Z1.12, Z1.17, Z1.25, Z3.1, Z3.3, Z3.7 and Z3.17), to assist with environmental permit surrender.

Supplementary Ground Investigation, Main Site – 2015

2.5.10 Based upon the findings of the 2014 supplementary ground investigation and additional site information provided by E.ON (now Uniper), an additional ground investigation was undertaken in 2015 *(RPS, 2015, 2016a)* within Zones 1 and 3 of the Assessment Site to investigate contamination at the following locations:

- Hydrocarbons (transformer oil) derived from a cable trench linking the Unit 2 transformer from the main plant area to National Grid land in Z1.12; and
- Hydrocarbons observed during the 2014 ground investigation, in the vicinity of the diesel storage tank and pump house in Z3.1, adjacent to Damhead Creek.

2.5.11 The objectives of this investigation were to better define the extent of soil and groundwater contamination, to update the controlled waters risk assessment and to allow a remediation options appraisal to be developed.

2.5.12 The ground investigation comprised the drilling of 2 cable percussive boreholes and 12 window sample boreholes and the installation of 7 groundwater monitoring wells. Following completion of the ground investigation and single round of groundwater monitoring was undertaken.

2.5.13 The risk assessments undertaken upon completion of the ground investigation identified the following:

- Free product was encountered within the shallow perched groundwater within borehole WS-Z1-67, within Z1.12. Laboratory analysis of a sample of the free product indicated the sample to be within the chemical range of transformer oil. PCBs were also detected suggesting that pre-permit historical contamination was also present;
- Concentrations of soil contaminants were below the appropriate human health screening values and risks to human health were considered to be low; and
- The updated controlled waters risk assessment concluded that within both Z1.12 and Z3.1, risks to controlled waters were low based upon the levels of chemical contamination identified and the hydrogeological conceptual models present at both locations.

2.5.14 Based upon the findings of the investigations, the site condition category for Z1.12 was revised from B (site condition is likely to have deteriorated under permit) to A (site condition has deteriorated under permit) and the site condition category for Z3.1 was revised from A / C* to C* (site condition is unlikely to have deteriorated under permit).

3 HUMAN HEALTH RISK ASSESSMENT

3.1 Introduction

3.1.1 An updated human health risk assessment has been undertaken to determine potential risks to human health from the presence of soil contamination at the Assessment Site, to identify the requirement for remediation under a generic commercial redevelopment scenario of the Assessment site. The risk assessment has also been undertaken to identify potential Part 2a liabilities from the presence of soil contamination. This risk assessment is based upon the 3 phases of ground investigation undertaken between 2013 and 2015 and provides an update to the risk assessments previously undertaken by RPS (*RPS, 2014b, 2014d and 2016a*).

3.1.2 This risk assessment provides a summary of the levels of chemical contaminants encountered during the 3 phases of ground investigation undertaken by RPS and relevant previous ground investigations and determines whether potentially unacceptable risks are posed to human health based upon a proposed commercial redevelopment scenario.

3.1.3 Risks to human health that are identified in the assessment may require further assessment and / or remediation to manage contamination risks under a redevelopment scenario or to manage environmental liabilities. Once redevelopment plans are known, the findings of this risk assessment will require re-evaluation for each parcel of land that is to be redeveloped based upon its actual proposed use and design.

3.2 Risk Assessment Methodology

3.2.1 The assessment of risks posed to human health by the presence of soil contaminants is based upon the guidelines outlined in CLR11 (*EA & DEFRA, 2004*), which provides a framework for risk assessment and follows a tiered process, with each subsequent tier involving a higher degree of input into the assessment should risks be identified. The Ground Investigation Interpretative Report *(RPS, 2014b)* provides an outline of the methodology utilised to assess risks to human health.

3.2.2 The Tier 2 Generic Quantitative Risk Assessment detailed below utilises Suitable 4 Use Levels (S4ULs) *(LQM, 2015)* using the Contaminated Land Exposure Assessment (CLEA) framework. Contaminant concentrations below the respective S4UL criteria represent a tolerable or minimal risk level to human health as described in the Environment Agency's SR2 Report (*EA, 2009*). Where contaminant concentrations are above S4UL criteria, further risk assessment (Tier 3) and possibly remediation may be required.

3.2.3 It is recognised that Category 4 Screening Levels (C4SLs), first published in 2014, for a limited number of contaminants have been developed by CL:AIRE in an attempt to align with the updated Part IIA guidance, by defining a level of contamination that would not be considered as contaminated land under Part IIA. However, in the continued absence of clear guidance about the applicability of the C4SLs in determining remedial requirements under the planning regime, C4SLs have not been applied within this risk assessment and instead S4ULs have been adopted, with the exception of lead, where no S4UL is available. Guidance on the development of C4SLs is presented in DEFRA document SP1010 (*CL:AIRE, 2014*).

3.2.4 In the absence of S4ULs and C4SLs, Generic Assessment Criteria (GAC) developed by CL:AIRE *(CL:AIRE, 2010),* have been used as a screening tool to indicate whether levels of contaminants may pose a risk to human health.

3.2.5 The Tier 2 risk assessment presented within this section is based upon the generic commercial land use scenario under the CLEA methodology using S4UL / C4SL / GAC on those contaminants for which laboratory analysis is available.

3.3 Tier 2 – Generic Quantitative Risk Assessment (GQRA)

3.3.1 This section provides a comparison of soil analysis derived from the ground investigations undertaken by RPS in 2013, 2014 and 2015 and relevant previous ground investigations at the Assessment Site against S4ULs / C4SL / GAC for a proposed commercial end use, in line with the previous risk assessments undertaken by RPS (*RPS, 2014b, 2014d and 2016a*).

3.3.2 This GQRA has been undertaken to re-evaluate potential risks to human health utilising the most up to date screening criteria.

3.3.3 For inorganic contaminants principally comprising metals, the statistical 95% Upper Confidence Limit (UCL) of the true mean concentration has been calculated for all data available, principally from the RPS 2013 investigation (*RPS, 2014a*), and compared against the relevant screening criteria, in line with UK good practice.

3.3.4 The presence of statistical outliers (maximum value test) have been considered in this assessment as they may indicate a second statistical dataset, i.e. separate or discrete contamination source, if any exceed the relevant screening criteria. An assessment has also been made where outliers are excluded from the 95% UCL calculation where they exceed the relevant screening criteria and in this case are considered separately.

3.3.5 For all TPH, PAH, VOC and SVOC contaminants, the results of the laboratory analysis have been compared directly against the appropriate screening criteria, as the most likely source of this contamination is considered to be from point sources e.g. spillages from storage tanks, pipelines. Therefore, the statistical assessment of data is not valid in this instance, which is considered to be in line with UK best practice.

3.3.6 The following sections provide a summary of the data assessment undertaken on the chemical laboratory analysis results derived from the various phases of ground investigation within Zones 1, 2, 3, 6 and 8.

Inorganic Contaminants

3.3.7 A Tier 2 risk assessment has been undertaken utilising the results of the heavy metal / inorganic soil analysis from samples taken from the RPS 2013 ground investigation and from previous investigations, where laboratory analysis is available for each zone, following the approach outlined above.

3.3.8 Tables 1 - 5 in *Appendix A* summarise the results of the laboratory analysis for inorganic contaminants for each zone and compares them with the relevant screening criteria for a commercial end use.

3.3.9 The results indicate that the 95% UCL values for each determinant within each zone lie below the relevant screening criteria and therefore lie at levels of tolerable risk to human health. Numerous statistical outliers were identified within the dataset; however, they all lie below the relevant screening criteria with the exception of the following:

- Nickel within trial pit TP-Z8-07 at 1.0 mbgl with a concentration of 2,668 mg/kg exceeding the S4UL of 980 mg/kg;
- Nickel within trial pit TP-Z8-15 at 3.0 mbgl with a concentration of 1,523 mg/kg exceeding the S4UL of 980 mg/kg; and
- Vanadium within trial pit TP-Z8-07 at 1.0 mbgl with a concentration of 10,880 mg/kg exceeding the S4UL of 9,000 mg/kg.

3.3.10 All these outliers are located in the area of waste materials in Zone 8, as shown on *Drawing JFR7105-SI-002*, and potentially lie above levels of tolerable risk to human health.

Polycyclic Aromatic Hydrocarbons (PAH)

3.3.11 A Tier 2 risk assessment has been undertaken utilising the results of the PAH soil analysis from samples taken from RPS' 2013, 2015 and 2015 ground investigations and previous investigations, where laboratory analysis is available and following the approach outlined in *paragraph 3.3.5*.

3.3.12 Table 7 in *Appendix A* summarise the results of the laboratory analysis for PAHs for each zone and compares them with the relevant screening criteria for a commercial end use.

3.3.13 The results indicate that all PAH concentrations lie below the relevant S4ULs within all zones, with the exception of the following:

- Benzo(a)pyrene within trial pit TP-Z2-05 at 0.5 mbgl with a concentration of 38.9 mg/kg exceeding the S4UL of 35 mg/kg;
- Dibenzo(ah)anthracene within window sample WS-Z3-51 at 0.2 mbgl with a concentration of 8.11 mg/kg exceeding the S4UL of 3.5 mg/kg; and
- Dibenzo(ah)anthracene within hand pit HP-Z3-55 at 0.3 mbgl with a concentration of 4.14 mg/kg exceeding the S4UL of 3.5 mg/kg.

3.3.14 Trial pit TP-Z2-05 is located within the coal stockyard and the coal stored at this location at the time of the investigation (2013) may be the source of the benzo(a)pyrene identified. Following completion of this investigation, remedial works were known to have been undertaken within the coal stockyard (*RPS, 2014b*) and it was considered likely that the contamination would have been removed during these works.

3.3.15 Evidence of hydrocarbon contamination was recorded at the locations of WS-Z3-51 and HP-Z3-55 during the ground investigation undertaken in 2014 and this is considered likely to be the source of the elevated dibenzo(ah)anthracene concentrations identified at these locations.

3.3.16 On this basis, it is considered that further assessment or remediation may be required to manage risks to human health from the presence of PAH contamination within these soils.

Total Petroleum Hydrocarbons (TPH)

3.3.17 A Tier 2 risk assessment has been undertaken utilising the results of the TPH soil analysis from samples taken from RPS' 2013, 2015 and 2015 ground investigations and previous investigations, where laboratory analysis is available, following the approach outlined in *paragraph 3.3.4*.

3.3.18 Table 6 in *Appendix A* summarise the results of the laboratory analysis for TPH for each zone and compares them with the relevant screening criteria for a commercial end use.

3.3.19 The results indicate that all TPH concentrations lie below the relevant S4ULs within all zones, with the exception of the following:

- TPH >C8-C10 within window sample WS-Z1-34 at 0.3 – 0.5 mbgl with a concentration of 17,900 mg/kg exceeding the S4UL of 2,000 mg/kg;
- TPH >C21-C35 within trial pit TP-Z3-21 at 0.65 mbgl with a concentration of 32,900 mg/kg exceeding the S4UL of 28,000 mg/kg;
- TPH >C21-C35 within trial pit TP-Z3-31 at 0.2 mbgl with a concentration of 53,100 mg/kg exceeding the S4UL of 28,000 mg/kg;
- TPH >C21-C35 within window sample WS-Z3-26 at 0.0 mbgl with a concentration of 50,100 mg/kg exceeding the S4UL of 28,000 mg/kg;

- Aromatic >C21-C35 within window sample WS-Z3-26 at 0.0 – 0.15 mbgl with a concentration of 41,400 mg/kg exceeding the S4UL of 28,000 mg/kg; and

- Aromatic >C21-C35 within window sample WS-Z3-51 at 0.2 mbgl with a concentration of 28,400 mg/kg exceeding the S4UL of 28,000 mg/kg.

3.3.20 There is no obvious source of the TPH contamination identified within WS-Z1-34 and this contamination is therefore considered to lie above levels of tolerable risk to human health and further assessment or remediation may be necessary.

3.3.21 The elevated concentrations of TPH within TP-Z3-21, TP-Z3-31, WS-Z3-26 and WS-Z3-51 are considered to be associated with the visual / olfactory presence of hydrocarbon contamination (HFO) at the surface of these locations and lie above levels of tolerable risk to human health. Further assessment or remediation may be required to manage risks to human health from the presence of TPH contamination within these soils.

Other Organic Contaminants

3.3.22 Tables 8 and 9 in *Appendix A* summarise the results of the soil contaminants contained within the VOC, SVOC, Phenol and PCB analysis suites, where encountered above the laboratory detection limit.

3.3.23 Concentrations of VOCs, SVOCs and Phenol were encountered at low concentrations at isolated locations across the Assessment Site, but no concentrations exceeded the appropriate screening criteria, where such values exist.

3.3.24 At least 1 sample from each of the site zones identified PCBs above the laboratory detection limit, however with one exception all concentrations were below the screening criteria of 240 ug/kg. The exception was within trial pit TP-Z8-01 at a depth of 3.5 mbgl (within waste materials associated with the historical tip). In this sample a total PCB concentration of 1521.7 ug/kg lies above the screening criteria of 240 ug/kg and may therefore theoretically pose an unacceptable risk to human health.

3.3.25 *Drawing JFR7105-SI-002* shows the location of this exceedance.

Asbestos

3.3.26 A total of 45 soil samples were analysed for the presence of asbestos, 19 of which were identified as containing asbestos fibres. Potential asbestos containing materials (ACMs) were observed in 2 locations and samples were taken of each.

3.3.27 A total of 9 samples contained amosite, including the suspected ACM in Zone 8. 6 samples contained chrysotile, including the suspected ACM in Zone 6 and 4 samples contained both amosite and chrysotile. *Drawing JFR7105-SI-002* shows the locations where asbestos was encountered.

3.3.28 Asbestos was encountered within a total of 17 samples (16 soil and 1 ACM) within Zone 8 (waste tip area), at depths ranging between 0.2 and 5.0 mbgl and 2 samples (1 soil and 1 ACM) within Zone 6 were identified as containing asbestos at a depth of 0.4 mbgl.

3.3.29 Four samples from Zone 8 (trial pits TP-Z8-16, 3m and TP-Z8-03, 0.5m and boreholes BH-Z8-08, 5.0m and BH-Z8-09, 1.5m) and 1 from Zone 6 (hand pit HP-Z6-07, 0.4m) were scheduled for asbestos quantification. The results indicated low concentrations of asbestos within soil, with a maximum concentration of 0.019% observed in trial pit TP-Z8-03, and all other concentrations below a laboratory limit of detection of 0.001%.

3.3.30 The presence of ACMs within the soils and asbestos fibres within the soil matrix is considered to pose a risk to human health should these soils be disturbed. The former tip area in Zone 8 is known to have asbestos waste tipped within in it (*RPS, 2013a*) and any disturbance of this area

during redevelopment (should this area be redeveloped in the future) needs careful management due to asbestos being present within the waste materials.

3.3.31 Asbestos was encountered at a total of 2 locations within shallow soils within Zone 6 and it is considered that there is a potential for asbestos to be present within the Made Ground across this Zone and will require careful management of asbestos during future redevelopment of this area. In addition, given the history of the Assessment Site, there is potential for asbestos to be present within shallow soils within the remainder of the Assessment Site. The potential for asbestos to be present within these areas will need to be considered during future redevelopment of these areas.

3.4 Summary of Risks to Human Health

Chemical Contaminants

3.4.1 The Tier 2 human health risk assessment has shown that levels of chemical contaminants within the soil are generally low with respect to the screening criteria used. Several areas of chemical contamination have been identified however that lie above levels of tolerable risk to human health. These are summarised and discussed below.

Inorganic Contaminants

3.4.2 Statistical outliers or 'hotspots' of nickel and vanadium were identified within trial pits TP-Z8-07 (nickel and vanadium) and TP-Z8-15 (nickel), exceeding the appropriate screening values, at depths of 1.0 mbgl and 3.0 mbgl respectively.

3.4.3 It is considered that the presence of nickel and vanadium at these locations is unlikely to be of significance in terms of risk to human health due to depth at which the contamination was encountered if the soils remain undisturbed and the isolated nature of their occurrence. On this basis the contamination identified is unlikely to constitute Significant Possibility of Significant Harm (SPOSH) in the context of Part IIA.

3.4.4 Should the Zone 8 area be considered for future redevelopment, further risk assessment and / or remediation will be required to manage risks to human health in line with the proposed redevelopment end use.

Polycyclic Aromatic Hydrocarbons (PAH)

3.4.5 Elevated concentrations of PAH were identified at a total of 3 locations across the Assessment Site:

- Benzo(a)pyrene within trial pit TP-Z2-05 at 0.5 mbgl with a concentration of 38.9 mg/kg exceeding the S4UL of 35 mg/kg;
- Dibenzo(ah)anthracene within window sample WS-Z3-51 at 0.2 mbgl with a concentration of 8.11 mg/kg exceeding the S4UL of 3.5 mg/kg; and
- Dibenzo(ah)anthracene within hand pit HP-Z3-55 at 0.3 mbgl with a concentration of 4.14 mg/kg exceeding the S4UL of 3.5 mg/kg.

3.4.6 Trial pit TP-Z2-05 is located within the coal stockyard and the coal stored at this location at the time of the investigation (2013) may be the source of the benzo(a)pyrene identified. Following completion of this investigation, remedial works were known to have been undertaken within the coal stockyard (*RPS, 2014b*) and it was considered likely that the contamination would have been removed during these works.

3.4.7 Evidence of hydrocarbon contamination was recorded at the locations of WS-Z3-51 and HP-Z3-55 during the ground investigation undertaken in 2014 and this is considered likely to be the source of the elevated dibenzo(ah)anthracene concentrations identified at these locations. Previous works undertaken by RPS (*RPS, 2017*) have however identified the areas that include these exploratory hole locations to have been impacted by TPH contamination during the lifetime of the Assessment

Site's EP. Remediation of the identified TPH contamination will therefore be undertaken to assist with surrender of the EP for the Assessment Site and will therefore remediate the contamination with respect to human health in the future.

Total Petroleum Hydrocarbons (TPH)

3.4.8 Elevated concentrations of TPH were identified at a total of 5 locations across the Assessment Site:

- TPH >C8-C10 within window sample WS-Z1-34 at 0.3 – 0.5 mbgl with a concentration of 17,900 mg/kg exceeding the S4UL of 2,000 mg/kg;
- TPH >C21-C35 within trial pit TP-Z3-21 at 0.65 mbgl with a concentration of 32,900 mg/kg exceeding the S4UL of 28,000 mg/kg;
- TPH >C21-C35 within trial pit TP-Z3-31 at 0.2 mbgl with a concentration of 53,100 mg/kg exceeding the S4UL of 28,000 mg/kg;
- TPH >C21-C35 within window sample WS-Z3-26 at 0.0 mbgl with a concentration of 50,100 mg/kg exceeding the S4UL of 28,000 mg/kg;
- Aromatic >C21-C35 within window sample WS-Z3-26 at 0.0 – 0.15 mbgl with a concentration of 41,400 mg/kg exceeding the S4UL of 28,000 mg/kg; and
- Aromatic >C21-C35 within window sample WS-Z3-51 at 0.2 mbgl with a concentration of 28,400 mg/kg exceeding the S4UL of 28,000 mg/kg.

3.4.9 The source of the contamination at WS-Z1-34 is unknown given that there are no known sources of 'light end' hydrocarbons within the vicinity of this location. It is therefore recommended that this area is assessed further once redevelopment plans are known and localised additional ground investigation and sampling works are undertaken to provide further information on the nature and extent of hydrocarbon contamination at this location.

3.4.10 The elevated concentrations of TPH within TP-Z3-21, TP-Z3-31, WS-Z3-26 and WS-Z3-51 are considered to be associated with the visual / olfactory presence of hydrocarbon contamination (HFO) at the surface at these locations and may constitute SPOSH. Previous works undertaken by RPS (*RPS, 2017*) have however identified the areas that include these exploratory hole locations to have been impacted by contamination during the lifetime of the Assessment Site's EP. Remediation of the identified TPH contamination will therefore be undertaken to assist with surrender of the EP for the Assessment Site and will therefore remediate the contamination with respect to human health in the future.

Polychlorinated Biphenyls (PCBs)

3.4.11 An elevated concentration of PCBs was identified within trial pit TP-Z8-01 at a sample depth of 3.5 mbgl, where a concentration of 1521.7 ug/kg exceeded the screening criteria of 240 ug/kg. TPH analysis of the same soil sample indicates a concentration of 1130 mg/kg, suggesting an area of hydrocarbon contamination to be present. A sample at the same location, taken at depth of 0.5m, was not analysed for PCBs, however a Total TPH concentration of 11 mg/kg was recorded within this shallow sample, suggesting that the contamination is not present in the shallow soils. Similarly, to nickel and vanadium, It is considered that the presence of PCBs at this location is unlikely to be of significance in terms of risk to human health due to depth at which the contamination was encountered if the soils remain undisturbed and is unlikely to constitute SPOSH.

3.4.12 Should the Zone 8 area be considered for future redevelopment, further risk assessment and / or remediation will be required to manage risks to human health in line with the proposed redevelopment end use.

Asbestos

3.4.13 Asbestos has been identified in soil samples in a total of 19 locations, including 2 Asbestos Containing Materials (ACMs), 17 of which were within Zone 8 (waste tip) and the other 2 within Zone 6 (western storage area).

3.4.14 Asbestos quantification of a limited number of soil samples has indicated low levels of asbestos fibres within the soil matrix, with a maximum of 0.019% encountered in the waste tip.

3.4.15 The ACMs were encountered at a depth of 0.4 m within Zone 6 and at a depth of 2.2 m within Zone 8. The results indicate that asbestos fibres are widespread across the waste tip (Zone 8) at a variety of depths and are present at a shallow depth (0.4 mbgl) in the western storage area (Zone 6).

3.4.16 The presence of asbestos within the waste tip in Zone 8 is not surprising given the known historical tipping of these materials. The presence of asbestos within the Made Ground in Zone 6 is in line with RPS' experience of similar developed industrial sites is considered that there is potential for asbestos to be present within the Made Ground soils across this zone.

3.4.17 The confirmed presence of ACMs within the soils and asbestos fibres within the soil matrix may pose a risk to human health should the soils be disturbed. Remediation measures will be required to manage risks to human health within Zone 6 and also within Zone 8, should this area be redeveloped.

3.4.18 Given the industrial history of the Assessment Site, there is potential for asbestos to present in the Made Ground across the Assessment Site. During site redevelopment, the potential for asbestos to be present within shallow soils will require consideration to manage asbestos exposure risks within each land parcel. Remediation plans developed to support redevelopment of each land parcel will require the implementation of robust strategies to manage asbestos in line with proposed redevelopment plans.

3.5 Ground Gas

3.5.1 Following completion of the ground investigation undertaken by RPS in 2013, 3 rounds of ground gas monitoring were undertaken across the Assessment Site. A ground gas risk assessment (*RPS, 2014b*) undertaken based upon the results of the ground gas monitoring for a demolished site scenario concluded that for the most part, a very low risk Characteristic Situation 1 was present at the Assessment Site. Characteristic Situations 2 (low risk) and 4 (medium to high risk) were derived for localised areas across the Assessment Site, based upon recorded concentrations of carbon dioxide and methane and observed flow rates.

3.5.2 Once development proposals are known, a more detailed assessment of ground gas risks will be required for each land parcel to determine the requirement for remediation or the implementation of ground gas protection measures in proposed structures.

3.6 Site Redevelopment Risks

3.6.1 During site redevelopment works, careful consideration of potential risks to construction workers and the general public will be required. The excavation, stockpiling and transport of contaminated soils and waters, particularly in relation to hydrocarbon and asbestos (particularly in Zone 6 and Zone 8, if redeveloped) contamination, has the potential to increase exposure to these receptors and suitable measures in line with the CDM Regulations (2015) will require implementation.

3.6.2 The following minimum procedures will be required during site redevelopment works to manage exposure risks to humans:

- Derivation and compliance with suitable Safe of Systems to manage contamination exposure to construction workers and the general public;

- Use of damping down equipment, particularly in areas where asbestos contaminated soils have been identified;
- Provision of wheel washing facilities and the cleaning of public highways if required;
- Provision of suitable welfare facilities to allow washing prior to use of mess facilities and leaving site for the day;
- Provision of suitable facilities to allow changing out of Personal Protective Equipment (PPE);
- Provision of decontamination units for use by construction workers;
- Provision and maintenance of suitable PPE, which may include hard hats, boots, eye protection, gloves, high visibility clothing, disposable overalls and P3 filter masks with particulate filters;
- Appropriate management of materials / wastes derived from the construction process; and
- Appropriate management of stockpiled soils to prevent generation of dusts and migration of contamination into surrounding areas

4 REMEDIATION OPTIONS APPRAISAL

4.1 Introduction

4.1.1 This section provides an appraisal of the various available remedial options in line with CLR11 *(EA & DEFRA, 2004)* to enable the identification of suitable remedial options for each of the areas where remediation is required to:

- Support surrender of the Assessment Site's EP; and
- Support redevelopment of the Assessment Site for commercial use.

4.2 Summary of Areas Requiring Remediation

Overview

4.2.1 A total of 3 phases of ground investigation have been undertaken at the Assessment Site to characterise the levels of Contaminants of Concern (CoC) within the soil and groundwater at each Contaminant Source Location (CSL), as identified by the Desk Top Study and Preliminary Risk Assessment (*RPS, 2013a*). The first investigation targeted each identified CSL, with the second and third phases of investigation being undertaken to delineate the extent of contamination at selected CSLs where evidence of potential deterioration in Site Condition during the lifetime of the EP had been identified.

4.2.2 The ground investigation information was combined with information supplied by E.ON and Uniper including staff interviews and various site inspections, to determine whether Site Condition may have deteriorated under EP.

4.2.3 In terms of redevelopment of the Assessment Site, the updated human health risk assessment included in Section 3 of the report has indicated that additional ground investigation / remediation is required to manage risks to human health from the presence of soil contaminants. Risks to controlled waters are deemed to be low, based upon risk assessments undertaken by RPS (*RPS, 2014b, 2014d and 2016a*) however the previous Remediation Strategy (*RPS, 2017*) identified the requirement for remediation of localised areas of hydrocarbon contamination within groundwater, as detailed in the following sections.

4.2.4 Based upon the industrial history of the Assessment Site there is the potential for previously unidentified contamination to be present, including asbestos.

4.2.5 Site disturbance itself during redevelopment has the potential to mobilise or spread contamination and therefore appropriate risk assessments and control measures will be required during remediation to minimise the potential for contamination to be spread across the Assessment Site.

Environmental Permit Surrender

4.2.6 Table 3 below summarises the CSLs where remediation is deemed to be required to support EP surrender and *JFR7105-SI-003* identifies the location of these CSLs.

Table 3: Summary of CSLs Requiring Remediation for EP Surrender

Contaminant Source Location	Contaminant Type	Site Condition Category*	Maximum Concentrations of Contaminants of Concern		Justification	Action Recommended to Support Permit Surrender
			Soil	Groundwater		
Z1.10 – Road running to the east of turbine building behind stack	Heavy Fuel Oil (HFO)	B	Total Petroleum Hydrocarbons (TPH) - 119 mg/kg Total Polycyclic Aromatic Hydrocarbons (PAH) - <1.49 mg/kg	Total TPH - 0.21 mg/l Total PAH - <0.259 ug/l	Uniper have confirmed that contamination has occurred in the area over the operational life of plant, with some contamination likely to have occurred during EP, although likely to be minor. Southern part of road covered in HFO, becoming more patchy to the north. Possible spills / leakages in front of some transformers.	Removal and suitable disposal of HFO spillages and associated contaminated soils and remediation verification sampling.
Z1.12 – Generation transformers associated with turbine hall	PCBs and Hydrocarbons	A	Polychlorinated Biphenyls (PCBs) - 20.9 ug/kg Total TPH - 33,400 mg/kg Total PAH) - 175.18 mg/kg	Total TPH – 1,827 mg/l Total PAHs - <17.592 ug/l Total PCBs - 0.13 ug/l	Unit 2 known to have been leaking under permit. Ground investigation has encountered heavy hydrocarbon contamination in soil and perched groundwater adjacent to cable trench that lies between Unit 2 and National Grid land. Observed presence of PCBs suggest pre-permit contamination to be present too.	Remediation of contaminated soils around Unit 2 cable trench. Inspection and remediation of soils under all transformers. Light Non-Aqueous Phase Liquid (LNAPL) remediation if required. Verification sampling of soils and groundwater (if required).
Z1.18 – Engineering Garages	Hydrocarbons	B	Total TPH - 761 mg/kg Total PAHs - <2.51 mg/kg Metals - 804.3 mg/kg (Zn)	Total TPH - 0.038 mg/l Total PAHs - <LoD Metals - 1.11 mg/l	Potential exists for contamination of soils due to cracked hardstanding in front of garage and known parking of plant in the area. Elevated levels of TPH encountered within soil.	Inspection and remediation of soils underlying bunded diesel tank and in front of garages post demolition.
Z1.25 – Heavy hydrocarbon staining on floors associated with plant	Hydrocarbons	B	Total TPH – 4,980 mg/kg Total PAHs - <9.09 mg/kg	Total TPH – 21.5 mg/l Total PAHs - <0.454 ug/l	Oil spills / blow outs known to have occurred in the area, but are pre EP. Generally, plant and bunds have been well maintained during life time of EP. Evidence of product spilling out of bunds during inspection in November 2015 suggests that contamination during EP may be limited in extent.	Emptying and cleaning of bunds. Localised remediation of soils where contamination identified. Inspection and remediation of contaminated soils from leakages around bunds and under road.

Contaminant Source Location	Contaminant Type	Site Condition Category*	Maximum Concentrations of Contaminants of Concern		Justification	Action Recommended to Support Permit Surrender
			Soil	Groundwater		
Z1.26 – Leaks from transformers	Oils /PCBs	B	Total PCBs - <LoD Total TPH - 267 mg/kg Total PAHs - <3.6 mg/kg	Total PCBs - <LoD Total TPH - 0.602 mg/l Total PAHs - <9.46 ug/l	Transformers in use since 2008. No significant leaks but evidence of minor leaks outside of bunded areas noted.	Clean up of leakages and contaminated soils and remediation verification sampling.
Z3.3 – Pipe works leaving Tank Farm	HFO / Light Fuel Oil (LFO)	B	Total TPH - 88,200 mg/kg Total PAHs - <406.73	Total TPH - 1.954 mg/l Total PAHs - <0.977 ug/l	E.ON / Uniper confirm that there is no history of spills in this area since EP issue in 2007. There were several incidents pre this date i.e. pre EP. During commissioning and demolition, pits and pipework were cleaned of oil and no evidence of hydrocarbon contamination was noted on ponded water during site inspection in November 2015. Although pipework has been removed and pits cleaned, adjacent soils are still likely to be required to be remediated.	Clean up of localised areas of contaminated soils associated with leakages and remediation verification sampling.
Z3.5 – Pig Receiving Station	HFO / LFO	B	Total TPH - 3430 mg/kg Total PAHs - <3.36 mg/kg	Total TPH - 0.07 mg/l Total PAHs - <0.251 ug/l	Pig station used since 2008 but no known significant spills although minor leaks are possible. Evidence of oil leaks / spills inside and outside of bund.	Clean up of leakage and associated contaminated soils and remediation verification sampling.
Z3.8 – NW Corner of Tank Farm	HFO / LFO	C	Total TPH - 16,070 mg/kg Total PAHs - 100.31 mg/kg	No Data	Area has been impacted from previous site operation, however area bunded off in early 2000s and it is unlikely that anything has been placed in the bunded area since.	No specific remedial action recommended for permit surrender. HFO contaminated soils could be remediated during remediation of adjacent areas.
Z3.9 – Central Area of Tanks 1-6	HFO / LFO	A	Total TPH – 388 mg/kg Total PAHs - <2.23 mg/kg	No Data	No known significant leaks since 2008, however small leaks may have occurred. HFO present at the surface.	Removal of HFO contaminated soils and remediation verification sampling.
Z3.10 – HFO Tanks 1-6	HFO / LFO	A	Total TPH – 86,400 mg/kg Total PAHs – 116.68 mg/kg	Total TPH – 0.025 mg/l Total PAHs - <0.174 ug/l	No known significant leaks since 2008, however small leaks may have occurred. HFO present at the surface. Oil contaminated material from Zone 2 currently being stored in area.	Removal of HFO contaminated soils and remediation verification sampling.

Contaminant Source Location	Contaminant Type	Site Condition Category*	Maximum Concentrations of Contaminants of Concern		Justification	Action Recommended to Support Permit Surrender
			Soil	Groundwater		
Z3.12 – Area of pipe junctions and filters within the bund of tanks 9 and 8	HFO / LFO	B	Total TPH – 99,100 mg/kg Total PAHs – 100.21 mg/kg	Total TPH – 0.105 mg/kg Total PAHs - <0.177 ug/l	No known significant leaks since 2008, however small leaks may have occurred. HFO present at the surface.	Removal of HFO contaminated soils and remediation verification sampling.
Z3.17 – Grain Boiler House	HFO / LFO	B	Total TPH – 261 mg/kg Total PAHs - <2.82 mg/kg	Total TPH – 0.31 mg/kg Total PAHs - <0.341 ug/l	Localised areas of leaks present within northern part of the building (pumphouse) and under transformers within southern part of the building.	Remediation will be required to clean up areas of obvious leaks within localised areas, including leaks under transformers. Remediation verification sampling.

* Refer to the Ground Investigation Interpretative Report *(RPS, 2014b)*

Site Condition Categories: A – Site Condition has Deteriorated Under Permit, B – Site Condition Likely to have Deteriorated Under Permit, C – Site Condition Unlikely to have Deteriorated Under Permit

4.2.7 The information contained within Table 3 includes three 'types' of contamination to be present within the CSLs that are considered to require remediation:

- HFO contaminated soils associated with leaks and spillages, namely within CSLs Z3.3, Z3.5, Z3.8, Z3.9, Z3.10 and Z3.12;
- Residual hydrocarbon contaminated soils from leaks and spillages in areas of hydrocarbon storage and transformers, namely within CSLs Z1.10, Z1.12, Z1.18, Z1.25, Z1.26 and Z3.17; and
- Areas of hardstanding that have been contaminated by leaks and spillages, namely within CSLs Z1.10, Z1.25 and Z1.26.

4.2.8 PCBs (Polychlorinated Biphenyls) have been excluded from the list above, given that they were banned from use in the UK in the 1970s/80s i.e. prior to permit and it is understood that PCB containing transformer oils have not been used at the Assessment Site during the lifetime of the EP. On this basis therefore it is considered that there is no requirement to remediate PCBs to facilitate permit surrender.

4.2.9 In addition to the three 'types' of soil contamination listed, ground investigations at the Assessment Site have encountered a localised area of hydrocarbon contaminated groundwater in CSL Z1.12, comprising free product and high levels of TPH in shallow perched groundwater, within the vicinity of the cable trench linking the Unit 2 transformer with the National Grid land to the west. Any remedial excavation works within CSL Z1.12 will likely encounter shallow contaminated groundwater and therefore a combination of remedial techniques will likely be required in this area.

4.2.10 Table 4 below provides a summary of estimated volumes of soil and groundwater that will require remediation to assist with EP surrender. Note the volumes are indicative only and actual volumes requiring remediation will vary.

Table 4: Summary of Estimated Remediation Volumes for EP Surrender

Site Area	'Type' of Contamination to be Remediated	Estimated Volume to be Remediated
Z1.10 – Road running to the east of turbine building behind stack	Residual Hydrocarbon Contaminated Soils	632 m^3
	Stained Hardstanding	543 m^3
Z1.12 – Generation transformers associated with turbine hall	Residual Hydrocarbon Contaminated Soils	5,000 m^3
	Groundwater	100 m^3
Z1.18 – Engineering Garages	Residual Hydrocarbon Contaminated Soils	150 m^3
Z1.25 – Heavy hydrocarbon staining on floors associated with plant	Residual Hydrocarbon Contaminated Soils	1,152 m^3
	Stained Hardstanding	288 m^3
Z1.26 – Leaks from transformers	Residual Hydrocarbon Contaminated Soils	50 m^3
	Stained Hardstanding	22 m^3
Z3.3 – Pipe works leaving Tank Farm	HFO Contaminated Soils	759 m^3

Site Area	'Type' of Contamination to be Remediated	Estimated Volume to be Remediated
Z3.5 – Pig Receiving Station	HFO Contaminated Soils	135 m^3
Z3.8 – NW Corner of Tank Farm	HFO Contaminated Soils	241 m^3
Z3.9 – Central Area of Tanks 1-6	HFO Contaminated Soils	2,227 m^3
Z3.10 – HFO Tanks 1-6	HFO Contaminated Soils	4,500 m^3
Z3.12 – Area of pipe junctions and filters within the bund of tanks 9 and 8	HFO Contaminated Soils	3,868 m^3
Z3.17 – Grain Boiler House	Residual Hydrocarbon Contaminated Soils	100 m^3

Site Redevelopment

4.2.11 Table 5 below summarises the site areas where remediation is expected to be required to support redevelopment of the Assessment Site for a commercial end use.

Table 5: Summary of Areas Requiring Remediation for Site Redevelopment

Site Area	Contaminant Type	Justification	Additional Comment
WS-Z1-34 (0.3 – 0.5 mbgl)	TPH >C8-C10 (soil)	TPH concentration of 17,900 mg/kg in soil lying above the commercial S4UL of 2,000 mg/kg	Extent of contamination is unknown and requires delineation
Zone 6 (TP-Z6-04 (0.4 mbgl), HP-Z6-07 (0.4 mbgl))	Asbestos (soil)	Asbestos identified within the Made Ground	It is considered that there is potential for asbestos to be more widely present within the Made Ground in Zone 6 and therefore any proposed remedial measures must take this into account
CSL Z3.1	Hydrocarbons (groundwater)	Elevated concentrations of TPH, PAH and BTEX within groundwater	Controlled water risk assessments (*RPS, 2014b, 2014 and 2016a*) have not indicated a risk to controlled waters, however remediation of hydrocarbon impacted shallow groundwater is likely to be required during excavations for any future development works in this area

4.2.12 As indicated in Table 5 above, ground investigations at the Assessment Site have encountered a localised area of hydrocarbon contaminated groundwater in the western extents of CSL Z3.1, comprising free product and high levels of TPH within shallow perched groundwater. Any excavation works in relation to site redevelopment within CSL Z3.1 will likely encounter shallow contaminated groundwater and therefore a combination of groundwater remedial techniques will likely be required in this area. During redevelopment in this area, suitable measures will also require implementation to manage potential risks of contamination migration towards Damhead Creek.

4.2.13 It should be noted that there is also the potential for hydrocarbon contaminated shallow groundwater to be encountered within excavations across the remainder the Assessment Site, which may require the implementation of remedial measures.

4.2.14 Although the human health risk assessment outlined in Section 3 of this report has indicated the presence of localised areas of nickel, vanadium and PCBs and the widespread presence of asbestos within Zone 8 (waste tip), it is understood that future redevelopment plans are unlikely to

include this area of the Assessment Site and this area is outside the scope of this document. On this basis, no further consideration is given to Zone 8 within this site wide Remediation Strategy.

4.2.15 Table 6 below provides a summary of estimated volumes of soil and groundwater that will require remediation to assist with site redevelopment.

Table 6: Summary of Estimated Remediation Volumes for Site Redevelopment

Site Area	'Type' of Contamination to be Remediated	Estimated Quantity to be Remediated
WS-Z1-34 (0.3 – 0.5 mbgl)	Residual Hydrocarbon Contaminated Soils	100 m^3
Zone 6 (TP-Z6-04 (0.4 mbgl), HP-Z6-07 (0.4 mbgl))	Asbestos	82,000 m^2 (Zone 6 Area)
CSL Z3.1	Groundwater	1,000 m^3

4.3 Remediation Objectives

4.3.1 The remediation of the Assessment Site needs to meet two objectives:

Environmental Permit Surrender

4.3.2 The overall objective of the remediation works for EP surrender will be to remediate the contamination within each of the CSLs that is considered to have / is likely to have occurred during the lifetime of the permit, as listed in Table 3, in order to assist in the surrender of the Assessment Site's EP.

Site Redevelopment

4.3.3 The overall objective of the remediation works for site redevelopment will be to remediate the contamination within each of the areas identified within Table 5 to ensure that identified risks to sensitive receptors are suitably managed in line with any future proposed commercial development plans for the Assessment Site i.e. that each parcel of the Assessment Site is suitable for use.

4.3.4 Consideration will also need to be given to the safe management of contaminated soils and waters during remediation. Whilst, in certain areas, these materials are not currently posing a risk, there is potential for these materials to pose risks to human health and the environment if they are not managed appropriately. A Materials Management Plan (MMP) should be implemented to manage contaminated soil and water to ensure that risks to human health and the environment are suitably managed.

4.3.5 The remediation requirements for each land parcel will need to be considered once redevelopment plans are known.

4.4 Remediation Option Selection Criteria

4.4.1 Table 7 below details the factors and associated criteria that will be used to evaluate the remedial options for each soil contamination 'type' identified, to achieve the remedial objectives with respect to the site specific conditions and constraints.

Table 7: Remediation Option Selection Criteria

Factor	Criteria
Effectiveness	Performance with respect to reducing the respective pollutants to levels that are acceptable or breaking pathways. Therefore, options that are not suitable for the particular physical and chemical characteristics of the site are not considered any further.
Timescale	Remediation techniques that require a significant period of time to successfully meet the remedial objectives are not considered suitable for this site given the proposed development timetable.
Cost	Only remedial options that fulfil the remedial objectives within an acceptable cost bracket have been considered any further. The appraisal of cost is based on small treatment volumes that are anticipated to be presented, and therefore remedial approaches with significant set up/mobilisation cost are not considered suitable for the site.
Durability	All remedial options must be long lasting and minimise the potential for residual impacts to become apparent as the requirement for further remedial works post development of the site is unacceptable.
Commercial Availability	There are many remediation technologies that have been used within the UK, however only a limited number of these are commercially available in the UK.
Track Record	Only remedial options with a proven track record in the UK have been selected. Options with no or poor UK track records may impact on other factors in this table such as effectiveness, timescale and cost.
Environmental Impact	Some remedial options have not been selected because of the likely environmental impacts. Examples include energy and material requirements.
Compatibility	The risk assessment has identified a number of pollutant linkages that may require different remediation techniques to successfully meet the remedial objectives. Therefore, all remedial options must be compatible with each other as well as the proposed development scheme.
Permissions	Some remedial options will require forms of waste management licences & potentially other forms of licensing such as discharge consents etc. The form of licence may influence the selection of the remediation technique because of the likely timescales required for applications and the cost of application.
Site Constraints	The site conditions may limit the likely effectiveness of a given remedial technique due to issues such as access, available space and ground conditions.

4.5 Options Appraisal

4.5.1 In considering potential remedial options, account must be taken of the contamination related objective and constraints. The table included within *Appendix B* evaluates a number of remedial options principally in relation source treatment, given that the majority of the areas requiring remediation are in relation to returning site condition to 'pre-permit levels' i.e. to assist with EP surrender.

4.5.2 A number of different techniques with the potential to satisfy the remedial objectives are evaluated in terms of their advantages and disadvantages and applicability for the remediation of HFO and hydrocarbon contaminated soils as well as asbestos contaminated soils.

4.5.3 A remediation options appraisal has not been undertaken for hydrocarbon contamination within the shallow perched groundwater within CSLs Z1.12 and Z3.1 as it is considered that the lateral extent of the contamination within these areas are likely to be limited and volumes of groundwater requiring remediation are likely to be relatively limited. As outlined in paragraphs 4.2.9and 4.2.12 however, any remedial excavations within these CSLs are likely to encounter contaminated groundwater (including hydrocarbon free product), therefore suitable remediation measures will be required to address any such contamination entering remedial excavations and to prevent the spread of contamination.

4.5.4 Table 8 below provides a qualitative assessment of the remediation techniques included within the options appraisal in *Appendix B* in terms of their feasibility for remediation of the HFO and hydrocarbon contaminated soils and the asbestos contaminated soils at the Assessment Site.

Table 8: Feasibility of Remediation Options

Remediation Technique	Description	Feasibility for Remediation of HFO Contaminated Soils	Feasibility for Remediation of Hydrocarbon Contaminated Soils	Feasibility for Remediation of Asbestos Contaminated Soils
Thermal Desorption	Excavation of contaminated soils and heating to volatilise hydrocarbons	High	High	N/A
Excavation and Disposal at landfill	Excavation and disposal off site of contaminated soils	Medium	Medium	Medium
Ex-situ Bioremediation	Excavation of contaminated soils and enhancement of biodegradation of hydrocarbons e.g. windrowing, biopiles	Medium	High	N/A
Soil Flushing	Injection of treatment agents in-situ, encouraging 'flushing' of contamination to recovery wells	Low	Low	N/A
Soil Washing	Excavation of contaminated soils and washing with treatment agents	Low	Low	N/A
Hydraulic Binders / Soil Stabilisation	In situ mixing of contaminated soils with treatment agents e.g. cement to reduce mobility of contamination	Low	Low	Low
Vitrification	Heating of the soils in-situ to melt soils and thus stabilise contamination once cooled down	Low	Low	Low
Incineration	Excavation and off site incineration of soils	Low	Low	Low
Capping	Construction of capping layer to break contamination exposure pathway	N/A	N/A	High

4.6 Selected Remedial Options for Soil Contamination

4.6.1 The options appraisal undertaken with *Appendix B* and Table 8 has allowed appropriate remedial options to be selected for soil contaminants, a summary of which is provided in Table 9 below.

Table 9: Selected Remedial Options for Soil Contaminants

Contamination Source	Contamination Location	Selected Remedial Techniques	Justification
HFO Contaminated Soils	Z3.3, Z3.5, Z3.8, Z3.9, Z3.10, Z3.12	Thermal desorption OR Ex-situ bioremediation of HFO contaminated soils, depending upon results of pilot trials; and / or excavation and off-site disposal of HFO contaminated soils.	Thermal desorption: Track record as a remedial technique in the UK has increased and could potentially remove up to 99% of the contaminant mass in a very short timeframe. It is potentially slightly cheaper than partial ex-situ bioremediation and off-site disposal. Ex-situ bioremediation may be considered as it is a widely available remedial technique and has a proven track record in the UK for the cost effective remediation of soils impacted with a range of hydrocarbons. The effectiveness of the remedial technique will need to be demonstrated through pilot trials, however it is anticipated that even if ex-situ bioremediation does not completely remediate the soils, it may reduce the volume of contaminated soils requiring off-site disposal to a hazardous landfill. Remediation timescales are likely to be elongated (potentially > 6 months)
Residual Hydrocarbon Contaminated Soils	Z1.10, Z1.12, Z1.18, Z1.25, Z1.26, Z3.17	Thermal desorption OR Ex-situ bioremediation of hydrocarbon contaminated soils	Thermal desorption: Track record as a remedial technique in the UK has increased and could potentially remove up to 99% of the contaminant mass in a very short timeframe. It is significantly more expensive than ex situ bioremediation. Ex-situ bioremediation is a widely available remedial technique and has a proven track record in the UK for the cost effective remediation of soils impacted with a range of hydrocarbons. The size of the Assessment Site will likely provide enough space for the remediation however remediation timescales are likely to be elongated (potentially >6 months) and less contaminant mass is likely to be removed than thermal desorption.
Stained Hardstanding	Z1.10, Z1.25, Z1.26	Excavation and off-site disposal of stained hardstanding	It is considered that treatment of the limited volumes of stained hardstanding anticipated will not be economical on the Assessment Site. Quantities of hardstanding requiring off-site disposal are likely to be relatively limited, but may be suitable for treatment at an offsite facility.
Asbestos Contaminated Soils	Zone 6	Capping	Capping is a cost effective technique that is compatible with a wide variety of developments and effectively breaks the contamination exposure pathway.

4.6.2 Within CSLs Z1.12 and Z3.1, the most cost effective remedial option for the remediation of ingress of shallow contaminated groundwater into excavations is considered to be pumping and on / off site treatment and disposal. In addition, should free product be identified within shallow groundwater within any of the other remedial excavations across the site, it is considered that this would also be the most suitable option for addressing such contamination.

4.6.3 It should be noted that the potential size of individual land parcels to be redeveloped may mean that thermal desorption / bioremediation is not an economically feasible remedial option. Once the size of land redevelopment parcels has been defined, this remedial options appraisal should be re-evaluated to ensure that the most economically feasible remedial option is selected for implementation, in line with this Remediation Strategy.

4.7 Previously Unidentified Contamination

4.7.1 It is anticipated that given the history of the Assessment Site there is the potential for previously unidentified contamination to be identified during future site redevelopment works. Previously unidentified contamination may include areas of asbestos and hydrocarbons and may be present across the Assessment Site.

4.7.2 If previously unidentified chemical contamination is encountered during the site redevelopment, works will be immediately halted and a qualified Environmental Consultant contacted to undertake an inspection of the contamination.

4.7.3 The Contractor should undertake investigations to establish the nature and extent of the previously unidentified contamination present and update land contamination risk assessments as appropriate to establish the requirement for remediation works.

4.7.4 Any remedial works that are deemed necessary shall be undertaken in line with the procedures outlined within the document and specific Remediation Strategies developed for each development area.

4.7.5 Any additional remediation works will require approval by the Regulators, prior to implementation.

4.7.6 Based upon the scope of ground investigation works undertaken at the Assessment Site to date, consideration should also be given to undertaking additional ground investigation works in areas of the Assessment Site where:

- There is currently no or limited ground investigation coverage e.g. Zone 9;
- Ground investigation works have been undertaken, but no chemical analysis is known to have been undertaken on soil or groundwater samples e.g. Zone 7; or
- To further delineate contamination identified by the ground investigations undertaken by RPS e.g. asbestos within Zone 6.

4.7.7 Any such ground investigations should be undertaken once future redevelopment plans are known to allow the investigations to be suitably designed.

5 REMEDIATION CLEAN UP CRITERIA

5.1 Introduction

5.1.1 The scope of this site wide Remediation Strategy is to cover remedial requirements in relation to EP surrender and to support future site redevelopment. As such, the scope of remediation covers two separate regulatory regimes, the Environmental Permitting Regulations *(EA, 2013*) and the Town and Country Planning Act (1990) and therefore remediation clean up criteria will differ between the regulatory regimes.

5.1.2 The scope of remediation also manages potential contamination risks in the context of Part IIA by virtue of ensuring that land will be suitable for use under the planning regime, where under the National Planning Policy Framework the land cannot be determined as 'contaminated land' once the development has been completed.

EP Surrender

5.1.3 Under the Environmental Permitting Regulations applicants for Environmental Permits are required to identify sources of contamination present at the application site and typically undertake a ground investigation to determine the 'Site Condition' by obtaining 'reference data' thereby 'benchmarking' soil and groundwater quality. To enable permit surrender, the ground investigation is normally repeated, taking into account any pollution incidents that may have occurred under permit, to determine whether Site Condition i.e. soil and / or groundwater quality, has deteriorated since the permit was issued. Should it be deemed that the Site Condition has deteriorated under permit, the permit holder is required to return Site Condition to that 'benchmarked' at the time of permit application.

5.1.4 It is important to note that the Environmental Permitting Regulations do not apply a risk based clean up approach and that any deterioration of site condition needs to be remediated irrespective of risk to human health or the environment. However, there is no definition of what level of clean up constitutes a "satisfactory state" as set out in the Industrial Emissions Directive (*IED, 2010*).

5.1.5 At the time of the permit application at the Assessment Site, no ground investigations were undertaken to 'benchmark' soil and groundwater quality to establish the presence of any historical, pre-existing contamination. Consequently as the extent of contamination that has occurred under permit due to site operations cannot be quantitatively determined, there are no specific pre-permit Site Condition remedial criteria for the remediation to achieve to assist with permit surrender.

5.1.6 The Environmental Permitting Regulations specify that only contamination that has occurred under permit requires clean up in order to return the Assessment Site to a "satisfactory state". The Environmental Permitting Regulations do not require historical (pre-permit) contamination to be cleaned up as other legislative regimes manage legacy contamination. However, where an operator has not undertaken a reference data ground investigation at the start of the permit, if contamination is identified that could have been introduced during permit, but is also the same or cannot be differentiated from historical contamination, all such contamination would require clean up.

5.1.7 On this basis therefore, a site-specific, judgemental approach will be adopted to select the most appropriate remedial criteria for the contamination identified within the specified CSLs where Site Condition has been deemed to have deteriorated under permit. This approach is discussed in the remainder of this section of the report.

Site Redevelopment

5.1.8 The Town and Country Planning Act is supported by the National Planning Policy Framework (NPPF) (*MHCLG, 2018*) which provides a risk-based approach to the management of land contamination. The NPPF sets out how planning policies and decisions should contribute to and enhance the natural and local environment by:

- Preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water, or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans; and

- Remediating and mitigating despoiled, degraded, derelict, contaminated and unstable land, where appropriate.

5.1.9 The NPPF acts as policy for local planning authorities and decision-takers, both in drawing up plans and determining planning applications. Local planning authorities may determine the need requirement for assessment and remediation of sites during the planning process. The NPPF at paragraph 178 also requires planning decisions to ensure that:

"a) a site is suitable for its proposed use taking account of ground conditions and any risks arising from land instability and contamination. This includes risks arising from natural hazards or former activities such as mining, and any proposals for mitigation including land remediation (as well as potential impacts on the natural environment arising from that remediation)."

5.1.10 On this basis, the remedial criteria selected for a site redevelopment scenario will be risk based for the contamination identified and are also considered to be suitable for the management of Part IIA risks as outlined in paragraph 5.1.2. This approach is discussed in the remainder of this section of the report.

5.1.11 Various assessments have been undertaken by RPS (*RPS, 2014b, 2014d and 2016a*) to determine potential risks to controlled waters from the presence of soil contamination at the Assessment Site. These assessments have identified a low risk to controlled waters and therefore the remediation criteria are based on human health only and remedial action will lead to a betterment of controlled waters.

5.2 Specific Remediation Objectives

EP Surrender

5.2.1 As stated within Section 4.3 the overall objective of the remediation works will be to remediate the contamination within each of the CSLs that is considered to have / is likely to have occurred during the lifetime of the permit, in order to assist in the surrender of the Assessment Site's permit.

5.2.2 More specifically, the objectives of the remediation are to:

- Remove and clean up the HFO contaminated soils identified within the CSLs defined within Table 3 and paragraph 4.2.7;

- Remove and clean up the residual hydrocarbon contaminated soils within the CSLs defined within Table 3 and paragraph 4.2.7;

- Remove the areas of HFO / hydrocarbon impacted hardstanding within the CSLs defined within Table 3 and paragraph 4.2.7;

- Remediate localised areas of hydrocarbon impacted shallow groundwater where encountered within excavations within CSL Z1.12 and in any other remedial excavations across the Assessment Site;

- Remediate the excavated contaminated soils utilising a suitable remedial technique to ensure that the soils are suitable to be reused on site to backfill the remediation excavation voids; and

- Provide 'lines of evidence' to show that the remediation works have been implemented in line with this document, to enable a Remediation Verification Report to be completed to

assist with permit surrender and demonstrate that the Assessment Site is in a “satisfactory state”.

Site Redevelopment

5.2.3 As stated within Section 4.3 the overall objective of the remediation works for site redevelopment will be to remediate the contamination within each of the areas identified within Table 5 to ensure that identified risks to sensitive receptors are suitably managed in line with any future proposed commercial development plans for the Assessment Site.

5.2.4 More specifically, the objectives of the remediation are to:

- Remove and clean up the TPH contaminated soils in the vicinity of WS-Z1-34;
- Implement remedial measures to break the human exposure pathway for asbestos in Zone 6; and
- Remediate a localised area of hydrocarbon impacted shallow groundwater within CSL Z3.1 during future excavations in relation to site redevelopment.

5.3 HFO Contaminated Soils Clean Up Criteria

5.3.1 Table 3 and paragraph 4.2.7 provide a summary of the CSLs where ground investigations have identified the presence of HFO contaminated soils that will undergo remediation to assist with permit surrender. The investigations have also allowed an estimate of the volume of soils that are likely to require remediation, although it should be recognised that the actual volume of soils from each CSL that will require remediation will only be quantified once the remedial works have commenced.

5.3.2 The human health risk assessment detailed in Section 3 of this report has identified elevated TPH and PAH contaminant concentrations above the commercial end use screening criteria that may be attributed to the presence of HFO at a total of 5 locations within the Assessment Site, with the majority of sampling locations having concentrations lying below the appropriate screening criteria. Given the extent of the shallow soils that are believed to have been impacted by HFO under permit within Zone 3 and that very few elevated concentrations have been identified, it is considered that the simple application of commercial use soil screening criteria as suitable remedial targets is not suitable i.e. soils are believed to have been impacted under permit, however soil concentrations lie below the adopted commercial screening criteria at the majority of sampling locations.

5.3.3 Figure 1 in *Appendix C* therefore defines the general procedure that is to be adopted for the remediation of the HFO contaminated soils as no benchmark data is available to inform the remediation criteria. Table 10 below provides a summary of the steps to be followed during the remediation of CSLs Z3.3, Z3.5, Z3.8, Z3.9, Z3.10 and Z3.12 and specifies the remedial criteria that will be adopted for each step. The adoption of public open space (park) soil screening criteria in tandem with the commercial criteria for the acceptability for re-use of treated soils is designed to ensure overall betterment of the soils (i.e. to enable the site condition to be regarded as a “satisfactory state”), to ensure the suitability of the soils to be re-used and to provide remedial criteria that are likely to be achievable through ex-situ soil remediation.

Table 10: Summary of Remediation Actions and Criteria - HFO Contaminated Soils

Step	Action	Remediation Criteria
1	Excavate known areas of HFO contaminated soils as defined by *Drawing JFR7105-SI-005*	Excavation base and sides visually clean of HFO
2	Stockpile excavated HFO contaminated soils for treatment situated on-site or off-site or removal off site	-
3	Obtain verification samples from excavation base and sides and analyse for Total Organic Carbon (TOC)*, Total Petroleum Hydrocarbons Criteria Working Group (TPH CWG) and speciated Polycyclic Aromatic Hydrocarbons (PAH)	If concentrations of TPH or PAH exceed the commercial screening criteria (Criteria 1) defined in *Appendix D*, return to Step 1
4	Undertake trial pit inspections in adjacent areas to define or confirm presence / absence of HFO in those areas not previously identified	If HFO is visually identified and is attributable to deterioration in site condition, return to Step 1
5	Treat or remove off-site HFO contaminated soils	-
6	Take samples of treated soils on a 1 sample per 250 m^3 basis and analyse for TOC, TPH CWG and PAH	If sample concentrations do not exceed the lowest Suitable 4 Use Levels (S4ULs) for commercial / public open space (park) scenarios (Criteria 2), included within *Appendix D*, the soils are suitable for backfill into excavation voids. If the samples exceed any S4UL, return to Step 5

* A review of available TOC data has tentatively indicated that there is a correlation between the presence of HFO contamination with high (>10%) TOC. TOC is noted to be >10% within samples obtained at locations where visual evidence of HFO was encountered, namely TP-Z3-16, TP-Z3-20, HP-Z3-57 and WS-Z3-51. During the remediation verification process it is envisaged that a more robust correlation between TOC and HFO / hydrocarbon contamination can be established and may lead to a quick and easy determination of whether HFO / hydrocarbon contamination requiring treatment is present.

5.3.4 The remedial technique to be utilised to treat excavated contaminated soils will be selected once site redevelopment proposals are known and after a period of consultation with remediation contractors.

5.4 Residual Hydrocarbon Contaminated Soils Clean Up Criteria

Introduction

5.4.1 Table 3 and paragraph 4.2.7 provide a summary of the CSLs / site areas where ground investigations have identified the presence of residual hydrocarbon contaminated soils that will require remediation to assist with permit surrender and site redevelopment. The investigations have also allowed an estimate of the volume of soils that are likely to require remediation, although it should be recognised that the actual volume of soils that will require remediation will only be quantified once the remedial works have commenced.

5.4.2 *Drawings JFR7105-SI-004 and JFR7105-SI-005* detail the extent of remediation of the residual hydrocarbon contaminated soils, as defined by ground investigations within Zones 1 and 3. The remediation of hydrocarbon contaminated soils required in these zones is split into 2 broad categories:

- Remediation of residual hydrocarbon contaminated soils; and
- Investigation of soils to determine extent of remediation.

5.4.3 The human health risk assessment detailed in Section 3 of this report has identified a single exceedance of the commercial screening criteria, within WS-Z1-34. This elevated concentration is not considered to be indicative of deterioration in Site Condition and remediation is required to support site redevelopment only and the application of commercial screening criteria for site redevelopment purposed is considered to be suitable.

5.4.4 As with the HFO contamination described in Section 5.3, it is considered likely however that elevated concentrations of contaminant concentrations may be present within the other areas of hydrocarbon impacted soils, in localised areas. Given the extent of the shallow soils that are believed to have been impacted by residual hydrocarbons under permit within the relevant CSLs and that no elevated concentrations have been identified in these areas, it is considered that the simple application of commercial use soil screening criteria as suitable remedial targets for permit surrender is not suitable i.e. soils are believed to have been impacted under permit, however soil concentrations lie below the adopted commercial screening criteria at all sampling locations where site condition has deteriorated under permit.

Remediation of Residual Hydrocarbon Contaminated Soils

5.4.5 Figure 2 in *Appendix C* defines the general procedure that is to be adopted for the remediation of the residual hydrocarbon contaminated soils as no benchmark data is available to inform the remediation criteria for permit surrender. Table 11 below provides a summary of the steps to be followed during the remediation and specifies the remedial criteria that will be adopted for each step. The adoption of public open space (park) soil screening criteria in tandem with the commercial criteria for the acceptability for re-use of treated soils is designed to ensure overall betterment of the soils (i.e. to enable the site condition to be regarded as a "satisfactory state"), to ensure the suitability of the soils to be re-used and to provide remedial criteria that are likely to be achievable through ex-situ soil remediation.

Table 11: Summary of Remediation Actions and Criteria – Residual Hydrocarbon Contaminated Soils

Step	Action	Remediation Criteria
1	Excavate Made Ground in defined contaminated areas as per Drawings *JFR7105-SI-004 and JFR7105-SI-005.* The anticipated excavation depths are defined in Table 14	Excavation base and sides visually clean of hydrocarbon contamination
2	Transport excavated soils to treatment area situated on-site or off-site or removal off-site	-
3	Obtain verification samples from excavation base and sides and test for PCBs (Z1.12 only) Total Organic Carbon (TOC)* and Total Petroleum Hydrocarbons Criteria Working Group (TPH CWG)	If concentrations of PCBs or TPH exceed the commercial screening criteria (Criteria 1) defined in *Appendix D*, return to Step 1. If concentrations do not exceed screening criteria, the soils are suitable to remain in-situ and no further excavation is required
4	Place excavated soils in two stockpiles. Stockpile 1: Soils with visual / olfactory evidence of hydrocarbon contamination Stockpile 2: Soils with no visual / olfactory evidence of hydrocarbon contamination	-
5a	Treat hydrocarbon contaminated soils contained within Stockpile 1	-
5b	Take samples from Stockpile 2 on a 1 sample per 100 m^3 basis and analyse for TPH CWG and PCBs	If sample concentrations exceed the lower criteria of commercial / public open space screening criteria (Criteria 2) defined in *Appendix D*, soils are required to be placed in Stockpile 1 for treatment. If sample concentrations lie below the lower criteria of commercial / public open space screening criteria (Criteria 2), soils are suitable for reuse to infill excavation voids

Step	Action	Remediation Criteria
6	Take samples of treated soils on a 1 sample per 250 m^3 basis and analyse for TPH CWG	If sample concentrations lie below the lower criteria of commercial / public open space screening criteria (Criteria 2) included within *Appendix D*, the soils are suitable for backfill into excavation voids. If the samples exceed any S4UL, return to Step 5a

* A review of available TOC data has tentatively indicated that there is a correlation between the presence of HFO contamination with high (>10%) TOC. TOC is noted to be >10% within samples obtained at locations where visual evidence of HFO was encountered, namely TP-Z3-16, TP-Z3-20, HP-Z3-57 and WS-Z3-51. During the remediation verification process it is envisaged that a more robust correlation between TOC and HFO / hydrocarbon contamination can be established and may lead to a quick and easy determination of whether HFO / hydrocarbon contamination requiring treatment is present.

5.4.6 The remedial technique to be utilised to treat excavated contaminated soils will be selected once site redevelopment proposals are known and after a period of consultation with remediation contractors.

Investigation of Soils to Determine Extent of Remediation

5.4.7 Figure 3 in *Appendix C* defines the outline procedure that is to be adopted for the investigation of shallow soils in the relevant CSLs to determine if remediation in these areas is required. These areas have been defined on the basis of the fact that either they were covered in hardstanding and could not be fully inspected during the various phases of ground investigation (CSLs, Z1.10, Z1.18 and areas of Z1.25 and Z1.26), were not accessible for health and safety reasons during ground investigations (areas of CSL Z1.12) or were not delineated as there was no requirement for remedial action for EP surrender (WS-Z1-34).

5.4.8 Based upon the available ground investigation information, assumptions were made on whether Site Condition in these areas had deteriorated under permit and therefore there is a requirement to validate this assumption during the remedial works. Furthermore, as stated previously, there is a requirement to delineate the contamination identified in WS-Z1-34 to support redevelopment of the Assessment Site. Table 12 below provides a summary of the steps to be followed.

Table 12: Summary of Remediation Ground Investigation and Inspection Requirements

Step	Action	Review Criteria
1	Undertake ground investigations in areas defined by *Drawing JFR7105-SI-004*	Is there visual / olfactory evidence of hydrocarbon / HFO contamination within the soils? If there is no evidence of contamination or contamination is unlikely to have occurred under permit, no further action required
2a (EP surrender)	If there is evidence if hydrocarbon / HFO contamination within the soils and is attributable to contamination having occurred under permit, revert to Step 1 in Figure 1 (for HFO contaminated soils) or Figure 2 (for hydrocarbon contaminated soils) in *Appendix 2*	-
2b (site redevelopment)	Obtain soil samples from ground investigation locations and test for TPH CWG	If sample concentrations lie below commercial screening criteria in *Appendix D*, soil contamination is delineated and revert to Step 1 in Figure 2. If sample concentrations lie above commercial screening criteria, revert to Step 1 and continue ground investigations

5.5 Hydrocarbon / HFO Stained Hardstanding

5.5.1 Table 4 provides a summary of the CSLs (Z1.10, Z1.25 and Z1.26) where ground investigations and site inspections have identified the presence of hydrocarbon / HFO stained hardstanding as a

result of surface leakages / spillages that will require remediation to assist with permit surrender. The investigations and inspections have also allowed an estimate of the volume of hardstanding that will require remediation.

5.5.2 As stated in Table 9, the most suitable remedial technique is considered to be the excavation and off-site disposal of the stained hardstanding due to the unsuitable nature of the materials for any other remedial technique.

5.5.3 The remediation shall remove all hydrocarbon / HFO stained hardstanding where evident within the appropriate CSLs and site inspections shall be undertaken to confirm that the hardstanding has been satisfactorily removed within each CSL.

5.5.4 These works shall be undertaken in tandem with the works outlined within Table 12 and Figure 3 in *Appendix C* as ground investigations within the underlying soils are also required to be undertaken within CSLs Z1.10, Z1.25 and Z1.26 to determine whether the underlying soils may have been impacted under permit.

5.6 Asbestos Contaminated Soils

Overview

5.6.1 A cover system will be utilised to mitigate risks to human health from the presence of asbestos in shallow soils in Zone 6. The cover systems proposed will be capable of preventing exposure to asbestos and will need to be compatible with proposed future development plans for Zone 6 and with any other areas of site redevelopment at the Assessment Site where capping is the selected remedial technique. A cover system may also be required across other areas of the Assessment Site, depending upon proposed development plans for each land parcel and whether previous unidentified contamination is encountered during site redevelopment works.

5.6.2 Two types of cover system are likely to be required in line with future development plans, namely:

1. Areas of hardstanding; and
2. A soft cover system comprising an unconsolidated topsoil and subsoil cover.

Soft Cover System – Prior to Acceptance of Imported Soils

5.6.3 Prior to acceptance of imported soils to be used as capping material, the following details relating to cover soils should be obtained and verified:

- The past and current use of the imported soils should be known and documented. The specific materials that are to be imported need to be identified and segregated from other materials at the supplier;
- The imported soils will be free of detritus materials and any items larger than 50 mm in size;
- Prior to moving the soils onto site representative samples will be obtained from the material. Samples will be taken at a frequency of 1 per 250 m^3 with a minimum of 5 samples being obtained, and
- Laboratory analysis will be undertaken on the soil samples, comprising the suite of analysis included within Table 13. All results of the laboratory analysis must lie below the capping criteria outlined in Table 13 to ensure that the materials are acceptable to be imported to site. The criteria used are the Suitable 4 Use Levels (S4UL) published by LQM for a commercial end use where applicable. The exception to this is lead, where a Category 4 Screening Level (C4SL) for a commercial end use has been adopted.

5.6.4 Should site won soils be incorporated into the soft capping system, once redevelopment plans for specific land parcels are known, a Materials Management Plan (MMP) in line with CL:AIRE Code of Practice (*CL:AIRE, 2011*) will be required to ensure that the materials are suitable for reuse within the soft cover system. Furthermore, the MMP should ensure that movement and placement of any site won materials does not lead to future potential contamination risks to humans or the environment.

Table 13: Capping Material Chemical Acceptance Criteria

Contaminant	Capping Criteria (Maximum Concentration for Capping Materials) (mg/kg)	Contaminant	Capping Criteria (Maximum Concentration for Capping Materials) (mg/kg)
Arsenic	<640	Aliphatics >C10-C12	<9,700
Boron	<240,000	Aliphatics >C12-C16	<59,000
Cadmium	<190	Aliphatics >C16-C21	<1,600,000
Chromium	<8,600	Aliphatics >C21-C35	<1,600,000
Chromium VI	<33	Fluorene	<63,000
Copper	<68,000	Phenanthrene	<22,000
Lead	<2,300	Anthracene	<520,000
Mercury	<1,100	Fluoranthene	<23,000
Nickel	<980	Pyrene	<54,000
Selenium	<12,000	Benzo(a)anthracene	<170
Zinc	<730,000	Chrysene	<350
Aromatic EC 5-7	<26,000	Benzo(b)fluoranthene	<44
Aromatic >EC7-8	<56,000	Benzo(k)fluoranthene	<1,200
Aromatic >EC8-EC10	<3,500	Benzo(a)pyrene	<35
Aromatic >EC10-EC12	<16,000	Indeno(123cd)pyrene	<500
Aromatic >EC12-EC16	<36,000	Dibenzo(ah)anthracene	<3.5
Aromatic >EC16-EC21	<28,000	Benzo(ghi)perylene	<3,900
Aromatic >EC21-EC35	<28,000	Acenaphthene	<84,000
Aliphatics C5-6	<3,200	Acenaphthylene	<83,000

Contaminant	Capping Criteria (Maximum Concentration for Capping Materials) (mg/kg)	Contaminant	Capping Criteria (Maximum Concentration for Capping Materials) (mg/kg)
Aliphatics >C6-8	<7,800	Naphthalene	<190
Aliphatics >C8-10	<2,000	Asbestos	No visual containing materials and <0.001% asbestos fibres

1 All criteria are LQM S4ULs for a commercial end use, with the exception of lead which is a C4SL for a commercial end use

2 TPH and PAH based on 1% SOM

5.6.5 In addition, topsoil will need to meet the specification within BS3882 *(BSI, 2015)* for areas of proposed planting.

5.6.6 The acceptability of the material for import onto site will be determined through a comparison of the identified concentrations with the criteria outlined in Table 13.

Following Importation

- Soils will be visually checked for the presence of unsuitable materials during placement by the Contractor;
- Any non-conforming materials will be removed; and
- Delivery notes detailing the origin of the material must be presented.

5.6.7 Materials should not be imported onto site until they have been confirmed as acceptable.

5.7 Groundwater

5.7.1 Table 4 and Table 6 provide a summary of the CSLs where ground investigations have identified the presence of localised areas of the hydrocarbon free product on the shallow groundwater. The risk assessments have concluded that a low risk is posed to controlled waters from the presence of hydrocarbon contamination within the groundwater and that from a risk perspective, no specific groundwater remediation is deemed necessary.

5.7.2 It is recognised however that shallow groundwater appears to have been impacted by site operations under permit within CSL Z1.12 and pre-permit activities have led to high concentrations of hydrocarbons and the presence of free product within shallow groundwater within CSL Z3.1. There is also the potential for free product to be encountered within the shallow groundwater within the other CSLs across the Assessment Site.

5.7.3 It is anticipated that through the remediation of soils in Z1.12 and through site development activities in Z3.1 (and any other CSL where contaminated groundwater is identified), the ingress of any hydrocarbon contaminated groundwater into remedial excavations will require the remediation of contaminated shallow groundwater to be undertaken.

5.7.4 Due to the low risk posed to controlled waters from the presence of contamination within the groundwater, there are no specific remedial criteria that will require to be met during the remedial works. The remediation criteria for the shallow groundwater remediation shall therefore comprise the removal of visible hydrocarbon impacted groundwater i.e. free product and suitable treatment to allow suitable on or off-site disposal. Remediation of dissolved phase hydrocarbons is not considered necessary although the removal of free product will lead to site betterment.

5.7.5 Should previously unidentified groundwater contamination be identified during site redevelopment, further assessment and remediation may be required if considered necessary by the Environmental Consultant.

6 REMEDIATION PLAN

6.1 Introduction

6.1.1 This section provides details of how the remediation will be implemented. At this stage the technique to be applied for the treatment of the HFO contaminated soils and residual hydrocarbon contaminated soils as well as the details of the asbestos capping system have not been defined. The technique that will be applied will be decided once future site redevelopment plans are known and following a period of consultation with Remediation Contractors to define the most practical and cost effective remedial solution.

6.1.2 Once the remedial technique(s) has been defined, individual remediation plans will be developed to support planning applications for each land parcel that is to be redeveloped. Each specific Remediation Plan will follow the general requirements set out in this Remediation Strategy, tailored to ensure that the proposed development is suitable for use from a land contamination perspective. Each Remediation Plan will include a Remediation Implementation Plan and a Remediation Verification Plan. Upon completion a Remediation Verification Report shall be prepared to demonstrate the remediation of the land parcel was successful and is complete. These Remediation Plans will provide detail on the remedial works to be undertaken.

6.2 Remediation Implementation Plan

Introduction

6.2.1 The Remediation Implementation Plan (RIP) presents the detailed approach to the remedial techniques selected in *Section 4*. The RIP covers the following aspects:

- Source removal excavation methodology;
- Treatment of contaminated soils;
- Waste Disposal;
- Capping system implementation;
- General waste handling requirements;
- Programme documentation;
- Discovery strategy;
- PPE and nuisance management; and
- Verification testing requirements.

6.2.2 It is considered that the implementation of the above remedial procedures will enable the remedial objectives set out in Section 5.2 to be achieved.

Source Removal Excavation Methodology

6.2.3 *Drawings JFR7105-SI-004 and JFR7105-SI-005* detail the approximate extent of the remedial excavations that will be required within Zones 1 and 3, as defined by the various phases of ground investigation undertaken by RPS at the Assessment Site. Table 14 below provides a summary of the approximate volume of material that will require excavation within each source location to remove the identified contamination. An estimated total of 19,497 m^3 is likely to require remediation based upon ground investigation data, site inspection observations and judgement. However it should be noted that the actual volume may vary.

Table 14: Approximate Volumes Requiring Remediation

Contaminant Type	Contaminant Source Location	Estimated Average Affected Soil Thickness (m)	Approximate Volume Requiring Remediation
HFO Contaminated Soils	Z3.3 – Pipe works leaving Tank Farm	1.5	759 m^3
	Z3.5 – Pig Receiving Station	1.0	135 m^3
	Z3.8 – NW Corner of Tank Farm (Non-Permit Area)	0.5	241 m^3
	Z3.9 – Central Area of Tanks 1-6	0.5	2227 m^3
	Z3.10 – HFO Tanks 1-6	0.5	4500 m^3
	Z3.12 – Area of pipe junctions and filters within the bund of tanks 9 and 8	0.5	3,868 m^3
Residual Hydrocarbon Contaminated Soils	Z1.10 – Road running to the east of turbine building behind stack	0.2	362 m^3
	Z1.12 – Generation transformers associated with turbine hall	1.0	5,000 m^3
	Z1.18 – Engineering Garages	1.5	150 m^3
	Z1.25 – Heavy hydrocarbon staining on floors associated with plant	1.2	1,152 m^3
	Z1.26 – Leaks from transformers	0.7	50 m^3
	Z3.17 – Grain Boiler House	1.0	100 m^3
	WS-Z1-34	1.0	100 m^3
Stained Hardstanding	Z1.10 – Road running to the east of turbine building behind stack	0.3	543 m^3
	Z1.25 – Heavy hydrocarbon staining on floors associated with plant	0.3	288 m^3
	Z1.26 – Leaks from transformers	0.3	22 m^3

6.2.4 The steps outlined below will be followed when undertaking excavations to remove the contaminant sources:

1. Excavation of the contaminated areas will be undertaken in a controlled manner and inspected by an independent Environmental Consultant;

2. Excavation will be undertaken with equipment of an appropriate scale to allow segregation of materials as they are excavated, based on visual and olfactory evidence of contamination;

3. Where groundwater is identified within excavations, that is contaminated or may become contaminated through exposure to the materials being excavated, it will be controlled through the following steps:

    a. Excavation will be stopped to allow the pumping of waters, and where required a sump constructed at the base of the excavation; and

    b. The groundwater will be pumped from the sump to temporary storage containers until all visually hydrocarbon contaminated groundwater is removed.

4. All hydrocarbon contaminated groundwater will be sampled and analysed to support waste sentencing. Once characterised the groundwater will be disposed of by a licensed liquid waste carrier or via discharge to foul sewer in accordance with a discharge licence obtained from the relevant water company. Where required, groundwater will be treated prior to disposal;

5. Stockpiled materials will be designated via markers to show whether they are contaminated or uncontaminated. Contaminated and uncontaminated stockpiles shall be located a sufficient distance apart to minimise the potential for cross contamination between stockpiles;

6. Materials placed on stockpiles will be stored such that cross-contamination from dust dispersal, run-off from rainfall and contamination of underlying clean soils is prevented. As a minimum, materials should be stockpiled in a bunded hardstanding or plastic sheeted area and be covered by plastic sheeting; and

7. A schedule of stockpiles and material movements will be maintained by the Remediation Contractor and provided to the appointed Environmental Consultant.

6.2.5 Once all contaminated material is considered to have been removed, the excavation will be halted and made safe for verification by the appointed Environmental Consultant:

- Inspection by the appointed Environmental Consultant to check that gross visual / olfactory contamination has been removed;

- Verification samples will be taken from the base and faces of the excavation. Samples will be taken at 10 m linear intervals from each side of the excavation, with a minimum of one sample from each side. One sample will be taken from each 20 m^2 of base of the excavation, with a minimum of two samples being taken. The samples will be analysed at an MCERTS accredited laboratory for:

    - TOC, TPHCWG and PAH within CSLs containing HFO contaminated soils (as per Figure 1 in *Appendix C*); and

    - PCBs (Z1.12 only), TOC and TPHCWG within CSLs containing residual hydrocarbon contaminated soils (as per Figure 2 in *Appendix C*).

- Where verification sampling confirms that the remaining material does not contain contaminant concentrations above the site specific remedial targets for the contaminants of concern, excavation will cease. If following verification sampling contaminant concentrations within the remaining material exceed the site specific remedial criteria, excavation will continue in accordance with the procedures outlined above;

- Following verification of the removal of materials exceeding the site specific criteria, the excavations shall be made safe for future infilling with treated soil or clean soils / materials; and

- If deemed necessary, where materials are disposed of off-site to a licensed waste management facility, a schedule of information will be maintained by the Remediation

Contractor, which will include waste transfer ticket number, vehicle registration, landfill and weight recorded by the weighbridge at the landfill. All materials will be appropriately characterised prior to disposal.

Treatment of Contaminated Soils

6.2.6 Upon excavation, soils will be transported to and stockpiled within the designated treatment areas, which may be located on or off-site. The treatment areas shall be suitably designed, prepared and maintained to ensure that the stockpiling of soils does not lead to the cross contamination of in-situ soils through direct soil contact or through surface water runoff.

6.2.7 At this stage further consultation with Remediation Contractors is required to select the final remediation treatment option for the remediation of HFO and residual hydrocarbon contaminated soils. The final remediation treatment option shall be detailed in the Remediation Plan developed for each individual land parcel that is to be redeveloped.

6.2.8 For soils derived from the CSLs with HFO contaminated soils, soils shall be placed in a single stockpile for treatment.

6.2.9 For soils derived from the residual hydrocarbon contamination CSLs and WS-Z1-34, soils shall be placed in two separate stockpiles:

- Stockpile 1: Soils with visual / olfactory evidence of hydrocarbon contamination; and
- Stockpile 2: Soils with no visual / olfactory evidence of hydrocarbon contamination.

6.2.10 Soils placed in Stockpile 1 are to undergo remedial treatment. Soils placed in Stockpile 2 are to be sampled on a one sample per 100 m^3 basis and analysed for TPHCWG to determine whether these soils require treatment. If TPH concentrations exceed the criteria specified within Table 11 the applicable soils are required to be added to Stockpile 1 for remedial treatment. If however, TPH concentrations lie below the criteria specified within Table 11, these soils are deemed to be suitable for reuse to infill the excavation voids.

6.2.11 The length of time needed to treat the contaminated soils will be dependent upon the treatment method used. Treatment of the soils shall be undertaken for the minimum length of time required to achieve the remedial criteria specified within Table 10 and Table 11 for HFO contaminated soils and residual hydrocarbon contaminated soils respectively.

6.2.12 Upon completion of the treatment period, receipt of soil verification analysis results that have met the clean up criteria and confirmation from the appointed Environmental Consultant that the soils are suitable for re-use, the treated soils shall be used to infill the excavation voids created during removal of the contaminant sources.

Waste Disposal

6.2.13 As previously stated, redevelopment plans for the Assessment Site are currently unknown. On this basis therefore, there is the potential for some land redevelopment parcels to be too small to make bioremediation or thermal treatment an economically viable option. Under such circumstances, the off-site disposal of soils may be the only suitable remedial option.

6.2.14 Where soils are to be disposed of off-site, including the general off-site disposal of construction arising, the general requirements as detailed in paragraph 6.2.23 shall be adhered to.

Capping System Implementation

6.2.15 A cover system will be utilised to mitigate risks to human health from the presence of asbestos in shallow soils in Zone 6. The cover systems proposed will be capable of preventing exposure to asbestos and will need to be compatible with proposed future development plans for Zone 6 and with any other areas of site redevelopment at the Assessment Site where capping is the selected remedial technique.

6.2.16 At the Assessment Site, the following types of cover system are likely to be required in line with future development plans:

- A hardstanding cap; or
- Soft cover system comprising an unconsolidated topsoil and subsoil cover.

6.2.17 The implementation of the capping design will need consider the proposed finished development levels, as any excavation and disposal of shallow soils to accommodate the cover system or to achieve development levels may remove the asbestos contaminated soils.

Hardstanding Cap

6.2.18 In all instances the hardstanding cap will present a competent, uncompromised barrier separating the underlying contamination sources. The hardstanding may be implemented in the following areas of proposed hardstanding:

- Roads and any laydown areas;
- Pavements;
- Footpaths; and
- Within the footprint of new structures.

Soft Cover System

6.2.19 The cover system will form the areas of landscaping that will be incorporated into the development design and will likely comprise subsoil and topsoil to allow establishment of vegetation. The thickness of cover will be dependent upon landscaping requirements that will vary depending upon the nature of the landscaping e.g. grassed areas, tree pits etc. It is anticipated that a thickness of 300 - 600mm of topsoil / subsoil may be required within these areas to fulfil landscaping requirements and is considered to provide a suitable capping thickness that will be maintained across areas of soft cover. The thickness of the soft cover system will be specific for land parcel in line with proposed redevelopment plans.

6.2.20 The placement of the cover must be strictly controlled to ensure that it is appropriately installed to the required thickness. The following procedures will be followed when placing the capping soils:

- Capping soils imported onto site will only be accepted where it has appropriate test data to demonstrate chemical suitability (refer to Section 5.6);
- Prior to placement of the cover the ground surface will be flattened to remove excessive peaks and troughs ensuring a consistent surface on which to place the cover;
- The capping soils will be placed in areas in which construction is complete to minimise the potential for disturbance;
- The capping soils will be deposited into areas of softstanding. The material will be hand raked to the appropriate thickness. Heavy compaction of the capping soils is to be avoided as the soils are to be used as a growing medium;
- The capping soils will not be subject to vehicle traffic following placement;
- The thickness of material placed will account for future settlement of the cover; and
- An essential element of the performance of a cover system is assurance that it has been installed in accordance with the design criteria. In order to ensure that the cover system has been appropriately placed a systematic validation procedure will be undertaken by an

independent Environmental Consultant. Validation will be through the excavation of up to 10 hand pits or hand augers on an approximate 25 m x 25 m grid to validate that the required thickness of material has been achieved.

6.2.21 Should site won soils be incorporated into the soft capping system, a Materials Management Plan (MMP) in line with CL:AIRE Code of Practice (*CL:AIRE, 2011*) will be required to ensure that the materials are suitable for reuse within the soft cover system. Furthermore, the MMP should ensure that movement and placement of any site won materials does not lead to future potential contamination risks to humans or the environment.

General Waste Handling Requirements

6.2.22 During site redevelopment contaminated soils may need excavating and handling to enable construction such as the excavation of foundations, substructures, drainage and utilities. It may be possible to reuse the excavated soils, possibly following treatment but where soils cannot be reused, they will require off-site disposal. A Materials Management Plan (*CL:AIRE, 2011*) will be required to manage the reuse of materials, as stated in paragraph 6.2.21.

6.2.23 With regard to the general soil waste handling requirements, the Remediation Contractor will adhere to the following general requirements while handling any waste materials derived from the remediation works:

- All waste will be segregated in labelled, appropriate containers / areas and will be suitably managed to avoid release or mixing of wastes;
- Inert, non-hazardous and hazardous wastes will be segregated and not mixed;
- Waste containers will be located in a secure, controllable location;
- All Remediation Contractor staff / personnel will be briefed on the waste management requirements and waste minimisation measures. Records will be kept of attendance;
- The Remediation Contractor will be responsible for determining whether wastes are hazardous in line with WM3 (*EA et al, 2015*) and will comply with both Hazardous Waste Regulations and Landfill Waste Regulations for disposal of waste to landfill, where such disposal is necessary; and
- Treatment of contaminated soils will need an Environmental Permit for the activity to be obtained from the Environment Agency by the remediation contractor, prior to works commencing.

Programme Documentation

6.2.24 It is an implicit requirement of these remediation works that a complete and thorough audit trail is maintained, documenting all works undertaken. As such all works undertaken in the remediation programme will be carefully documented by the Remediation Contractor for submission to the appointed Environmental Consultant. The routine documentation of the works to be carried out by the Remediation Contractor will include:

- Daily record sheets detailing activities on site;
- Excavation records, including details of the material removal from each excavation and the extent of any contamination within that material and plans showing the dimensions and nature of each excavation together with verification sampling locations;
- Details of any material changes to the remedial works due to findings on site;
- Stockpile plans detailing the volume and nature of the stockpiled material, including those materials requiring treatment;

- Duty of care register of contaminated soil (waste) removal off-site (if required), including a list of transfer notes and consignment notes against landfill weighbridge tickets, chemical test results for the material and any Environment Agency pre-notification; and

- Where encountered, a record of groundwater pumping and disposal, including volumes of water pumped, groundwater pumping rate and documentation to demonstrate duty of care.

6.2.25 Upon completion of the remedial works, all documentation will be submitted to the appointed Environmental Consultant to allow the production of Remediation Verification Reports, which will be provided to the Client and Environment Agency to assist with surrender of the Assessment Site's EP and also to support planning applications for redevelopment of individual land parcels.

Discovery Strategy

6.2.26 Areas of currently unknown contamination may be encountered during site development and remediation works, most notably within the shallow Made Ground following the removal of existing hardstanding and substructures etc.

6.2.27 Lines of evidence that will be considered indicative of significant soil contamination that may require remediation include:

- The presence of free phase contamination;

- Fibrous or cement bound asbestos materials;

- Significant staining and discolouration of exposed soils; and/or

- Olfactory evidence of volatile contamination.

6.2.28 In the event that previously unknown contaminated materials are revealed during construction and remediation works the Contractor will inform the appointed Environmental Consultant immediately. These materials will be characterised in-situ or stockpiled depending on the programme of the remediation works. Where materials are removed excavation works will be undertaken in accordance with the methodology detailed within this document.

6.2.29 All site personnel involved in construction and remediation works will be briefed in advance of excavation works on the likely nature and type of soils that could indicate the presence of contamination (e.g. asbestos, discolouration, oils, odours, ash and clinker materials).

6.2.30 Where any such currently unknown is identified, the Local Authority shall be contacted and a programme of remediation agreed with the Local Authority, in line with any planning conditions stipulated for redevelopment proposals for the Assessment Site.

Health & Safety, PPE and Nuisance Management

6.2.31 The Remediation Contractor will provide and implement detailed health and safety procedures to the meet the requirements of the CDM (2015) Regulations.

6.2.32 The following minimum procedures will be adopted to protect site personnel, which will be supplemented by Personnel Protective Equipment (PPE) / Respiratory Protective Equipment (RPE) and additional SSoWs as necessary are:

- Safe transport, handling and treatment of contaminated soils and groundwater;

- Use of damping down equipment; and

- Provision of welfare facilities to allow washing prior to use of mess facilities and leaving site for the day. Facilities also to allow for changing out of PPE.

6.2.33 The following minimum PPE is to be used, which will be maintained and worn:

- Hard hats, boots, gloves, eye protection and high visibility vests.

Verification Testing Requirements

6.2.34 The verification testing requirements are detailed in the sections above and are summarised in Table 15 below.

Table 15: Verification Testing Regime

Remediation Stage	Verification Testing Regime	Frequency
Excavation of contaminated soils in both HFO and residual hydrocarbon contaminated areas	Analysis of samples for TOC, TPHCWG and PAH for CSLs with HFO contamination. Analysis of samples for TOC and TPHCWG for CSLs within residual hydrocarbon contaminated areas. Screening of results against Criteria 1 included within *Appendix D*	One sample per 10 m linear intervals from each excavation side (minimum of one sample. per excavation side) and one sample per 10 m^2 of each excavation base (minimum of five samples per excavation)
Treatment of HFO contaminated soils	Analysis of samples for TPHCWG and PAH. Screening of results against Criteria 2 included within *Appendix D*	One sample per 250 m^3 of treated soil
Treatment of residual hydrocarbon contaminated soils	Analysis of samples for TPHCWG. Screening of results against the lower of Criteria 2 included within *Appendix D*	One sample per 250 m^3 of treated soil
Hardstanding Capping	None, unless visual and/or olfactory evidence of previously unidentified organic contamination is encountered; then laboratory analysis will be required on soil samples.	Sufficient samples to characterise previously unidentified contamination.
Soft Cover System	Chemical characterisation of imported material.	Samples to be taken and analysed as per Table 13**Error! Reference source not found.** prior to importation. Samples to be taken on a frequency of 1 per 250 m^3, with a minimum of 5 samples.
	Excavation of hand pits / augers to confirm thickness of the soft cover system constructed.	Minimum of 5 locations on a 25 m x 25 m grid per land parcel.
Unidentified Contamination (chemical and asbestos)	Field and / or laboratory analysis as deemed appropriate by the appointed Environmental Consultant in line with the criteria outlined in Table 13.	Frequency as deemed appropriate by the appointed Environmental Consultant.

6.3 Groundwater Monitoring

Introduction

6.3.1 A total of 5 rounds of groundwater monitoring and sampling have previously been undertaken by RPS, following the various phases of ground investigation undertaken at the Assessment Site:

- 3 rounds of site wide groundwater monitoring between October 2013 and December 2013, following completion of the first phase of ground investigation;
- 1 round of groundwater monitoring of localised areas of Zones 1 (CSL Z1.12) and 3 (tank farm area and Z3.1) in September 2014, following completion of the second phase of ground investigation; and
- 1 round of groundwater monitoring of localised areas of Zones 1 (CSL Z1.12) and 3 (CSL Z3.1) in July 2015, following completion of the third phase of ground investigation.

6.3.2 There have been no further rounds of groundwater monitoring and sampling at the Assessment Site since July 2015.

6.3.3 It is not considered that there is a requirement to undertake a specific programme of groundwater monitoring to support masterplanning for redevelopment of the Assessment Site. Once development proposals are known however, an appraisal of potential risks to controlled waters will be required to support associated planning applications for each specific land parcel being developed. These appraisals may require additional groundwater monitoring, sampling and assessment to be undertaken on a case by case basis.

6.3.4 A programme of groundwater monitoring will be undertaken however to provide information on baseline groundwater quality following completion of demolition and to manage Uniper's ongoing environmental liabilities with regards to potential contamination risks to controlled waters. This information may also be used to support future development proposals.

Baseline Groundwater Monitoring

Overview

6.3.5 The overall objectives of the baseline groundwater monitoring are to:

- Provide an understanding of the current status of groundwater quality across the Assessment Site; and
- Determine whether the recently completed demolition works have may have led to a deterioration in groundwater quality.

6.3.6 A number of groundwater monitoring wells were installed across the Assessment Site during the various phases of ground investigation undertaken by RPS and have been included, to varying degrees, in the monitoring rounds undertaken to date.

6.3.7 The baseline groundwater monitoring programme will comprise a 2 stage process:

1. Completion of a site audit to locate and determine the condition of each monitoring well identified for inclusion within the monitoring programme,
2. Completion of 2 rounds of groundwater monitoring and sampling at monthly intervals to baseline groundwater quality, utilising monitoring wells that are in a serviceable condition.

Groundwater Monitoring Well Selection

6.3.8 Table 16 below summarises the monitoring wells that have been identified for inclusion in the baseline monitoring programme. The majority of the monitoring wells identified have a response zone within the River Terrace Deposits, which are considered to be in hydraulic continuity with the River Medway and Damhead Creek. The monitoring wells in this stratum will enable future monitoring of any potential migration of contamination towards these sensitive receptors, thus allowing any additional risk assessment and / or remedial works to be identified to mitigate potential contamination risks.

6.3.9 The locations of the monitoring wells are shown on *Drawing JFR7105-SI-006*.

Table 16: Summary of Groundwater Monitoring Locations

Monitoring Location	Response Zone (mbgl)	Targeted Water Body	Location
BH-Z1-05	6.6 – 10.6	River Terrace Deposits	Situated to the north of CSL Z1.12
BH-Z1-09	7.6 – 9.6	River Terrace Deposits	Situated close to the southern boundary of Zone 1
BH-Z1-25	7.5 – 10.5	River Terrace Deposits	Situated on the northern boundary of Zone 1
BH-Z1-31	7.0 – 13.0	River Terrace Deposits	Situated on the eastern boundary of Zone 1
BH-Z1-35	5.0 – 8.2	Alluvium	Situated to the south of CSL Z1.25
WS-Z1-33	1.0 – 2.9	Alluvium	Situated to the north-east of CSL Z1.25
WS-Z1-47	1.0 – 3.0	Alluvium	Situated just to the north of the cable run connecting the Unit 2 transformer with the National Grid land within CSL Z1.12
BH-Z2-10	6.8 – 9.8	Alluvium / River Terrace Deposits	Situated close to the southern boundary of Zone 2
BH-Z2-11	3.0 – 6.0	Alluvium / River Terrace Deposits	Situated close to the southern boundary of Zone 2
BH-Z3-12	4.7 – 7.7	River Terrace Deposits	Situated close to the southern boundary of Zone 3
BH-Z3-14	7.2 – 11.2	River Terrace Deposits	Situated in south-east corner of Zone 3
BH-Z3-18	5.7 – 9.7	River Terrace Deposits	Situated within central area of tank farm
BH-Z3-40	6.0 – 9.0	River Terrace Deposits	Situated in north-west corner of Zone 3
BH-Z3-41	5.3 – 8.0	River Terrace Deposits	Situated in north-west corner of Zone 3
BH-Z3-42	5.6 – 8.0	River Terrace Deposits	Situated in north-west corner of Zone 3

Monitoring Location	Response Zone (mbgl)	Targeted Water Body	Location
WS-Z3-23	1.0 – 3.0	Made Ground	Situated in north-west corner of Zone 3
WS-Z3-44	1.0 – 4.0	Made Ground	Situated in south-east corner of Zone 3
WS-Z3-45	1.0 – 2.0	Made Ground	Situated in north-west corner of Zone 3
WS-Z3-47	0.4 – 1.0	Made Ground	Situated in north-west corner of Zone 3
WS-Z3-48	1.0 – 2.0	Made Ground	Situated in central area of Zone 3
WS-Z3-54	1.0 – 3.0	Made Ground	Situated in south-west corner of Zone 3
WS-Z3-55	1.0 4.0	Made Ground / Alluvium	Situated in north-west corner of Zone 3
WS-Z3-56	1.0 – 4.0	Made Ground / Alluvium	Situated in north-west corner of Zone 3
WS-Z6-01	0.3 – 0.8	Made Ground	Situated in central part of Zone 6
WS-Z6-09	1.0 – 4.0	Alluvium	Situated in central part of Zone 6

Management of Ongoing Liabilities

6.3.10 The controlled water risk assessments undertaken to date at the Assessment Site have indicated a low risk to controlled waters to be present.

6.3.11 It is noted however, particularly in relation to CSL Z3.1 located adjacent to Damhead Creek, there is a degree of variability in the hydrocarbon concentrations encountered, albeit to a reasonably limited extent. Due to this variability, the limited datasets that have been used to undertake the assessments and the potential lengthy timescales before contamination at the Assessment Site is remediated in line with site redevelopment proposals, a programme of annual groundwater monitoring will be undertaken to enable Uniper to manage their ongoing liabilities within respect to contamination risks to controlled waters.

6.3.12 This baseline groundwater monitoring will enable monitoring of any potential changes in groundwater baseline conditions, thus allowing any additional risk assessment and / or remedial works to be identified to manage potential contamination risks.

Laboratory Analysis and Data Review

6.3.13 Based upon the findings of the previous rounds of ground investigation and groundwater sampling, the principal contaminants of concern are considered to be Total Petroleum Hydrocarbons (TPH), and Polycyclic Aromatic Hydrocarbons (PAH). Each groundwater sample will therefore be submitted to the laboratory for the following analysis:

- Speciated USEPA 16 PAH;
- TPH with aromatic / aliphatic carbon banding and BTEX compounds; and
- PCBs (in the vicinity of Z1.12 only).

6.3.14 A total of 5 rounds of groundwater sampling have been undertaken at the Assessment Site since 2013. The table in Appendix D summarises the results of the TPH and PAH analysis for each of the monitoring wells identified to form part of the long term groundwater monitoring strategy.

6.3.15 Following completion of each round of groundwater baseline monitoring, the results of the laboratory analysis will be compared against the previous sampling results, detailed in Appendix D, to determine the nature and extent of any fluctuations in concentrations of the contaminants of concern. Time series graphs will also be plotted to illustrate these fluctuations over time.

6.3.16 The results of the groundwater baseline monitoring will be reviewed in the context of the following criteria to determine whether groundwater and surface water quality has deteriorated over time:

- Initial comparison of sample concentrations against appropriate screening criteria (Environmental Quality Standards [EQS] where available and UK Standards for the Protection of Surface Waters for the Abstraction of Drinking Water);
- Comparison of Total TPH and PAH sample concentrations with previous monitoring results, where available, to determine any significant variations in concentration trends e.g. concentration differences in orders of magnitude when compared to maximum concentrations from previous monitoring results; and
- Observations on whether Total TPH and PAH concentrations show an increasing or decreasing trend over time.

6.3.17 A review of the groundwater monitoring data will determine whether groundwater quality is in line with previous monitoring rounds. Should any significant deterioration in groundwater quality be observed, the monitoring data will enable decisions to be made on whether further risk assessment and / or remediation is required.

6.4 Remediation Verification Plan

Introduction

6.4.1 Based on CLR11 and the Environment Agency guidance document Verification of Remediation of Land Contamination (*EA, 2010*), a Remediation Verification Plan is set out in this section to demonstrate (verify) that the remediation strategy for each individual land parcel has been successfully implemented.

6.4.2 The main objective of verification testing is to provide suitable lines of evidence that the remedial measures have been suitably implemented in line with the requirements of the individual remediation strategies.

Remediation Contractor Documentation

6.4.3 All remedial works shall be carefully documented by the Remediation Contractor and to enable a Remediation Verification Report to be produced by the independent appointed Environmental Consultant. The documentation to be provided by the Remediation Contractor shall include, but shall not be limited to, the following:

- Details of any additional ground investigation works undertaken to provide further delineation on the extent of HFO contaminated soils;

- Details of investigations / inspections undertaken in those CSLs where hardstanding is to be removed to allow access to the underlying shallow soils;
- Details of additional ground investigation works in the vicinity of WS-Z1-34;
- Daily record sheets, detailing activities on site;
- Plans and records detailing the extent (depth and lateral extent) of excavations undertaken within each CSL;
- Records of volumes of materials excavated from each CSL for treatment;
- Inspection records confirming that all visual evidence of contamination has been removed from each CSL;
- Records of volumes of contaminated groundwater removed from each CSL (where applicable) for treatment / disposal;
- Plans detailing the destination of the excavated soil within the treatment stockpiles and plans detailing the dimensions and nature of the treatment stockpiles;
- Sample records detailing the location and composition of every sample collected by the Remediation Contractor with the results of site inspections and verification testing;
- Details of the ex-situ remediation technique selected, including but not limited to, details on the treatment area, volume of soil treated, duration of treatment and contaminant mass reduction;
- Sample chemical analysis results from remedial excavations and treated soils and comparison with the remediation criteria as detailed within Section 5;
- Records of any soil / groundwater disposed of off-site, detailing waste transfer ticket number, vehicle registration, waste disposal address and volume and weight of material disposed of;
- Details of any material changes to the remedial works due to findings during the works programme; and
- Details of any unexpected contamination including the following:
    - Ground investigation works to characterise and delineate the extent of the contamination;
    - Details of consultation and agreement with the Local Authority; and
    - Remediation measures implemented to address the identified contamination.

7 CONCLUSIONS

7.1 Conclusions

7.1.1 The Assessment Site has been subject to a number of ground investigations and land contamination risk assessments to determine potential risks to human health and controlled waters, to establish potential liabilities in the context of Part IIA and also to determine whether Site Condition has deteriorated during the lifetime of the Assessment Site's Environmental Permit.

7.1.2 The assessments undertaken by RPS have established:

- That Site Condition has or is likely to have deteriorated under permit and that remediation is required to assist with permit surrender; and
- Remediation is required to enable redevelopment of the Assessment Site for proposed future commercial use.

7.1.3 This site wide Remediation Strategy sets out the general requirements and remedial criteria for remediation of the Assessment Site for both permit surrender and site redevelopment. Each land parcel will however require development of a remediation plan to facilitate site redevelopment and to ensure that the remedial works undertaken are sufficient to achieve permit surrender.

7.1.4 Contaminated soils and waters derived from excavations undertaken as part of site redevelopment works will require careful management to minimise the potential for the spread and migration of any such contamination.

7.1.5 A Material Management Plan may be required to assist with redevelopment of some land parcels to assist with reuse of site won contaminated soils.

7.1.6 A gas risk assessment specific to each land parcel will be required to provide a robust assessment of ground gas risks in line with proposed developments, once they are known, and to determine the requirements for ground gas protection measures in proposed structures, if deemed necessary.

7.2 A programme of groundwater monitoring will be undertaken to provide information on baseline groundwater quality to manage ongoing environmental liabilities with regards to potential contamination risks to controlled waters. This information may also be used to support future redevelopment proposals.

7.3 A Remediation Verification Report (RVR) is required for each land parcel to demonstrate that the requirements of each land parcel specific remediation plan have been satisfactorily implemented (refer to Section 7.2 below).

7.2 Remediation Verification Report

7.2.1 Upon completion of the remediation works, a Remediation Verification Report (RVR) shall be prepared for each land development parcel by the appointed independent Environmental Consultant in cognisance with the Environment Agency guidance document *Verification of Remediation of Land Contamination* (*EA, 2010*). The RVR will detail all remedial works undertaken and will present the Remediation Contractor's documentation set out in Section 6.4.3 including excavation records, plans, sample records, treatment records, details of any waste disposal and verification results and a summary of the information is identified in this section. The Environmental Consultant's inspection records and independent verification testing and analysis results will also be provided, including groundwater and surface water monitoring results.

7.2.2 The RVR will present lines of evidence to verify that the objectives of the remediation have been achieved. These lines of evidence include:

- Plans detailing the extent of the remedial excavations undertaken within each remediation area and volumes of soil and groundwater removed at each location;
- Site photographs and site records of remedial excavations confirming that all visual evidence of contamination has been removed within each area where remediation has been undertaken;
- Details of any additional ground investigations undertaken to delineate the extent of the contamination source areas;
- Details of cover systems including drawings showing the location of hardstanding and as built drawings;
- Details of the material source, thickness and chemical composition of imported materials used to form a soft cover system;
- Plans / laboratory analysis / photographs of any previously unidentified contamination encountered during remediation that is considered to have resulted in deterioration of site condition under permit and details of remedial solutions implemented;
- Laboratory records confirming the suitability of soils to remain in situ and confirming the suitability of treated soils to be used to backfill excavations;
- Waste disposal records (both soil and groundwater) including the provision of waste transfer notes;
- Groundwater and surface water monitoring results and comments on whether any significant changes in the groundwater quality were observed and if remedial action was required; and
- Details of unexpected contamination encountered with justifications on whether it was remediated or not, along with associated details of any clean up.

7.2.3 The Remediation Verification Report shall be provided to the Environment Agency upon completion to assist with surrender of the Assessment Site's permit and also to the Local Authority for each individual redevelopment area, in compliance with any specific planning permissions.

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GLOSSARY

ACM	Asbestos Containing Material
C4SL	Category 4 Screening Level
CLEA	Contaminated Land Exposure Assessment
CoC	Contaminant of Concern
CSL	Contaminant Source Location
DQRA	Detailed Quantitative Risk Assessment
EP	Environmental Permit
EQS	Environmental Quality Standard
GAC	Generic Assessment Criteria
GQRA	Generic Quantitative Risk Assessment
HFO	Heavy Fuel Oil
NPPF	National Planning Policy Framework
mbgl	metres below ground level
MMP	Materials Management Plan
PAH	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PPE	Personal Protective Equipment
RVR	Remediation Verification Report
S4UL	Suitable 4 Use Level
SPOSH	Significant Possibility of Significant Harm
SVOC	Semi-Volatile Organic Compound
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TPHCWG	Total Petroleum Hydrocarbons Criteria Working Group
UCL	Upper Confidence Limit
VOC	Volatile Organic Compound

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Legend

- Environmental Permit Boundary
- Site Zones

Zone	Zone Name
1	Main Plant Area
2	Coal Stockyard
3	Tank Farm
4	Ash Lagoons
5	National Grid Substations
6	Western Storage Area
7	Area Proposed for Units 5 and 6
8	Former Waste Tip
9	Northern Laydown Area
10	Long Reach Jetty
11	Oakham Ness Jetty

Rev	Description	By	CB	Date

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T: +44(0)1454 853 000 E: rpssw@rpsgroup.com

Client: Uniper Energy

Project: Kingsnorth Power Station

Title: Site Layout & Zones

Status	Drawn By	PM/Checked By
DRAFT	RW	GM
Project Number	**Scale @ A3**	**Date Created**
JFR7105	1:12,000	SEP 2019

Drawing Number: **JFR7105-SI-001** Rev: **-**

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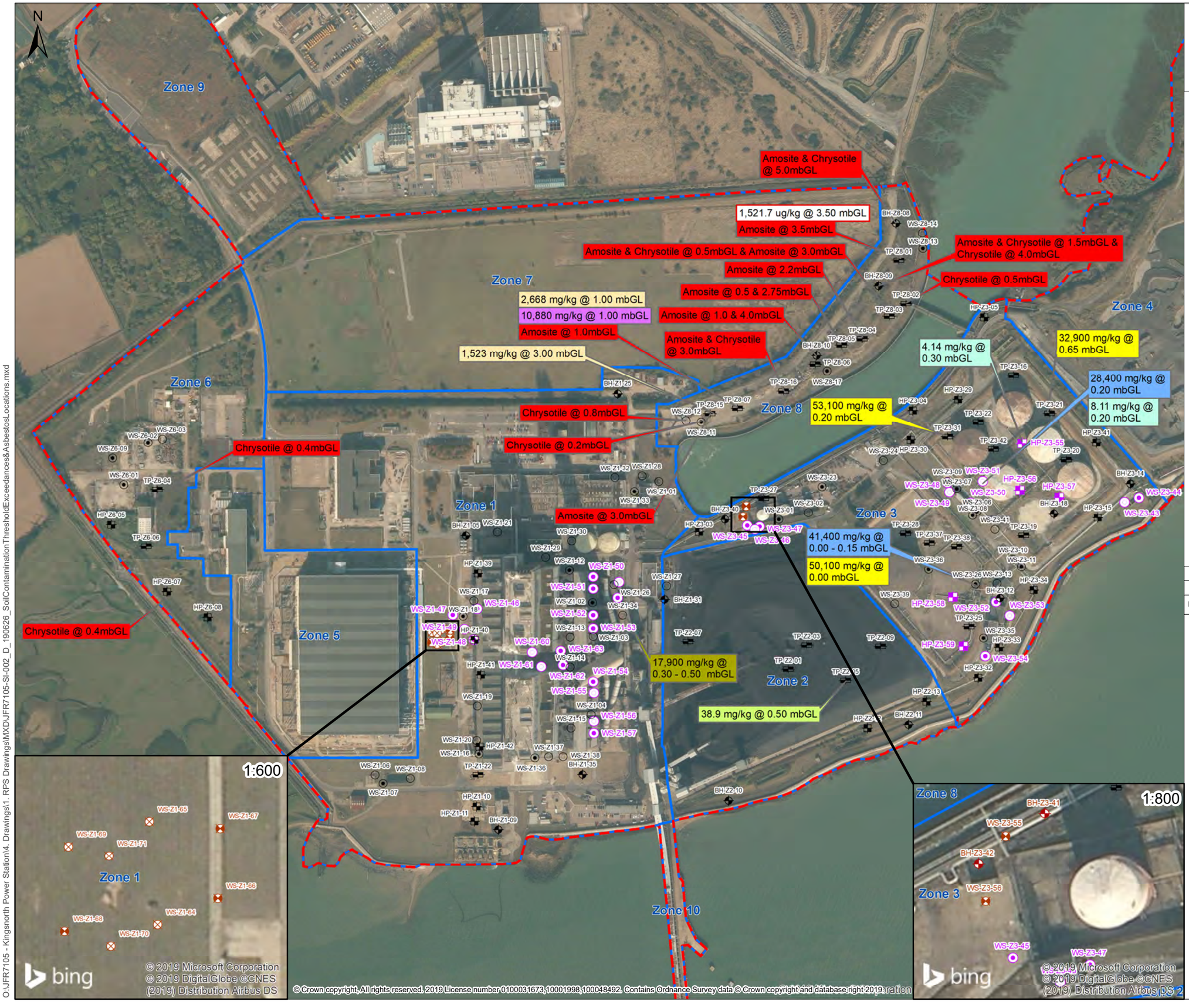

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Legend

- Environmental Permit Boundary
- Site Zones

Soil Contamination in Made Ground

Exceedances of S4UL Screening Values for Commercial Land Use

- Dibenzo(ah)anthracene (3.5 mg/kg)
- Vanadium (9,000 mg/kg)
- Nickel (980 mg/kg)
- PCB (12 Congeners) (240 ug/kg)
- Benzo(a)pyrene (35 mg/kg)
- Total Petroleum Hydrocarbons: Aromatics >C21 - C35 (28,000 mg/kg)
- Total Petroleum Hydrocarbons: >C21 - C35 (28,000 mg/kg)
- Total Petroleum Hydrocarbons: >C8 - C10 (2,000 mg/kg)
- Asbestos Identified in Soil Matrix

Rev	Description	By	CB	Date

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Client	Uniper Energy
Project	Kingsnorth Power Station
Title	Soil Contamination Threshold Exceedances & Asbestos Locations

Status	Drawn By	PM/Checked By
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Project Number	**Scale @ A3**	**Date Created**
JFR7105	1:5,000	SEP 2019

Drawing Number: **JFR7105-SI-002** Rev: **-**

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Source Zone / Site Area	Remedial Action Required for Site Redevelopment
Z3.1	Remediation of hydrocarbon contaminated soils and shallow perched groundwater. LNAPL remediation if required
WS-Z1-34	Contamination deliniation and removal of TPH contaminated soils
Zone 6	Capping of asbestos contaminated soils

Source Zone	Remedial Action Required for Environmental Permit Surrender
Z1.10	Removal and suitable disposal of HFO spillages and associated contaminated soils
Z1.12	Remediation of contaminated soils around Unit 2 cable trench. Inspection and remediation of soils under all transformers. LNAPL remediation if required
Z1.18	Inspection and remediation of soils underlying bunded diesel tank and in front of garages
Z1.25	Emptying and cleaning of bunds. Localised remediation of soils where contamination identified. Inspection and remediation of contaminated soils from leakages around bunds and under road
Z1.26	Clean up of leakages and contaminated soils
Z3.3	Clean up of localised areas of contaminated soils associated with leakages
Z3.5	Clean up of leakage and associated contaminated soils
Z3.8	Removal of HFO contaminated soils
Z3.9	Removal of HFO contaminated soils
Z3.10	Removal of HFO contaminated soils
Z3.12	Removal of HFO contaminated soils
Z3.17	Remediation will be required to clean up areas of obvious leaks within localised areas, including leaks under transformers

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Legend

- Site Zones Subject to Investigation

Deterioration of Site Condition Under Environmental Permit

- Site Condition has Deteriorated Under Permit (A)
- Site Condition in Permitted Area Unlikely to have Deteriorated Under Permit (A)
- Site Condition Likely to have Deteriorated Under Permit (B)
- Site Condition in Permitted Area Unlikely to have Deteriorated Under Permit (B)
- Site Condition Unlikely to have Deteriorated Under Permit (C)

Remediation Areas for Site Redevelopment

- Asbestos Contamination
- WS-Z1-34
- Z3.1

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Project: Kingsnorth Power Station

Title: Location of Remediation Areas

Status	Drawn By	PM/Checked By
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Project Number	**Scale @ A3**	**Date Created**
JER7105	1:5,000	SEP 2019

Drawing Number: **JER7105-SI-003** Rev: **-**

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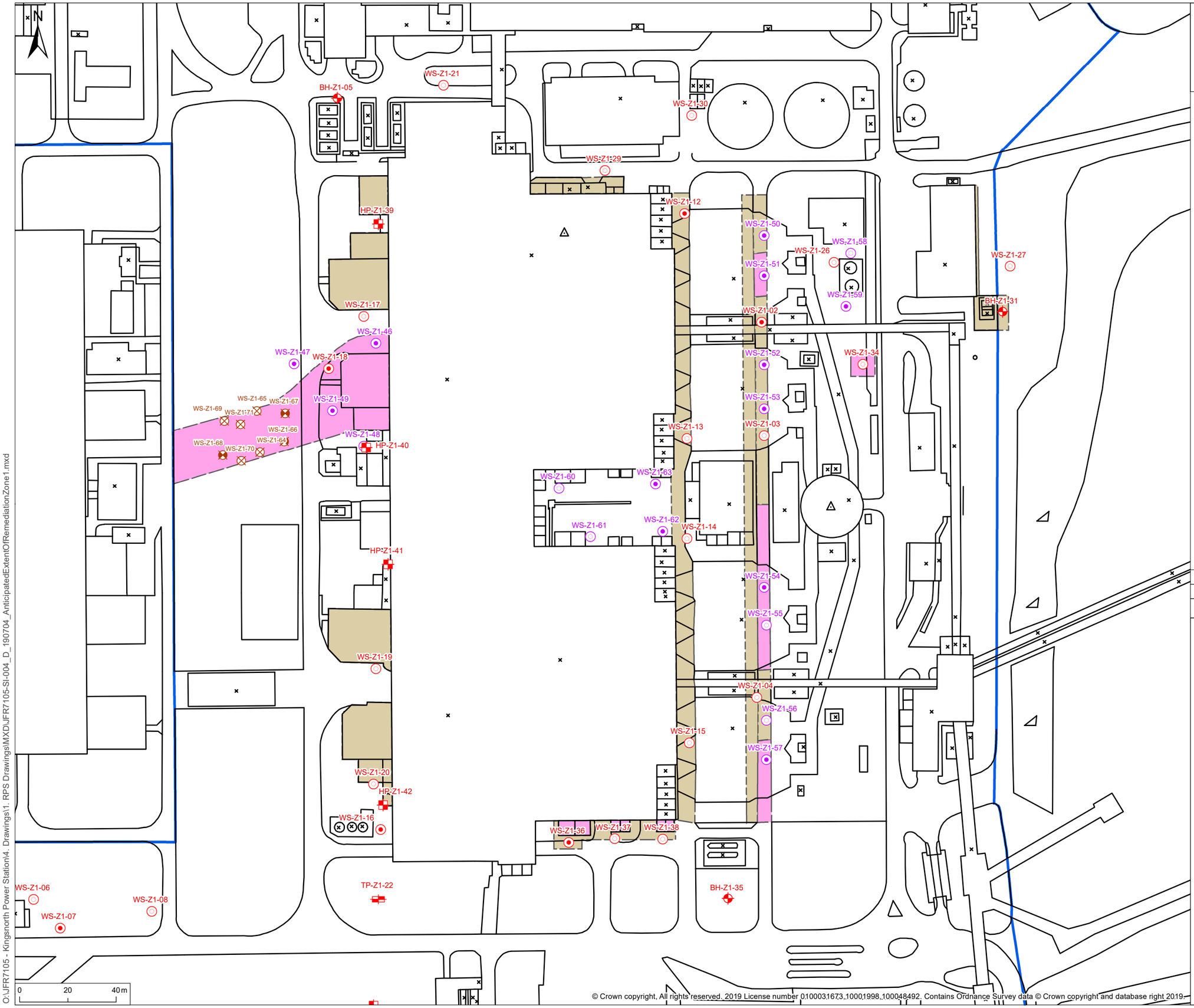

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Legend

- Zone 1

Required Remediation

- Removal of Hardstanding and Inspection of Underlying Soils to Determine if Remediation is Required
- Remediation of Residual Hydrocarbon Contaminated Soils

RPS (2013)

- Deep Borehole with Monitoring Well
- Shallow Borehole with Monitoring Well
- Shallow Borehole
- Machine Excavated Trial Pit
- Hand Dug Pit

RPS (2014)

- Shallow Borehole with Monitoring Well
- Shallow Borehole

RPS (2015)

- Window Sample
- Window Sample With Monitoring Well Installation

Rev	Description	By	CB	Date

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Client	Uniper Energy
Project	Kingsnorth Power Station
Title	Anticipated Extent of Remediation - Zone 1

Status	Drawn By	PM/Checked By
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Project Number	**Scale @ A3**	**Date Created**
JFR7105	1:1,500	JUL 2019

Drawing Number: **JFR7105-SI-004** Rev: **-**

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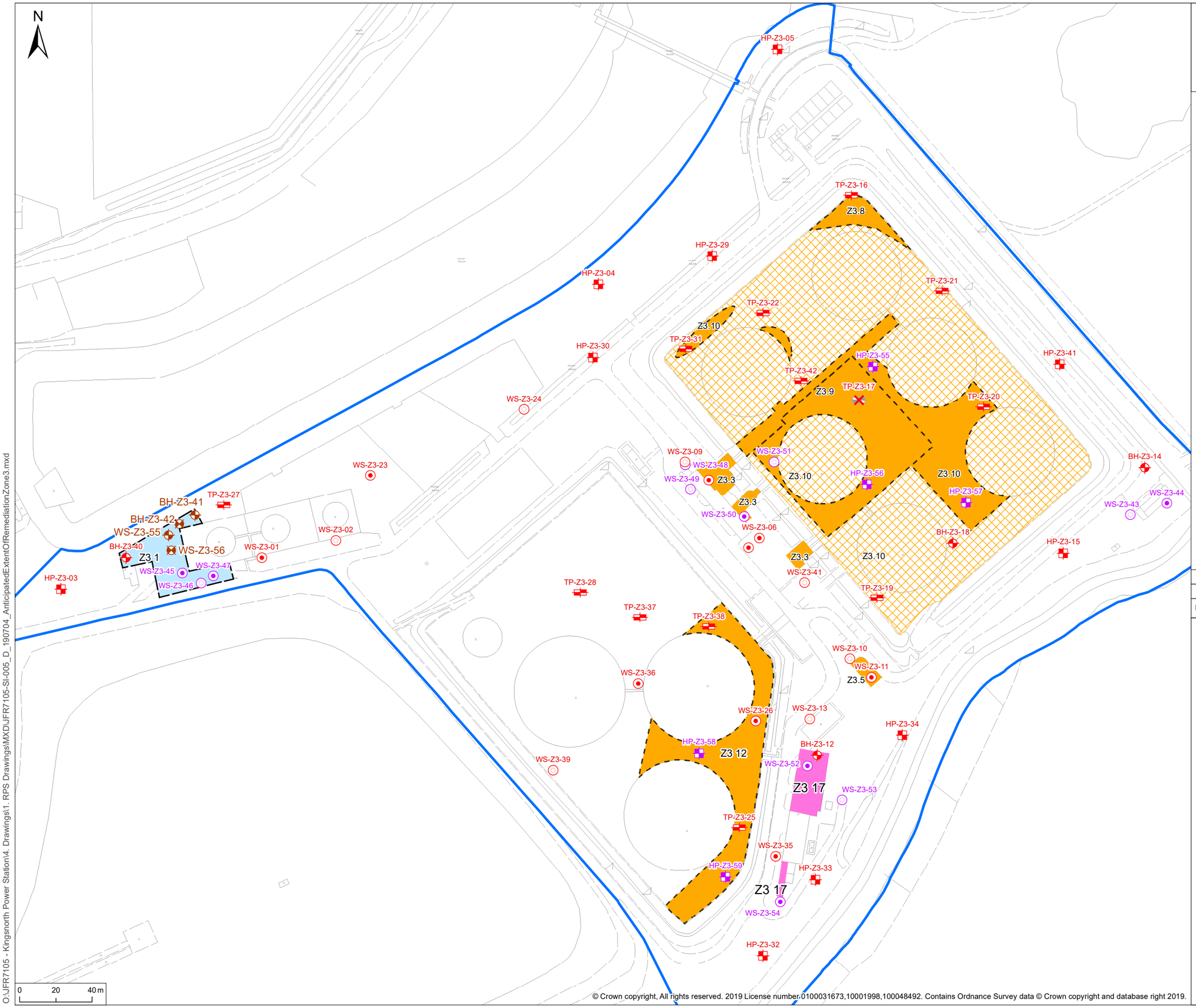

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Legend

- Zone 3
- Approximate HFO Extent

Required Remediation

- Remediation of HFO Contaminated Soils
- Trial Pit Inspections Required to Define or Confirm Presence/Absence of HFO Contaminated Soils
- Inspection & Removal of Obvious Residual Hydrocarbon Contamination
- Remediation of Hydrocarbon Contaminated Groundwater During Excavations

RPS (2013)

- Deep Borehole with Monitoring Well
- Shallow Borehole with Monitoring Well
- Shallow Borehole
- Machine Excavated Trial Pit
- Hand Dug Pit
- Machine Excavated Trial Pit - Not Completed

RPS (2014)

- Shallow Borehole with Monitoring Well
- Shallow Borehole
- Hand Dug Pit

RPS (2015)

- Cable Percussive Borehole
- Window Sample Borehole With Monitoring Well Installation

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Client: Uniper Energy

Project: Kingsnorth Power Station

Title: Anticipated Extent Of Remediation - Zone 3

Status	Drawn By	PM/Checked By
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Project Number	Scale @ A3	Date Created
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Drawing Number: **JFR7105-SI-005**

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Legend

- Zone 1
- Zone 2
- Zone 3
- Zone 6

Target Groundwater Body

- Made Ground
- Made Ground / Alluvium
- Alluvium / River Terrace Deposits
- Alluvium
- River Terrace Deposits

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Client	Uniper Energy
Project	Kingsnorth Power Station
Title	Proposed Groundwater Monitoring Locations

Status	Drawn By	PM/Checked By
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Project Number	**Scale @ A3**	**Date Created**
JFR7105	1:5,000	SEP 2019

Drawing Number: **JFR7105-SI-006** Rev: **-**

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Appendix A

Summary of Soil Chemical Analysis Results

Table 1 Inorganics - Zone 1

Zone 1 - All Ground Investigation Data										
Determinand	**Units**	**No. Samples**	**Min**	**Max**	**95% UCL (incl. outliers)**	**No. Outliers**	**Location of Outliers**	**Screening Value Commercial (mg/kg)**	**Does 95% UCL Exceed Screening Value?**	**Number of Outliers Exceeding Screening Value**
Boron	mg/kg	63	<0.5	69.8	13.86	8	WS4 (69.8), BH8 (49.3), WS6 (18.8), BH6 (46), WS5 (27), WS3A (26.2), WS4 (23.4), WS-Z1-19 (14.6 at 3m)	240,000*	No	0
Arsenic	mg/kg	66	4.2	32.7	15.66	3	TP1001 (32.7), WS-Z1-19 (32.3 at 3m), BH-Z1-09 (28.8 at 5m)	640*	No	0
Cadmium	mg/kg	66	<0.1	1.1	0.36	2	WS-Z1-18 (1.1 at 0.5m), BH-Z1-31 (1.03 at 0.75m)	190*	No	0
Chromium	mg/kg	66	14.4	81.1	42.54	5	BH-Z1-31 (81.1 at 3.0m), WS4 (75.8), WS4 (72), WS-Z1-18 (68.7 at 0.5m), WS-Z1-37 (67.4 at 0.6m)	8,600*	No	0
Copper	mg/kg	66	2.6	1,405	137.24	2	WS-Z1-16 (1405 at 0.5m), HP-Z1-11 (299.5 at 0.3m)	68,000*	No	0
Lead	mg/kg	66	<1	539.5	90.81	5	BH-Z1-31 (539.5 at 0.75m), WS-Z1-18 (459.8 at 0.5m), HP-Z1-42 (151.4 at 0.3m), BH-Z1-09 (104.2 at 2.0m), BH2021NE (91.2)	2,300~	No	0
Mercury	mg/kg	66	<0.02	0.82	0.17	6	WS-Z1-18 (0.82 at 0.5m), HP-Z1-11 (0.32 at 0.3m), BH-Z1-31 (0.25 at 0.75m), HP-Z1-42 (0.2 at 0.3m), TP1001 (0.2), BH8 (0.17)	1,100*	No	0
Nickel	mg/kg	66	5.6	196.8	40.75	1	WS-Z1-18 (196.8 at 0.5m)	980*	No	0
Selenium	mg/kg	66	<0.5	5.6	0.92	4	WS-Z1-18 (2 at 0.5m), BH-Z1-09 (1.3 at 2.0m), WS-Z1-18 (1.2 at 2.0m), TP1001 (5.6)	12,000*	No	0
Vanadium	mg/kg	70	8.2	368.1	84.80	2	WS-Z1-18 (368.1 at 0.5m), WS-Z1-17 (236.1 at 0.6m)	9,000*	No	0
Zinc	mg/kg	66	17.8	3,527	429.14	9	WS-Z1-18 (3527 at 0.5m), BH2021NE (1060), BH-Z1-31 (804.3 at 0.75m), WS-Z1-27 (598.4 at 0.5m), WS-Z1-15 (576 at 0.5m), HP-Z1-39 (448.2 at 0.2m), BH2021NW (394.9), WS-Z1-30 (307.9 at 0.75m), HP-Z1-11 (203.1 at 0.3m)	730,000*	No	0
Barium	mg/kg	10	12	149	87.25	0	-	22,000#	-	-
Beryllium	mg/kg	10	<0.5	4	2.55	1	TP1001 (4)	12*	No	0
pH	pH Units	64	5.6	11.9	-	-	-	-	-	-
Cyanide (free) as CN	mg/kg	2	<0.5	<0.5	-	-	-	-	-	-
Cyanide (total) as CN	mg/kg	2	<0.5	<0.5	-	-	-	-	-	-

* LQM Suitable 4 Use Level (S4UL)
~ Category 4 Screening Level (C4SL)
# CL:AIRE GAC

Table 2 Inorganics - Zone 2

Zone 2 - All Ground Investigation Data										
Determinand	**Units**	**No. Samples**	**Min**	**Max**	**95% UCL (incl. outliers)**	**No. Outliers**	**Location of Outliers**	**Screening Value Commercial (mg/kg)**	**Does 95% UCL Exceed Screening Value?**	**Number of Outliers Exceeding Screening Value**
Boron	mg/kg	17	<0.5	48.6	22.98	2	WS8 (48.6), BH5 (43.6)	240,000*	No	0
Arsenic	mg/kg	15	4.9	20.3	17.85	0	-	640*	No	0
Cadmium	mg/kg	15	<0.1	0.36	0.32	0	-	190*	No	0
Chromium	mg/kg	15	6.5	53.9	32.98	0	-	8,600*	No	0
Copper	mg/kg	15	4.1	48.6	35.29	0	-	68,000*	No	0
Lead	mg/kg	15	3.3	239.5	102.41	1	TP-Z2-05 (239.5 at 0.5m)	2,300~	No	0
Mercury	mg/kg	15	<0.1	0.15	0.12	1	TP-Z2-05 (0.15 at 0.5m)	1,100*	No	0
Nickel	mg/kg	15	10.1	122.4	63.30	1	TP-Z2-09 (122.4 at 2.5m)	980*	No	0
Selenium	mg/kg	15	<0.5	3.3	1.60	2	HP-Z2-13 (3.3 at 0.15m), TP-Z2-07 (1.1 at 0.1m)	12,000*	No	0
Vanadium	mg/kg	15	11.9	333.2	158.50	1	HP-Z2-13 (116 at 0.15m)	9,000*	No	0
Zinc	mg/kg	15	19.8	138.5	91.22	0	-	730,000*	No	0
Barium	mg/kg	2	77.6	91	-	-	-	22,000#	-	-
Beryllium	mg/kg	2	0.7	0.8	-	-	-	12*	-	-
pH	pH Units	16	7.1	9.1	-	-	-	-	-	-
Cyanide (free) as CN	mg/kg	1	<0.5	<0.5	-	-	-	-	-	-
Cyanide (total) as CN	mg/kg	1	<0.5	<0.5	-	-	-	-	-	-

* LQM Suitable 4 Use Level (S4UL)
~ Category 4 Screening Level (C4SL)
# CL:AIRE GAC

Table 3 Inorganics - Zone 3

Zone 3 - Ground Investigation Data										
Determinand	**Units**	**No. Samples**	**Min**	**Max**	**95% UCL (incl. outliers)**	**No. Outliers**	**Location of Outliers**	**Screening Value Commercial (mg/kg)**	**Does 95% UCL Exceed Screening Value?**	**Number of Outliers Exceeding Screening Value**
Boron	mg/kg	71	<0.5	73.9	15.29	9	BHOBH3 (73.9), BHOBH5 (59.2), BHOBH4 (59.3),TP-Z3-28 (42.4 at 0.75m), BHOBHJ2A (24.9), BHOBH1 (24.5), WS1 (23.5), TP-Z3-20 (16 at 3.5m & 15.7 at 1m)	240,000*	No	0
Arsenic	mg/kg	71	1.4	39.1	17.44	2	TP-Z3-20 (39.1 at 3.5m), BH-Z3-40 (38.9 at 1.2m)	640*	No	0
Cadmium	mg/kg	71	<0.1	8.9	1.11	4	BHOBH1 (8.9), HP-Z3-04 (4.59 at 0.5m), BH-Z3-18 (1.55 at 0.3m), TP-Z3-20 (1.41 at 0.4m)	190*	No	0
Chromium	mg/kg	71	12.7	61.7	37.50	0	-	8,600*	No	0
Copper	mg/kg	71	6.1	106.1	29.23	14	WS1 (106.1), BHOBH1 (73.8), BHOBH2A (66.7), HP-Z3-04 (60.3 at 0.5m), HP-Z3-S$ (48.9 @ 0.1m), HP-Z3-39 (46.9 @ 0.2m), TP-Z3-22 (44.7 @ 0.4m), TP-Z3-20 (42.5 @ 0.4m), WS-Z3-35 (39.8 @ 1.3m), BH-Z3-40 (36.3 @ 1.2m), TP-Z3-19 (35.3 @ 0.3m), TP-Z3-28 (30.2 @ 0.75m), WS-Z3-23 (29.1 @ 0.6m)	68,000*	No	0
Lead	mg/kg	71	2.7	745.2	126.53	10	WS-Z3-07 (745.2 at 3m), WS-Z3-23 (529 at 0.6m), BHOBH1 (435.5), BH-Z3-18 (256.4 at 0.3m), HP-Z3-04 (211 at 0.5m), TP1124 (170), WS-Z3-08 (136.4 at 0.5m), WS-Z3-26 (125 at 0m), TP-Z3-38 (120.5 at 0.1m), BHOBH2A (110.8)	2,300~	No	0
Mercury	mg/kg	71	<0.1	0.52	0.16	7	BHOBH1 (0.52), BHOBH2A (0.4), TP-Z3-28 (0.36 at 0.75m), HP-Z3-04 (0.25 at 0.5m), TP-Z3-20 (0.24 at at 1m), TP11224 (0.18), TP-Z3-16 (0.17 @ 0.4m)	1,100*	No	0
Nickel	mg/kg	71	14.1	136.4	36.62	5	WS1 (136.4), TP-Z3-20 (60.7 at 0.4m), TP-Z3-19 (57.6 at 3.5m), BHOBH1 (53.2), HP-Z3-29 (51.4 at 0.2m)	980*	No	0
Selenium	mg/kg	71	<0.5	3.3	1.00	6	TP-Z3-19 (3.3 at 0.3m), HP-Z3-04 (2.7 at 0.5m), BH-Z3-40 (2.2 at 1.2m), TP-Z3-16 (1.7 @ 0.4m), HP-Z3-29 (1.6 @ 0.2m), HP-Z3-03 (1.4 @ 0.1m)	12,000*	No	0
Vanadium	mg/kg	77	5	384.3	82.05	3	WS1 (384.3), HP-Z3-29 (175.1 at 0.2m), TP-Z3-20 (145.9 at 0.4m)	9,000*	No	0
Zinc	mg/kg	71	14.4	500.5	127.46	4	HP-Z3-34 (500.5 at 0.1m), TP-Z3-20 (420.4 at 0.4m), BHOBH1 (251.6), HP-Z3-03 (249.5 at 0.1m)	730,000*	No	0
Barium	mg/kg	8	20	356	218.13	0	-	22,000#	No	-
Beryllium	mg/kg	8	<0.5	2	1.67	1	TP1124 (2)	12*	No	0
pH	pH Units	71	4.7	9.1	-	-	-	-	-	-
Cyanide (free) as CN	mg/kg	1	<0.5	<0.5	-	-	-	-	-	-
Cyanide (total) as CN	mg/kg	1	<0.5	<0.5	-	-	-	-	-	-

* LQM Suitable 4 Use Level (S4UL)
~ Category 4 Screening Level (C4SL)
# CL:AIRE GAC

Table 4 Inorganics - Zone 6

Zone 6 - All Ground Investigation Data										
Determinand	**Units**	**No. Samples**	**Min**	**Max**	**95% UCL (incl. outliers)**	**No. Outliers**	**Location of Outliers**	**Screening Value Commercial (mg/kg)**	**Does 95% UCL Exceed Screening Value?**	**Number of Outliers Exceeding Screening Value**
Boron	mg/kg	11	<0.5	57.4	30.79	2	WS7 (57.4), BH9 (15.6)	240,000*	No	0
Arsenic	mg/kg	12	2.6	24.1	19.79	0	-	640*	No	0
Cadmium	mg/kg	12	<0.1	0.78	0.83	0	-	190*	No	0
Chromium	mg/kg	12	21.2	89.2	65.77	2	WS7 (89.2)WS-Z6-01 (78.3 at 0.75m)	8,600*	No	0
Copper	mg/kg	12	6.2	171.7	92.26	2	HP-Z6-05 (171.7 at 0.75m), WS-Z6-09 (63.3 at 0.5m)	68,000*	No	0
Lead	mg/kg	12	10.8	354.5	198.59	1	HP-Z6-05 (354.5 at 0.75m)	2,300~	No	0
Mercury	mg/kg	12	<0.1	38.2	17.18	2	WS7)38.2), HP-Z6-05 (0.96 at 0.75m)	1,100*	No	0
Nickel	mg/kg	12	14	70	52.1	3	HP-Z6-05 (70 at 0.75m), C1011 (51.3), WS-Z6-09 (0.5m)	980*	No	0
Selenium	mg/kg	12	<0.5	1.9	1.54	0	-	12,000*	No	0
Vanadium	mg/kg	12	25	125.4	85.42	1	WS-Z6-01 (125.4 at 0.75m)	9,000*	No	0
Zinc	mg/kg	12	42.4	7,982	4205.42	2	HP-Z6-05 (7982 at 0.75), WS-Z6-09 (2471 at 0.5m)	730,000*	No	0
Barium	mg/kg	3	38	86.2	-	-	-	22,000#	-	-
Beryllium	mg/kg	3	<0.5	2	-	-	-	12*	-	-
pH	pH Units	12	7.4	11	-	-	-	-	-	-

* LQM Suitable 4 Use Level (S4UL)
~ Category 4 Screening Level (C4SL)
# CL:AIRE GAC

Table 5 Inorganics - Zone 8

Zone 8 - All Ground Investigation Data										
Determinand	**Units**	**No. Samples**	**Min**	**Max**	**95% UCL (incl. outliers)**	**No. Outliers**	**Location of Outliers**	**Screening Value Commercial (mg/kg)**	**Does 95% UCL Exceed Screening Value?**	**Number of Outliers Exceeding Screening Value**
Boron	mg/kg	36	<0.5	27.8	6.39	4	BH19 (27.8), TP7 (21.1), BH10 (18.8)TP-Z8-07 (16.3 at 1.0m)	240,000*	No	0
Arsenic	mg/kg	39	5.3	56.1	27.09	2	BH10 (56.1), TP-Z8-04 (53.4 at 2.2m)	640*	No	0
Cadmium	mg/kg	39	0.13	2.19	0.88	2	TP-Z8-07 (2.19 at 1.0m), TP-Z8-15 (2.13 at 3.0m)	190*	No	0
Chromium	mg/kg	39	14.9	138.3	48.12	2	TP-Z8-15 (138.3 at 3.0m), TP-Z8-04 (66.4 at 2.2m)	8,600*	No	0
Copper	mg/kg	39	8.4	262.5	95	1	TP-Z8-04 (262.5 at 2.2m)	68,000*	No	0
Lead	mg/kg	39	6.2	318.8	119.06	8	TP-Z8-01 (318.8 at 3.5m), TP-Z8-15 (256.9 at 3.0m), BH-Z8-08 (248.2 at 5.0m), TP-Z8-16 (215.1 at 3.0m), TP-Z8-07 (167.5 at 1.0m), BH-Z8-09 (144.6 at 1.5m), TP-Z8-04 (121.2 at 2.2m), WS-Z8-17 (96.9 at 2.0m)	2,300~	No	0
Mercury	mg/kg	39	<0.1	0.72	0.27	6	TP-Z8-01 (0.72 at 3.5m), TP-Z8-07 (0.6 at 1.0m), BH-Z8-08 (0.49 at 5.0m), TP-Z8-04 (0.4 at 2.2m), TP-Z8-15 (0.38 at 3.0m), BH10 (0.34)	1,100*	No	0
Nickel	mg/kg	39	10	2,668	490.52	5	TP-Z8-07 (2668 at 1.0m), TP-Z8-15 (1523 at 3.0m), WS-Z8-11 (298 at 1.5m), TP-Z8-04 (191.4 at 2.2m), WS-Z8-12 (179.5 at 0.8m)	980*	No	2
Selenium	mg/kg	39	<0.5	4.3	1.88	1	BH-Z8-10 (4.3 at 1.0m)	12,000*	No	0
Vanadium	mg/kg	39	20.8	10,880	1,997.92	2	TP-Z8-07 (10880 at 1.0m), TP-Z8-15 (7457 at 3.0m)	9,000*	No	1
Zinc	mg/kg	39	33	1,196	515.86	0	-	730,000*	No	0
Barium	mg/kg	12	24.9	239	187.34	0	-	22,000#	-	-
Beryllium	mg/kg	12	<0.5	1.82	1.12	1	WS-Z8-12 (1.82 at 2.5m)	12*	No	0
pH	pH Units	34	4.18	10.5	-	-	-	-	-	-
Cyanide (free) as CN	mg/kg	3	<0.5	-	-	-	-	-	-	-
Cyanide (total) as CN	mg/kg	3	<0.5	-	-	-	-	-	-	-

* LQM Suitable 4 Use Level (S4UL)
~ Category 4 Screening Level (C4SL)
# CL:AIRE GAC

Table 6. TPH - Zones 1, 2, 3, 6, 8

		Zone 1						Zone 2						Zone 3						Zone 6						Zone 8					
Determinands	Units	No. Samples	Min	Max	Screening Criteria Commercial (mg/kg)	No. of Exceedances above Screening Criteria	Location of Exceedances	No. Samples	Min	Max	Screening Criteria Commercial (mg/kg)	No. of Exceedances above Screening Criteria	Location of Exceedances	No. Samples	Min	Max	Screening Criteria Commercial (mg/kg)	No. of Exceedances above Screening Criteria	Location of Exceedances	No. Samples	Min	Max	Screening Criteria Commercial (mg/kg)	No. of Exceedances above Screening Criteria	Location of Exceedances	No. Samples	Min	Max	Screening Criteria Commercial (mg/kg)	No. of Exceedances above Screening Criteria	Location of Exceedances
Benzene	mg/kg	59	<0.01	-	27*	0	-	1	<0.01	-	27*	0	-	38	<0.01	0.624	27*	0	-	1	<0.01	-	27*	0	-	6	<0.01	-	27*	0	-
Toluene	mg/kg	59	<0.01	0.15	56,000*	0	-	1	<0.01	-	56,000*	0	-	38	<0.01	3.148	56,000*	0	-	1	<0.01	-	56,000*	0	-	6	<0.01	0.14	56,000*	0	-
Ethylbenzene	mg/kg	59	<0.01	0.015	5,700*	0	-	1	<0.01	-	5,700*	0	-	38	<0.01	2.273	5,700*	0	-	1	<0.01	-	5,700*	0	-	6	<0.01	0.184	5,700*	0	-
mp-Xylene	mg/kg	46	<0.01	0.043	5,900*	0	-	1	<0.01	-	5,900*	0	-	29	<0.01	11.362	5,900*	0	-	1	0.042	-	5,900*	0	-	6	<0.01	0.304	5,900*	0	-
o-Xylene	mg/kg	46	<0.01	0.035	6,600*	0	-	1	<0.01	-	6,600*	0	-	29	<0.01	8.98	6,600*	0	-	1	0.044	-	6,600*	0	-	6	<0.01	0.454	6,600*	0	-
Xylenes	mg/kg	13	<0.02	1.15	5,900*	0	-	-	-	-	-	-	-	9	<0.01	0.55	5,900*	0	-	-	-	-	-	-	-	-	-	-	-	-	-
MTBE	ug/kg	25	<20	-	-	-	-	-	-	-	-	-	-	29	<20	-	-	-	-	1	<20	-	-	-	-	6	<20	-	-	-	-
C5 - C6	mg/kg	59	<0.2	-	3,200*	0	-	1	<0.2	-	3,200*	0	-	38	<0.2	0.3	3,200*	0	-	1	<0.2	-	3,200*	0	-	6	<0.2	-	3,200*	0	-
>C6 - C7	mg/kg	59	<0.2	-	7,800*	0	-	1	<0.2	-	7,800*	0	-	38	<0.2	0.5	7,800*	0	-	1	<0.2	-	7,800*	0	-	6	<0.2	-	7,800*	0	-
>C7 - C8	mg/kg	59	<0.2	0.07	7,800*	0	-	1	<0.2	-	7,800*	0	-	38	<0.2	10.2	7,800*	0	-	1	<0.2	-	7,800*	0	-	6	<0.2	0.6	7,800*	0	-
>C8 - C10	mg/kg	124	<0.2	17,900	2,000*	1	WS-Z1-34 at 0.3 - 0.5m	15	<0.2	17.3	2,000*	0	-	113	<0.2	739	2,000*	0	-	10	<0.2	15.2	2,000*	0	-	34	<0.2	17.9	2,000*	0	-
>C10 - C12	mg/kg	65	<2	199	9,700*	0	-	14	<2	27.6	9,700*	0	-	74	<2	2,060	9,700*	0	-	9	<2	-	9,700*	0	-	28	<2	105	9,700*	0	-
>C12 - C16	mg/kg	65	<2	131	36,000*	0	-	14	<2	122	36,000*	0	-	74	<2	8,250	36,000*	0	-	9	<2	6.7	36,000*	0	-	28	<2	454	36,000*	0	-
>C16 - C21	mg/kg	65	<2	765	28,000*	0	-	14	<2	227	28,000*	0	-	74	<2	25,000	28,000*	0	-	9	<2	174	28,000*	0	-	28	<2	1,220	28,000*	0	-
>C21 - C35	mg/kg	65	<4.38	3,140	28,000*	0	-	14	<4.38	752	28,000*	0	-	74	<4.38	53,100	28,000*	3	TP-Z3-21 at 0.65m TP-Z3-31 at 0.2m WS-Z3-26 at 0.0m	9	<4.38	397	28,000*	0	-	28	<4.38	13,200	28,000*	0	-
Aliphatics >C8 - C10	mg/kg	59	<4	68.6	2,000*	0	-	-	-	-	2,000*	0	-	38	<4	469	2,000*	0	-	1	11.5	-	2,000*	0	-	6	<4	-	2,000*	0	-
Aliphatics >C10 - C12	mg/kg	59	<4	552	9,700*	0	-	-	-	-	9,700*	0	-	38	<4	2,410	9,700*	0	-	1	116	-	9,700*	0	-	6	<4	7.78	9,700*	0	-
Aliphatics >C12 - C16	mg/kg	59	<4	3,780	59,000*	0	-	-	-	-	59,000*	0	-	38	<4	5,390	59,000*	0	-	1	765	-	59,000*	0	-	6	<4	70.2	59,000*	0	-
Aliphatics >C16 - C21	mg/kg	46	<4	214	1,600,000*	0	-	-	-	-	1,600,000*	0	-	29	<4	8,270	1,600,000*	0	-	1	773	-	1,600,000*	0	-	6	<4	1,680	1,600,000*	0	-
Aliphatics >C16 - C35	mg/kg	13	14.9	14,200	1,600,000*	0	-							9	<11.9	555	1,600,000*	0	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatics >C21 - C35	mg/kg	46	<8.76	4,480	1,600,000*	0	-	-	-	-	1,600,000*	0	-	29	<8.76	22,700	1,600,000*	0	-	1	3,020	-	1,600,000*	0	-	6	<8.76	5,480	1,600,000*	0	-
Aliphatics >C35 - C44	mg/kg	13	22.5	18,600	1,600,000*	0	-	-	-	-	-	-	-	9	<5.62	38.2	1,600,000*	0	-	-	-	-	-	-	-	-	-	-	-	-	-
Aliphatics >C8 - C40	mg/kg	46	<20	5,430	-	-	-	-	-	-	-	-	-	29	<20	41,300	-	-	-	1	5,720	-	-	-	-	6	<20	9,400	-	-	-
Aromatics >C8 - C10	mg/kg	59	<4	-	3,500*	0	-	-	-	-	3,500*	0	-	29	<4	397	3,500*	0	-	1	4.61	-	3,500*	0	-	6	<4	-	3,500*	0	-
Aromatics >C10 - C12	mg/kg	59	<4	7.1	16,000*	0	-	-	-	-	16,000*	0	-	29	<4	2,020	16,000*	0	-	1	71.5	-	16,000*	0	-	6	<4	77.9	16,000*	0	-
Aromatics >C12 - C16	mg/kg	59	<4	142	36,000*	0	-	-	-	-	36,000*	0	-	29	<4	10,400	36,000*	0	-	1	652	-	36,000*	0	-	6	<4	190	36,000*	0	-
Aromatics >C16 - C21	mg/kg	59	<4	325	28,000*	0	-	-	-	-	28,000*	0	-	29	<4	13,500	28,000*	0	-	1	573	-	28,000*	0	-	6	<4	474	28,000*	0	-
Aromatics >C21 - C35	mg/kg	59	<8.76	2,050	28,000*	0	-	-	-	-	28,000*	0	-	29	<8.76	41,100	28,000*	2	WS-Z3-26 at 0.0-0.15m WS-Z3-51 at 0.2m	1	2,850	-	28,000*	0	-	6	<8.76	2,070	28,000*	0	-
Aromatics >C35 - C44	mg/kg	13	<20	14,800	28,000*	0	-							9	9.5	333	28,000*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aromatics >C8 - C40	mg/kg	46	<20	2,360	-	-	-	-	-	-	-	-	-	29	<20	57,800	-	-	-	1	5,180	-	-	-	-	6	<20	3,420	-	-	-
Total TPH	mg/kg	20	<1	1,140	-	-	-	-	-	-	-	-	-	8	<1	1,270	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* LQM Suitable 4 Use Level (S4UL) assuming a Soil Organic Matter Content of 1%
Note: BTEX compounds from BTEX suite only

Table 7. PAHs - Zones 1, 2, 3, 6, 8

		Zone 1						Zone 2						Zone 3						Zone 6						Zone 8					
Determinands	Units	No. Samples	Min	Max	Screening Criteria Commercial (mg/kg)	No. of Exceedances above Screening Criteria	Location of Exceedances	No. Samples	Min	Max	Screening Criteria Commercial (mg/kg)	No. of Exceedances above Screening Criteria	Location of Exceedances	No. Samples	Min	Max	Screening Criteria Commercial (mg/kg)	No. of Exceedances above Screening Criteria	Location of Exceedances	No. Samples	Min	Max	Screening Criteria Commercial (mg/kg)	No. of Exceedances above Screening Criteria	Location of Exceedances	No. Samples	Min	Max	Screening Criteria Commercial (mg/kg)	No. of Exceedances above Screening Criteria	Location of Exceedances
Naphthalene	mg/kg	236	<0.08	1.17	190*	0	-	37	<0.08	11.4	190*	0	-	254	<0.08	90.5	190*	0	-	13	<0.08	18.7	190*	0	-	86	<0.08	3.4	190*	0	-
Acenaphthylene	mg/kg	195	<0.08	0.67	83,000*	0	-	27	<0.08	2	83,000*	0	-	186	<0.08	16.4	83,000*	0	-	11	<0.08	0.83	83,000*	0	-	59	<0.08	0.25	83,000*	0	-
Acenaphthene	mg/kg	195	<0.08	5.27	84,000*	0	-	27	<0.08	17.3	84,000*	0	-	186	<0.08	46.9	84,000*	0	-	11	<0.08	17.3	84,000*	0	-	59	<0.08	0.52	84,000*	0	-
Fluorene	mg/kg	195	<0.08	8	63,000*	0	-	27	<0.08	20.6	63,000*	0	-	186	<0.08	46.3	63,000*	0	-	11	<0.08	9.11	63,000*	0	-	59	<0.08	0.44	63,000*	0	-
Phenanthrene	mg/kg	195	<0.08	41.4	22,000*	0	-	27	<0.08	112	22,000*	0	-	186	<0.08	68.2	22,000*	0	-	11	<0.08	14.8	22,000*	0	-	59	<0.08	3.2	22,000*	0	-
Anthracene	mg/kg	195	<0.08	11.8	520,000*	0	-	27	<0.08	41.3	520,000*	0	-	186	<0.08	24	520,000*	0	-	11	<0.08	4.38	520,000*	0	-	59	<0.08	2.2	520,000*	0	-
Fluoranthene	mg/kg	195	<0.08	31.9	23,000*	0	-	27	<0.08	126	23,000*	0	-	186	<0.08	13.2	23,000*	0	-	11	<0.08	6.15	23,000*	0	-	59	<0.08	1.9	23,000*	0	-
Pyrene	mg/kg	195	<0.08	23.1	54,000*	0	-	27	<0.08	102	54,000*	0	-	186	<0.08	67.5	54,000*	0	-	11	<0.08	4.62	54,000*	0	-	59	<0.08	2.2	54,000*	0	-
Benzo[a]anthracene	mg/kg	195	<0.08	11.8	170*	0	-	27	<0.08	57.6	170*	0	-	186	<0.08	40.7	170*	0	-	11	<0.08	1.42	170*	0	-	59	<0.08	1	170*	0	-
Chrysene	mg/kg	195	<0.08	9.46	350*	0	-	27	<0.08	51.7	350*	0	-	186	<0.08	77.7	350*	0	-	11	<0.08	1.27	350*	0	-	59	<0.08	1.2	350*	0	-
Benzo[b]fluoranthene	mg/kg	195	<0.08	9.74	44*	0	-	27	<0.08	45.3	44*	0	-	186	<0.08	13.5	44*	0	-	11	<0.08	1.15	44*	0	-	59	<0.08	1.3	44*	0	-
Benzo[k]fluoranthene	mg/kg	195	<0.08	3.59	1,200*	0	-	27	<0.08	22.3	1,200*	0	-	186	<0.08	2.23	1,200*	0	-	11	<0.08	0.45	1,200*	0	-	59	<0.08	0.4	1,200*	0	-
Benzo[a]pyrene	mg/kg	195	<0.08	7.66	35*	0	-	27	<0.08	38.9	35*	1	TP-Z2-05 at 0.5m	186	<0.08	26	35*	0	-	11	<0.08	1.08	35*	0	-	59	<0.08	1.7	35*	0	-
Indeno[1,2,3-cd]pyrene	mg/kg	195	<0.08	5.76	500*	0	-	27	<0.08	22.2	500*	0	-	186	<0.08	7.33	500*	0	-	11	<0.08	0.77	500*	0	-	59	<0.08	1	500*	0	-
Dibenzo[a,h]anthracene	mg/kg	195	<0.08	1.14	3.5*	0	-	27	<0.08	2.2	3.5*	0	-	186	<0.08	8.11	3.5*	2	WS-Z3-51 at 0.2m HP-Z3-55 at 0.3m	11	<0.08	0.25	3.5*	0	-	59	<0.08	0.3	3.5*	0	-
Benzo[g,h,i]perylen	mg/kg	195	<0.08	3.81	3,900*	0	-	27	<0.08	19.3	3,900*	0	-	186	<0.08	16.7	3,900*	0	-	11	<0.08	1.08	3,900*	0	-	59	<0.08	1.4	3,900*	0	-

* LQM Suitable 4 Use Level (S4UL) assuming a Soil Organic Matter Content of 1%

Table 8. VOCs and SVOCs - Zones 1, 2, 3, 6, 8

			Zone 1					Zone 2					Zone 3					Zone 6					Zone 8				
Determinands	Units	GAC/SGV Commercial	No. Samples >LoD	Min	Max	No. of Exceedances above Screening Criteria	Location of Exceedances	No. Samples >LoD	Min	Max	No. of Exceedances above Screening Criteria	Location of Exceedances	No. Samples >LoD	Min	Max	No. of Exceedances above Screening Criteria	Location of Exceedances	No. Samples >LoD	Min	Max	No. of Exceedances above Screening Criteria	Location of Exceedances	No. Samples >LoD	Min	Max	No. of Exceedances above Screening Criteria	Location of Exceedances
1,2,4 Trimethylbenzene	ug/kg	42,000#	1	2	-	0	-	-	-	-	-	-	14	1	24,600	0	-	1	412	-	0	-	6	1	36	0	-
Benzene	ug/kg	27,000*	1	2	-	0	-	2	1	2	0	-	3	1	105	0	-	-	-	-	-	-	10	1	10	0	-
Hexachlorobutadiene	ug/kg	31,000*	2	4	5	0	-	1	3	-	0	-	-	-	-	-	-	-	-	-	-	-	3	2	4	0	-
n-Butylbenzene	ug/kg	-	1	12	-	-	-	-	-	-	-	-	8	26	4,510	-	-	1	59	-	-	-	1	27	-	-	-
sec-Butlybenzene	ug/kg	-	1	12	-	-	-	-	-	-	-	-	10	2	945	-	-	1	33	-	-	-	2	11	36	-	-
Tetrachloroethene	ug/kg	19,000*	2	5	6	0	-	1	3	-	0	-	4	3	11	0	-	1	26	-	0	-	3	3	6	0	-
Toluene	ug/kg	56,000,000*	7	6	39	0	-	-	-	-	-	-	7	5	651	0	-	-	-	-	-	-	5	10	23	0	-
Trichloroethene	ug/kg	1,200*	2	1	2	0	-	-	-	-	-	-	1	2	-	0	-	-	-	-	-	-	2	2	5	0	-
Chloromethane	ug/kg	1,000#	1	10	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	15	-	-	-
1,1,2,2, Tetrachloroethane	ug/kg	270,000*	-	-	-	-	-	-	-	-	-	-	6	21	1,220	0	-	-	-	-	-	-	-	-	-	-	-
1,1,2 Trichloroethane	ug/kg	94,000#	-	-	-	-	-	-	-	-	-	-	1	15	-	0	-	-	-	-	-	-	-	-	-	-	-
1,2,3 Trichlorobenzene	ug/kg	102,000*	-	-	-	-	-	-	-	-	-	-	1	4	-	0	-	-	-	-	-	-	-	-	-	-	-
1,2,4 Trichlorobenzene	ug/kg	220,000*	-	-	-	-	-	-	-	-	-	-	1	4	-	0	-	-	-	-	-	-	-	-	-	-	-
1,2 Dichlorobenzene	ug/kg	2,000,000*	-	-	-	-	-	-	-	-	-	-	2	1	246	0	-	-	-	-	-	-	-	-	-	-	-
1,3,5 Trimethylbenzene	ug/kg	-	-	-	-	-	-	-	-	-	-	-	8	2	6,170	-	-	1	129	-	-	-	3	5	62	-	-
1,4 Dichlorobenzene	ug/kg	4,400,000*	-	-	-	-	-	-	-	-	-	-	2	2	306	0	-	-	-	-	-	-	-	-	-	-	-
1,3 Dichlorobenzene	ug/kg	30,000*	-	-	-	-	-	-	-	-	-	-	2	1	325	0	-	-	-	-	-	-	-	-	-	-	-
p-Isopropyltoluene	ug/kg	-	-	-	-	-	-	-	-	-	-	-	9	9	1,970	-	-	1	44	-	-	-	3	23	34	-	-
Chlorobenzene	ug/kg	56,000*	-	-	-	-	-	-	-	-	-	-	2	21	26	0	-	-	-	-	-	-	-	-	-	0	-
Chloroform	ug/kg	99,000*	-	-	-	-	-	-	-	-	-	-	1	2	-	0	-	-	-	-	-	-	1	9	-	0	-
Ethylbenzene	ug/kg	5,700,000*	-	-	-	-	-	-	-	-	-	-	11	4	2,040	0	-	1	12	-	0	-	4	3	23	0	-
iso-Propylbenzene	ug/kg	1,400,000#	-	-	-	-	-	-	-	-	-	-	4	17	1,210	0	-	1	16	-	0	-	2	2	8	0	-
mp-Xylene	ug/kg	5,900,000*	-	-	-	-	-	-	-	-	-	-	9	12	7,830	0	-	1	40	-	0	-	7	8	43	0	-
0-Xylene	ug/kg	6,600,000*	-	-	-	-	-	-	-	-	-	-	11	5	7,000	0	-	1	28	-	0	-	6	3	42	0	-
Propylbenzene	ug/kg	4,100,000#	-	-	-	-	-	-	-	-	-	-	9	2	2,710	0	-	1	32	-	0	-	1	12	-	0	-
tert-Butylbenzene	ug/kg	-	-	-	-	-	-	-	-	-	-	-	3	7	150	-	-	-	-	-	-	-	-	-	-	-	-
Trichlorofluoromethane	ug/kg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	8	-	-	-
1,1,1 Trichloroethane	ug/kg	660,000*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	7	-	0	-
1,1 Dichloroethane	ug/kg	280,000#	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5	-	0	-
Dichloromethane	ug/kg	270,000#	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	12	-	0	-
Styrene	ug/kg	3,300,000#	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	7	-	0	-
bis(2-Ethylhexyl)phthalate	mg/kg	85,000,000#	1	0.5	-	0	-	-	-	-	-	-	-	-	-	-	-				-	-	3	0.5	6.6	0	-
1-Methylnapthalene	mg/kg	-	1	0.2	-	-	-	4	0.5	15.4	-	-	7	0.2	86	-	-	1	25.4	-	-	-	8	0.7	4	-	-
2-Methylnapthalene	mg/kg	-	-	-	-	-	-	4	0.6	22.7	-	-	6	0.3	107	-	-	1	25.7	-	-	-	8	0.5	4.6	-	-
4-Chloroaniline	mg/kg	-	-	-	-	-	-	1	1.2	-	-	-	2	24.1	69.9	-	-	-	-	-	-	-	1	2.2	-	-	-
Biphenyl	mg/kg	-	-	-	-	-	-	2	2.1	2.2	-	-	2	10.1	30.2	-	-	-	-	-	-	-	2	0.3	0.9	-	-
Dibenzofuran	mg/kg	-	-	-	-	-	-	2	5.7	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0.7	1	-	-

* LQM Suitable 4 Use Level (S4UL) assuming a Soil Organic Matter Content of 1%
\# CL:AIRE GAC assuming a Soil Organic Matter Content of 1%
Note: Table above excludes PAHs as these have been included within Table 3. BTEX compounds are from VOC suite only

Table 9. PCBs and Phenol - Zones 1, 2, 3, 6, 8

			Zone 1					Zone 2					Zone 3					Zone 6					Zone 8				
Determinands	Units	SGV Commercial	No. Samples >LoD	Min	Max	No. of Exceedances above SGV	Location of Exceedances	No. Samples >LoD	Min	Max	No. of Exceedances above SGV	Location of Exceedances	No. Samples >LoD	Min	Max	No. of Exceedances above SGV	Location of Exceedances	No. Samples >LoD	Min	Max	No. of Exceedances above SGV	Location of Exceedances	No. Samples >LoD	Min	Max	No. of Exceedances above SGV	Location of Exceedances
Total PCBs	ug/kg	240	6	6.5	214.3	0	-	1	5.5	-	0	-	1	8.1	-	0	-	1	108.9	-	0	-	10	5.1	1521.7	1	TP-Z8-01 at 3.5m
Phenol	mg/kg	440	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.7	-	0	-

Appendix B

Remedial Options Appraisal

Remediation Option	Assessment	Feasibility for Remediation Option for HFO Contaminated Soils (CSL Z3.12 for EP surrender)	Feasibility of Remediation Option for Residual Hydrocarbon Contaminated Soils (CSLs Z1.10, Z1.12, Z1.18, Z1.25, Z1.26 and Z3.17 for EP surrender and Z3.1 and WS-Z1-34 for site redevelopment)	Feasibility for Asbestos Contaminated Soils (Zone 6 for site redevelopment)
Thermal Desorption.	**Effectiveness:** Can result in up to 99% contaminant mass reduction. **Timescales:** Relatively quick process (Potentially around 8 weeks treatment, not including excavation and backfilling). **Cost:** Marginally more expensive than bioremediation and disposal to landfill option. **Durability:** Permanent. **Commercial Availability**: Widely available. **Track record**: Proven track record with refinery sludges and hydrocarbon impacted soils. **Environmental Impact:** Treated on-site in dedicated area with vapour off-gas delivered to a dedicated vapour treatment module. Majority of constituents are oxidised or pyrolised into harmless materials (CO_2, carbon and water). **Compatibility:** Soil thermal conductivity varies little and so treatment is effective and predictable regardless of the soil permeability or heterogeneity. **Permissions:** Unknown. **Site Constraints:** Dedicated treatment area required.	Heater wells reach temperatures in excess of 300ºC resulting in an overall temperature rise of the entire treatment zone. As temperatures rise contaminants and water contained in the soil matrix are vaporised. HFO that is solid at normal atmospheric conditions will be effectively heated to molten state and oxidised or pyrolised by heat. A vacuum vapour extraction well collects the vapours driven off by the heating process.	As HFO process. Lighter hydrocarbon fractions will, in particular, be rapidly driven off from the soil matrix as steam distillation occurs within the treatment zone.	N/A for remediation of asbestos
Excavate and Disposal at landfill.	**Effectiveness:** Effectively removes shallow contamination source. **Timescales:** Very quick. **Cost:** Likely to be very expensive as HFO / hydrocarbon / asbestos contaminated soils will likely be classified as hazardous waste. **Durability:** Permanent. **Commercial Availability**: Widely available. **Track record**: Proven track record. **Environmental Impact:** Requires haulage potentially over long distances to hazardous landfill and will require imported fill materials to backfill voids created. Short term dust and odour nuisance may be created during works. **Compatibility:** Addresses all contaminant sources at site so no compatibility issues. **Permissions:** None required. **Site Constraints:** No major issues.	Excavation and disposal quickly and effectively remediates HFO contaminated soils and has a proven track record. HFO contaminated soils are likely to be classified as hazardous waste and will be expensive to dispose of. Will involve significant haulage cost and movements.	Excavation and disposal quickly and effectively remediates hydrocarbon contaminated soils and has a proven track record. Hydrocarbon contaminated soils are likely to be classified as hazardous waste and will be expensive to dispose of. Will involve significant haulage cost and movements	Excavation and disposal quickly and effectively remediates asbestos contaminated soils and has a proven track record. Asbestos contaminated soils are likely to be classified as hazardous waste and will be expensive to dispose of. Will involve significant haulage cost and movements
Ex-situ Bioremediation (biopiles, bioventing etc).	**Effectiveness:** Effectively remediates a wide range of hydrocarbons although cohesive soils may require additional processing. Effectiveness on HFO contaminated soils is unknown, but possible that bioremediation may reduce volume of contamination within soils **Timescales:** Likely to lead to extended periods of treatment. **Cost:** Can be considered as a cost effective solution if sufficient volumes of soil require remediation. **Durability:** Permanent. **Commercial Availability:** Bioremediation as a remediation technique is widely available. **Track record:** Bioremediation as a remediation technique has a proven track record in the UK. **Environmental Impact:** Produces greenhouse gases as part of process. May create ongoing odour and dust nuisance. **Compatibility:** Likely to be compatible with hydrocarbon contaminants present within the soil. Pilot trials may be required for longer chained hydrocarbons and HFO contaminated soils **Permissions:** Mobile Treatment Licence may be required for certain techniques. **Site Constraints:** No major issues due to potential amount of land available to place soils for remediation	The effectiveness of bioremediation of HFO contaminated soils is relatively unknown. It is possible however that bioremediation may reduce the volume of contamination within the soils, with the residual soils requiring application of a secondary remedial technique. Pilot trials will be required to establish effectiveness of bioremediation on HFO contaminated soils. Bioremediation likely leads to extended periods of treatment.	Bioremediation of hydrocarbon contaminated soils is an effective and proven remedial technique in the UK. Bioremediation is considered a cost effective technique where large volumes of soil require remediation. Pilot trials will likely be required for longer chained hydrocarbons. Bioremediation likely leads to extended periods of treatment.	N/A for remediation of asbestos

Remediation Option	Assessment	Feasibility for Remediation Option for HFO Contaminated Soils (CSL Z3.12 for EP surrender)	Feasibility of Remediation Option for Residual Hydrocarbon Contaminated Soils (CSLs Z1.10, Z1.12, Z1.18, Z1.25, Z1.26 and Z3.17 for EP surrender and Z3.1 and WS-Z1-34 for site redevelopment)	Feasibility for Asbestos Contaminated Soils (Zone 6 for site redevelopment)
Soil Flushing	**Effectiveness:** Unlikely to be effective due to cohesive nature of shallow soils and the solid state of HFO in normal atmospheric conditions **Timescales:** Likely to lead to extended periods of treatment, depending on effectiveness and flush recovery. **Cost:** Cohesive nature of soils will likely increase treatment time, increasing costs therefore likely to be expensive. **Durability:** Permanent. **Commercial Availability**: Not commonly used in the UK. **Track record**: Has been successfully applied in the USA, but very dependant upon site conditions. **Environmental Impact**: May result in dispersion of contamination into saturated zone if extraction wells not positioned correctly. **Compatibility**: Likely to be compatible with hydrocarbons present within the shallow soils, but cohesive soils will limit effectiveness. Unlikely to be suitable for HFO **Permissions**: Discharge consent may be required to disposed of recovered flush effluent **Site Constraints:** No major issues	Soil flushing is unlikely to be effective for the remediation of HFO contaminated soils due to the solid state of HFO under normal atmospheric conditions and the generally cohesive nature of the shallow soils, leading to extended treatment times and cost.	Soil flushing has been successfully applied in the remediation of hydrocarbon contaminated soils in the USA, but has not been commonly used in the UK. Cohesive nature of the shallow soils may limit effectiveness of remediation and would mean an extended treatment times and cost.	N/A for remediation of asbestos
Soil Washing	**Effectiveness**: Unlikely to be effective due to cohesive nature of the shallow soils and solid state of HFO in normal atmospheric conditions. **Timescales**: Soil washing is a relatively quick process. **Cost**: Mobilisation costs likely to be high for a relatively small amount of soil requiring treatment **Durability**: Permanent. **Commercial Availability**: Soil washing widely available in UK. **Track record**: Proven track record for DRO / PRO / VOCs / SVOCs in sandy / gravelly soils, but not cohesive soils. No proven track record for HFO **Environmental Impact**: Produces a contaminated sludge that requires disposal. Can require large volumes of wash water **Compatibility**: Compatible for range of hydrocarbons identified within shallow soils, but unlikely to be suitable for HFO. **Permissions**: Water treatment plant required. **Site Constraints**: No major issues	Soil washing is a widely available technique in the UK, however it is unlikely to be suitable for the remediation of HFO contaminated soils due to the solid state of HFO in normal atmospheric conditions.	Soil washing is a widely available technique in the UK and has a proven track record in the remediation of hydrocarbon contaminated soils Soil washing is however unlikely to be suitable due to the generally cohesive nature of the soils.	N/A for remediation of asbestos
Hydraulic Binders / Soil Stabilisation (e.g. with cement)	**Effectiveness**: Effectively stabilises contaminants by binding them to cement matrix, although effectiveness depends upon results of pilot trials. **Timescales**: Short timescale in comparison to bioremediation. **Cost**: Moderate cost. **Durability**: Semi permanent. **Commercial Availability**: Widely available. **Track record**: Proven track record. **Environmental Impact**: Produces a hard stabilised material which would decrease the drainage capacity of the shallow soils. **Compatibility**: Environment Agency may not agree with the approach for EP surrender as contaminant mass remains. Approval from the Environment Agency would be required to confirm if remediation meets the surrender requirements. **Permissions:** Mobile Treatment Licence required. **Site Constraints**: No major issues	Soil stabilisation is an effective methodology for reducing exposure to contamination and has a proven track record in the UK. Soil stabilisation is unlikely to be agreeable with the Environment Agency as a remediation solution for permit surrender, as the contaminant mass still remains in the ground, albeit in a stabilised form.	Soil stabilisation is an effective methodology for reducing exposure to contamination and has a proven track record in the UK. Soil stabilisation is unlikely to be agreeable with the Environment Agency as a remediation solution for permit surrender, as the contaminant mass still remains in the ground, albeit in a stabilised form. Soil stabilsation could be considered for site redevelopment, however hard stablised material may present a development constraint on site	Soil stabilisation could be considered for site redevelopment, however hard stabilised material may present a development constraint on site

Remediation Option	Assessment	Feasibility for Remediation Option for HFO Contaminated Soils (CSL Z3.12 for EP surrender)	Feasibility of Remediation Option for Residual Hydrocarbon Contaminated Soils (CSLs Z1.10, Z1.12, Z1.18, Z1.25, Z1.26 and Z3.17 for EP surrender and Z3.1 and WS-Z1-34 for site redevelopment)	Feasibility for Asbestos Contaminated Soils (Zone 6 for site redevelopment)
Vitrification	**Effectiveness**: Effectively stabilises contaminants by melting soil and destroying organic pollutants. **Timescales**: Short timescale. **Cost**: Likely to be very high due to amount of energy required to heat the ground to melt the soil. **Durability**: Permanent. **Commercial Availability**: Technique available, but not commonly used. **Track record**: Proven track record in nuclear industry. **Environmental Impact**: Large quantities of energy required to melt soil. Produces a hard stabilised material which would decrease the drainage capacity of the shallow soils. **Compatibility**: Environment Agency may not agree with the approach as contaminant mass remains. Approval from the Environment Agency would be required to confirm if remediation meets the surrender requirements. **Permissions**: Unknown. **Site Constraints**: No major issues	Vitrification is an effective methodology for reducing exposure to contamination through the stabilisation of contaminants in soils. Vitrification is unlikely to be agreeable with the Environment Agency as a remediation solution for permit surrender, as the contaminant mass still remains in the ground, albeit in a stabilised form. Large quantities of energy are likely to be required to melt the soil.	Vitrification is an effective methodology for reducing exposure to contamination through the stabilisation of contaminants in soils. Vitrification is unlikely to be agreeable with the Environment Agency as a remediation solution for permit surrender, as the contaminant mass still remains in the ground, albeit in a stabilised form. Large quantities of energy are likely to be required to melt the soil.	Vitrification is an effective methodology for reducing exposure to contamination through the stabilisation of contaminants in soils. Large quantities of energy are likely to be required to melt the soil.
Incineration	**Effectiveness**: Effectively removes contamination source from site through excavation of soils. **Timescales**: Short timescale. **Cost**: Likely to be high due to amount of energy required to incinerate soil and requirement to remove soils from site to incinerators. **Durability**: Permanent. **Commercial Availability**: Technique available, but not commonly used for disposal of contaminated soils. **Track record**: Proven track record. **Environmental Impact**: Large quantities of energy required to incinerate soil and gases produced by incineration process. Produces an ash that will require disposal. **Compatibility**: Compatible with site and remedial objectives. **Permissions**: Waste licences required for transportation and incineration of soils. **Site Constraints**: No major issues	Incineration effectively removes contamination from site through the excavation and incineration of soils. Costs are likely to be high due to energy required to incinerate the soils and technique not likely to be suitable for anticipated quantities of HFO contaminated soils requiring remediation.	Incineration effectively removes contamination from site through the excavation and incineration of soils. Costs are likely to be high due to energy required to incinerate the soils and technique not likely to be suitable for anticipated quantities of hydrocarbon contaminated soils requiring remediation.	Incineration effectively removes contamination from site through the excavation and incineration of soils. Costs are likely to be high due to energy required to incinerate the soils and technique not likely to be suitable for anticipated quantities of hydrocarbon contaminated soils requiring remediation.
Capping	**Effectiveness**:Effectively breaks exposure pathway between source and receptor. **Timescales**: Short timescale. **Cost**: Moderate cost depedning on extent of capping required. **Durability**: Will last through lifetime of development. **Commercial Availability**: Technique widely used in the UK. **Track record**: Proven track record. **Environmental Impact**: Low environmental impact althrough clean materials required to form capping material. **Compatibility**: Environment Agency will unlikley agree with the approach as contmainant mass for RP surrender remains. **Permissions**: None. **Site Constraints**: No major issues	Unlikley to be suitble for EP surrender as contaminant mass remains.	Unlikley to be suitble for EP surrender as contaminant mass remains. Unlikely to be suitable for remediation of contaminat in WS-Z1-34 due to the presence of short chained hydrocarbons that will be a source of vapours	**Effective technique for managing asbestos risks. Capping solution can easily be designed around proposed redevelopment plans**

Appendix C

Remediation Procedures

Figure 1 – Remediation of HFO Contaminated Soils

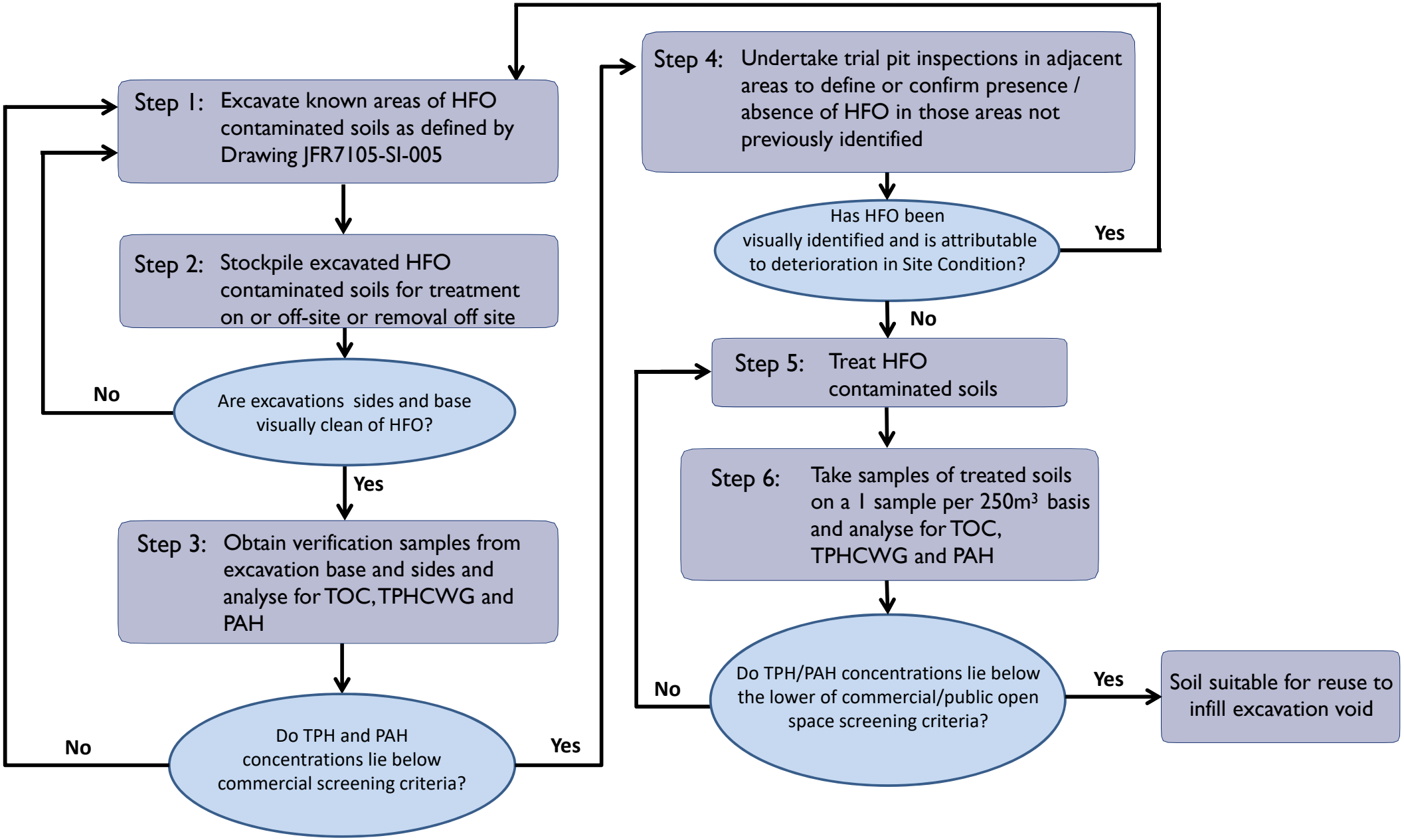


Figure 2 – Remediation of Residual Hydrocarbon Contaminated Soils

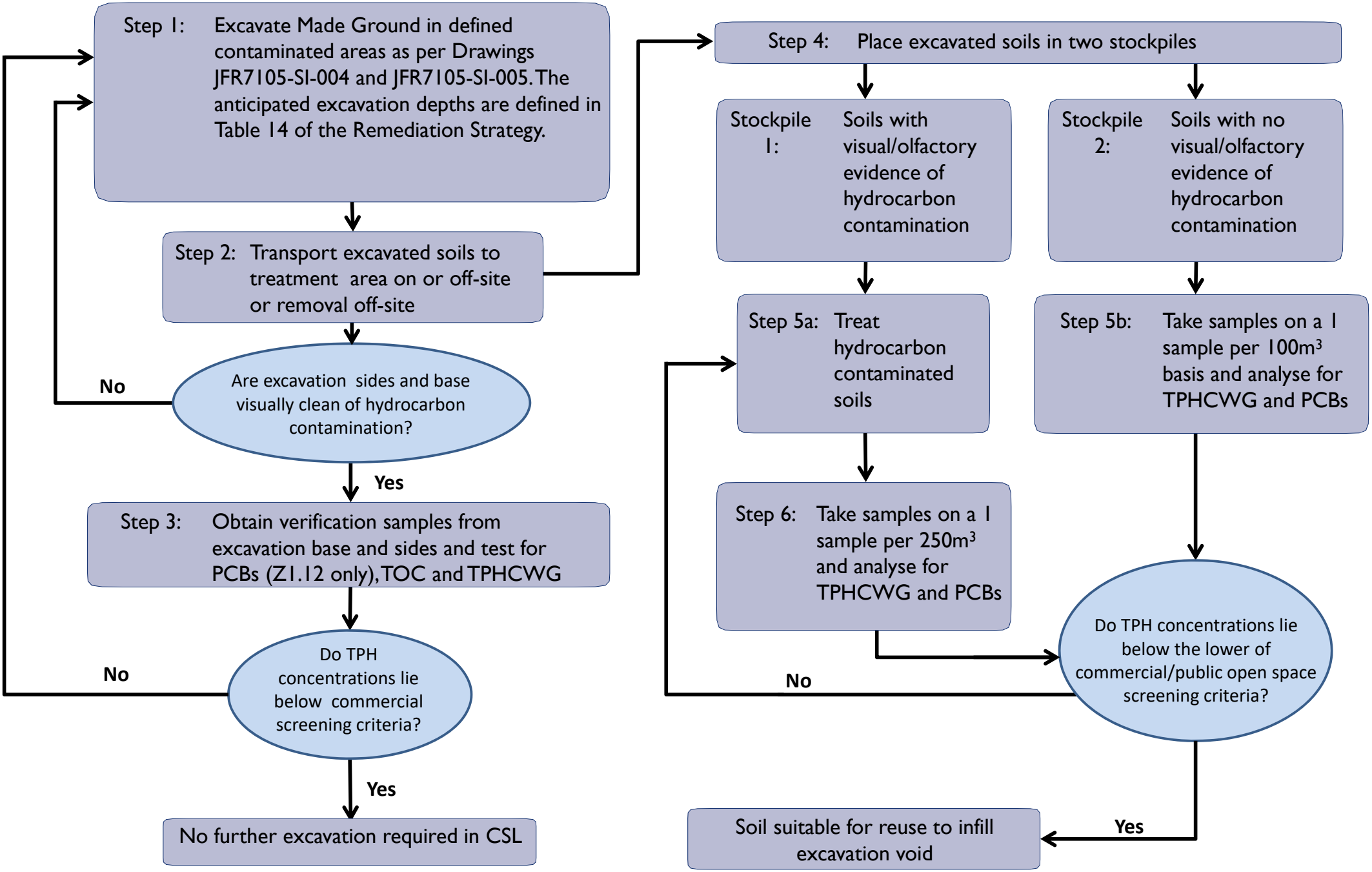
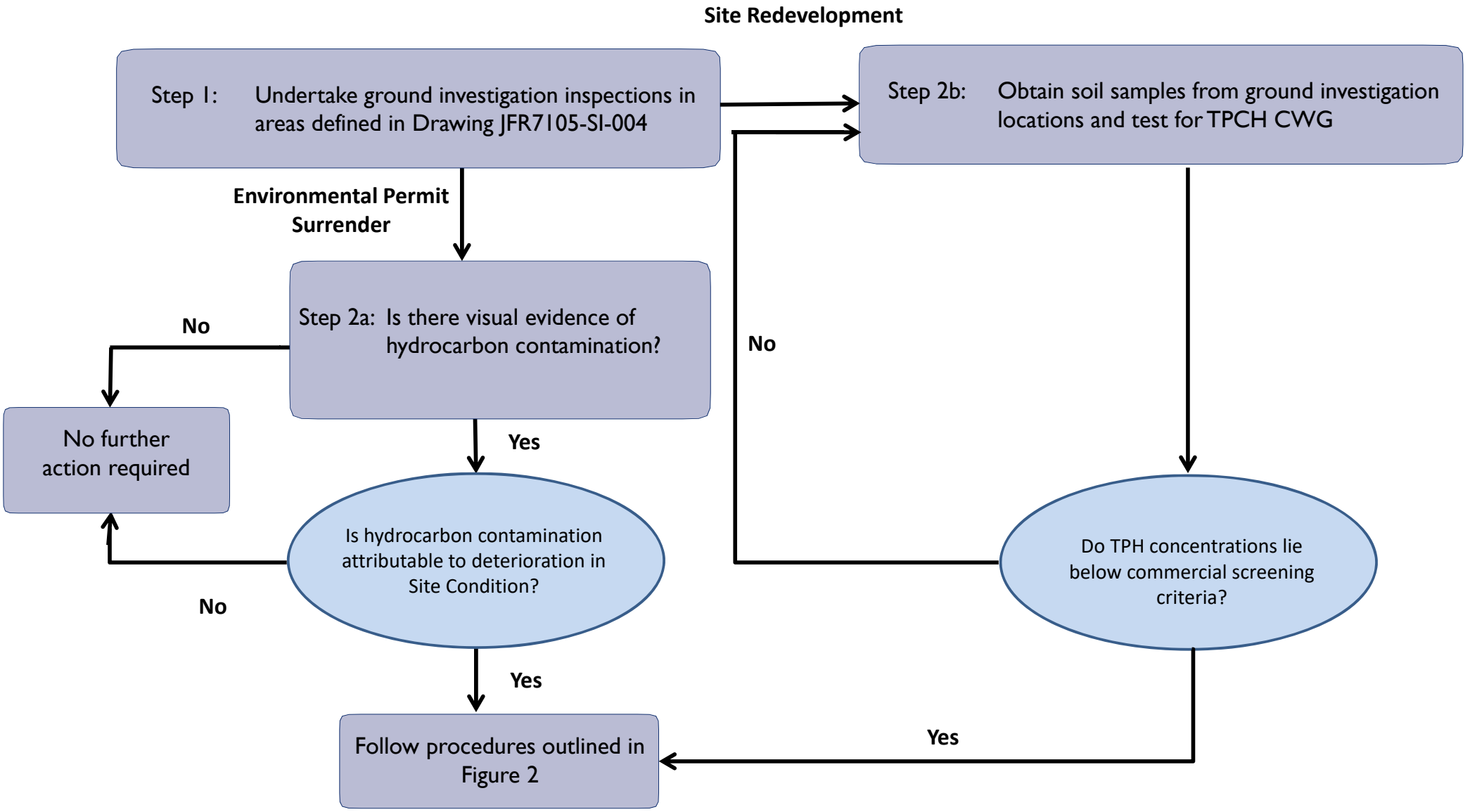


Figure 3 – Investigation of Shallow Soils to determine if remediation is required



Appendix D

Remediation Criteria

Criteria 1		Criteria 2	
Total Petroleum Hydrocarbons (TPH)		**Total Petroleum Hydrocarbons (TPH)**	
Aliphatic EC 5-6	3200*	Aliphatic EC 5-6	3200*
Aliphatic EC >6-8	7800*	Aliphatic EC >6-8	7800*
Aliphatic EC >8-10	2000*	Aliphatic EC >8-10	2000*
Aliphatic EC >10-12	9700*	Aliphatic EC >10-12	9700*
Aliphatic EC >12-C16	59000*	Aliphatic EC >12-C16	25000**
Aliphatic EC >16-35	1600000*	Aliphatic EC >16-35	450000**
Aliphatic EC >35-44	1600000*	Aliphatic EC >35-44	450000**
Aromatic EC5-7 (benzene)	26000*	Aromatic EC5-7 (benzene)	26000*
Aromatic EC >7-8 (toluene)	56000*	Aromatic EC >7-8 (toluene)	56000*
Aromatic EC >8-10	3500*	Aromatic EC >8-10	3500*
Aromatic EC >10-12	16000*	Aromatic EC >10-12	9200**
Aromatic EC >12-16	36000*	Aromatic EC >12-16	10000**
Aromatic EC >16-21	28000*	Aromatic EC >16-21	7600**
Aromatic EC >21-35	28000*	Aromatic EC >21-35	7800**
Aromatic EC >35-44	28000*	Aromatic EC >35-44	7800**
Polycyclic Aromatic Hydrocarbons (PAH)		**Polycyclic Aromatic Hydrocarbons (PAH)**	
Acenaphthene	84000*	Acenaphthene	29000**
Acenaphthylene	83000*	Acenaphthylene	29000**
Anthracene	520000*	Anthracene	150000**
Benzo(a)anthracene	170*	Benzo(a)anthracene	49**
Benzo(a)pyrene	35*	Benzo(a)pyrene	11**
Benzo(b)fluoranthene	44*	Benzo(b)fluoranthene	13**
Benzo(g,h,i)perylene	3900*	Benzo(g,h,i)perylene	1400**
Benzo(k)fluoranthene	1200*	Benzo(k)fluoranthene	370**
Chrysene	350*	Chrysene	93**
Dibenzo(a,h)anthracene	3.5*	Dibenzo(a,h)anthracene	1.1**
Fluoranthene	23000*	Fluoranthene	6300**
Fluorene	63000*	Fluorene	20000**
Indeno(1,2,3-c,d)pyrene	500*	Indeno(1,2,3-c,d)pyrene	150**
Naphthalene	190*	Naphthalene	190*
Phenanthrene	22000*	Phenanthrene	6200**
Pyrene	54000*	Pyrene	15000**

* Suitable 4 Use Levels (S4ULs) for a Commercial end use scenario, assuming 1% Soil Organic Matter (SOM)

** Suitable 4 Use Levels (S4ULS) for a Public Open Space (Parks) end use scenario, assuming 1% SOM

Appendix E

Summary of Groundwater Analysis Results

Borehole	Targeted Groundwater Body	Contaminant of Concern	Round 1 – October 2013	Round 2 – November 2013	Round 3 – December 2013	Round 4 – September 2014	Round 5 – July 2015
BH-Z1-05	River Terrace Deposits	Total TPH	-	-	**0.11 mg/l**	-	-
		Sum of Benzo(b)fluoranthene & Benzo(k)fluoranthene	0.026 ug/l	-	**0.043 ug/l**	-	-
		Sum of Indeno(123cd)pyrene & Benzo(ghi)perylene	**0.017 ug/l**	-	**0.053 ug/l**	-	-
BH-Z1-09	River Terrace Deposits	Total TPH	-	-	-	-	-
		Total PAH	-	-	-	-	-
BH-Z1-25	River Terrace Deposits	Total TPH*	0.045 mg/l	0.05 mg/l	0.05 mg/l	-	-
		Sum of Indeno(123cd)pyrene & Benzo(ghi)perylene	**0.018 ug/l**	-	-	-	-
BH-Z1-31	River Terrace Deposits	Total TPH*	0.038 mg/l	0.03 mg/l	0.03 mg/l	-	-
		Total PAH*	<0.17 ug/l	-	-	-	-
BH-Z1-35	Alluvium	Total TPH*	0.016 mg/l	0.01 mg/l	0.03 mg/l	-	-
		Total PAH*	<0.17 ug/l	-	-	-	-
WS-Z1-33	Alluvium	Total TPH	-	0.03 mg/l	**0.32 mg/l**	-	-
		Total PAH*	-	<0.17 ug/l	<0.17 ug/l	-	-
WS-Z1-47	Alluvium	Total TPH	-	-	-	**0.239 mg/l**	0.045 mg/l
		Total PAH	-	-	-	<0.183 ug/l	<0.187 ug/l
BH-Z2-10	Alluvium / River Terrace Deposits	Total TPH	-	-	-	-	-
		Total PAH	-	-	-	-	-

Borehole	Targeted Groundwater Body	Contaminant of Concern	Round 1 – October 2013	Round 2 – November 2013	Round 3 – December 2013	Round 4 – September 2014	Round 5 – July 2015
BH-Z2-11	Alluvium / River Terrace Deposits	Total TPH*	-	-	-	-	-
		Total PAH*	-	-	-	-	-
BH-Z3-12	River Terrace Deposits	Total TPH	<0.01 mg/l	**0.223 mg/l**	**0.232 mg/l**	-	-
		Sum of Benzo(b)fluoranthene & Benzo(k)fluoranthene	**0.035 ug/l**	-	<0.01 ug/l	-	-
BH-Z3-14	River Terrace Deposits	Total TPH*	0.016 mg/l	<0.01 mg/l	<0.01 mg/l	-	-
		Sum of Benzo(b)fluoranthene & Benzo(k)fluoranthene	**0.036 ug/l**	-	-	-	-
BH-Z3-18	River Terrace Deposits	Total TPH*	0.025 mg/l	0.02 mg/l	0.02 mg/l	-	-
		Sum of Indeno(123cd)pyrene & Benzo(ghi)perylene	**0.01 ug/l**	-	<0.01 ug/l	-	-
BH-Z3-40	River Terrace Deposits	Total TPH	<0.1 mg/l	-	-	**0.313 mg/l**	**0.059 mg/l**
		Total PAH*	-	-	-	<0.340 ug/l	<0.171 ug/l
BH-Z3-41	River Terrace Deposits	Total TPH	-	-	-	-	**0.11 mg/l**
		Total PAH*	-	-	-	-	<0.312 ug/l
BH-Z3-42	River Terrace Deposits	Total TPH	-	-	-	-	**0.091 mg/l**
		Total PAH*	-	-	-	-	<0.237 ug/l
WS-Z3-23	Made Ground	Total TPH	-	<0.01 mg/l	**0.478 mg/l**	-	-
		Total PAH	-	-	-	-	-

Borehole	Targeted Groundwater Body	Contaminant of Concern	Round 1 – October 2013	Round 2 – November 2013	Round 3 – December 2013	Round 4 – September 2014	Round 5 – July 2015
WS-Z3-44	Made Ground	Total TPH	-	-	-	**0.183 mg/l**	-
		Fluoranthene	-	-	-	**0.114 ug/l**	-
WS-Z3-45	Made Ground	Total TPH	-	-	-	**52.7 mg/l**	**201.6 mg/l**
		Benzene*	-	-	-	<0.005 mg/l	<0.005 mg/l
		Toluene	-	-	-	<0.005 mg/l	**0.072 mg/l**
		Ethylbenzene*	-	-	-	<0.005 mg/l	0.136 mg/l
		Xylenes	-	-	-	0.03 mg/l	**0.306 mg/l (m/p) and 0.412 mg/l (o)**
		Fluoranthene	-	-	-	**2.64 ug/l**	**35.2 ug/l**
		Naphthalene	-	-	-	**7.49 ug/l**	**27.3 ug/l**
		Benzo(a)pyrene	-	-	-	**0.32 ug/l**	**0.789 ug/l**
		Sum of Benzo(b)fluoranthene & Benzo(k)fluoranthene	-	-	-	**0.611 ug/l**	**1.608 ug/l**
		Sum of Indeno(123cd)pyrene & Benzo(ghi)perylene	-	-	-	**0.292 ug/l**	**0.797 ug/l**
		Total PAH	-	-	-	69.95 ug/l	998.284 ug/l
WS-Z3-48	Made Ground	Total TPH	-	-	-	**0.317 mg/l**	-

Borehole	Targeted Groundwater Body	Contaminant of Concern	Round 1 – October 2013	Round 2 – November 2013	Round 3 – December 2013	Round 4 – September 2014	Round 5 – July 2015
		Total PAH*	-	-	-	<0.717 ug/l	-
WS-Z3-47	Made Ground	Total TPH	-	-	-	**34 mg/l**	**9.41 mg/l**
		Benzene*	-	-	-	0.10 mg/l	0.01 mg/l
		Toluene*	-	-	-	0.012 mg/l	<0.005 mg/l
		Ethylbenzene*	-	-	-	0.021 mg/l	<0.005 mg/l
		Xylenes	-	-	-	**0.089 mg/l (m/p) and 0.077 mg/l (o)**	0.01 mg/l
		Fluoranthene	-	-	-	**2.11 ug/l**	**0.542 ug/l**
		Benzo(a)pyrene	-	-	-	**0.311 ug/l**	**0.071 ug/l**
		Sum of Benzo(b)fluoranthene & Benzo(k)fluoranthene	-	-	-	**0.601 ug/l**	**0.145 ug/l**
		Sum of Indeno(123cd)pyrene & Benzo(ghi)perylene	-	-	-	**0.357 ug/l**	**0.082 ug/l**
		Total PAH	-	-	-	57.866 ug/l	<17.577 ug/l
WS-Z3-48	Made Ground	Total TPH	-	-	-	**0.317 mg/l**	-
		Total PAH*	-	-	-	<0.717 ug/l	-
WS-Z3-54	Made Ground	Total TPH	-	-	-	**0.204 mg/l**	-

Borehole	Targeted Groundwater Body	Contaminant of Concern	Round 1 – October 2013	Round 2 – November 2013	Round 3 – December 2013	Round 4 – September 2014	Round 5 – July 2015
		Total PAH*	-	-	-	<0.341 ug/l	-
WS-Z3-55	Made Ground / Alluvium	Total TPH	-	-	-	-	**17.21 mg/l**
		Benzene*	-	-	-	-	<0.005 mg/l
		Toluene*	-	-	-	-	<0.005 mg/l
		Ethylbenzene*	-	-	-	-	<0.005 mg/l
		Xylenes	-	-	-	-	**0.071 mg/l**
		Fluoranthene	-	-	-	-	**0.208 ug/l**
		Total PAH	-	-	-	-	<0.315 ug/l
WS-Z3-56	Made Ground / Alluvium	Total TPH	-	-	-	-	**0.443 mg/l**
		Benzene*	-	-	-	-	<0.005 mg/l
		Toluene*	-	-	-	-	<0.005 mg/l
		Ethylbenzene*	-	-	-	-	0.009 mg/l
		Xylenes*	-	-	-	-	0.099 mg/l
		Total PAH	-	-	-	-	<16.472 ug/l

Borehole	Targeted Groundwater Body	Contaminant of Concern	Round 1 – October 2013	Round 2 – November 2013	Round 3 – December 2013	Round 4 – September 2014	Round 5 – July 2015
WS-Z6-01	Made Ground	Total TPH	**0.567 mg/l**	**1.07 mg/l**	**1.14 mg/l**	-	-
		Fluoranthene	**2.65 ug/l**	**3.09 ug/l**	**2.94 ug/l**	-	-
		Naphthalene	**54 ug/l**	**47.5 ug/l**	**41.7 ug/l**	-	-
		Benzo(a)pyrene	**0.072 ug/l**	0.045 ug/l	0.032 ug/l	-	-
		Sum of Benzo(b)fluoranthene & Benzo(k)fluoranthene	**0.121 ug/l**	**0.091 ug/l**	**0.073 ug/l**	-	-
		Sum of Indeno(123cd)pyrene & Benzo(ghi)perylene	**0.1 ug/l**	**0.038 ug/l**	**0.049 ug/l**	-	-
		Total PAH	<87.153 ug/l	<111.009 ug/l	106.485 ug/l	-	-
WS-Z6-09	Alluvium	Total TPH*	0.03 mg/l	0.03 mg/l	0.03 mg/l	-	-
		Fluoranthene	**0.022 ug/l**	-	**0.030 ug/l**	-	-
		Sum of Indeno(123cd)pyrene & Benzo(ghi)perylene	**0.036 ug/l**	-	**0.035 ug/l**	-	-
		Total PAH	<0.241 ug/l	-	<0.270 ug/l	-	-

* No elevated concentrations encountered, but total concentration included for the purposes of comparison

- No sampling undertaken / monitoring well not installed at time of monitoring round

Concentrations in **red** lie above Tier 1 screening levels