

Proposed Carriage Shed &
Locomotive Running Shed
Buckley Wells Locomotive Works, Bury

Overarching Contamination Risk Assessment

Job Number: LKC 23 1449

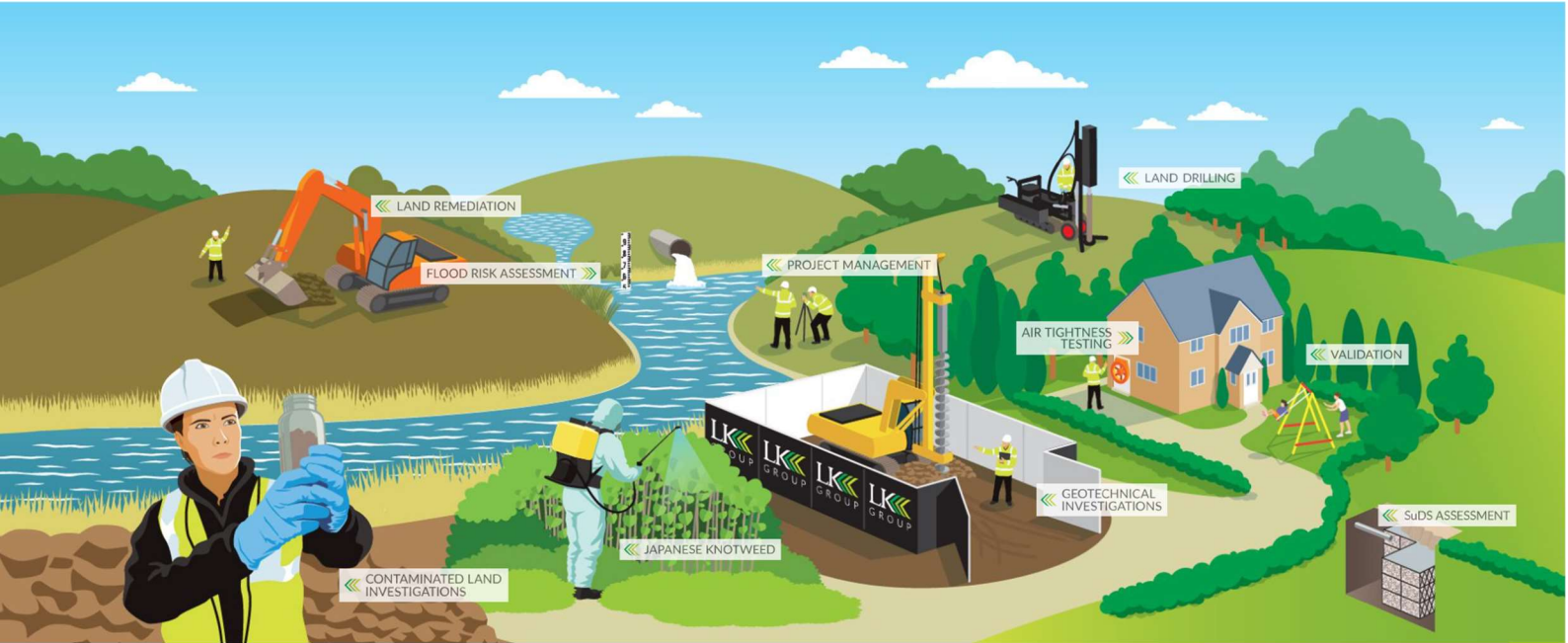
Date: July 2024

Client: East Lancashire Light Railway Ltd



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1. Introduction

1.1. Background

LK Consult Ltd (LKC) has been commissioned to carry out an overarching contamination risk assessment to support development proposals for a new carriage shed and locomotive running shed at Buckley Wells Locomotive Works.

The development is with recourse to planning approval ref. 66745. Copies of previous selected historic site investigation reports have previously been provided to Bury Council for review in support of this planning approval and elicited the following comments from the Environmental Protection Officer:

“In order for this Section to be satisfied that this development does not pose a risk to human health or the environment, the following information needs to be submitted to the Council for approval:

- (i) Updated risk assessment based on up-to-date assessment criteria and the current proposals to assess the risks to human health and the environment including controlled waters.*
- (ii) Pre-demolition asbestos survey report and confirmation asbestos containing materials have been removed.*
- (iii) Japanese Knotweed and invasive species survey and eradication plan.*
- (iv) A detailed remediation strategy and materials management plan.*
- (v) After completion of site works, a verification report is required to validate that the work undertaken conforms to the remediation proposals received and agreed by this Section. “*

On the basis of the above, this report seeks to address items (i) and (iv) for the areas of the proposed carriage shed and proposed locomotive running shed only and with recourse to a contamination risk assessment. The risk from potential land instability associated with legacy shallow mining and slope stability are assessed by others.

The following reports previously undertaken has been reviewed as part of this overarching contamination risk assessment:

- Site Investigation, undertaken by Campbell Reith Hill (ref. PRIk6955-100699Rep/Buckley Wells, Bury, dated June 1999).
- Ground Investigation and Risk Assessment Report, undertaken by LKC (Ref: JB578-02, dated 25th October 2006).
- Embankment Intrusive Works Letter Report, undertaken by LKC (Ref: JB578-04, dated 26th March 2007).
- Mineshaft Search Letter Report, undertaken by LKC (no ref., dated 26th March 2007).
- Proposed Diesel Shed, Ground Investigation Letter Report, undertaken by LKC (Ref: JB578, dated 9th October 2009).
- Supplementary Site Investigation and Coal Mining Risk Assessment, undertaken by NXConsulting (Ref: NX397, dated April 2020).

The aims of this report are also to establish the feasibility of developing this site, to demonstrate to the Local Planning Authority that in accordance with the National Planning Policy Framework (NPPF)¹ the site may be developed for the proposed carriage shed and proposed locomotive running shed and that appropriate contamination risk assessment works are in place.

A summary of the site details is presented in Table 1-1. Site location and development plans are provided in Appendix A.

Location	Buckley Wells Locomotive Works, Baron Street, Bury. Centred at approximate National Grid Reference 379818E 410010N.
Area	7.5Ha (full site). c. 0.62Ha (footprint of proposed carriage shed and boundary car parking). c. 0.20Ha (footprint of proposed locomotive running shed).
Topography	Proposed shed - 81-82 metres above ordnance datum (AOD). Generally level. Proposed locomotive shed – 83-85mAOD with a slight rise toward the north and west of the study area towards Baron Street entrance.
Land Use	Proposed carriage shed site - sidings and an area with compacted gravel. Proposed locomotive shed – storage of railway materials and portacabins.
Proposed Development	New carriage shed including external car parking. New locomotive running shed to the northwest elevation of the existing 1857 locomotive shed and associated workshops and training facilities.

Table 1-1. Summary of site details.

2. Summary of Previous Work

2.1. Campbell Reith Hill (CRH) – Site Wide Investigation (1999)

This report included a Preliminary Risk Assessment (PRA) and intrusive ground investigation of the full Buckley Wells site.

Sampling positions within the proposed locomotive shed area comprised BH G1 and TP15. BH G2 is c. 30m southwest and BH G3 c. 70m southwest. TP2 is c. 25m northwest.

Sampling positions within the proposed carriage shed area comprised TP8, TP9, TP14, BH C2 and BH C4.

CRH detected “limited contamination” across the site although elevated levels (in comparison to the standards and guidelines in use at the time) of arsenic, copper and zinc were encountered in the ash deposits. No evidence of hydrocarbons or asbestos was encountered.

Leachability data did not identify significant levels of available contaminants and groundwater monitoring did not identify any significant impact.

Gas monitoring was undertaken on six of the boreholes on two occasions. Methane was detected in BHG4 at concentrations up to 6% by volume. Carbon dioxide was encountered at concentrations up to 5.5% by volume in BH C1A. Negligible flows were detected. During a site walkover, LKC were unable to identify any surviving CRH boreholes, therefore further boreholes with gas monitoring installations are required to fully characterise the gas regime at the site.

2.2. LKC – Site Wide Investigation (2006)

Notwithstanding the findings of the PRA in the CRH report, LKC provided an updated PRA and conceptual model which include a review of further factual information provided by Bury Council and also noted there was a potential risk from shallow coal mining. Intrusive investigation was carried out across the site to inform the development proposals of the time.

Sampling positions within the proposed locomotive shed area comprised BH3 and BH4 with R1 adjacent northwest and BH5 c. 60m southwest.

Sampling positions within the proposed carriage shed area comprised R2, CP2, CP3 and BH7 with HA1-HA5 adjacent.

Further soil sampling including for PCBs was undertaken across the site. Groundwater or leachate testing was not undertaken due to the results of the CRH investigation.

The results of the solid soil samples collected from the upper metre across the full Buckley Wells site show arsenic between 3.6 and 130 milligrams per kilogram (mg/kg); cadmium between <0.5 and 17mg/kg, chromium III between 5.1 and 32mg/kg; lead between 6 and 2,300mg/kg; mercury between <0.1 and 8.9mg/kg; selenium between <0.1 and 2.1mg/kg, nickel between 2.3 and 83mg/kg, copper between 4.4 and 770mg/kg and zinc between 4.7 to 490mg/kg.

Concentrations of phenols varied between 0.96 and 6.9mg/kg, total cyanide concentrations varied between <0.1 and 0.85mg/kg and sulphide concentrations varied between <5 and 96mg/kg.

USEPA PAH 16 values ranged between <1 and 860mg/kg. LKC considered that the main drivers for PAHs were naphthalene and benzo(a)pyrene. Naphthalene results ranged between <1 and 14mg/kg and benzo(a)pyrene results ranged between <1 and 22mg/kg.

Speciated TPH screening values ranged between <10 and 5,016mg/kg and TPH CWG speciated values (TPH Risk) varied between <40 and 930mg/kg. These were the heavier end fractions such as >C16.

Concentrations of VOCs, SVOCs and pesticides were all below the relevant analytical limit of detection. Concentrations of PCBs ranged between <0.1 and 0.21mg/kg.

No asbestos fibres were detected in any of the soil samples.

No elevated results (compared to the generic assessment criteria of the time) were encountered in the proposed locomotive running shed or proposed carriage shed areas.

Boreholes BH1, BH3, BH4, BH7 and CP2 and CP3 were instrumented with gas monitoring standpipes and were subsequently monitored on ten occasions between 4th January 2006 and 29th March 2006.

2.3. LKC – Embankment (2007)

The investigation comprised window sample boreholes from the higher plateau and at the base of the embankment. In the area adjacent to the proposed new carriage shed boreholes WS101-WS103 were undertaken on the higher plateau at the top of the embankment and WS106-WS108 undertaken at the base of the embankment.

2.4. NXC – Proposed Carriage Shed (2020)

The investigation comprised the drilling of 3no. rotary boreholes ref. NXRBH01, NXRBH01b and NXRBH02. The were located in a NE-SW direction, down dip of the conjectured outcrop position of the Hell Hole Mine coal seam (as encountered in LKC borehole R2) within the footprint of the proposed carriage shed.

2.5. Contemporary Site Reconnaissance

As part of the current assessment the study site was revisited on 19th February 2024.

2.5.1. Proposed Carriage Shed

The study area comprises railway siding near to slope approximately 8-10m in height. It is proposed to construct a new carriage shed to cover existing and additional sidings with the shed being located approximately 8m from the crest of the existing slope. Car parking will be built up to and adjacent to the crest of the slope.

The ground on the upper plateau where the sidings are located is flat, surfaced predominantly with coarse gravel hardstanding. The crest of the slope falls steeply, c. 40° down to a level which undulates with small embankments. The slope and lower level are heavily vegetated by self-seeded trees and invasive plant species (Japanese knotweed, buddleia identified).

The slope appears constructed of ash material and includes much end tipped detritus (ceramic insulators from electric power lines, Yorkshire flags, concrete sleepers etc.).

The vegetation on the slope, and at the base of the slope, shows some movement and geotropism, leaning down slope. This may also be an indication that the trees have shallow root systems and could also be prone to being blown over by wind.

At the base of the slope is a drainage channel which was not noted during previous walkover surveys. There is an area of ponding and marshy ground at the base of the slope which the drainage channel feeds, anecdotal information indicates that this area is always wet and that the fields further south of the pond are prone to flooding.

Lighting masts along the crest of the slope appear to be piled whereas a mast located further west on the lower level appears to have a gravity base.

Photographs are provided in Plate 2-1.

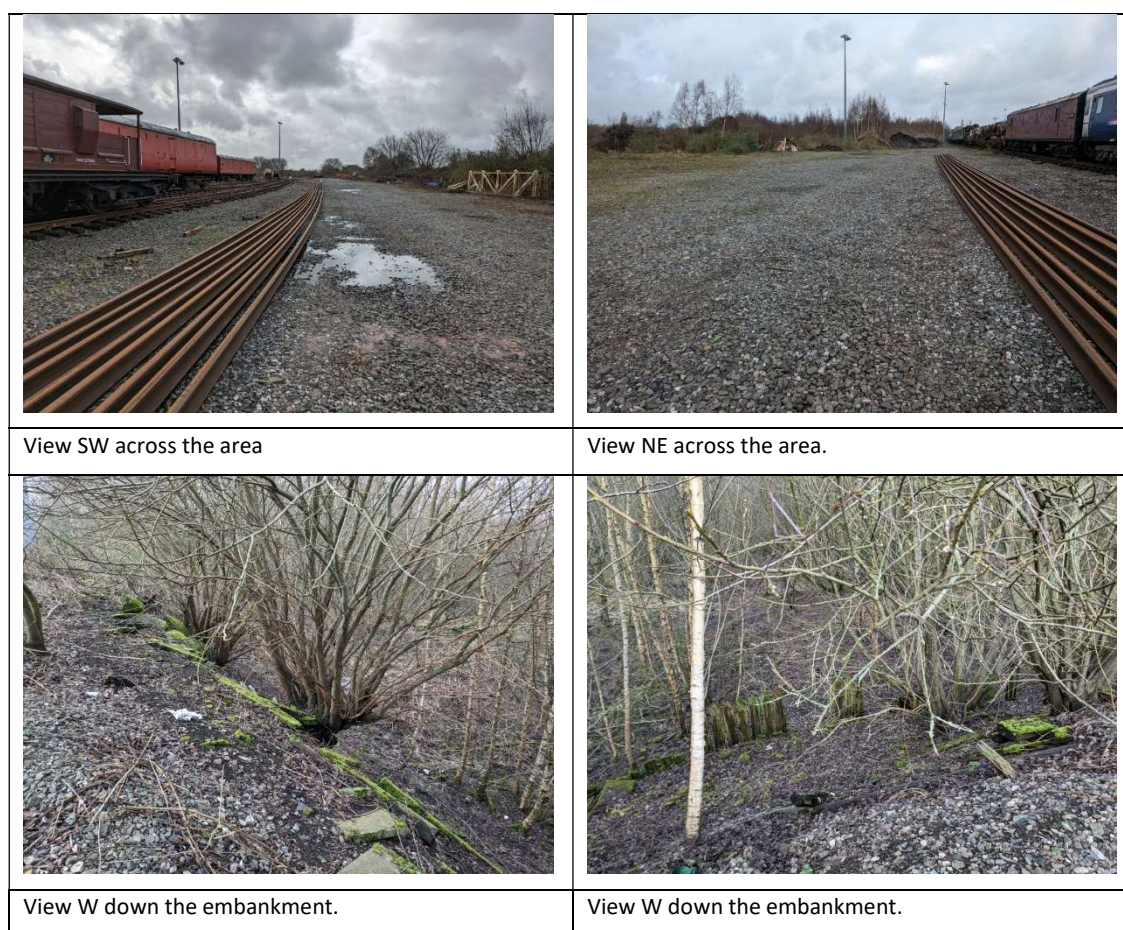


Plate 2-1: Proposed Carriage Shed Area and Embankment.

2.5.2. Proposed Locomotive Running Shed

The surfacing of the study area is a mix of compacted gravel, discrete hardstood bases and vegetation. Site levels fall slightly from the northwest (Baron Street entrance).

A portacabin is present along with scaffolding on the adjacent 1857 Locomotive Works Shed. The area is used for storage of pallets, building materials and railway materials such as bogies, wheels, cable drums and engine parts.

The land use and potential contaminative activities do not appear be different that those noted by LKC during previous investigations. Photographs are provided in Plate 2-2.



Plate 2-2: Proposed Locomotive Running Shed Area.

2.6. Preliminary Conceptual Model

Pertinent information has been summarised from the previous reports, supplemented by contemporary information, is presented in Table 2-2.

Main Historical Features	The Buckley Wells site comprises a railway line (possibly on a small embankment and small engine house (pre 1848). The Locomotive works expands and sidings are added over subsequent years. By 1893 mapping the proposed locomotive running shed is occupied by an engine shed which appears to have been removed between 1970 and 1979. In the area of the proposed carriage shed an embankment adjacent to the running lines appears by 1893 mapping. Between 1910 and 1930 mapping this embankment expands to the west forming the current plateau to the northwest of the railway lines with a further extension westwards by 1957/58 mapping. Anecdotal evidence from depot staff (from the LKC 2006 study) indicated that the embankment was formed by the deposit of ash waste from a number of depots in the area and was associated with former sidings, although no sidings are indicated on the embankment area on historical plans or aerial photographs.
Geology / Hydrogeology	Artificial: No BGS recorded artificial. Superficial: River Terrace deposits below the proposed carriage shed (Secondary A Aquifer) and Glacial Till below the proposed locomotive running shed (undifferentiated aquifer). Bedrock: Coal Measures Strata (Secondary A Aquifer). Proposed carriage shed underlain by undifferentiated coal measures strata with a band of sandstone on

	the northern extent. Proposed locomotive running shed underlain by Trencherbone Sandstone.
Landfills / Infilled Ground	Landfills recorded c. 180m north of the proposed locomotive running shed. Infilling identified on site. Former pond approximately 40m southwest of the site and a former reservoir approximately 100m south of the site.
Other Relevant Environmental Settings	Radon Proposed Locomotive Running Shed area- <1% of homes at or above the action level. Proposed Carriage Shed area – 1-3% of homes at or above the action level. Reports are provided in Appendix B. Proposed locomotive shed area is c. 25m southwest of a coal mining DHRA. A Mineshaft is shown adjacent west. Proposed carriage shed is within a coal mining DHRA. The coal mining risk has been assessed by NX Consulting.

Table 2-2: Summary of site details, historical review and environmental settings.

The preliminary contamination conceptual model using contaminant-pathway-receptor linkages based on guidance in LCRM² has been summarised in Table 2-3.

Each pollutant linkage is described along with an assessment of the risk based upon guidance on probabilities and consequences outlined in CIRIA C552³. The risk matrix is provided in Appendix C.

The previous contamination conceptual model in the LKC 2006 report has been updated to be in line with LKC current risk assessment methodology (detailed below) and the updated development proposals. The model is based on the contamination sources, pathways and receptors identified in the original report and additionally includes potential sources of radon and gas from coal measures strata.

The conceptual model is based on the future use of the site (post development), in line with proposed development scheme.

Due to the minor consequence associated with the phytotoxic effect to flora (i.e., loss of plants in a landscaping scheme), the overall risk for most sites will be very low to low. here soils contain significant concentrations of heavy metals, in general there will other pollutant linkages (i.e., the risk to human health) that will trigger the requirement for remediation (e.g., a clean environmental cover system). As such the risk to flora associated with phytotoxic contaminants will not be considered further.

The risk to buildings associated with elevated sulphate will be considered by others as part of the geotechnical assessment and will not be included in the contamination risk assessment.

PL	Contaminants of Concern (source)	Pathway	Receptor	Probability	Consequence	Risk
1	ACM, heavy metals, TPH, PCBs, Herbicides, PAHs (railway land, ash and clinker made ground).	Dermal contact. Inhalation of soil, fibres, and dust. Ingestion of soils, dust. Windblown dust.	Future site users. Offsite receptors.	Likely	Medium	Moderate
2	Volatile contaminants, BTEX, naphthalene, hydrocarbons (railway land)	Inhalation of vapours. Migration via permeable strata and preferential pathways.	Future site users. Offsite receptors.	Likely	Medium	Moderate
3	Hazardous / ground gas: methane, carbon dioxide (embankment, infill, made ground, coal measures, mineshaft)	Migration via permeable strata and preferential pathways. Inhalation of gas. Explosion in confined spaces.	Future site users. Buildings. Offsite receptors.	Low Likelihood	Severe	Moderate
3	Radon	Migration via permeable strata and preferential pathways. Exposure to radon.	Future site users.	Unlikely	Medium	Low
4	Mobile contaminants: leachable heavy metals, hydrocarbons, PAHs.	Surface run-off. Migration via permeable strata and preferential pathways. Perched waters migration.	Groundwater Surface water	Unlikely	Medium	Low
5	Hydrocarbons, VOCs (naphthalene), PAHs (railway land, made ground)	Permeation of pipes. Ingestion of tainted water supply.	Future site users. Water pipes.	Likely	Medium	Moderate

Table 2-1: Preliminary Contamination Conceptual Model.

3. Ground Investigation

3.1. Site Investigation Scope

Based on investigations to date, the sampling locations pertinent to the current study areas are summarised in Table 3-1.

Location	LKC Sampling Locations	Other works
Proposed Locomotive Running Shed	<u>CRH</u> BH-G1 & TP15 onsite. TP2, BH G2, BH G3 in the vicinity.	Soil sampling, groundwater sampling, leachate testing and gas monitoring at selected locations.
	<u>LKC</u> BH3 & BH4 onsite. R1 adjacent.	Soil sampling, gas monitoring.
Proposed New Carriage Shed	<u>CRH</u> TP8, TP9, TP14, BH-C2, BH-C4 onsite.	Soil sampling Groundwater, leachate testing and gas monitoring at selected locations.
	<u>LKC</u> CP2, CP3, BH7, R2 onsite HA1-HA4 adjacent. WS101-WS103. WS106-WS108 (base of embankment)	Soil sampling and gas monitoring. Soil Sampling. Groundwater level monitoring.
	<u>NXC</u> NXRBH01, NXRBH01b and NXRBH02 onsite	Gas monitoring during drilling.

Table 3-1. Summary of relevant sampling locations.

Sampling location plans are provided in in Appendix A.

Relevant profile logs are provided in Appendix D, certificates of analysis are provided in Appendix E and gas monitoring results are provided in Appendix F.

3.2. Sampling Protocol

3.2.1. Soil Sampling (Contamination)

Soil samples were subjected to a range of contaminants including asbestos, heavy metals, pH, BTEX, TPH banded, TPH speciated and banded (TPHCWG), total and speciated PAHs, halocarbons, PCBs, herbicides, triazine herbicides, pesticides, phenols, sulphate, sulphide and thiocyanate.

A total of 4no. samples from the proposed locomotive running shed and 17no. samples from the proposed carriage shed area were tested for varying contaminants.

3.2.2. Water Sampling / Leaching Testing

1no. leaching test and 2no. groundwater samples were subjected to testing for varying inorganic and organic contaminants.

6no leaching tests and 4no. groundwater samples from the proposed carriage shed area were subjected to testing for varying inorganic and organic contaminants.

3.3. Gas Monitoring

Boreholes BH3 and BH4 (locomotive running shed) and BH7, CP2 and CP3 (proposed carriage shed) were instrumented with gas monitoring standpipes and were subsequently monitored on ten occasions between 4th January 2006 and 29th March 2006.

In addition CRH borehole BH-C4 was instrumented with a gas monitoring standpipe and was monitored on two occasions on 3rd and 11th March 1999.

The gas monitoring results are reproduced in full in Appendix F.

4. Ground Conditions

4.1. Geology

The ground conditions beneath the study areas are summarised below. Logs are provided in Appendix D.

4.1.1. *Proposed Locomotive Running Shed*

Made ground (ash and clinker) was recorded in all locations to depths of 1.7mbgl to 2.7mbgl.

This was underlain by natural clay to depths of between 2.7mbgl-4.9mbgl over granular material identified to depths of between 4.0-6.7mbgl. Clay was then encountered (band of silt in BH HG1 from 9.3mbgl) and proven to 14.5mbgl in R1 where rockhead was encountered.

4.1.2. *Proposed Carriage Shed*

Made ground (ash and clinker) was recorded in all sampling locations and appeared to slightly thicken towards the western embankment slope. A level of approximation should be given to observations from rotary open hole methods; depths of c. 7.5m to 8.5m were recoded within the proposed building footprint with boreholes close to the crest of the embankment recorded made ground depths of >8.8m. The made ground depth of 13.0m reporting in the log in NXBH02 is considered to be erroneous. This may be a function of the rotary open hole method employed and LKC note the report text suggests a depth of 7.50mbgl.

Below the made ground granular deposits were generally encountered to depths of 9.6 to 10.7m over clay in the window sample and cable percussion boreholes. The NXC rotary boreholes indicate the granular deposits present to 25.0-27.0mbgl over bedrock.

Coal was encountered from 32.0-32.25 in NHRBH02 and LKC R2 from 26.0-27.5mbgl.

At the base of the embankment, boreholes encountered topsoil over beds of sand and then clay.

4.1.3. *Contamination*

Except for the anthropogenic material encountered in the made ground (as described above), there was no visual / olfactory evidence of hydrocarbons or volatile contaminants noted.

4.2. Groundwater

4.2.1. *Groundwater Levels*

Groundwater strikes were recorded during the investigation in trial pits and boreholes. This data is provided in the profile logs (Appendix D).

Groundwater level monitoring was also undertaken during gas monitoring visits and this data is provided in Appendix F.

4.2.2. *Contamination*

No evidence of contamination was identified in the groundwater was reporting during the investigation work or monitoring.

5. Generic Risk Assessment

5.1. Introduction

Current good practice requires that the findings from a site investigation should be evaluated on a site-specific basis, using a risk-based approach. Risk assessment involves identification and evaluation of the hazards presented by the concentrations of contaminants measured followed by an evaluation of the risks which are associated with these hazards (LCRM⁴). Information gathered from the risk assessment has been collated in the revised contamination conceptual model in Section 5.6.

5.2. Soil Risk Assessment

5.2.1. Methodology

With regards to the soil risk assessment LKC will use the following hierarchy:

- Category 4 Screening Levels (C4SLs) ^{5, 6}.
- LQM Suitable 4 Use Levels (S4ULs) ^{7, 8, 9, 10}.
- ATRISK Soil Screening Values (SSVs) and CL:AIRE Generic Assessment Criteria (GACs)¹¹

The proposed development is for new buildings to an existing railway facility, therefore the assessment criteria for a 'commercial' end use has been used for both sites.

All criteria have been generated using the CLEA V1.06 model¹² based either on 1%, 2.5% and 6% Soil Organic matter (SOM). Results will be compared to the nearest appropriate SOM.

A summary of the generic assessment criteria used in this assessment is provided in Appendix G.

B(a)P as Surrogate Marker

LKC consider the main risk drivers for PAHs are benzo(a)pyrene (B(a)P) and naphthalene. This is due to B(a)P possibly being a carcinogen and most toxic of the PAHs^{13,14} and naphthalene the most volatile and soluble¹⁵. The C4SLs indicate B(a)P as a surrogate marker for carcinogenic PAHs, if it falls within appropriate limits, since the risk from other non-carcinogenic PAHs are considered negligible¹⁶. For B(a)P to be used as a surrogate marker it should follow the profile described by the HPA (2008)¹⁷ and CL:AIRE (2013). Naphthalene will be treated separately using the LQM S4ULs.

LKC undertook an assessment of the available speciated PAH data for the site with regards to using B(a)P as a surrogate marker for carcinogenic PAHs as per HPA and CL:AIRE guidelines. The primary toxicological study related to Culp *et.al*¹⁸, which was based on coal tar mixtures (>80,000mg/kg of total PAHs) fed in food to mice over a two-year carcinogenicity study.

All the data points that could be used to calculate ratios fall inside the upper or lower limits.

Based on this distribution of data LKC considers B(a)P can be used as a surrogate marker for carcinogenic PAHs and the C4SL criteria is suitable for this dataset.

5.2.2. Soil Results Comparison against Assessment Criteria

All analysis sheets are presented in Appendix E and all the data has been compared to relevant assessment criteria and is presented in Appendix G. A conservative SOM of 1% was used.

The testing identified a single exceedance of lead at 2,400mg/kg at BH C2 at 3.2mbgl. The generic assessment criteria value is 2,330mg/kg.

No asbestos fibres were noted in the soil screening tests, concentrations of PCBs (embankment area), chlorinated VOCs and SVOCs, herbicides and BTEX were below the analytical limits of detection.

No elevated PAHs (specifically B(a)P and naphthalene) were encountered in the samples obtained by LKC, however it is noted that CRH reported generally a "total" PAH. LKC note that based upon the soil samples analysed across the site that the B(a)P concentration is approximately 5-10% and the naphthalene concentration is approximately 3.5-7.5% of the total PAH concentration. Therefore, as a screening tool LKC consider that 10% of the total PAH concentration may be attributed to a both a B(a)P and a naphthalene concentration. The CRH total PAH results range between <10 and 470mg/kg. Therefore a maximum concentration of 47mg/kg is considered as a screen for both B(a)P and naphthalene. This approach is also considered appropriate based upon LKC archive data for other sites which ash and clinker made ground.

5.2.3. Direct Contact Risk – Pollutant Linkage 1

A single elevated lead concentration has been encountered in the made ground in BH C2 (proposed carriage shed area). This was at depth of 3.2mbgl but it is recognised that similar material may be present at shallow depth.

The source of the contamination is expected to the ash and clinker in the made ground.

At the concentrations identified, the contaminants are considered to pose a potential risk to future site users in any soft landscaped areas, where made ground may be exposed. The principal pathways are the ingestion pathways (soil, dust, and homegrown produce) and dermal contact.

The probability of metal contamination affecting site users is likely. With a medium consequence, the risk is considered to be moderate, and remediation is recommended in any soft landscaped areas.

No asbestos was identified in any of the samples; therefore, the probability of asbestos affected site users is considered to be unlikely. With a severe consequence, the risk is moderate / low. At this stage, a low risk is assumed (as no asbestos identified) and remediation is not required. However, as a precaution, construction workers should be and vigilant for any suspected ACM during groundworks.

No elevated concentrations of hydrocarbons, herbicides, chlorinated VOCs and SVOCs and PAHs were identified, therefore the probability of these contaminants posing a risk to site users is considered unlikely. With a medium consequence, the risk is considered to be low, and no remediation is recommended.

5.2.4. Risk from Inhalation of Vapours – Pollutant Linkage 2

No visual / olfactory evidence of volatile contaminants was identified during the investigation. Confirmatory soil analysis (including adopting a conservative screen for

naphthalene concentrations from total PAH concentrations) did not detect any VOCs / SVOCs above the generic assessment criteria.

LKC therefore consider the probability of volatile contaminants affecting site users as unlikely. The consequence is expected to be medium, giving a low risk and no remediation is required.

5.3. Gas Risk Assessment

2no. gas monitoring visits were carried out by CRH and up to 11no. visits were carried out by LKC.

Gas monitoring results in full are presented in Appendix F and summarised in Table 5-1 (proposed locomotive running shed) and Table 5-2 (proposed carriage shed). Following guidance set out in CIRIA C665¹⁹ and BS8485²⁰ methane and carbon dioxide concentrations have been used in the gas risk assessment. In addition, and as per guidance, flow rates were measured first by LKC.

Borehole Ref.	Visit	Peak CH ₄ (%v/v)	Peak CO ₂ (%v/v)	Min O ₂ (%v/v)	Flow (l/h)	Groundwater Level (mbgl)	Pressure (mb)	Prev 24hr Pressure Trend
BH G1	1	<0.1	<0.1	20.1	-	1.54	965	-
	2	<0.1	0.8	18.9	0.2	1.82	1004	-
BH3	1	<0.1	<0.1	20.3	0.5	0.9	1023	Falling
	2	<0.1	3.9	17.0	0.5	0.6	1012	Rising
	3	<0.1	4.2	16.7	0.1	0.9	1001	Falling
	4	<0.1	4.0	17.1	0.1	3.7	1019	Rising
	5	<0.1	3.8	17.3	<0.1	1.1	1017	Falling
	6	<0.1	3.9	17.8	0.1	1.0	1016	Rising
	7	<0.1	3.9	17.2	<0.1	1.8	970	Rising
	8	<0.1	3.0	17.6	<0.1	1.1	971	Steady
	9	<0.1	1.8	18.7	-1.1	1.1	1001	Falling
	10	<0.1	2.4	16.9	-0.2	1.8	995	Falling
BH4	1	<0.1	<0.1	19.1	0.3	0.8	1024	Falling
	2	<0.1	<0.1	20.6	0.9	0.9	1012	Rising
	3	<0.1	<0.1	20.9	0.2	0.6	1001	Falling
	4	<0.1	<0.1	20.1	0.2	2.8	1019	Rising
	5	<0.1	<0.1	19.7	-0.3	1.4	1016	Falling
	6	<0.1	<0.1	19.7	-0.3	1.4	1016	Rising
	7	<0.1	<0.1	20.6	0.1	1.3	970	Rising
	8	<0.1	<0.1	20.8	0.3	0.7	972	Rising
	9	<0.1	<0.1	20.6	0.5	0.6	1001	Steady
	10	<0.1	<0.1	20.3	-0.9	0.5	995	Falling
	11	<0.1	<0.1	20.2	-1.0	0.6	1010	Falling

Table 5-1: Gas Monitoring Assessment (proposed locomotive running shed).

Borehole Ref.	Visit	Peak CH4 (%v/v)	Peak CO2 (%v/v)	Min O2 (%v/v)	Flow (l/h)	Groundwater Level (mbgl)	Pressure (mb)	Prev 24hr Pressure Trend
BH C4	1	<0.1	1.3	18.4	1.65	7.64	967	-
	2	<0.1	1.1	18.7	0.54	7.8	1002	-
CP2	1	<0.1	4.0	17.1	0.7	3.1	1023	Falling
	2	<0.1	3.0	18.6	1.6	4.8	1012	Rising
	3	<0.1	2.0	18.9	0.5	1.1	1019	Rising
	4	<0.1	<0.1	20.0	-0.1	4.0	1016	Falling
	5	<0.1	<0.1	20.7	0.1	2.8	1017	Rising
	6	<0.1	0.4	19.6	-1.6	7.2	995	Falling
CP3	1	<0.1	0.5	20.4	0.7	2.5	1010	Falling
	2	<0.1	0.8	20.3	1.7	3.1	1012	Rising
	3	<0.1	0.7	20.2	0.5	2.8	1001	Falling
	4	<0.1	0.4	20.0	0.8	0.9	1019	Rising
	5	<0.1	1.5	19.5	0.2	1.7	1016	Falling
	6	<0.1	<0.1	20.6	-0.7	2.0	1016	Rising
	7	<0.1	1.0	20.	-0.1	5.6	970	Rising
	8	<0.1	1.0	20.4	-0.2	4.1	972	Rising
	9	<0.1	<0.1	20.4	-5.3	3.7	1001	Steady
	10	<0.1	<0.1	20.3	-1.8	7.4	995	Falling
BH7	1	<0.1	3.8	18.0	0.3	4.7	1010	Falling
	2	<0.1	3.8	16.9	1.6	3.2	1012	Rising
	3	<0.1	4.3	16.8	0.4	3.4	1001	Falling
	4	<0.1	2.5	19.3	0.7	3.1	1019	Rising
	5	<0.1	1.7	19.4	0.1	2.9	1016	Falling
	6	<0.1	1.7	19.4	0.1	2.9	1016	Rising
	7	<0.1	3.3	18.8	<0.1	2.4	970	Rising
	8	<0.1	3.4	19.1	-0.4	6.0	972	Rising
	9	<0.1	3.1	19.1	-0.1	5.1	1001	Steady
	10	<0.1	2.4	18.9	-1.9	4.7	995	Falling
	11	<0.1	2.6	17.9	-2.0	DRY	1010	Falling

Table 5-2: Gas Monitoring Assessment (proposed carriage shed).

No concentrations of methane above the limit of detection were recorded. The highest carbon dioxide reading was 4.2%v/v in the proposed locomotive running shed area and 4.3% v/v in the proposed carriage shed area.

Sporadic detectable positive and negative flow rates were recorded which do not seem to track atmospheric pressure trends or change in groundwater levels in the response zones.

The low / negligible methane and carbon dioxide concentrations and the low / negligible flow readings would appear to be typical of ash and clinker rich deposits where any hazardous gas is generated at such low rates.

5.3.1. Ground Gas – Coal Measures and Coal Mining Features

There appears to be no discernible difference between shallower and deeper monitoring installations, suggesting that any ground gas from coal measures strata is either not present or is not able to migrate upwards through the superficial deposits.

A suspected mineshaft (ref. 379410-003) is located to the west of the proposed locomotive running shed but no elevated gas readings have been recorded in nearby boreholes BH3 and BH4. LKC note that no visual evidence of this shaft was noted in the 2007 mineshaft search and trenching exercise.

No coal seams were recorded to a depth of 30m in Borehole R1 (proposed locomotive running shed area). Borehole R2 (proposed carriage shed area) encountered coal from 26.0-27.5mbgl. Further NXC boreholes in this area did not encounter this seam, although a soft coal was noted in NXR BH02 from 32.0-32.25mbgl.

5.3.2. Gas Screening Value

In accordance with CIRIA C665²¹, a Gas Screening Value (GSV) may be calculated. Assuming worst-case scenario maximum gas concentrations and flow for each borehole have been used to calculate the GSV. The GSV can be used to determine the characteristic situation (CS).

Table 5-3 shows the maximum GSV for each development area based upon boreholes the highest gas concentrations and / or highest positive flow rates, with an appropriate characteristic situation (based on GSV only).

Location	Max GSV (l/hr)	CS
Proposed Locomotive Running Shed	BH3 = 0.021 (max. CO ₂ = 4.2%, max. flow = 0.5l/hr)	CS1
Proposed Carriage Shed	BH C4 = 0.02145 (max. CO ₂ = 1.3%, max. flow = 1.65l/hr) BH7 = 0.0688 (max. CO ₂ = 4.3%, max. flow = 1.6l/hr)	CS1

Table 5-3: Summary of Worst-Case Gas Screening Values (GSV).

Notes:

CS = Characteristic Situation

Given the above calculated GSVs, the amount of return monitoring visits, the ash and clinker nature of the made ground, clay overlying coal measures strata and the maximum concentrations being below 1% (methane) and 5% carbon dioxide then LKC consider the hazardous and ground gas regime in the proposed development areas has been appropriately characterised.

LKC consider the probability of carbon dioxide and methane gas affecting site users and buildings as unlikely. Assuming a severe consequence, there is a moderate / low risk. Given the above reasoning, a low risk is considered most appropriate, and no remediation is required.

5.4. Controlled Water Assessment

The PRA identified a low risk with respect to controlled waters as no significant source of mobile contamination was anticipated.

No evidence of significant mobile contamination was identified on the site. Although elevated metals and PAHs were identified within the soils, the source is anticipated to be ash and clinker noted within the made ground. Contamination associated with ash and clinker is not anticipated to be mobile due to the residual crystalline nature of the matrix.

LKC considers the River Irwell and the Secondary A Aquifers as the primary receptors. Groundwater testing and leaching tests were carried out by CRH. In addition, leaching tests were carried out by LKC on the embankment soils from WS101 and WS102.

LKC have compared results above Limits of Detection (LOD). Where relevant the review of priority substances takes precedence considering threshold values for groundwater cannot be used '*as part of site-specific investigations*'. The hierarchy is as follows:

- River Basin District Standards²² and updated Water Framework Directive²³ for Annual Average / Maximum Allowable Concentration Environmental Quality Standards (AA-MAC-EQS) for priority substances (surface water risk).
- 2016 private water supply standards (UKDWS potable)²⁴.
- 2001 Environment Agency Values for Environmental Quality Standards (EQS) and UK Drinking Water Standard (UKDWS)²⁵.
- Resource Protection Values (RPVs)²⁶.

With regards to hydrocarbon mixtures (TPHCWG) for UKDWS, LKC will use the CL:AIRE guidance on petroleum hydrocarbons in groundwater²⁷ based on WHO guidelines.

The leaching test is aggressive (de-ionised water) and is not in aqueous equilibrium (steady state) with the solid sample. This may cause rapid dissolution and overestimation of the aqueous phase concentrations compared to groundwater in contact with contaminated soils. Although dissolution may be reduced for highly hydrophobic contaminants²⁸ such as B(a)P, it is likely that the initial leaching will remove the most readily available hydrocarbons and subsequent flushing would reduce the leachable concentrations²⁹. Traditionally the leaching test was developed for inorganic constituents and the leaching of organics is poorly understood³⁰.

CRH encountered concentrations of , BTEX, TPH bands, chlorinated VOCs and SVOCs, and PAHs in both groundwater and leaching tests below the analytical limits of detection and with occasional detections of boron (max. 0.19mg/l), nickel (max. 20µg/l), sulphate (max. 0.16g/l), zinc (max. 20µg/l)

Leaching tests carried out by LKC encountered TPH bands below the analytical limits of detection. Heavy metals were detected: arsenic (max. 2µg/l), chromium (max. 3µg/l), copper (max. 8µg/l), lead (max. 2µg/l), nickel (max. 1µg/l) and zinc (max. 12µg/l). Total PAH concentrations were 0.11µg/l and 0.51µg/l.

No elevated contaminants above detection limits were identified in any of the groundwater or leaching test samples except for Total PAH (when contrasted to the DWS) at WS103 (1.2m).

Given this is from a leaching test and the groundwater in the area is not extracted for drinking water supply and the clay present at depth across the site should significantly reduce any sub-surface migration and processes including dilution, attenuation and biodegradation will reduce the concentration of contamination.

Based on the above, LKC considers the probability of contaminants on site affecting the River Irwell and Secondary A Aquifers as unlikely. Given the medium consequence, a low risk is anticipated (Pollutant Linkage 4) and no remediation is required.

5.5. Potable Water Supply (Pollutant Linkage 5)

Soil results may be compared to United Utilities (UU) guidelines for the selection of potable water pipes in land potentially affected by contamination. Only contaminants of concern, based on the preliminary conceptual model and ground conditions encountered, were analysed.

Elevated VOCs (based on naphthalene only) and hydrocarbon fractions have been identified. Based on the ground conditions encountered, this is likely to be widespread across the site.

The probability of organic contaminants affecting potable water pipes is likely. Given the consequence is considered to be medium, the risk (Pollutant Linkage 5) is anticipated to be moderate and remediation is likely to be required.

Once details of the pipeline location and depths are known a UU Water Pipe Risk Assessment in line with the utility provider should be undertaken to confirm the most appropriate pipework for potable water.

5.6. Revised Contamination Conceptual Model

The preliminary contamination conceptual model (Table 2-3) has been revised following the risk assessments undertaken in Sections 5.1-5.5. The revised contamination conceptual model follows the same methodology and guidance used in the preliminary contamination conceptual model. The risk matrix is provided in Appendix C.

The revised contamination conceptual model is presented in Table 5-4.

Where a very low risk or low risk is identified no specific remediation is required.

Where there is a moderate / low risk is identified, some form of remediation may be required depending on the pollutant linkage, the type and concentration of contaminants present and the proposed development.

Where LKC identifies a moderate or higher risk, remediation or further investigation work is recommended.

PL	Contaminants of Concern (source)	Pathway	Receptor	Probability	Consequence	Risk	Recommendations
1	Lead.	Dermal contact. Inhalation of soil, fibres, and dust. Ingestion of soils, dust. Windblown dust.	Future site users.	Likely	Medium	Moderate	Remediation recommended in any new soft landscaping areas.
2	Volatile contaminants.	Inhalation of vapours. Migration via permeable strata and preferential pathways.	Future site users. Offsite receptors.	Unlikely	Medium	Low	No remediation recommended.
3	Hazardous and ground gas: methane, carbon dioxide.	Migration via permeable strata and preferential pathways. Inhalation of gas. Explosion in confined spaces.	Future site users. Buildings. Offsite receptors.	Low Likelihood	Severe	Moderate / Low	No remediation recommended.
3	Radon	Migration via permeable strata and preferential pathways. Exposure to radon.	Future site users.	Unlikely	Medium	Low	No remediation recommended.
4	Mobile and leachable contaminants	Surface run-off. Migration via permeable strata and preferential pathways. Perched waters migration.	Groundwater Surface water	Unlikely	Medium	Low	No remediation recommended.
5	Hydrocarbons, naphthalene.	Permeation of pipes. Ingestion of tainted water supply.	Future site users. Water pipes.	Likely	Medium	Moderate	Remediation recommended for any new inground potable water supply pipes.

Table 5-4: Revised Contamination Conceptual Model.

6. Conclusions

The aim of this report is to provide an overarching risk assessment with respect to potential contamination risks in the proposed locomotive running shed and proposed carriage shed areas only. A geotechnical assessment, slope stability assessment and shallow mining instability assessment are covered elsewhere.

6.1. Contamination Assessment

A revised contamination conceptual model has been produced by LKC which is summarised in Table 6-1 below (more detailed model provided in Section 5).

PL	Contaminant	Risk	Recommendations
1	Metals	Moderate	Remediation required.
	Asbestos	Low	No remediation required.
	PAHs		
	Petroleum hydrocarbons Other inorganic / inorganic contaminants		
2	Volatile contaminants	Low	No remediation required.
3	Carbon dioxide & Methane	Moderate / Low	No remediation required.
3	Radon	Low	No remediation required.
4	Groundwater and surface water (mobile contaminants)	Low	No remediation required.
5	Organic contaminants.	Moderate	Barrier pipe likely required for any new inground potable supplies.

Table 6-1: Summary Risk Table.

PL=Pollutant Linkage, see Table 5-4 for details.

7. Recommendations and Outline Remediation Strategy

The recommendations/requirements provided below are considered appropriate for the site based on the site investigation work undertaken. LKC should stress that no remediation, enabling works or designing works should take place until Regulatory approval has been obtained.

A summary of remediation requirements is included in Table 7-1.

PL	Recommendation
1	Environmental cover system required in any new soft landscaping areas in the proposed development areas.
2	No remediation required.
3	No remediation required.
4	No remediation required.
5	Potable water pipe assessment required for any new in ground water supply pipes. Barrier pipe is likely to be required.

Table 7-1: Remediation Summary.

Based on the findings of the site investigation and risk assessment, no remediation is required.

A watching brief for any unexpected contamination should be maintained during groundworks and any imported soils brought to site for use in soft landscaping should be validated to ensure they are suitable for use.

7.1. Remediation and Validation Recommendations

7.1.1. Environmental Cover System (PL1)

In any new soft landscaping areas, an environmental cover system will be required and should comprise a minimum 450mm depth of soil. The environmental cover system should be constructed as shown in Plate 7-1.

Either (physical break layer)		Or (geotextile membrane)	
450mm (minimum)	Chemically validated TOPSOIL ¹	450mm (minimum)	Chemically validated TOPSOIL ¹
	Chemically validated SUBSOIL		Chemically validated SUBSOIL
	100mm (minimum) PHYSICAL BREAK LAYER ²		GEOTEXTILE MEMBRANE (at base of subsoil)
Existing MADE GROUND			

Plate 7-1: Typical Environmental Cover System Construction.

Notes:

Hardstood Areas – No Remediation Required.

¹NHBC recommend 100mm minimum topsoil depth.

²Gravel break layer, minimal fines.

Validation of environmental cover soils will be required and should include measuring depth using a staff and providing photographic evidence. Photographic evidence of the granular physical break or geotextile layer should also be collected.

Chemical validation of imported soils is required, details are included in Section 7.3.

7.1.2. Potable Water Pipe Remediation (PL5)

Should new in ground potable water supplies be required then it is likely that barrier pipe will be required. The utility provider will require a Water Pipeline Assessment³¹ is undertaken once the location and depth of potable water pipes are known.

Validation of pipeline installation should include delivery notes of pipe materials, photographs of installed pipe and confirmation of connections.

7.2. Other Considerations

7.2.1. Unexpected Contamination

The relevant contractors should be briefed that during development works at the site should any unusual ground conditions and / or visual or olfactory evidence of contamination (including asbestos containing material) be encountered at the site, LKC and the Local Authority should be informed, and further assessment of the material may be required.

Impacted soils should be placed on an impermeable surface to await further assessment, treatment, or removal from site (this may be subject to chemical testing to confirm suitable waste facility). The work should be done under the supervision and instruction of an environmental consultant.

To determine that significantly impacted soils have been removed, verification samples will be collected from the base and sides of the excavation. If all impacted ground cannot be removed and contamination remains on the ground, further remediation may need to be considered.

Validation requirements should include a log of work undertaken, including photographs and details of any sampling undertaken and validation of any potential additional remedial work.

7.3. Validation of Imported / Site Won Soils

Chemical validation of all imported and site-won soils to be used on site in any proposed soft landscaping areas should be undertaken. Imported soils should be accompanied by a certificate of analysis and source details.

A summary of the required imported material sampling requirements is presented in Table 7-2 and is based on the YALPAG guidance (2021)³². Ideally, the material should be sampled at source to prevent double handling if soil fails, with confirmatory sampling undertaken on importation to site. Where this is not possible then material imported should be segregated based on source and soil type. Validation samples should be taken prior to placement in gardens to ensure suitability for use.

Material Type	Source	Suite of Analysis	Sampling Rate
Topsoil / Subsoil	Greenfield / manufactured / site-won natural	Suite A*	1 sample per 50m³
	Brownfield / unknown	Suite B**	
Subsoil	Quarried sand	No testing required. Certification of material provenance is required.	
Gravel break layer	Quarried stone		
	Recycled stone (6F2 / screened)	Suite B*	1 sample per 500m³

Table 7-2: Sampling Requirements for Imported and Site Won Soils.

Notes:

Suite A - Heavy metals, pH, water soluble sulphate, speciated PAH, soil organic matter and asbestos screen.

Suite B - Heavy metals, pH, water soluble sulphate, speciated PAH, phenol, total and free cyanide, soil organic matter, asbestos screen, banded petroleum hydrocarbons (TPH CWG), BTEX, MTBE.

*Minimum sampling rate of 3 samples per source.

**Minimum sampling rate of 6 samples per source.

Any soil with visual or olfactory evidence of hydrocarbons should be rejected.

In addition, it should be ensured that the matrix of the topsoil is suitable as a growing medium and no undesirable material is present (in line with BS3882³³). LKC advise this information is provided by the supplier before material is imported onto site.

Imported material to be used in gardens will be compared against the generic assessment criteria as used in the contamination risk assessment in Section 5.

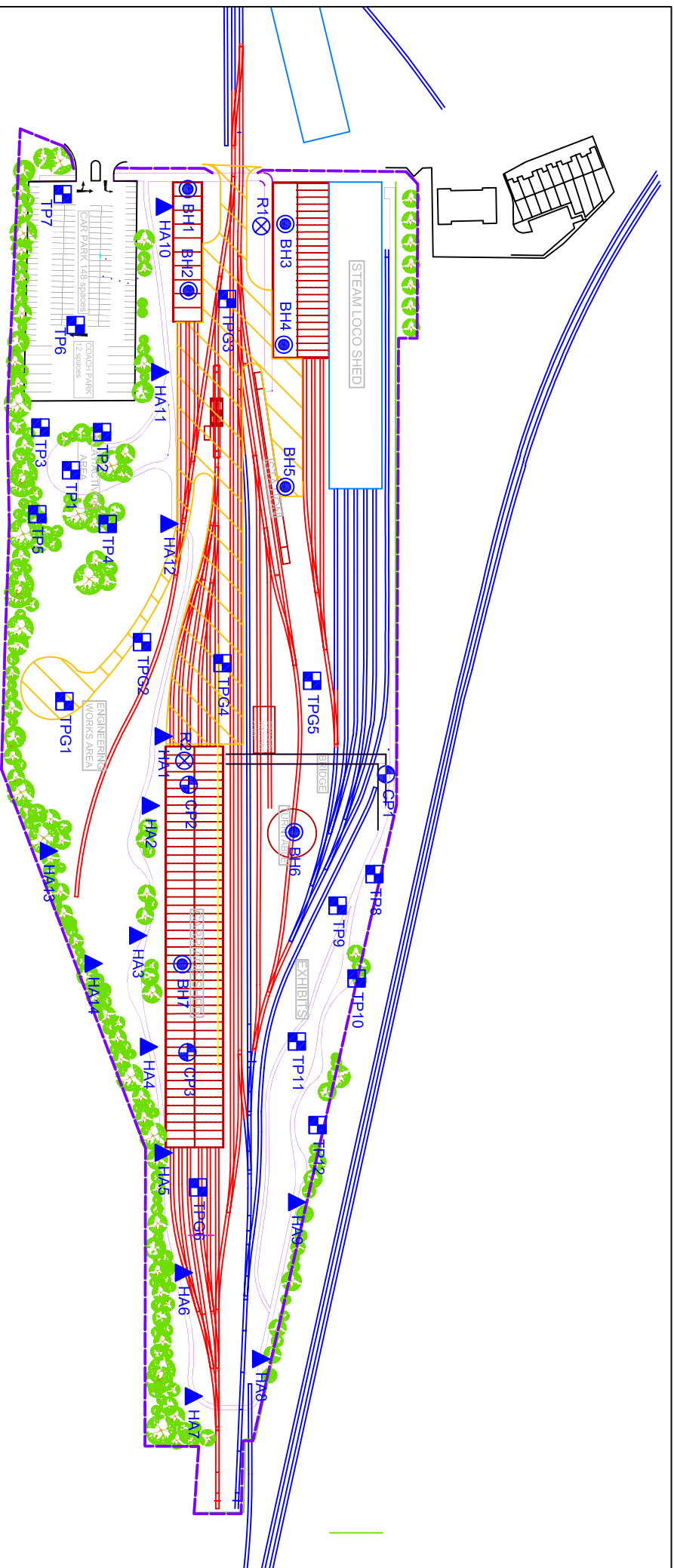
7.4. Site Completion Report

All remediation and validation work should be documented in a Site Completion Report. The Site Completion Report will allow discharge of relevant planning conditions.

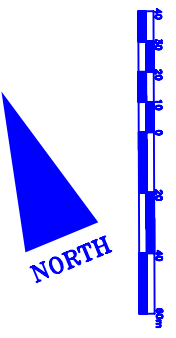
Appendix A – Site Plans



Client: East Lancashire Light Railway Ltd				Title: Site Location & Boundary Plan				
Site: Buckley Wells Loco Works, Bury								
Job No.: LKC 23 1449		Drawn By: CC	Checked By: PQ	Drawn: July 2024	Scale (see scale bar): 1:25,000 & 1:5000 @ A4			



- Key to LKA Sampling Locations**
- Window Sample Borehole
 - ▲ Hand Auger
 - Trial Pit
 - ⊗ Rotary Borehole
 - ⊕ Cable Percussion Borehole



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Title: **Site: JB578 Buckley Walls Locomotive Works**

Figure 3-1 LKA Sampling Locations

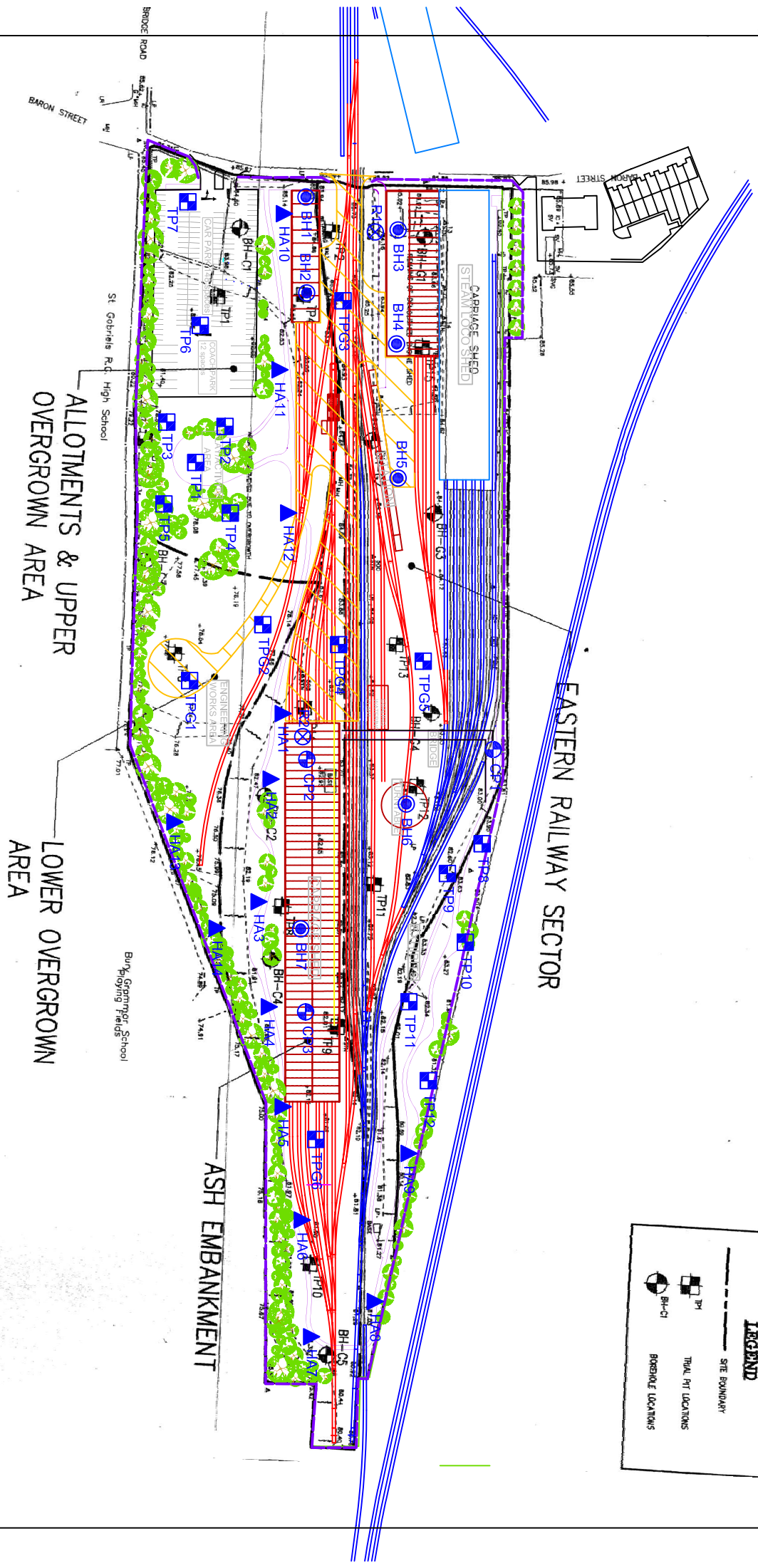
Date: September 2006 | Scale: ~1:2500 @ A4

LEGEND

--- SITE BOUNDARY

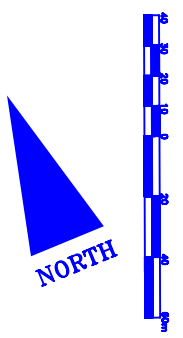
TP1 TRIAL PIT LOCATIONS

BH-C1 BOREHOLE LOCATIONS



Key to LKA Sampling Locations

- Window Sample Borehole
- ▲ Hand Auger
- Trial Pit
- ⊗ Rotary Borehole
- ⊕ Cable Percussion Borehole



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Site: JB578 Buckley Wells Locomotive Works

Title:

Figure 3-2 LKA & CRH Sampling Locations

Date: September 2006 Scale: ~1:2500 @ A4