INTERIM REMEDIAL OPTIONS APPRAISAL, REMEDIATION STRATEGY AND VERIFICATION PLAN FOR DEESIDE, SHOTTON

TE1920-TE-00-XX-RP-GE-008-V05

20 JANUARY 2026

FINAL

Prepared for:

Knauf Insulation Limited

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DOCUMENT CONTROL

Report No. :	TE1920-TE-00-XX-RP-GE-008-V05
Report Status:	FINAL
Project Engineer:	Adrian Read
Date of Issue:	20/01/2026

Version No.	Description of Issue / Revision	Date of Issue	Author	Reviewed By	Approved By
1	FINAL	03/10/2025	Adrian Read	Alex Preston	Sean Lee
2	Update based on latest masterplan and site boundary	24/10/2025	Stuart Milne	Adrian Read	Adrian Read
3	Minor text updates	07/11/2025	Adrian Read	Sean Lee	Sean Lee
4	Minor text updates	09/12/2025	Adrian Read	Sean Lee	Sean Lee
5	Minor text updates	20/01/2026	Adrian Read	Sean Lee	Sean Lee

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Proposed land use	Planning permission to erect a state of the art, low carbon rock mineral wool insulation product manufacturing plant, including storage, office space, vehicular access, landscaping, parking and associated infrastructure, substation, external works, remediation and demolition of existing buildings.
Remediation options appraisal and remediation strategy	An interim remediation strategy has been prepared to **solely** manage/mitigate the identified pollutant linkages associated with the localised hotspots and unexpected / as yet unidentified localised contamination in soils at the site. Other identified outline remedial measures associated with a 300mm clean cover system is covered by **separate ROARS document** and should be read in conjunction with this report. The following remedial measures are proposed within this document: • Removal and verification of localised and incidental impacts and potential sources of contamination associated with structures and items related to the former use of the site as a steelworks – e.g. presence of localised / incidental historical barrel containing residual possible weathered fuel oil (located at TPWS03) and presence of localised visual / olfactory evidence of hydrocarbon hotspots including a pipe at TP207 / CP206 containing product plus any unexpected / as yet unidentified localised contamination in soils at the site, where required. Such measures to achieve this have been identified as one or more of the following: o Supply of appropriately trained geoenvironmental staff to conduct the visual inspection of soils during a full time watching brief during enabling works; o Localised excavation and off-site disposal of discrete features / structures and any associated grossly contaminated soils (if encountered); o Vacuum tanker pumping of grossly impacted groundwater / free phase product (if encountered) to significantly reduce the primary source mass; o Verification soil and groundwater chemical analysis (as required); o Lines of evidence approach to demonstrate local betterment of ground conditions and consideration of other remedial measures being implemented to break any residual pathways identified • Removal, crushing and screening of all oversized material and obstructions in the ground; • Bulk earthworks to achieve the proposed development levels, including with fill materials compacted in accordance with the Tier Environmental Enabling Works and Earthworks Strategies. Re-use of site won materials to be conducted in via a Materials Management Plan in accordance with the Definition of Waste Code of Practice; • All earthworks and groundworks to be conducted in accordance with the Control of Asbestos Regulations (CAR) 2012; • Supply of appropriately trained geoenvironmental staff to conduct the visual inspection of soils during a full time watching brief during enabling works and appropriately trained contractor staff to then subsequently hand pick any visually identified ACMs, double bag and dispose off-site under the Duty of Care. If gross contamination is encountered within soils in the ground, then these materials will be excavated at the direction of the supervising geoenvironmental engineer, segregated, temporarily stockpiled / placed on visqueen for subsequent hand picking and subsequent off-site disposal to be conducted. All works to be conducted and managed in accordance with an Asbestos Management Plan; • Backfill of resultant excavations with suitable (likely site-won) material. In addition, suites of analysis on samples and frequency of testing on imported materials or atypical site won materials (that have not been already characterised by the extensive previous chemical testing conducted during the GIR and supplementary GIR) to be as per Table 5.1 in this report. The above integrated strategy is designed to: o Mitigate risks to human health from localised / discrete areas of gross contamination via direct contact, ingestion, dust inhalation and vapour inhalation pathways; o Mitigate any residual risks to the controlled waters environment from such localised features / contamination;

	○ Provide flexibility in the event that localised unexpected gross contamination is identified beneath the site, inclusive of any localised ACMs.
Asbestos Licence Status	The risk assessment indicates that most activities are expected to fall under Non-Licensed Work (NLW) or Notifiable Non-Licensed Work (NNLW)—the latter requiring pre-notification, medical surveillance, and exposure records, but not an HSE licence. However, any encounter with gross contamination (e.g., visible fragments of insulation or other non-bonded asbestos) may necessitate further investigation, sampling, and interpretation to determine the likely working conditions and licence status under CAR-SOIL. **Given the site history and the realistic prospect of encountering such materials locally, all contractors engaged for enabling and earthworks should hold (or engage a specialist subcontractor who holds) an HSE asbestos licence so that any licensed asbestos removal can be undertaken safely, and in compliance with regulatory requirements.** **For the avoidance of doubt, Tier Environmental recommends that contractors on site be prepared to undertake "Licensed work" with asbestos (for anticipated localised higher-risk—e.g., asbestos insulation/lagging, AIB, or other work where significant fibre release or non-brief exposures are likely). If the task is licensable, it must be done by a licensed contractor and must be notified to HSE via an ASB5 at least 14 days before starting.**

1. INTRODUCTION

Tier Environmental was commissioned by Knauf Insulation Limited to undertake a Land Contamination Risk Management (LCRM) Interim Remedial Options Appraisal, Remediation Strategy and Verification Plan for an area of land referred to as Deeside, Shotton, located at land in the east of Shotton Steel Works, Deeside CH5 2NH (the "site").

Presently, the following key remediation components are anticipated for the site based on the results from previous Ground Investigation and Supplementary Ground Investigation works:

- Hotspot removal of any incidental / localised features (such as the barrel identified at TPWS03 in the northern area of the site containing some residual fuel oil free phase product) to be excavated and disposed off site to an appropriate landfill / waste treatment facility.
    - Any surrounding impacted soils or groundwater that are not considered to have been already assessed via the works contained within previous reporting will be subject to further sampling and risk assessment as necessary.
- Removal and off-site disposal (to an appropriate landfill / waste treatment facility) of any unexpected or previously unidentified contamination hotspots.
- 300mm clean cover system is implemented in all soft landscaping areas.

This report is designed to cover the items identified in **red text**, above. The remaining bulletpoint items are addressed via a separate Remedial Options Appraisals, Remediation Strategy and Verification Plan.

The title of this report is in accordance with that described in the Land Contamination Risk Management guidance (available at https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm) which has superseded CLR 11:

- Stage 2 - LCRM Options Appraisal Report
- Stage 3 - LCRM Remediation Strategy

1.1. Proposed Development

Planning permission to erect a state of the art, low carbon rock mineral wool insulation product manufacturing plant, including storage, office space, vehicular access, landscaping, parking and associated infrastructure, substation, external works, remediation and demolition of existing buildings, as presented on the drawings in Appendix A.

As such, in accordance with the *'Updated technical background to the CLEA model'* (Environment Agency, 2009) and *'Suitable 4 Use Levels'* (LQM / CIEH 2015) the proposed generic land use for this development is commercial / industrial.

1.2. Previous Reports

The following documents were available following review of information on the local planning portal:

- A Validation Report for the HVDC Western Link, Flintshire Bridge Converter Station, by WSP (Ref: 70022417-10666, dated January 2018);
- An Ecology Update Report for the Proposed CHP Plant, by Etive Ecology (Ref: No reference, dated January 2013); and,
- An Ecology Report for the Shotton Combined Heat and Power Plant, by Black & Veatch Ltd (Ref: 121303, dated May 2009).

The following pertinent previous reports have also been prepared:

- Preliminary Risk Assessment Report For Deeside, Shotton, Tier Environmental (Ref: TE1920-TE-00-XX-RP-GE-001-V04, dated November 2025);
- Explosive Ordnance Desk Top Study for Land Adjacent to Shotton Works, EOD Contracts, (Ref: EOD/25/25150/DTS/, dated 26th March 2025);
- Ground Investigation Report for Deeside, Shotton, Tier Environmental (Ref: TE1920-TE-00-XX-RP-GE-002-V06, dated November 2025);
- Supplementary Ground Investigation Report For Deeside, Shotton, Tier Environmental (Ref: TE1920-TE-00-XX-RP-GE-006-V04, dated November 2025)

1.3. Background and Previous Works Summary

The Ground Investigation Report (reference: TE1920-TE-00-XX-RP-GE-002-V05, dated October 2025), hereafter referred to as the 'GIR' report included a generic quantitative risk assessment of laboratory chemical analysis data obtained from soil and groundwater to determine potential risks to human health for the proposed land use and the controlled waters environment. This was then updated following supplementary ground investigation works reported in the Supplementary Ground Investigation Report (Ref: TE1920-TE-00-XX-RP-GE-006-V03, dated October 2025), hereafter referred to as the 'Supplementary GIR' report.

The results of a generic quantitative human health risk assessment across these two reports have determined the following:

- Measured soil concentrations of iron and manganese exceed adopted GACs protective of commercial / industrial land use – these are likely driven by the presence of slag identified in the ground beneath the site.
    - In addition, localised PAHs (benzo(a)pyrene, dibenzo(ah)anthracene and benzo(k)fluoranthene) have been reported at depth (1.80m bgl) locally at CP07 in the southwest of the original site extent (outside of the proposed development area) which exceed the respective GACs for a commercial / industrial land user; however, this is no longer within the site boundary now being adopted for the proposed development such that it can be disregarded to some extent. It should be noted; however, that the proposed remediation would also be sufficient to address this impact in any case.
- Chrysotile and amosite (and locally crocidolite) asbestos free fibres, fibre bundles ACM debris and locally bitumen products have been at reported concentrations between <0.001% w/w and 0.018% w/w. Asbestos has been positively identified in 28 No. of the 75 No. samples analysed (i.e. 37% of samples). During the fieldwork no suspected ACMs were identified; however, a single sample was obtained off-site to the northwest of some pipework encased in concrete obtained to assist with client decision making with regards to this parcel of land ('TANKCORE 1 (PIPE)' at 0.80m) – this is not presently regarded as being relevant to the on-site human health risk assessment due to its presence outside the red line boundary considered within this report. It is possible, given the prevalence of non-visible asbestos encountered in the soils for previously unidentified visible ACMs to be present in soils beneath the site and an asbestos management plan is recommended to provide recommendations in the event of discovery of such materials. Consideration has also been made within this report for such impacts, upon discovery.
- Ground gas monitoring has demonstrated a Characteristic Situation 1 – Very Low Risk Scenario with conservatism built into the GSV calculation to provide additional confidence in this conclusion. Additional consideration has also been made to the concentrations of carbon monoxide and hydrogen sulphide reported beneath the site and no significant risk was identified. Therefore, no ground gas protection measures are required at the site.
- The majority of the site is recorded to have less than 1% of properties above the Action Level. Areas of 1-3% above Action Level are recorded encroaching into the far western edge of the site. This corelates with a change in bedrock geology to the Gwespyr Sandstone,

however given the presence of anticipated 50m of superficial deposits the risk from radon is considered low. The BGS radon report confirms that "no radon protective measures are required for the report area".

The conceptual site model considerations and results of a generic quantitative controlled waters environment risk assessment from the initial GIR determined the following:

- The superficial deposits (Tidal Flat Deposits) are classified as a Secondary Undifferentiated Aquifer and the bedrock (Pennine Lower Coal Measures) is classified as a Secondary A Aquifer. The site is not within a Source Protection Zone, and there are no active potable or non-potable abstraction wells within 2km. The nearest surface water features are 2 No. artificial water bodies/ponds with associated surface water drainage channels constructed during the historical industrial development, the closest major feature is the River Dee circa 545m south of the site (distance updated to from 425m, due to subsequent confirmation of the site boundary extent).
- Groundwater flow was determined using groundwater monitoring data demonstrating a general groundwater flow direction across the site to the southeast. Through a combination of ground investigation information obtained and nearby BGS borehole records, Tidal Flat Deposits are present to circa 17.60m to ~30m bgl comprised of silts, sands and clays overlying Till to circa 50m bgl, onto the Pennine Lower Coal Measures bedrock. On this basis the controlled waters sensitivity is regarded as being low for the bedrock aquifer (deeper bedrock Secondary A Aquifer protected from vertical migration by layers of low permeability cohesive Glacial Till) and low/moderate for the superficial aquifer, with a generally low/moderate sensitivity for on-site surface water features.
- Justification for the use of the surface water ponds as a proxy for the purposes of assessing risks to the River Dee have been presented in the Supplementary GIR report:
    - the proposed development area is such that the southern boundary of the site can be re-drawn in such a manner that the distance between the subject site River Dee is Circa 545m south and the ponds effectively sit hydraulically down gradient between the observed phenol impacts at CP01 and the River Dee;
    - Tier Consult has been involved in commissioning of underground service trace and drainage surveys at the site and it can be confirmed that no significant preferential pathways (such as via culverts or preferential drainage routes) are present beneath the site that may act as preferential pathways to connect the area of phenol impacts (around CP01) and the River Dee.
    - The Ground Investigation Report states that "Groundwater has been monitored across the site at depths between 1.79 and 4.55m bgl (3.82m and 4.55m AOD) and is representative of a single groundwater body within the Made Ground / Tidal Flat Deposits that appears to be in continuity with the surface water ponds on site (based on topographical elevations recorded at the pond water edge).". As such, given that 1) the ponds are located hydraulically downgradient of the phenol impacted groundwater location 2) appear in continuity with the groundwater 3) are located within Circa 100m of the previously identified phenol impacts and, 4) the absence of any other viable preferential pathways that would otherwise circumnavigate the ponds - it is considered that the ponds would likely intercept any phenol impacts and therefore represent appropriate proxies for the purposes of assessing risks to surface water receptors (inclusive of the River Dee).
- No free phase product has been measured in the monitoring wells at site (measured using an oil / water interface probe) or observed in bailers / low flow equipment during groundwater sampling.
- A controlled waters risk assessment has been conducted which has considered the results of soil leachate testing, groundwater and surface water testing holistically. Due consideration has also been made of the magnitude of selected Water Quality Standard (WQS) exceedances and in the context of the conceptual site model.
    - The measured leachable concentrations of metals and PAHs reported in excess of WQS from the initial GIR are **not** considered to represent a significant risk to the controlled waters environment. It should be noted that the proposed development will include extensive hardstanding, buildings and a dedicated drainage system which will reduce infiltration rates through the site significantly.

- Measured dissolved phase groundwater concentrations of metals, PAHs, ammonia and sulphate, plus isolated VOC, phthalate, electrical conductivity and TPH concentrations **are not regarded** as being representative of a significant risk to the controlled waters environment given the low to low/moderate sensitivity of the controlled waters receptors.
- Specific consideration has been made of the groundwater quality at CP01 due to the groundwater being described by the sampling technician as opaque black / dark brown in colour with a strong 'antiseptic-type' odour. CP01 is located in the northwest of the site in proximity to the former boiler houses (located off-site) and the No. 1 furnace of the former Shotton Works and associated soaking pits and fitting shop. It is not considered that the measured concentrations of PAHs or TPHs at this location represent a significant risk to the wider controlled waters environment based on the extensive groundwater quality information hydraulically downgradient from this location from both the initial GIR and the supplementary Ground Investigation works, and based on the surface water quality assessment. However, supplementary ground investigation works have been conducted to further assess the measured concentrations of phenols and specifically 4-Chloro-3-methylphenol plus 4-Methylphenol, 2,4-Dimethylphenol and 2-Methylphenol.
    - The results of the supplementary ground investigation have demonstrated that the phenol impacts are extremely localised to CP01, with no evidence of a wider source area identified. It has been possible to demonstrate that the impacts are not representative of a wider plume and no evidence of an off-site source area has been identified. Indeed, the evidence suggests that the groundwater quality within the monitoring well at CP01 may have been influenced by a small, localised bottle, former pipe or perched volume of phenols, likely a biocide based on the spike of the 4-Chloro-3-methylphenol observed. Indeed, the feature must have been extremely small because it was not observed during the drilling of CP01 (and neither were any visual / olfactory evidence of contamination during the drilling of CP01 or nearby supplementary investigations). It is evident from the laboratory data that the impacts have not had a wider effect on the groundwater or surface water quality.
    - The groundwater quality at CP01 has improved and benefitted from the removal of water that has taken place during the supplementary ground investigation sampling works. The groundwater quality at CP01 has continued to improve following successive purging and sampling. Between the initial and second supplementary monitoring visits, measured concentrations of 2,4-Dimethylphenol, 4-Chloro-3-methylphenol and 4-Methylphenol reduced by 92–94%, and by the third sampling event (Visit 2) had decreased by more than 99.5% relative to the original results. These progressive reductions are consistent with the sampling engineer's field observations that the groundwater quality improved both visually and olfactorily during development and purging of the well. The data from CP01 and hydraulically downgradient wells therefore confirm that the residual phenolic impacts are diminishing and not representative of a replenishing or migrating source.
    - Accordingly, it is concluded that the phenolic impacts at CP01 were transient and localised, consistent with disturbance or flushing of a small, perched source during well installation and initial sampling. The substantial reductions in concentrations, coupled with the absence of corresponding detections elsewhere and the low aquifer sensitivity, provide a robust weight of evidence that the residual phenols at CP01 do not pose a significant risk to controlled waters receptors, including the adjacent surface water bodies or the River Dee located approximately 545 m south of the site.

1.4. Anticipated Outline Remedial Works

The Supplementary GIR report included the following updated outline remediation requirements on the basis of the risk assessment conclusions summarised above. In essence, the outline remedial strategy that has been previously presented is:

- The proposed human health elements of the outline remediation strategy contained within the GIR remain unchanged, based on the results of the Supplementary GIR report.
    - It is considered that a 300mm clean cover system should be implemented in all soft landscaping areas (comprising geotextile membrane or hard dig layer overlain by clean imported topsoil) to mitigate the direct contact, dust inhalation and ingestion pathways associated with the iron and manganese concentrations reported in the soils across the site. This clean cover system will also act to break the dust inhalation pathways associated with the low level asbestos reported in soils beneath the site.
    - Any incidental / localised features such as the barrel identified at TPWS03 in the northern area of the site containing some residual fuel oil free phase product, or the pipe containing product reported at TP207 / CP206 at 1.99m bgl, shall be excavated and disposed off site to an appropriate landfill / waste treatment facility. Any surrounding impacted soils or groundwater that are not considered to have been already assessed via the works contained within this report will be subject to further sampling and risk assessment as necessary.
- The supplementary investigation and monitoring have confirmed that the phenolic impacts previously identified at CP01 are extremely localised and have reduced by over 99.5% following well development and purging. These findings, when considered alongside the conceptual site model indicating low aquifer sensitivity and no downgradient impacts, demonstrate that active remediation (previously recommended on a precautionary basis in the original GI) is not warranted.

1.5. Objectives

On the basis of the above, the objectives of this report are to:

- To reproduce the Refined Conceptual Site Model derived within the previous Supplementary GIR;
- Undertake An Interim Remediation Options Appraisal to address reported:
    - Localised hotspots of gross contamination (e.g. such as the barrel identified at TPWS03 in the northern area of the site containing some residual fuel oil free phase product, or the pipe containing product reported at CP206 at 1.99m bgl);
    - Unexpected or previously unidentified contamination, inclusive of any previously unidentified Asbestos Containing Materials (ACMs).
- Produce an Interim Remediation Strategy and Verification Plan on the basis of the selected viable approaches determined during the Remedial Options Appraisal.

This report, which was designed to meet the requirements of all relevant current guidance including 'Land contamination: risk management' (LC:RM) (which supersedes CLR11) presents the factual information available during this appraisal, interpretation of the data obtained and recommendations relevant to the defined objectives.

1.6. Assumptions

The following assumptions are made in this report:

- It is assumed that ground levels will not change significantly from those described in this report or a shown on proposed development drawings. If this is not the case, then amendments to the recommendations made in this report may be required.
- The ground investigations that have informed this remediation strategy were designed with due consideration of known or suspected constraints (including underground services and access constraints).
- Any references to observations of suspected asbestos-containing materials are for information only and should be verified by a suitably qualified asbestos specialist and/or confirmed by laboratory analysis.

- The use of the term 'Topsoil' within this report is based on a visual identification only and that these materials have not been classified in accordance with BS3882:2015.
- The use of the terms ‘shallow’ and ‘deep’ within this report (from a geotechnical perspective) assume *typically* between ground level to circa 3.00m below ground level (bgl) for ‘shallow’ and greater than 3.00m bgl regarded as ‘deep’;
- The comments and opinions presented in this report are based on the findings of the desk study, ground conditions encountered during intrusive investigation works performed by Tier Environmental and the results of tests carried out within one or more laboratories. There may be other conditions prevailing on the site which have not been revealed by these previous investigations and which have not been taken into account by this report.
- Responsibility cannot be accepted for any conditions not revealed by the previous investigations. Any diagram or opinion on the possible configuration of the findings is conjectural and given for guidance only. Confirmation of intermediate ground conditions should be undertaken if deemed necessary.

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2. SITE DETAILS AND DESCRIPTION

Table 2.1 Current Site Overview.

Site name	Deeside, Shotton
Site address	Shotton Steel Works, Deeside CH5 2NH. A site location plan is included as Drawing No. TE1920-TE-00-XX-DR-GE-001-V01 within Appendix A.
National Grid Reference (NGR)	331231 370196
Approximate site area	The site area covers approximately 12.28 hectares with the red line boundary area (including the access road) spanning to 17.68 hectares.
Site shape	The site is irregular in shape.
Current land use on the site	The majority of the site comprises undeveloped land laid to grass and low lying vegetation. Areas of mature vegetation are located around the ponds and towards the south of the site with limited access. In the northwest and south east there are areas of gravel surface material associated with old buildings/compounds. Existing buildings on site include a unit in the northwest and small brick structures in the southeast, one presumed to be a historic substation. Two water bodies/ponds are located in the centre of the site with connecting drains/water courses; local surface water and storm drainage is observed to drain into the ponds which are used for recreational fishing. A number of private roads bisect the site with access via level crossings off site. A bund runs along the eastern side of the road that runs roughly north south through the site. Site is accessed only via the Tata Steel north security gate, and the eastern boundary of the site is fenced by a metal palisade fence.
Surrounding land uses	The site is set within a wider industrial area of Deeside, with Tata Steel located immediately southwest and the River Dee was previously reported as being circa 420m south. However the site boundary of the proposed development area is such that the distance between the site's southern boundary and the River Dee can be re-evaluated as being Circa 545m.
General topography and ground levels	The site and surrounding area in a broader sense can be regarded as being generally flat lying. The results of the topographical assessment indicate that elevations in the north east are Circa 8.50m AOD, in the northwest, Circa 8.0m to 8.5m AOD. The central area around drainage channels and ponds is Circa 6.50m AOD giving way to the water's edge in the ponds at Circa 4.80m AOD. The southwestern part of the site lies at around 7.5-8.0m AOD and the southeastern area slopes down to Circa 7.0 to 6.50m AOD. So overall there is a gradient towards the southeast of the site.

3. REVISED CONCEPTUAL MODEL

The revised combined conceptual site model and conceptual exposure model, developed for the proposed future land use from the desk study information and subsequent ground investigation and the chemical analysis results presented in the GIR and Supplementary GIR report has been reproduced below.

The potential pollutant linkages identified and a generic quantitative risk assessment are presented in Table 3.1. The terms used in the generic quantitative risk assessment are defined in Appendix C.

Table 3.1 Revised Assessment of Potential Pollutant Linkages.

Justification / Comments
• The ground conditions generally comprise Made Ground, associated with the various historic steelworks buildings that were located across the site, underlain by Tidal Flat Deposits, in turn by Till and Pennine Lower Coal Measures. The deepest Made Ground corresponds to locations of former structures. The shallowest Made Ground was encountered surrounding the two ponds where limited development has taken place. Made Ground generally consisted of gravelly sand with gravels of brick, concrete, slag, asphalt and mixed natural lithologies. High concentrations of boulders and cobbles were observed throughout. Extensive deposits of slag were encountered within Made Ground materials in various forms, ranging from very low density highly vesicular slag to high density metallic slag. In some locations slag deposits were encountered fused together forming a metalliferous concrete. A large number of obstructions were encountered across the site area, again predominantly concentrated within areas of former structures. The obstructions encountered included very large concrete foundations (2.00m diameter) large steel beams / scrap metal, voids associated with historic brick flues, boulders and brick structures. • Tidal Flat Deposits are present underlying the Made Ground soils generally comprising sands, silty sands and sandy silts with rare gravel and shells. The Tidal Flat Deposits encountered were generally medium dense with locally loose bands or dense and very dense gravel layers around 20m bgl in the central portion of the site. Till deposits were encountered generally between 20m bgl to 24m bgl comprising firm to stiff slightly sandy gravelly clays. Locally former paleo river channels with coarser sand and gravels were observed above the Till strata. Local BGS boreholes indicate bedrock of the Pennine Lower Coal Measures is present approximately 50m bgl. • Groundwater has been monitored across the site at depths between 1.79 and 5.18m bgl (3.82m and 4.55m AOD) and is representative of a single groundwater body within the Made Ground / Tidal Flat Deposits that appears to be in continuity with the surface water ponds on site (based on topographical elevations recorded at the pond water edge). Groundwater contours presented in the GIR indicate a general groundwater flow towards the southeast of the site and likely to represent regional flow towards the River Dee (located approximately 545m south of the site). • The results of a human health risk assessment (augmented by supplementary soils testing) have demonstrated that measured soil concentrations of iron and manganese exceed adopted GACs protective of commercial / industrial land use – these are likely driven by the presence of slag identified in the ground beneath the site. • In addition, chrysotile and amosite (and locally crocidolite) asbestos free fibres, fibre bundles ACM debris and locally bitumen products have been at reported concentrations between <0.001% w/w and 0.018% w/w. Asbestos has been positively identified in 28 No. of the 75 No. samples analysed (i.e. 37% of samples) during the original GIR and within 4 of 9 No. samples obtained during the supplementary ground investigation. During the fieldwork no suspected ACMs were identified; however, a single sample was obtained off-site to the northwest of some pipework encased in concrete obtained to assist with client decision making with regards to this parcel of land ('TANKCORE 1 (PIPE)' at 0.80m) – this is not presently regarded as being relevant to the on-site human health risk assessment due to its presence outside the red line boundary considered within this report. It is possible, given the prevalence of non-visible asbestos encountered in the soils for previously unidentified visible ACMs to be present in soils beneath the site and an asbestos management plan is recommended to provide recommendations in the event of discovery of such materials. • A controlled waters risk assessment has been conducted which has considered the results of soil leachate testing (from the initial GIR), groundwater and surface water testing holistically (including the supplementary groundwater and surface water sampling and testing works). Due consideration has also been made of the magnitude of selected Water Quality Standard (WQS) exceedances and in the context of the conceptual site model which has identified a low to low/moderate sensitivity for the controlled waters environment inclusive of nearby surface water drainage and ponds, the River Dee located 545m south of the site, a shallow Secondary (Undifferentiated Aquifer) and a deeper bedrock Secondary A Aquifer protected from vertical migration by layers of low permeability cohesive Glacial Till. o The measured leachable concentrations of metals and PAHs reported in excess of WQS from the initial GIR are not considered to represent a significant risk to the controlled waters environment. It should be noted that the proposed development will include extensive hardstanding, buildings and a dedicated drainage system which will reduce infiltration rates through the site significantly. o Measured dissolved phase groundwater concentrations of metals, PAHs, ammonia and sulphate, plus isolated VOC, phthalate, electrical conductivity and TPH concentrations are not regarded as being representative of a significant risk to the controlled waters environment given the low to low/moderate sensitivity of the controlled waters receptors. o Specific consideration has been made of the groundwater quality at CP01 due to the groundwater being described by the sampling technician as opaque black / dark brown in colour with a strong 'antiseptic-type' odour. CP01 is located in the northwest of the site in proximity to the former boiler houses (located off-site) and the No. 1 furnace of the former Shotton Works and associated soaking pits and fitting shop. It is not considered that the measured concentrations of PAHs or TPHs at this location represent a significant risk to the wider controlled waters environment based on the extensive groundwater quality information hydraulically downgradient from this location from both the initial GIR and the supplementary Ground Investigation works, and based on the surface

water quality assessment. However, supplementary ground investigation works have been conducted to further assess the measured concentrations of phenols and specifically 4-Chloro-3-methylphenol plus 4-Methylphenol, 2,4-Dimethylphenol and 2-Methylphenol.

  - The results of the supplementary ground investigation have demonstrated that the phenol impacts are extremely localised to CP01, with no evidence of a wider source area identified. It has been possible to demonstrate that the impacts are not representative of a wider plume and no evidence of an off-site source area has been identified. Indeed, the evidence suggests that the groundwater quality within the monitoring well at CP01 may have been influenced by a small, localised bottle, former pipe or perched volume of phenols, likely a biocide based on the spike of the 4-Chloro-3-methylphenol observed. Indeed, the feature must have been extremely small because it was not observed during the drilling of CP01 (and neither were any visual / olfactory evidence of contamination during the drilling of CP01 or nearby supplementary investigations). It is evident from the laboratory data that the impacts have not had a wider effect on the groundwater or surface water quality.
  - The groundwater quality at CP01 has continued to improve following successive purging and sampling. Between the initial and second supplementary monitoring visits, measured concentrations of 2,4-Dimethylphenol, 4-Chloro-3-methylphenol and 4-Methylphenol reduced by 92–94%, and by the third sampling event (Visit 2) had decreased by more than 99.5% relative to the original results. These progressive reductions are consistent with the sampling engineer's field observations that the groundwater quality improved both visually and olfactorily during development and purging of the well. The data from CP01 and hydraulically downgradient wells therefore confirm that the residual phenolic impacts are diminishing and not representative of a replenishing or migrating source.
  - Considering the local hydrogeological setting, the Tidal Flat Deposits represent a low sensitivity Secondary (Undifferentiated) Aquifer underlain by Glacial Till and the Pennine Lower Coal Measures. The presence of low-permeability strata (circa 9–10 m thick) provides an effective barrier against vertical migration. In addition, there are no known groundwater abstractions (potable or non-potable) within 1 km of the site.
  - Accordingly, it is concluded that the phenolic impacts at CP01 were transient and localised, consistent with disturbance or flushing of a small, perched source during well installation and initial sampling. The substantial reductions in concentrations, coupled with the absence of corresponding detections elsewhere and the low aquifer sensitivity, provide a robust weight of evidence that the residual phenols at CP01 do not pose a significant risk to controlled waters receptors, including the adjacent surface water bodies or the River Dee located approximately 545 m south of the site.

- The results from the completed ground gas programme (during the original GIR) demonstrate that a Characteristic Situation 1 – Very Low Risk Scenario is appropriate for the site and therefore no ground gas protection measures are required.

Source	Potential Contaminants of Concern	Pathway	Receptor	Consequence	Probability	Qualitative Risk Assessment
Made Ground associated with industrial land uses including Steelworks and associated rail tracks, inclusive of slag materials.	Elevated soil concentrations of iron and manganese with respect to adopted human health screening criteria.	Direct contact, dust inhalation and ingestion	Future site users (commercial)	Medium	Low Likelihood	Moderate / Low Risk
			Adjacent site users (commercial)	Medium	Unlikely	Low Risk
			Construction, site investigation, demolition and future maintenance workers	Medium	Likely	Moderate Risk
		Migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits	Adjacent site users (commercial)	Medium	Unlikely	Low Risk
	Localised elevated soil concentrations of Benzo(a)pyrene, Dibenzo(ah)anthracene and Benzo(k)fluoranthene at depth (1.80m bgl) at CP07 in the southwest of the site (outside of the proposed development area). Risk ratings reduced due to depth of impacts observed.	Direct contact, dust inhalation and ingestion	Future site users (commercial)	Medium	Unlikely	Low Risk
			Adjacent site users (commercial)	Medium	Unlikely	Low Risk
			Construction, site investigation, demolition and future maintenance workers	Medium	Unlikely	Low Risk
		Migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits	Adjacent site users (commercial)	Medium	Unlikely	Low Risk
	Chrysotile and amosite (and locally crocidolite too) asbestos free fibres, fibre bundles ACM debris and locally bitumen products at reported concentrations between <0.001% w/w and 0.018% w/w.	(Dust migration and) dust inhalation	Future site users (commercial)	Medium	Likely	Moderate Risk
			Adjacent site users (commercial)	Medium	Likely	Moderate Risk
			Construction, site investigation, demolition and future maintenance workers	Medium	Likely	Moderate Risk
Presence of localised / incidental historical barrels containing residual possible weathered fuel oil. Presence of localised visual / olfactory evidence of hydrocarbon hotspots including a pipe at TP207 / CP206 containing product.	TPH Free Phase Product	Vapour inhalation, direct contact, dust inhalation and ingestion	Future site users (commercial)	Medium	Low Likelihood	Moderate / Low Risk
			Adjacent site users (commercial)	Medium	Unlikely	Low Risk
			Construction, site investigation, demolition and future maintenance workers	Medium	Likely	Moderate Risk
		Migration of mobile contaminants from Made Ground soils to adjacent sites along services and conduits	Adjacent site users (commercial)	Medium	Unlikely	Low Risk
		Migration via water pipes	Future site users (commercial)	Medium	Low Likelihood	Moderate / Low Risk
		Lateral and/or vertical migration of mobile contaminants.	Aquifer 1 - Secondary (Undifferentiated) Aquifer associated with Tidal Flat Deposits	Mild	Likely	Moderate Risk
			Aquifer 2 - Secondary A Aquifer associated with Pennine Lower Coal Measures Formation	Medium	Unlikely	Negligible risk due to presence of low permeability Glacial Till Clay overlying the bedrock aquifer.
			Ponds located approximately on site.	Medium	Unlikely	Low Risk

For definition of the terms used in the qualitative risk assessment, please see Appendix C.

4. INTERIM REMEDIAL OPTIONS APPRAISAL

The information presented in the previous GIR report and Supplementary GIR report summarises the physical conditions of the site, the nature of the soils / materials, the contamination status of the Made Ground soils and presents an overview of the controlled waters regime. For completeness, however, it would be prudent to refer to the previous ground investigation reports, should additional information be required. The following section identifies the interim remediation strategy that could be utilised to **effectively manage/mitigate the identified pollutant linkages associated with the localised hotspots and unexpected / as yet unidentified localised contamination in soils at the site**. In determining the most effective remediation option(s) for the site, consideration needs to be given to a number of techniques, stating (where appropriate) the suitability and limitations of each chosen method.

As previously noted, the Remedial Options Appraisal for the following elements of the proposed outline remediation strategy has been presented in a separate ROARS report:

- 300mm clean cover system is implemented in all soft landscaping areas.

4.1. Ground Gas Risk Considerations

The conclusions of the previously conducted ground gas risk assessment have demonstrated that no ground gas protection measures (or radon protection measures) are required. As such, ground gas mitigation has therefore not been considered further within the remediation options appraisal.

4.2. Remedial Options Appraisal

The following elements have been considered for the site with respect to remedial options, where necessary/appropriate, during the feasibility and options appraisal stage:

- degree to which risks need to be reduced or controlled;
- time within which the remediation strategy is required to take effect;
- practicability of implementing and, where appropriate, maintaining the strategy;
- technical effectiveness of the strategy in reducing or controlling risks;
- longevity of the strategy - i.e. the potential for the proposed remediation technologies to mitigate against contaminant rebound;
- sustainability of the strategy (i.e., how well it meets other environmental objectives, for example on the use of energy and other material resources, and avoids or minimises adverse environmental impacts in off-site locations, e.g. neighbouring residents, or on other environmental compartments, such as air and water);
- cost of the strategy; benefits of the strategy – all remediation strategies should deliver direct benefits (the reduction or control of unacceptable risks) – but many have merits that extend well beyond the boundaries of the site; and
- legal, financial and commercial context within which the site is being handled including the specific legal requirements that remediation has to comply with, and the views of stakeholders on how unacceptable risks should be managed.

Due consideration has been given for possible feasible options, as presented in the tables below to effectively evaluate the practicality, effectiveness, durability and sustainability of potential remedial solutions.

It is also considered that all risks to construction/maintenance workers will be effectively managed via the measures detailed in Section 8.5 of the Tier Environmental GIR Report, inclusive of an Asbestos Management Plan. As such, risks to construction/maintenance workers fall outside the remit of this Remedial Options Appraisal.

Table 4.1 Interim Remedial Options Appraisal – Localised Gross Impacts

Contaminant Source	Localised and incidental impacts and potential source so of contamination associated with structures and items related to the former use of the site as a steelworks – e.g. . presence of localised / incidental historical barrel containing residual possible weathered fuel oil (located at TPWS03). Presence of localised visual / olfactory evidence of hydrocarbon hotspots including a pipe at TP207 / CP206 containing product. Inclusive of unexpected / as yet unidentified localised contamination in soils at the site.
Pollutant Linkages	Vapour inhalation, direct contact, dust inhalation and ingestion. Preferential migration via localised services and conduits. Migration via water pipes Lateral and/or vertical migration of mobile contaminants.
Excavation with Disposal	Wholesale removal of localised structures and surrounding localised impacted Made Ground soils. Pollutant linkage is broken, and site works can commence quickly. Given the localised nature this may be commercially viable but not as sustainable as some other options as impacted materials would need to be landfilled or subject to off-site treatment.
Hand picking of ACM fragments (if and when encountered)	Would be effective option to remove the 'grossly' asbestos impacted materials and dispose off-site in a controlled manner. Would facilitate residual low-level asbestos impacted soils for suitability for re-use. As such, this is viable but would need to be carried out in conjunction with other techniques such as the 300mm clean cover system to protect against residual low-level asbestos.
Capping including Membrane / Break layer	Earthworks would be required to bring the site to proposed levels; leaving localised impacted Made Ground *in situ* and capping off would be a viable alternative. Capping the entire site would be extremely unsustainable and not cost effective given the localised nature of the impacts; however, targeted re-use of the localised impacted materials via an MMP and controlled in such a manner that the materials are placed in fill areas which will ultimately be capped by a building hardstanding or beneath a 300mm clean cover system in soft landscaped areas is viable and could be verified.
On site re-use	As above. Excavation and on-site retention of impacted soils as geotechnical materials for any proposed areas of fill under a Materials Management Plan. Impacted materials remain on site which is a sustainable solution but would have to be used in conjunction with other techniques.
Stabilisation / solidification	This is unlikely to be commercially or practicably viable when compared to other viable techniques. May create geotechnical 'hardspot' given localised nature of the impacts.
Physical and Thermal Methods	For small, discrete hydrocarbon hotspots like the historic barrel at TPWS03 and the product-bearing pipe at TP207 / CP206, physical technologies are technically misaligned and commercially disproportionate. Vapour-phase methods such as SVE, air sparging and dual-phase extraction depend on volatility and permeability; weathered fuel oils have low volatility, so removal efficiencies are poor and systems must run for prolonged periods with off-gas treatment and rebound risk once switched off. Pump-and-treat primarily contains dissolved plumes rather than removing small source masses, creating long OPEX tails. Permeable reactive barriers are designed to intercept migrating groundwater plumes and require significant civil works; they do not remove a point source within Made Ground. Thermal approaches can be effective but the energy, plant, emissions controls and permitting burden are disproportionate for limited tonnages. In UK terms, proportionality under LCRM and SuRF-UK sustainability guidance points away from high-energy/long-duration plant for a small, accessible source that can be quickly removed and verified.
Chemical Methods	In-situ chemical oxidation (and other chemical treatments) can reduce certain dissolved or sorbed organics, but for small, heterogenous Made Ground hotspots the delivery effort, oxidant demand and health and safety controls are substantial relative to the benefit, and performance is uncertain where preferential pathways and utilities complicate distribution. Critically, chemical methods do not remove physical sources such as a drum or a product-filled pipe, nor do they reliably address any residual LNAPL; UK best practice for LNAPL/source zones emphasises managing or removing the source where practicable. Within the LCRM options appraisal, a solution that is certain, verifiable and proportionate is preferred for discrete, accessible sources—chemical treatments rarely meet that test here when compared with simple excavation.
Biological Methods	Monitored natural attenuation and enhanced bioremediation are generally inappropriate as primary remedies where there is evidence of free or residual product, because regulatory lines-of-evidence frameworks require plume stability and the absence of mobile NAPL before relying on attenuation. Weathered oils degrade slowly, programmes run long, and significant monitoring is needed to demonstrate effectiveness; none of this removes the physical sources or cuts off preferential pathways around services. Ex-situ biological options (biopiles, windrows, landfarming) add odour/dust management and setup costs that are disproportionate for limited volumes. In the context of LCRM and recent UK guidance on MNA/NSZD, these methods may play a supporting role after source removal, but they are not justified as stand-alone remedies for the TPWS03 / TP207/CP206 hotspots.

Justification	Localised excavation with off-site disposal of the discrete sources, together with removal of immediately surrounding impacted soils, is the most effective, proportionate and defensible approach. It eliminates the source quickly, breaks all relevant linkages (vapour inhalation, direct contact, dust/ingestion, and preferential migration), and allows straightforward verification via sidewall/base sampling so construction can proceed. This aligns with LCRM's options appraisal emphasis on effectiveness, certainty and proportionality; with SuRF-UK's sustainability principles, which favour solutions with lower whole-life energy and monitoring burdens for small problems; and with NRW's position that, in specified circumstances, small-scale remediation can proceed without an environmental permit—streamlining delivery for targeted removals. Selectively, marginally impacted arisings outside the hotspot can be re-used under a DoWCoP Materials Management Plan beneath hardstanding or 300mm clean cover to minimise disposal while still removing the discrete sources that drive risk.

5. REMEDIATION STRATEGY

5.1. Introduction

Tier Environmental considers that a combined remedial approach will be required to address the following pollutant linkages:

- presence of localised / incidental historical barrel containing residual possible weathered fuel oil (located at TPWS03). Presence of localised visual / olfactory evidence of hydrocarbon hotspots including a pipe at TP207 / CP206 containing product.
- unidentified and localised visual / olfactory evidence of gross contamination (inclusive of any ACMs, if and when encountered).

5.2. Anticipated Remedial Works

Based upon the findings of the Ground Investigation / Supplementary Ground Investigation and the above Remedial Options Appraisal the following remediation strategy has been devised in order to make the site safe and suitable for redevelopment, as proposed:

- Removal and verification of localised and incidental impacts and potential sources of contamination associated with structures and items related to the former use of the site as a steelworks – e.g. presence of localised / incidental historical barrel containing residual possible weathered fuel oil (located at TPWS03) and presence of localised visual / olfactory evidence of hydrocarbon hotspots including a pipe at TP207 / CP206 containing product plus any unexpected / as yet unidentified localised contamination in soils at the site, where required. Such measures to achieve this have been identified as one or more of the following:
    - Supply of appropriately trained geoenvironmental staff to conduct the visual inspection of soils during a full time watching brief during enabling works;
    - Localised excavation and off-site disposal of discrete features / structures and any associated grossly contaminated soils (if encountered);
    - Vacuum tanker pumping of grossly impacted groundwater / free phase product (if encountered) to significantly reduce the primary source mass;
    - Verification soil and groundwater chemical analysis (as required);
    - Lines of evidence approach to demonstrate local betterment of ground conditions and consideration of other remedial measures being implemented to break any residual pathways identified
- Removal, crushing and screening of all oversized material and obstructions in the ground;
- Bulk earthworks to achieve the proposed development levels, including with fill materials compacted in accordance with the Tier Environmental Enabling Works and Earthworks Strategy. Re-use of site won materials to be conducted in via a Materials Management Plan in accordance with the Definition of Waste Code of Practice;
- All earthworks and groundworks to be conducted in accordance with the Control of Asbestos Regulations (CAR) 2012;
- Supply of appropriately trained geoenvironmental staff to conduct the visual inspection of soils during a full time watching brief during enabling works and appropriately trained contractor staff to then subsequently hand pick any visually identified ACMs, double bag and dispose off-site under the Duty of Care. If gross contamination is encountered within soils in the ground, then these materials will be excavated at the direction of the supervising geoenvironmental engineer, segregated, temporarily stockpiled / placed on visqueen for subsequent hand picking and subsequent off-site disposal to be conducted. All works to be conducted and managed in accordance with an Asbestos Management Plan;
- Backfill of resultant excavations with suitable (likely site-won) material.

The above integrated strategy is designed to:

- Mitigate risks to human health from localised / discrete areas of gross contamination via direct contact, ingestion, dust inhalation and vapour inhalation pathways;
- Mitigate any residual risks to the controlled waters environment from such localised features / contamination;
- Provide flexibility in the event that localised unexpected gross contamination is identified beneath the site, inclusive of any localised ACMs.

5.3. Site Turnover and Obstruction Removal

A number of obstructions were encountered during the GIR and Supplementary GIR associated with the site's former use as a steelworks.

It is therefore proposed that the site is turned over to depths detailed in Drawing TE1920-TE-00-XX-DR-GE-051-V01, presented in Appendix A. Such features will be surveyed in as required and assessments will be made throughout by the full time supervising engineer as to whether any features represent potential vertical preferential pathways if removed or altered. If there is any risk of creation of preferential pathways the Local Authority Environmental Health Officer / Contaminated Land Officer or equivalent and Natural Resources Wales will be informed and proposals discussed and agreed to mitigate or adequately reduce any identified risks. Any materials (soils and concrete / brick etc) to be re-used on site should be done so under an appropriate end-of-waste protocol such as a U1 Exemption / WRAP Protocol or Materials Management Plan in accordance with the CL:AIRE Definition of Waste Code of Practice.

5.4. Hand Picking Visible ACMs

Asbestos is usually encountered in two forms:

- Asbestos as loose or clumps of fibres usually not visible to the naked eye
- Cement bonded materials visible to the naked eye (e.g. roof tile fragments)

Chrysotile and amosite (and locally crocidolite) asbestos free fibres, fibre bundles ACM debris and locally bitumen products have been at reported concentrations between <0.001% w/w and 0.018% w/w during the GIR. Asbestos was positively identified in 28 No. of the 75 No. samples analysed (i.e. 37% of samples) during the original GIR and then subsequently in 4 of 9 No. samples during the Supplementary GIR. During the fieldwork no suspected ACMs were identified within the main subject site boundary. It is possible / likely; however, given the prevalence of non-visible asbestos encountered in the soils for previously unidentified visible ACMs to be present in soils beneath the site and an asbestos management plan is recommended to provide recommendations in the event of discovery of such materials.

The risk assessment indicates that most activities are expected to fall under Non-Licensed Work (NLW) or Notifiable Non-Licensed Work (NNLW)—the latter requiring pre-notification, medical surveillance, and exposure records, but not an HSE licence. However, any encounter with gross contamination (e.g., visible fragments of insulation or other non-bonded asbestos) may necessitate further investigation, sampling, and interpretation to determine the likely working conditions and licence status under CAR-SOIL. Given the site history and the realistic prospect of encountering such materials locally, all contractors engaged for enabling and earthworks should hold an HSE asbestos licence (or engage subcontracted specialist contractors who hold HSE asbestos license) so that any licensed asbestos removal can be undertaken safely, and in compliance with regulatory requirements. If any additional ACMs are identified during ground disturbance works (following the removal of any ACMs previously identified at surface) and they prove to be isolated occurrences, then removing the asbestos, placing into appropriate bags and appropriate disposal via the Duty of Care would be an acceptable course of action. The person removing the asbestos would be required to have the appropriate license, risk assessments and method statements.

Tier Environmental will supply appropriately trained staff to conduct the visual inspection of soils during a full time watching brief during enabling and earthworks and appropriately trained contractor staff to then subsequently hand pick visually identified ACMs, double bag and dispose off-site under the Duty of Care. If gross contamination is encountered within soils in the ground, then these materials will be excavated at the direction of the Tier Environmental supervising engineer, segregated, temporarily stockpiled / placed on visqueen for subsequent hand picking and subsequent off-site disposal to be conducted. All works to be conducted and managed in accordance with an Asbestos Management Plan.

Further details regarding compliance with the Control of Asbestos Regulations 2012 is included in Appendix G.

5.5. Localised / Discrete Hotspot Removal

The vertical and lateral extent of localised features such as the presence of localised / incidental historical barrel containing residual possible weathered fuel oil (located at TPWS03) and localised visual / olfactory evidence of hydrocarbon hotspots including a pipe at TP207 / CP206 containing product shall initially be made via a combination of visual / olfactory observations by a suitable trained geoenvironmental engineer during a full time watching brief during the enabling works, and where relevant, the use of a photoionisation detector to assist with delineation decision making.

The removal of sufficient localised impacted structures and surrounding soils will be validated by a supervising engineer who will measure out the defined delineated area and conduct confirmatory supplementary testing ensuring that the excavation extends to the point where remedial targets have been met and a suitable material should be used (which will wither comprise 'clean' imported materials or 'clean' site-derived materials deemed suitable for use as identified by a separate Materials Management Plan and/or U1 Exemption) to backfill the excavations.

Based on the results of soil waste classification and waste disposal route determination, the impacted features and associated soil will be placed into a road haulage truck and subsequent disposal at a suitable landfill site (testing conducted to date has determined the materials would comprise hazardous waste that would be disposed of to a hazardous waste landfill, potentially with off-site pre-treatment required). On site precautions will be required to prevent the spreading of contaminated soils around the site or to adjacent land.

Remediation Criteria

It is proposed that commercial/industrial LQM/CIEH (2015) S4ULs are implemented as remediation criteria for comparison with soil samples obtained on a 5 m grid basis from the sides and base of the excavation area. This will ensure that residual concentrations do not present a potentially significant risk to human health for a commercial land use. In the event of any exceedances, Tier Environmental will also consider the potential for any viable pathways in the context of the proposed clean cover system and controlled waters conceptual site model understanding. For instance, it may be possible to demonstrate that any low mobility heavy end residual hydrocarbons which exceed the remediation criteria can remain on site in the absence of any viable pathways, post-construction. Any such discussion would be subject to review by the regulators.

5.6. Imported Materials Testing

The completed ground investigations, together with the supplementary works, are considered sufficient to characterise the materials likely to be excavated and re-used on site. Accordingly, Tier Environmental will maintain a full-time Watching Brief during earthworks to verify that materials selected for turnover/re-use are consistent with those already characterised through previous testing. Provided no suspect materials—or populations that materially differ from those previously encountered—are observed, no additional testing of site-won materials will be required. If suspect or atypical materials are identified, they will be segregated and sampled in accordance with the procedures proposed for imported soils, below which is cognisant of the Welsh Land Contamination Working Group's *'Requirements for the Chemical Testing of Imported Materials for Various End Uses and Validation of Cover Systems'* (V.1, dated May 2013):

Table 5.1 Imported Materials or Atypical Site Won Materials Verification Requirements

Objective	It will be necessary to ensure that the development of the site does not cause an increased risk to receptors. All materials imported to the site, or atypical site won materials that have not been characterised by chemical testing conducted during the GIR or Supplementary GIR works conducted to date, will be tested to determine its suitability for use on the site.
Testing frequency	Imported materials will need to be tested **before they are imported to site** at a rate of 4 No. per 250m^3 for Topsoil (with a minimum of 3 No. samples), and subsoil / other soil materials (with a minimum of 3 No. samples) and 1 No. per 500m^3 (minimum 2 No. samples) for any crush / aggregate used to form a hard dig layer (as likely to be >1,000m^3 total).
Testing Suite	• Metals (comprising arsenic, boron, cadmium, chromium (total), copper, lead, mercury, selenium, nickel and zinc); • Speciated PAH; • Speciated TPH (inc BTEX); • Total phenol; • pH; • Asbestos screen All testing will be carried out at an MCERTS (where applicable) / UKAS accredited laboratory. Additional suites of testing / determinands may be required in the event that observations from atypical site won materials warrant such additional analysis. Due consideration has also been made with respect to the conceptual site model. Imported aggregates are not considered likely to require additional leachate testing given that the site will be subject to a dedicated drainage system installation and that the buildings and hardstanding across the site are considered appropriate to reduce infiltration through such materials to a minimum. It is also considered that the leachate testing and groundwater sampling conducted to date during the GIR and supplementary GIR is sufficient to demonstrate that any atypical site won materials are unlikely to require additional leachate testing – this is particularly the case as the majority of the current site layout is such that infiltration is presently freely possible and the proposed hardstanding and buildings plus dedicated drainage system will only seek to reduce the infiltration through the site, post-development.
Screening Criteria	The purpose of the testing is to verify the quality of any materials imported to the site / any atypical site won materials not considered to have been characterised by extensive chemical analysis conducted to date, and to determine the contaminant concentrations of materials. The samples will be compared with appropriate LQM / CIEH 2015 S4UL values protective of a commercial/industrial land use to confirm suitability for re-use. Due consideration will be given; however, of the conceptual site model, post-remediation, in the event that LQM / CIEH 2015 S4UL values protective of a commercial/industrial land use are exceeded. For instance, if minor exceedances of contaminants are reported but the use of the materials is such that the proposed clean cover system will break any residual associated pathways, then this may form a line of evidence within the suitability for use assessment.

5.7. Contingency for any Unknowns or Previously Unidentified Localised Contamination

Whilst the ground investigation works conducted to date are regarded as comprehensive, given the nature of the site and its history Tier Environmental wishes to demonstrate that due consideration has been given at an early stage on possible remedial solutions in the event that local grossly impacted soils or groundwater are identified on site.

Should any suspicious material be encountered during the redevelopment works that are substantially different from that already observed during the GIR and supplementary GIR, works shall be ceased within this part of the site and the area should then be investigated further by a suitably qualified geo-environmental engineer and sampled as necessary. The Contaminated Land Officer (or equivalent) at the Local Authority should also be notified immediately. Samples (if deemed necessary) will be forwarded to a UKAS/MCERTS accredited laboratory for a suite of analytical testing deemed appropriate based upon an appraisal of the material identified.

Once the results of the analysis are known and have been interpreted, the final required remedial action (if any) and remedial targets (as appropriate) will be determined and approved with the relevant regulatory authorities.

5.8. Environmental Monitoring and Mitigation

Introduction

In order to mitigate the environmental impacts of the works on nearby surrounding land users, a programme of measures will be implemented during the remediation works.

Dust Mitigation

Appropriate measures shall be implemented at all times during the remediation works, to minimise dust emissions. Soils will be dampened down, as necessary, and activity will be minimised in extremely windy conditions to prevent dust nuisance. An adequate supply of water shall be maintained on site at all times to allow for dust suppression activities to be carried out at short notice.

When dusty material is being loaded onto trucks, extra care will be taken to ensure that the drop height is minimised. Trucks will be suitably covered when leaving the site with contaminated material to prevent dust migration.

The number of disturbed surfaces left exposed for significant time periods will be minimised. Stockpiles of fine or loose materials should be tamped down or covered, if necessary, to reduce the production of dust. Traffic both entering and working on the site shall obey a maximum speed limit of 10 mph.

Noise

The requirements of BS 5228:1997 “Noise and Vibration Control on Construction Sites” shall be adhered to at all times. All machinery shall be fitted with effective silencers and shall be serviced at regular intervals. No plant shall be operated with engine covers raised.

Run-off into Drains

All potential drainage on site and any discharge points will be identified, including land drains, foul sewers, surface water drains and any combined drains. These will be marked, as appropriate, for easy identification.

Works will be minimised during periods of heavy rainfall to reduce the likelihood of contaminated run-off. Temporary containment and cover measures or tamping down of stockpiles to reduce run-off shall be used where necessary.

5.9. Waste Soils – Basic Characterisation and WAC

It is currently anticipated that the majority of materials will be retained on site; however, for the known localised / discrete hotspots and in the event that localised previously unidentified contamination or other materials unexpectedly require removal from the site then the impacted material exported from the site to landfill shall be hauled by a registered waste carrier in accordance with Duty of Care Regulations, 1991 and the Hazardous Waste Regulations, 2005.

Preliminary assessment indicates that the vast majority of Made Ground samples would comprise hazardous waste if disposed off-site. In total 77 No. of 84 No. Made Ground samples have been reported as hazardous waste driven by both inorganic and organic contaminants. The results of WAC testing have demonstrated that in some instances the concentrations of TOC and LOI are such that pre-treatment would be required prior to disposal to hazardous waste landfill. In other cases, the materials could be accepted at a stable non-reactive hazardous waste cell located in some non-hazardous landfill facilities.

Representative samples of natural soils have been obtained during the investigation and of the 27 No. obtained, 12 No. have returned a classification of hazardous waste. Generally, these samples are directly beneath Made Ground and so are likely to represent a shallower layer where the natural soils are being influenced by the overlying Made Ground. Deeper natural soils (beyond 4.00m bgl) are non-hazardous waste. It is likely that any natural soils (that are not impacted by any known contamination from shallow Made Ground, or unexpected contamination) would be suitable for disposal to an inert waste landfill. It is recommended that the landfill is approached to confirm this position prior to off-site disposal. Otherwise, additional testing will be required to confirm the waste disposal route for natural soils beneath the site.

There will be requirement for the waste producer to provide appropriate Waste Acceptance Criteria (WAC) testing of the soils for disposal to ensure that the soils are appropriately classified and that the landfill is licensed to receive such soils.

5.10. Verification Report

The Supervising Engineer should ensure that the requirements of the strategy are complied with. On satisfactory completion of all remedial works, a verification report should be produced. This report will comprise all relevant site records and act as certification that the remedial preparation works have been carried out in accordance with this remediation strategy.

The Verification Report shall include the following:

- A description of the works undertaken in accordance with the Remediation Strategy described above;
- Records of the works;
- Progress photographs;
- Waste Transfer Notes;
- Chemical verification test results.

6. REGULATORY APPROVALS

The conclusions and recommendations presented above are considered reasonable based on the findings of the site investigations. However, these cannot be guaranteed to gain regulatory approval and, therefore, the report should be passed to the appropriate regulatory authorities and/or other organisations for their comment and approval.

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8. GLOSSARY OF TERMS

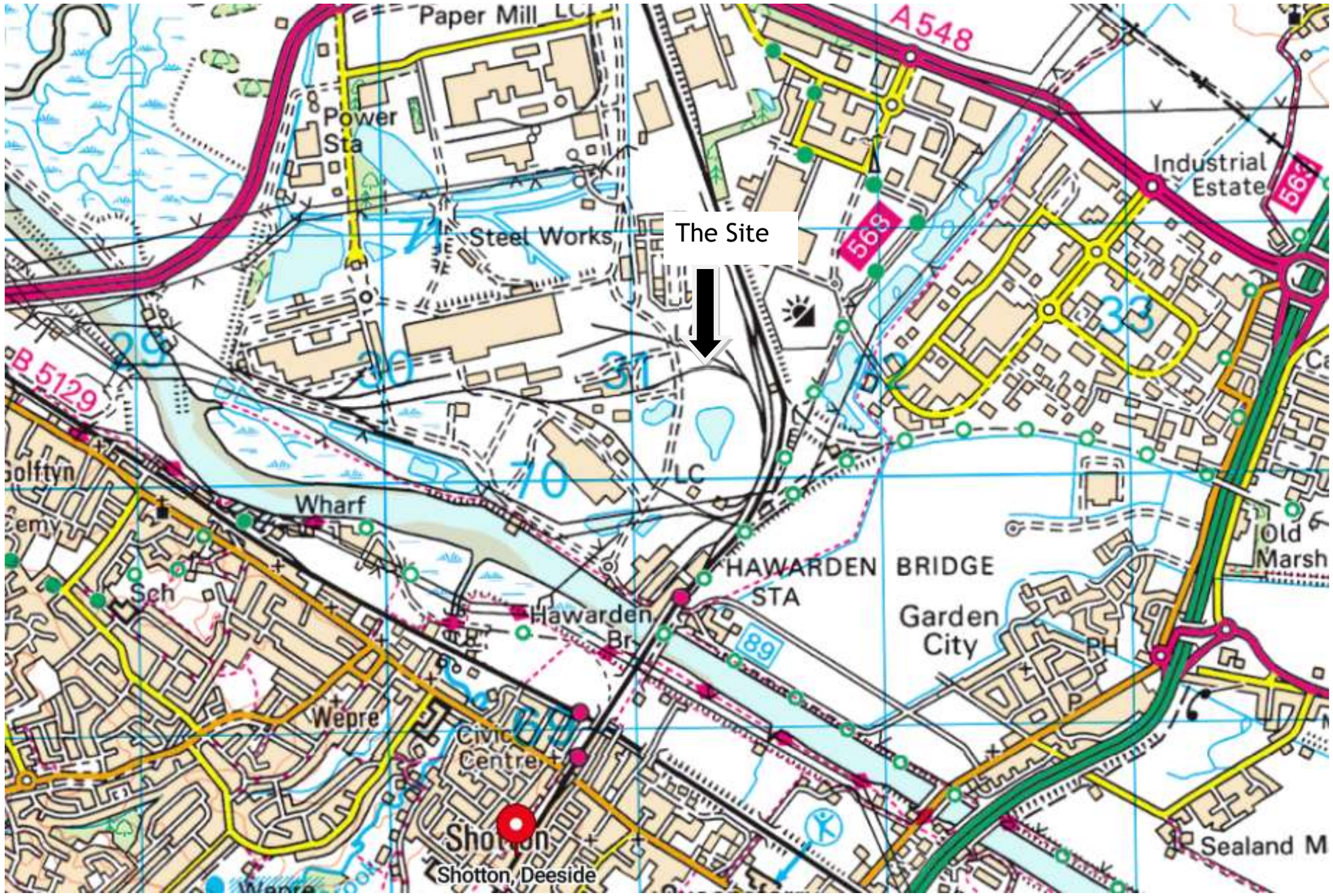
ACEC	Aggressive Chemical Environment for Concrete (classification)
aOD	Above Ordnance Datum
bgl	Below ground level
BGS	British Geological Survey
BRE	Building Research Establishment
CBR	California Bearing Ratio (test)
COMAH	Control of Major Accident Hazards (regulations)
Designated location	Site (and the ecosystem on that site) protected under national of international legislation. A potential ecological receptor to be considered as part of the assessment of land contamination. Example designated locations include SSSIs (q.v.), SACs (q.v.), national nature reserves, Ramsar sites and bird special protection areas.
DQA	Data Quality Assessment
DQO	Data Quality Objective
DQRA	Detailed Quantitative Risk Assessment
DWS	Drinking Water Standard
EQS	Environmental Quality Standard
GAC	Generic Assessment Criterion
GQA	General Quality Assessment
GSV	Gas Screening Value
HCV	Health Criteria Value
IPPC	Integrated Pollution Prevention and Control (regulations)
K_{ow}	Octanol-water partition coefficient
LEL	Lower Explosive Limit
LL	Liquid Limit
LoD	Limit of Detection (analytical)
LoQ	Limit of Quantification (analytical)
Mean Value Test	Statistical test (described in the CIEH Guidance) to estimate the mean value of a normally distributed population of data at a given level of confidence. Normally for contaminated land assessment, the 95th percentile (referred to as the 95%UCL or US95) is applied as a reasonable but conservative estimate of the mean concentration for comparison with the relevant assessment criteria.
Maximum Value Test	Statistical test (described in the CIEH Guidance) to identify whether an elevated concentration within a normally distributed data set forms part of the underlying population from which it has been sampled or whether it is an outlier (such as a localised area of contamination) that merits further consideration.
MC	Moisture Content
NGR	National Grid Reference
NIHHS	Notification of Installations Handling Hazardous Substances (regulations)
OS	Ordnance Survey
PI	Plasticity Index
PID	Photoionisation Detector
PL	Plastic Limit
ppm	Parts per million
ppmv	Parts per million by volume
QA	Quality Assurance
QC	Quality Control
SAC	Special Area of Conservation
SOM	Soil Organic Matter

SPT	Standard Penetration Test
SPZ	Source Protection Zone (see Appendix E)
SSAC	Site-Specific Assessment Criterion
SSSI	Site of Special Scientific Interest
SVOC	Semi-Volatile Organic Compound
TEF	Toxicity Equivalent Factor
TPH	Total Petroleum Hydrocarbons
TWA	Time Weighted Average
US95	95th percentile estimate of the true mean value of a data population (also known as 95%UCL).
VOC	Volatile Organic Compound

APPENDIX A - DRAWINGS

Contract Number	TE1920
Contract	Knauf, Shotton
Client	Knauf Insulation

Site Location Plan



Scale	NTS		
Drawn by	SM	Approved	SL
Drawing Number	TE1920-TE-00-XX-DR-GE-001-V01		

WEIGHBRIDGE ROAD

WYCHBRIDGE ROAD

NORTH ROAD

RIVER ROAD

RIVER DEE

Tank

Tanks

Water

Electricity Distribution Site

NOTES

- All dimensions and levels are to be checked on site.
- Any discrepancies are to be reported to the architect before any work commences
- Whilst information on this sheet is issued to scale, scaling directly from this drawing may result in inaccuracies. For precise measurements, refer to the stated dimensions or contact the Architect
- This drawing shall not be reproduced without express written permission from AEW.
- Title overlay drawings and ownership boundaries are produced using all reasonable endeavors. AEW cannot be responsible for the accuracy or scale discrepancy of base plans supplied to them.
- All works are to be undertaken in accordance with Building Regulations and the latest British Standards.
- All proprietary materials and products are to be used strictly in accordance with the manufacturers recommendations.

0 20 40 60 80 100m

Scale 1:2500

N

Red Line Application Boundary:
43.70 acres / 17.68 ha

REV	Date	Drawn by: -	Checked by: -
P4	03/12/25	TF	DOH
Amended to WSP comments			
P3	02/12/25	TF	DOH
Project Title amended			
P2	04/11/25	TF	DOH
Document title amended			
P1	15/10/25	TF	DOH
Initial issue			

Status: S4 — Purpose of Issue: For Approval

drawing stage: **RIBA Stage 3**

client: **Knauf Insulation Ltd**

project: **Knauf Insulation
Shotton, Deeside**

drawing title: **Location Plan
(Remediation Works)**

date 15/10/25 drawn TF

scale@A0 1:2500 checked DOH

AEW Reference Number **14173**

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Job No **14173-AEW-SI-XX-DR-A-05701**

Rev **P4**

Proposed amendments to existing junction shown in blue linework as Tier drawing 2933-TCG-XX-XX-DR-C-6502-T01

6.2m

5.4m

SL

ED Bay

Unit

Out of hours manual swing gates

Proposed new 7.3m wide road with 2m wide footpath. Refer to Tier Consult information for detailed design

Automatic rising arm barrier and call point

Proposed weighbridge location

Sprinkler tanks and pumphouses

Proposed gatehouse and driver welfare hub

20no. HGV parking bays

126no. car parking spaces inc. 6no. accessible

Smoking Shelter

26m Turning Circle

Area reserved for potential future SPEN compound to be grass seeded and to be left free from services / mounds

Toilet

Tent

Offices

Refuse Store

WEP

Melter

Production Building

Fibre Extension

Covered Storage

Existing buildings retained outside of applicants control

Existing buildings to be retained and refurbished (including replacement of all cladding to older structures)

Large opening to be provided to southern elevation of existing building

Area reserved for potential future storage building to be grass seeded and to be left free from services / mounds

6.5m

6.3m

Existing pond

External gas pressure reduction station and base to be provided by utility service provider. KI to provide meter. Final size and location tbc.

NOTES

- All dimensions and levels are to be checked on site.
- Any discrepancies are to be reported to the architect before any work commences
- Whilst information on this sheet is issued to scale, scaling directly from this drawing may result in inaccuracies. For precise measurements, refer to the stated dimensions or contact the Architect
- This drawing shall not be reproduced without express written permission from AEW.
- Title overlay drawings and ownership boundaries are produced using all reasonable endeavors. AEW cannot be responsible for the accuracy or scale discrepancy of base plans supplied to them.
- All works are to be undertaken in accordance with Building Regulations and the latest British Standards.
- All proprietary materials and products are to be used strictly in accordance with the manufacturers recommendations.

0 10 20 30 40 50m

Scale 1:1000

N

Red Line Site Boundary:
43.70 acres / 17.68 ha

Existing vegetation to be retained wherever possible

Proposed indicative structural planting - refer to landscape architect's information.

Proposed grass seeded areas - refer to landscape architect's information.

Proposed surplus earthworks mounding locations as shown on Tier levels model shared 11.08.25 and indicatively adjusted following design review ref: 2933-TCG-XX-XX-M3-C-6014

14no. Electric Vehicle Charging Bays

NOTES

- Building layout as shown on Knauf drawing ref: 4208-A-M-05-00-00015 received 23.12.2025.
- Extent of KI external plant and covered storage areas as shown on KI drawing ref: 4208-A-M-05-00-00015 received 23.12.2025, to be procured by KI. Refer to Tier Consult and design team drawings for all base build enabling works (including foundations and drainage).

SCHEDULE OF ACCOMMODATION

Unit Name	Ground Floor GIA	First Floor GIA	Second Floor GIA	Third Floor GIA	Fourth Floor GIA	Fifth Floor GIA	Overall GIA	Overall GEA
Process Building	91,410 ft²/ 8,493 m²	1,590 ft²/ 148 m²	-	-	-	-	**93,000 ft²/ 8,641 m²**	**122,977 ft²/ 11,425 m²**
Fibre Extension	760 ft²/ 71 m²	-	-	-	-	-	**760 ft²/ 71 m²**	
Office	11,250 ft²/ 1,045 m²	11,250 ft²/ 1,045 m²	-	-	-	-	**22,500 ft²/ 2,090 m²**	
Melter	-	10,020 ft²/ 931 m²	10,020 ft²/ 931 m²	10,020 ft²/ 931 m²	10,020 ft²/ 931 m²	10,020 ft²/ 931 m²	**50,100 ft²/ 4,655 m²**	**53,604 ft²/ 4,980 m²**
Total Production Building and Adjoining Office							***166,360 ft²/ 15,457 m²***	***176,581 ft²/ 16,405 m²***
Gatehouse	910 ft²/ 85 m²	-	-	-	-	-	**910 ft²/ 85 m²**	**11,538 ft²/ 1,072 m²**
Existing Retained Buildings	63,260 ft²/ 5,877 m²	-	-	-	-	-	**63,260 ft²/ 5,877 m²**	**63,464 ft²/ 5,896 m²**
Covered Store	21,520 ft²/ 2,000 m²	-	-	-	-	-	**21,520 ft²/ 2,000 m²**	**21,688 ft²/ 2,015 m²**
Tent	10,760 ft²/ 1,000 m²	-	-	-	-	-	**10,760 ft²/ 1,000 m²**	**11,452 ft²/ 1,064 m²**
Total Ancillary Buildings							***96,450 ft²/ 8,962 m²***	***108,143 ft²/ 10,047 m²***
Total Development							**262,810 ft²/ 24,419 m²**	**284,724 ft²/ 26,452 m²**

REV	Date	Drawn by: -	Checked by: -
P11	07/01/26	TF	DOH
Additional process building area included as Client comments			
P10	06/01/26	TF	DOH
Sprinkler tank position amended to Client comments			
P9	05/01/26	TF	DOH
Main building external plant updated to Client layout.			
P8	28/10/25	TF	DOH
Updated to show KI latest layout and substation			
P7	17/10/25	TF	DOH
Cycle parking numbers updated to Hilson Moran comments			
P6	15/10/25	TF	DOH
Red Line boundary amended to Client comments			
P5	08/10/25	TF	DOH
Updated to Client layout			
P4	18/08/25	TF	DOH
Future SPEN compound areas amended to Client comments			
P3	12/08/25	TF	DOH
Updated to show potential future SPEN compound areas			
P2	08/08/25	TF	DOH
Updated to latest site layout and building models			
P1	16/07/25	HC	TF
Initial issue			

Status: S4 For Approval

drawing stage: **RIBA Stage 3**

client: **Knauf Insulation Ltd**

project: **Knauf Insulation Manufacturing Facility Shotton, Deeside**

drawing title: **Proposed Site Plan (Main Works)**

date 16/07/25 drawn HC

scale@A0 1:1000 checked TF

AEW Reference Number **14173**

Rev **P11**

Job No **14173-AEW-SI-XX-DR-A-05110**

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APPENDIX B - PREVIOUS SITE INVESTIGATION REPORT (AVAILABLE AS A SEPARATE DOCUMENT)

APPENDIX C - DEFINITIONS OF TERMS USED IN QUALITATIVE AND QUANTITATIVE RISK ASSESSMENTS

CIRIA C552 Terminology

For the qualitative and quantitative assessment of risks posed by potential pollutant linkages have been undertaken using the risk matrix adapted from CIRIA C552 and outlined in the table below.

	Category	Definition
Potential severity	Severe	Acute (short term) risk to human health, Major pollution of sensitive controlled waters, ecosystems or habitat. Catastrophic damage to buildings or property or crops.
	Medium	Chronic (Medium / long term) risk to human health Pollution of sensitive controlled waters, ecosystems or species, Significant damage to crops, buildings or structures
	Mild	Easily preventable permanent health effects on humans. Pollution of non-sensitive controlled waters. Minor damage to buildings or structures.
	Minor	Easily preventable non-permanent health effects on humans, or no effects. Minor, low level and localised contamination of on-site soil. Easily repairable damage to buildings or structures.
Probability of risk	High Likelihood	Pollutant linkage may be present, and the risk is almost certain to occur , or there is evidence of harm already occurring.
	Likely	Pollutant linkage may be present, and it is probable that the risk will occur over the long term.
	Low Likelihood	Pollutant linkages may be present and there is a possibility of the risk occurring, although there is no certainty that it will do so.
	Unlikely	Pollutant linkage may be present but the circumstances under which harm would occur are improbable.

		Potential Severity			
		Severe	**Medium**	**Mild**	**Minor**
Probability of risk	**High Likelihood**	Very high risk	High risk	Moderate risk	Moderate / low risk
	Likely	High risk	Moderate risk	Moderate / low risk	Low risk
	Low Likelihood	Moderate risk	Moderate / low risk	Low risk	Very low risk
	Unlikely	Moderate / low risk	Low risk	very low risk	Very low risk

APPENDIX D - HUMAN HEALTH ASSESSMENT CRITERIA

HUMAN HEALTH ASSESSMENT CRITERIA

Context

Contaminated Land is defined under law through Part IIA of the Environmental Protection Act 1990, implemented through Section 57 of the Environment Act 1995 and associated guidance ("Part IIA"). These specify that a "suitable for use" approach is to be applied in the assessment of potentially contaminated land, implemented through a phased programme of site investigation and risk assessment appropriate to the site under consideration.

The assessment of potential risks posed by contaminated land is based upon the assessment of plausible contaminant source - pathway - receptor linkages ("pollutant linkages") for the current and/or proposed future use of the site. The process for the assessment of contaminated land adopted in this report is in line with guidance issued by the Environment Agency Land contamination risk management (LCRM) - GOV.UK (www.gov.uk)

Land contamination can harm:

- human health
- drinking water supplies, groundwater and surface water
- soils
- ecosystems including wildlife, animals and wetlands
- property

It can also affect the current and future land use. Dealing with land contamination helps make the environment clean and safe. Through regeneration it can:

- enhance the health and wellbeing of all
- add to the economic, ecological and amenity value of the area

Use land contamination risk management (LCRM) to:

- identify and assess if there is an unacceptable risk
- assess what remediation options are suitable to manage the risk
- plan and carry out remediation
- verify that remediation has worked

You can use LCRM in a range of regulatory and management contexts. For example, voluntary remediation, planning, assessing liabilities or under the Part 2A contaminated land regime. The Environment Agency expects you to follow LCRM if you are managing the risks from land contamination.

We support the use of the National Quality Mark Scheme (NQMS). You can use it for any type of land contamination report.

Using the NQMS:

- will make sure all legislative requirements and necessary standards related to managing land contamination are met
- can provide increased confidence by submitting reports of the quality we expect
- can result in cost and time savings by 'getting it right first time'

LCRM is made up of 4 guides.

1. LCRM: Before you start.
2. LCRM: Risk assessment.
3. LCRM: Options appraisal.
4. LCRM: Remediation and verification.

We use a staged risk based approach. There are 3 stages, and each stage is broken down into tiers or steps.

Stage 1: Risk assessment

You will use a tiered approach to risk assessment. The 3 tiers are:

1. Preliminary risk assessment.
2. Generic quantitative risk assessment.
3. Detailed quantitative risk assessment.

Stage 1 includes information for intrusive site investigations.

Stage 2: Options appraisal

There are 3 steps to follow.

1. Identify feasible remediation options.
2. Do a detailed evaluation of options.
3. Select the final remediation option.

Stage 3: Remediation and verification

There are 4 steps to follow.

1. Develop a remediation strategy.
2. Remediate.
3. Produce a verification report.
4. Do long term monitoring and maintenance, if required

You must always start with a preliminary risk assessment.

The risk assessment stage is an iterative process. You can do the 3 tiers in order or progress from a preliminary risk assessment to a detailed quantitative risk assessment. As part of a generic or detailed quantitative risk assessment you will need to collect detailed information about the site. This is usually through an intrusive site investigation.

Depending on the level of risk or regulatory requirements, you can proceed from a preliminary risk assessment to the options appraisal stage. If you proceed direct to the options appraisal stage, you still need to collect the detailed site investigation information required by the generic and detailed quantitative risk assessments. This is to confirm that your approach is viable and acceptable.

Following the risk assessment stage, if you conclude that the risks are acceptable, with agreement from the relevant regulator, you can end the process.

If there are unacceptable risks, then remediation or mitigation is required. Follow stages 2 and 3 in order.

In stage 2 options appraisal, you will:

- look at the most feasible options
- produce a shortlist of options
- use evaluation criteria to assess them
- select which ones are the most suitable to take forward to stage 3

In stage 3 remediation and verification, you will produce a remediation strategy, do the remediation and then produce a verification report.

You will decide at the options appraisal stage if long term monitoring and maintenance is the remediation option. You may need to do post-remediation monitoring for further verification.

The risk assessment and subsequent investigation, remediation and verification must address all potential sources of pollutants that may be present on the site (the “hazards”), all receptors that may be harmed by these (e.g., human health, controlled waters, ecological receptors) and the pathways by which the contamination may be transported from the contaminant source(s) to the receptor(s). This is defined within the conceptual model for the site, which represents the characteristics of the site in a form that shows the possible pollutant linkages. As further information becomes available (for example, through site investigation), so the conceptual model will be refined.

Remedial action can be specified at any phase within this assessment process to break the identified pollutant linkage in determining whether or not to undertake further assessment or to undertake remediation, the potential cost-savings arising from a more thorough assessment of the pollutant linkages and more tightly defined remedial strategy must be considered against the direct costs involved in the work and the time that this will take to execute and gain regulatory approval.

A different approach to the statistical appraisal of data is required depending on whether the assessment is being undertaken to assess land as Contaminated Land in accordance with the regulations or whether the assessment is to assess whether the site is suitable for new development in accordance with the Planning regime. The statistical approach to assessment is discussed further in CL:AIRE:2020 “Professional Guidance: Comparing Soil Contamination Data with a Critical Concentration”.

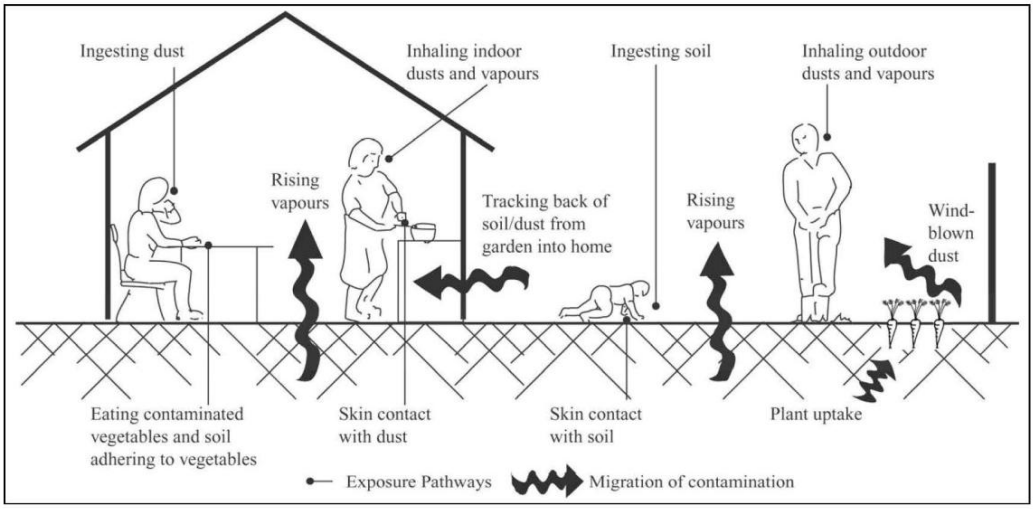
Some form of Detailed Quantitative Risk Assessment (DQRA) will be essential for those cases where appropriate GAC values cannot be established for the contaminant linkages under consideration.

Generic Assessment Criteria for Human Health Risk Assessment

In March 2002, the Department for Environment, Food and Rural Affairs (DEFRA) and the Environment Agency (EA) published the Contaminated Land Exposure Assessment (CLEA) Model and a series of related reports and guidance. These were designed to provide a scientifically based framework for the assessment of chronic risks to human health from contaminated land. The initial documents (CLR7 – 10) were withdrawn and replaced with revised guidance issued by the Environment Agency including:

- "Using Soil Guideline Values"; EA,2009; Land contamination: using soil guideline values (SGVs) - GOV.UK (www.gov.uk)
- "Human Health toxicology assessment of contaminants in soil" EA;, 2009; https://www.gov.uk/government/publications/human-health-toxicological-assessment-of-contaminants-in-soil
- "Update technical background to the CLEA model" 2009; https://www.gov.uk/government/publications/updated-technical-background-to-the-clea-model
- CLEA Software (Version1.05) Handbook 2015; https://www.gov.uk/government/publications/contaminated-land-exposure-assessment-clea-tool
- Compilation of Data for priority Organic Contaminants for Derivation of Soil Guideline Values; Science Report SC050021/SR7, 2008; and,
- "Professional Guidance: Comparing Soil Contamination Data with a Critical Concentration". CL:AIRE:2020 https://www.claire.co.uk/component/phocadownload/category/9-other-cl-aire-documents?download=745:2020-stats-guidance

The CLEA model and associated guidance was developed to calculate an estimated tolerable daily intake (TDI) of contaminants for site users given a set of 'typical' human health exposure pathways which are detailed in "SR3: Updated technical background to the CLEA model"



(Science Report SC050021/SR3, EA, 2009) and reproduced below.

Ingestion

- Outdoor soil;
- Indoor dust;
- Home grown produce;
- Soil attached to home grown produce.

Dermal Contact

- Outdoor soil;
- Indoor dust.

Inhalation

- Outdoor dust;
- Indoor dust;
- Outdoor vapour;
- Indoor vapour.

It should be noted that the CLEA model does not include an exhaustive list of potential exposure pathways, e.g. certain compounds can pass through plastic water pipes into drinking water supply.

The potential significance of each of the exposure pathways is dependent upon the type of land use and the nature of the contaminant being considered. The CLEA model considers principal 'default' land use scenarios and makes a series of assumptions with regards to building type (where applicable), identification of the critical human receptor group, exposure frequency and duration. The definitions of the principal land use types given in SR3 (EA, 2009) are:

Residential land use;

- A typical residential property consisting of a two-storey terraced house built on a ground-bearing slab of 0.15m thickness with a private garden consisting of lawn, flowerbeds, and a small fruit and vegetable patch. The occupants are assumed to be parents with young children, who make regular use of the garden. The critical receptor is a 0 – 6-year-old female.
- Active exposure pathways are ingestion of outdoor soil, ingestion of indoor dust, ingestion of home grown produce and soil adhering to home grown produce; direct dermal contact with outdoor soil and indoor dust; inhalation of outdoor dust and vapour and indoor dust and vapour

Allotments

- A plot of open space commonly made available by the Local Authority to tenants to grow fruit and vegetables for their own consumption. There are usually several plots to a site and the overall site area may cover more than one hectare. The tenants are assumed to be the parents or grandparents and that young children make occasional accompanied visits to the plots. The critical receptor is a 0 – 6-year-old female and there is no building present on site.
- Active exposure pathways are ingestion of outdoor soil, ingestion of home grown produce and soil adhering to home grown produce; direct dermal contact with outdoor soil; inhalation of outdoor vapour.

Commercial and industrial land use.

- A typical commercial or light industrial property consisting of a three-story office building (pre-1970) with a ground bearing floor slab at which employees spend most time indoors and are involved in office based or related light physical work. The critical receptor is a working female adult aged 16 – 65 years.
- Active exposure pathway is ingestion of outdoor soil, ingestion of indoor dust; direct dermal contact with outdoor soil and indoor dust; inhalation of outdoor dust and vapour and inhalation of indoor dust and vapour.

Soil Guideline Values

Based on the assumption of each land use type, the EA and DEFRA developed and published Soil Guideline Value (SGV) using the CLEA model for a number of principal contaminants and 'default' end-use scenarios of residential, allotments and commercial/industrial use. The primary purpose of the SGVs is as trigger value for the tolerable daily intake (TDI), below which it can be assumed that the soil does not pose an unacceptable risk to the identified receptor. Where soils contamination is present above this level further assessment may be required. SGVs were developed for the following contaminants:

- Heavy metals and other inorganic compounds: arsenic, cadmium, chromium, cyanide, lead (now withdrawn), mercury, nickel and selenium.
- Benzene, ethylbenzene, toluene and xylenes.
- Phenol.
- Dioxins and dioxin-like polychlorinated biphenyls (PCBs)
- Polycyclic aromatic hydrocarbons (PAHs) – 11 substances

LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment

In addition, in 2009 CIEH through LQM and EIC published generic assessment criteria (GACs) for 82 substances including metals, petroleum hydrocarbons, PAHs and explosive substances for a variety of soil types and the three 'default' land uses – (residential, allotments and commercial end-uses) as described in SR3 (EA, 2009). These have been superseded as described below.

Category 4 Screening Values

In 2013 "SP1010: Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination" (CL:AIRE 2013) was issued which detailed findings of a research project undertaken by CL:AIRE to set out the framework by which potential Category 4 Screening Levels (pC4SL) may be derived for 6 contaminants of concern, Arsenic, Benzene, Benzo(a)pyrene, Cadmium, Chromium VI and Lead.

This was supplemented in 2014 by "SP1010: Development of Category 4 Screening Levels for the Assessment of Land Affected by Contamination – Policy Companion Document" (DEFRA, 2014). SP1010 proposed several updated toxicology information relating to contaminant behaviour updated assumptions relating to the modelling of human exposure to soil contaminants, derivation of separate C4SLs for residential with the consumption of home grown produce, residential without the consumption of home grown produce, and two new land uses: public open spaces near residential housing (POS resi) and public parks (POS park).

Public Open Space: Residential

- For public open space in close proximity to residential housing and the central green area around which houses are located, as on many housing estates from the 1930s to 1970s. It is also applicable for smaller areas commonly incorporated in newer developments as informal grassed areas or more formal landscaped areas with a mixture of open space and covered soil with planting. It is considered to be a generally grassed area up to 0.5ha with up to 50% bare soil. The land use is an important resource

for children and the area is near the homes. The critical receptor is a female child age >3 - <9 years old (CLEA age class 4 – 9) as younger children are unlikely to play outdoors unsupervised.

- Active exposure pathways are ingestion of outdoor soil, ingestion of indoor dust; direct dermal contact with outdoor soil and indoor soil derived dust; inhalation of outdoor and indoor dust and inhalation of outdoor vapour.

Public Open Space: Park

- A public park is defined as an area of open space provided for recreational use and usually owned and maintained by the Local Authority. It is anticipated the park could be used for a wide range of activities, including the following:
    - Family visits and picnics;
    - Children's play area;
    - Sporting activities such as football on an informal basis (i.e. not a dedicated sports pitch); and
    - Dog walking.
- The park is modelled as an area >0.5 ha of predominantly grasses open space with no more than 25% of exposed soil.
- The critical receptor is a female child with CLEA age classes 1 – 6.
- Active exposure pathways are: ingestion of outdoor soil; direct dermal contact with outdoor soil; inhalation of outdoor dust and inhalation of outdoor vapour.

Furthermore, the C4SLs are based on a different toxicological benchmark, the 'low level of toxicological concern' (LLTC). This difference in approach was adopted because the C4SLs were primarily intended for use under Part2A of the EPA 1990 to quickly screen out Category 4 sites where there is "*no risk or that the level of risk posed is low*". SGVs and LQM GACs are based on the more conservative 'minimal or tolerable level of risk' as defined in SR2 (EA, 2009) and were derived for assessment of contamination for the Planning process.

LQM/CIEH Suitable 4 Use Levels (S4ULs)

The publication of the C4SLs resulted in considerable and inconclusive debate about the applicability of the lower level of protection of the C4SL, which are underlain by the LLTC, outside of the Part 2A context for which they were derived. In 2014 LQM/CIEH presented a Suitable 4 Use Levels (S4ULs), which incorporate the updated assumption exposure derived for the production of the C4SLs but within the context of deriving screening criteria above which further assessment of the risks or remedial action may be needed. The S4ULs replace the 82 substances, species and fractions and congeners contained in the previous LQM/CIEH GACs issued in 2009. Additionally, following changes and new land uses proposed in the C4SL research project, S4ULs have also been derived for the majority of substances for which the EA derived SGVs in 2009 with the exception of lead (see below).

Lead

The C4SL for lead provides a technically robust and conservative assessment tool using significantly updated toxicological modelling than the withdrawn SGV and derived in line with current science of lead toxicology.

EIC/AGS/CL:AIRE Soil Generic Assessment Criteria (2010)

In some instances, EIC/AGC/CL:AIRE GACs for certain VOC / SVOC potential contaminants of concern have been used *in lieu* of available LQM / CIEH S4UL values.

Parameter	Residential with homegrown produce			Residential without homegrown produce			Allotment			Commercial / Industrial			Public Open Space near Residential			Public Open Space - Park			Source
	(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			
SOM	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	
Metals/metalloids																			
Arsenic	37			40			43			640			79			170			LQM (2014)
Beryllium	1.7			1.7			35			12			2.2			63			LQM (2014)
Boron	290			11000			45			240000			21000			46000			LQM (2014)
Cadmium	11			85			1.9			190			120			560			LQM (2014 errata)
Chromium III	910			910			18000			8600			1500			33000			LQM (2014)
Chromium VI	6			6			1.8			33			7.7			220			LQM (2014)
Copper	2400			7100			520			68000			12000			44000			LQM (2014)
Lead	200			310			80			2330			630			1300			C4SL
Mercury (elemental)	1.2			1.2			21			58 (25.8)			16			30 (25.8)			LQM (2014)
Mercury (Inorganic)	40			56			19			1100			120			240			LQM (2014)
Methylmercury	11			15			6			320			40			68			LQM (2014)
Nickel	130			180			53			980			230			800			LQM (Revised 2015)
Selenium	250			430			88			12000			1100			1800			LQM (2014)

Parameter	Residential with homegrown produce			Residential without homegrown produce			Allotment			Commercial / Industrial			Public Open Space near Residential			Public Open Space - Park			Source
	(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			
SOM	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	
Vanadium	410			1200			91			9000			2000			5000			LQM (2014)
Zinc	3700			40000			620			730000			81000			170000			LQM (2014)
Other																			
Total Sulphate	2,400			2,400			2,400			2,400			2,400			2,400			BRE (2005)
Water Soluble Sulphate (g/l)	0.5			0.5			0.5			0.5			0.5			0.5			BRE (2005)
PAHs																			
Acenaphthene	210	510	1100	3000 (57)	4700(141)	6000 (336)	34	85	200	84000 (57)	97000 (141)	100000	15000	15000	15000	29000	30000	30000	LQM (2014)
Acenaphthylene	170	420	920	2900 (86.1)	4600 (212)	6000 (506)	28	69	160	8300 (86.1)	97000 (212)	100000	15000	15000	15000	29000	30000	30000	LQM (2014)
Anthracene	2400	5400	11000	31000 (1.17)	35000	37000	380	950	2200	520000	540000	540000	74000	74000	74000	150000	150000	150000	LQM (2014)
Benzo(a)anthracene	7.2	11	13	11	14	15	2.9	6.5	13	170	170	180	29	29	29	49	56	62	LQM (2014)
Benzo(a)pyrene	2.2	2.7	3	3.2	3.2	3.2	0.97	2	3.5	35	35	36	5.7	5.7	5.7	11	12	13	LQM (2014)
Benzo(b)fluoranthene	2.6	3.3	3.7	3.9	4	4	0.99	2.1	3.9	44	44	45	7.1	7.1	7.1	13	15	16	LQM (2014)
Benzo(g,h,i)perylene	320	340	350	360	360	360	290	470	640	3900	4000	4000	640	640	640	1400	1500	1600	LQM (2014)
Benzo(k)fluoranthene	77	93	100	110	110	110	37	75	130	1200	1200	1200	190	190	190	370	410	440	LQM (2014)
Chrysene	15	22	27	30	31	32	4.1	9.4	19	350	350	350	57	57	57	93	110	120	LQM (2014)

Parameter	Residential with homegrown produce			Residential without homegrown produce			Allotment			Commercial / Industrial			Public Open Space near Residential			Public Open Space - Park			Source
	(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			
SOM	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	
Dibenz(a,h)anthracene	0.24	0.28	0.3	0.31	0.32	0.32	0.14	0.27	0.61	3.5	3.6	3.6	0.57	0.57	0.58	1.1	1.3	1.4	LQM (2014)
Fluoranthene	280	560	890	1500	1600	1600	52	130	290	23000	23000	23000	3100	3100	3100	63	6300	6400	LQM (2014)
Fluorene	170	400	860	2800 (30.9)	3800 (76.5)	4500 (183)	27	67	160	63000 (30.9)	68000	71000	9900	9900	9900	20000	20000	20000	LQM (2014)
Indeno(1,2,3-cd)pyrene	27	36	41	45	46	46	9.5	21	39	500	510	510	82	82	82	150	170	180	LQM (2014)
Naphthalene	2.3	5.6	13	2.3	5.6	13	4.1	10	24	190 (76.4)	460 (183)	1100 (432)	4900	4900	4900	1200 (76.4)	1900 (183)	3000	LQM (2014)
Phenanthrene	95	220	440	1300 (36)	1500	1500	15	38	90	22000	22000	23000	3100	3100	3100	6200	6200	6300	LQM (2014)
Pyrene	620	1200	2000	3700	3800	3800	110	270	620	54000	54000	54000	7400	7400	7400	15000	15000	15000	LQM (2014)
Coal Tar (BaP as surrogate marker)	0.79	0.98	1.1	1.2	1.2	1.2	0.32	0.67	1.2	15	15	15	2.2	2.2	2.2	4.4	4.7	4.8	LQM (2014)
BTEX and TPH																			
Benzene	0.087	0.17	0.37	0.38	0.7	1.4	0.017	0.034	0.075	27	47	90	72	72	73	90	100	110	LQM (2014)
Toluene	130	290	660	880 vap (869)	1900	3900	22	51	120	56000 vap (869)	110000 vap (1920)	180000 vap (4360)	56000	56000	56000	87000 vap (869)	95000 vap (1920)	100000 vap (4360)	LQM (2014)
Ethylbenzene	47	110	260	83	190	440	16	39	91	5700 vap (518)	13000 vap (1220)	27000 vap (2840)	24000	24000	25000	17000 vap (518)	22000 vap (1220)	27000 vap (2840)	LQM (2014)
Xylene - o	60	140	330	88	210	480	28	67	160	6600 (478)	15000 (1120)	33000 (2620)	41000	42000	43000	17000 (478)	24000 (1120)	33000 (2620)	LQM (2014)

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	(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			
SOM	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	
Xylene - m	59	140	320	82	190	450	31	74	170	6200 (625)	14000 (1470)	31000 (3460)	41000	42000	43000	17000 (625)	24000 (1470)	32000 (3460)	LQM (2014)
Xylene - p	56	130	310	79	180	430	29	69	160	5900 (576)	14000 (1350)	30000 (3170)	41000	42000	43000	17000 (576)	23000 (1350)	31000 (3170)	LQM (2014)
Aliphatic EC 5-6	42	78	160	42	78	160	730	1700	3900	3200 (304)	5900 (558)	12000 (1150)	570000 (304)	590000	600000	95000 (304)	130000 (558)	180000 (1150)	LQM (2014)
Aliphatic EC >6-8	100	230	530	100	230	530	2300	5600	13000	7800 (144)	17000 (322)	40000 (736)	600000	610000	620000	150000 (144)	220000 (322)	320000 (736)	LQM (2014)
Aliphatic EC >8-10	27	65	150	27	65	150	320	770	1700	2000 (78)	4800 (190)	11000 (451)	13000	13000	13000	14000 (78)	18000 (190)	21000 (451)	LQM (2014)
Aliphatic EC >10-12	130 (48)	330 (118)	760 (283)	130 (48)	330 (118)	760 (283)	2200	4400	7300	9700 (48)	23000 (118)	47000 (283)	13000	13000	13000	21000 (48)	23000 (118)	24000(283)	LQM (2014)
Aliphatic EC >12-16	1100 (24)	2400 (59)	4300 (142)	1100 (24)	2400 (59)	4300 (142)	11000	13000	13000	59000 (24)	82000 (59)	90000 (142)	13000	13000	13000	25000 (24)	25000 (59)	26000 (142)	LQM (2014)
Aliphatic EC >16-35	65000 (8.48)	92000 (21)	110000	65000 (8.48)	92000 (21)	110000	260000	270000	270000	1600000	1700000	1800000	250000	250000	250000	450000	480000	490000	LQM (2014)
Aliphatic EC >35-44	65000 (8.48)	92000 (21)	110000	65000 (8.48)	92000 (21)	110000	260000	270000	270000	1600000	1700000	1800000	250000	250000	250000	450000	480000	490000	LQM (2014)
Aromatic EC 5-7	70	140	300	370	690	1400	13	27	57	26000 (1220)	46000 (2260)	86000 (4710)	56000	56000	56000	76000 (1220)	84000 (2260)	92000 (4710)	LQM (2014)
Aromatic EC >7-8	130	290	660	860	1800	3900	22	51	120	56000 (869)	110000 (1920)	180000 (4360)	56000	56000	56000	87000 (869)	95000 (1920)	100000 (4360)	LQM (2014)
Aromatic EC >8-10	34	83	190	47	110	270	8.6	21	51	3500 (613)	8100 (1500)	17000 (3580)	5000	5000	5000	7200 (613)	8500 (1500)	9300 (3580)	LQM (2014)
Aromatic EC >10-12	74	180	380	250	590	1200	13	31	74	16000 (364)	28000 (899)	34000 (2150)	5000	5000	5000	9200 (364)	9700 (899)	10000	LQM (2014)

Parameter	Residential with homegrown produce			Residential without homegrown produce			Allotment			Commercial / Industrial			Public Open Space near Residential			Public Open Space - Park			Source
	(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			
SOM	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	
Aromatic EC >12-16	140	330	660	1800	2300 (419)	2500	23	27	130	36000 (169)	37000	38000	5100	5100	5000	10000	10000	10000	LQM (2014)
Aromatic EC >16-21	260	540	930	1900	1900	1900	46	110	260	28000	28000	28000	3800	3800	3800	7600	7700	7800	LQM (2014)
Aromatic EC >21-35	1100	1500	1700	1900	1900	1900	370	820	1600	28000	28000	28000	3800	3800	3800	7800	7800	7900	LQM (2014)
Aromatic EC >35-44	1100	1500	1700	1900	1900	1900	370	820	1600	28000	28000	28000	3800	3800	3800	7800	7800	7900	LQM (2014)
Aromatic EC >44-75	1600	1800	1900	1900	1900	1900	1200	2100	3000	28000	28000	28000	3800	3800	3800	7800	7800	7900	LQM (2014)
VOCs																			
1,2-dichloroethane (1,2-DCA)	0.0071	0.011	0.019	0.0092	0.013	0.023	0.0046	0.0083	0.016	0.67	0.97	1.7	29	29	29	21	24	28	LQM (2014)
1,1,1-trichloroethane	8.8	18	39	9	18	40	48	110	240	660	1300	3000	140000	140000	140000	57000 (1425)	76000 (2915)	100000 (6392)	LQM (2014)
1,1,2,2,tetrachloroethane	1.6	3.4	7.5	3.9	8	17	0.41	0.89	2	270	550	1100	1400	1400	1400	1800	2100	2300	LQM (2014)
tetrachloroethene	0.18	0.39	0.9	0.18	0.4	0.92	0.65	1.5	3.6	19	45	95	1400	1400	1400	810 (424)	1100 (951)	1500	LQM (2014)
tetrachloromethane (Carbon tetrachloride)	0.026	0.056	0.13	0.026	0.056	0.13	0.45	1	2.4	2.9	6.3	14	890	920	950	190	270	400	LQM (2014)
Trichloroethene	0.016	0.034	0.075	0.017	0.036	0.08	0.041	0.091	0.21	1.2	2.6	5.7	120	120	120	70	91	120	LQM (2014)
Trichloromethane (chloroform)	0.91	1.7	3.4	1.2	2.1	4.2	0.42	0.83	1.7	99	170	350	2500	2500	2500	2600	2800	3100	LQM (2014)

Parameter	Residential with homegrown produce			Residential without homegrown produce			Allotment			Commercial / Industrial			Public Open Space near Residential			Public Open Space - Park			Source
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SOM	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	
Chloroethene (Vinyl chloride)	0.00064	0.00087	0.0014	0.00077	0.001	0.0015	0.00055	0.001	0.0018	0.059	0.077	0.12	3.5	3.5	3.5	4.8	5	5.4	LQM (2014)
2,4,6 Trinitrotoluene (TNT)	1.6	3.7	8.1	65	66	66	0.24	0.58	1.4	1000	1000	1000	130	130	130	260	270	270	LQM (2014)
RDX	120	250	540	13000	13000	13000	17	38	85	210000	210000	210000	26000	26000	27000	49000 (18.7)	51000	53000	LQM (2014)
HMX	5.7	13	26	6700	6700	6700	0.86	1.9	3.9	110000	110000	110000	13000	13000	13000	23000 (0.35)	23000 (0.39)	24000 (0.48)	LQM (2014)
Aldrin	5.7	6.6	7.1	7.3	7.4	7.5	3.2	6.1	9.6	170	170	170	18	18	18	30	31	31	LQM (2014)
Dieldrin	0.97	2	3.5	7	7.3	7.4	0.17	0.41	0.96	170	170	170	18	18	18	30	30	31	LQM (2014)
Atrazine	3.3	7.6	17.4	610	620	620	0.5	1.2	2.7	9300	9400	9400	1200	1200	1200	2300	2400	2400	LQM (2014)
Dichlovos	0.032	0.066	0.014	6.4	6.5	6.6	0.0049	0.01	0.022	140	140	140	16	16	16	26	26	27	LQM (2014)
Alpha-Endosulfan	7.4	18	41	160 (0.003)	280 (0.007)	410 (0.016)	1.2	2.9	6.8	5600 (0.003)	7400 (0.007)	8400 (0.016)	1200	1200	1200	2400	2400	2500	LQM (2014)
alpha-Hexachlorocyclohexane	0.23	0.55	1.2	6.9	9.2	11	0.035	0.087	0.21	170	180	180	24	24	24	47	48	48	LQM (2014)
beta-hexachlorocyclohexanes	0.085	0.2	0.46	3.7	3.8	3.8	0.013	0.032	0.077	65	65	65	8.1	8.1	8.1	15	15	16	LQM (2014)
gamma-hexachlorocyclohexanes	0.06	0.14	0.33	2.9	3.3	3.5	0.0092	0.023	0.054	67	69	70	8.2	8.2	8.2	14	15	15	LQM (2014)

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SOM	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	
Chlorobenzene	0.46	1	2.4	0.46	1	2.4	5.9	14	32	56	130	290	11000	13000	14000	1300 (675)	2000 (1520)	2900	LQM (2014)
1,2-Dichlorobenzene	23	55	130	24	57	130	94	230	540	2000 (571)	4800 (1370)	11000 (3240)	90000	95000	98000	24000 (571)	36000 (1370)	51000 (3240)	LQM (2014)
1,3-Dichlorobenzene	0.4	1	2.3	0.44	1.1	2.5	0.25	0.6	1.5	30	73	170	300	300	300	390	440	470	LQM (2014)
1,4-Dichlorobenzene	61	150	350	61	150	350	15	37	88	4400 (224)	10000 (540)	25000 (1280)	17000	17000	17000	36000 (224)	36000 (540)	36000 (1280)	LQM (2014)
1,2,3-Trichlorobenzene	1.5	3.6	8.6	1.5	3.7	8.8	4.7	12	28	102	250	590	1800	1800	1800	770 (134)	1100 (330)	1600 (789)	LQM (2014)
1,2,4-Trichlorobenzene	2.6	6.4	15	2.6	6.4	15	55	140	320	220	530	1300	15000	17000	19000	1700 (318)	2600 (786)	4000 (1880)	LQM (2014)
1,3,5-Trichlorobenzene	0.33	0.81	1.9	0.33	0.81	1.9	4.7	12	28	23	55	130	1700	1700	1800	380 (36.7)	580 (90.8)	860 (217)	LQM (2014)
1,2,3,4-Tetrachlorobenzene	15	36	78	24	56	120	4.4	11	26	1700 (122)	3080 (304)	4400 (728)	830	830	830	1500 (122)	1600	1600	LQM (2014)
1,2,3,5-Tetrachlorobenzene	0.66	1.6	3.7	0.75	1.9	4.3	0.38	0.9	2.2	49 (39.4)	120 (98.1)	240 (235)	78	79	79	110 (39)	120	130	LQM (2014)
1,2,4,5-Tetrachlorobenzene	0.33	0.77	1.6	0.73	1.7	3.5	0.06	0.16	0.37	42 (19.7)	72 (49.1)	96	13	13	13	25	26	26	LQM (2014)
Pentachlorobenzene	5.8	12	22	19	30	38	1.2	3.1	7	640 (43)	770 (107)	830	100	100	100	190	190	190	LQM (2014)

Parameter	Residential with homegrown produce			Residential without homegrown produce			Allotment			Commercial / Industrial			Public Open Space near Residential			Public Open Space - Park			Source
	(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			(mg/kg, unless otherwise stated)			
SOM	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	**1%**	**2.50%**	**6%**	
Hexachlorobenzene	1.8 (0.2)	3.3 (0.5)	4.9	4.1 (0.2)	5.7 (0.5)	6.7 (1.2)	0.47	1.1	2.5	110 (0.2)	120	120	16	16	16	30	30	30	LQM (2014)
Phenol	120	200	380	440[dir] (460)	690	1200	23	42	83	440[dir] (26000[f])	690[dir] (30000)	1300[dir] (34000)	440[dir] (10000)	690[dir] (10000)	1300[dir] (10000)	440[dir] (7600)	690[dir] (8300)	1300[dir] (9300)	LQM (2014 errata)
Chlorophenols (excluding pentachlorophenol)	0.87 (g)	2	4.5	94	150	210	0.13 (g)	0.3	0.7	3500	4000	4300	620	620	620	1100	1100	1100	LQM (2014)
Pentachlorophenol	0.22	0.52	1.2	27 (16.4)	29	31	0.03	0.08	0.19	400	400	400	60	60	60	110	120	120	LQM (2014)
Carbon Disulphide	0.14	0.29	0.62	0.14	0.29	0.62	4.8	10	23	11	22	47	11000	11000	12000	1300	1900	2700	LQM (2014)
Hexachlorobutadiene	0.29	0.7	1.6	0.32	0.78	1.8	0.25	0.61	1.4	31	66	120	25	25	25	48	50	51	LQM (2014)

(g) derived based on 2,3,4,6-tetrachlorophenol; dir - based on a threshold protective of direct skin contact with phenol (guideline in brackets based on health effects following long term exposure provided for illustration only); (vap) calculated for vapour phase only. SOM – Soil Organic Matter; (4.5) solubility. (f) This value also exceeds the vapour saturation limit of 24,200 mg/kg.

APPENDIX E - CONTROLLED WATERS RISK ASSESSMENT

CURRENT GUIDANCE FOR CONTROLLED WATERS RISK ASSESSMENT

Regulatory Context

Government policy in Wales is based upon a "suitable for use" approach, which is relevant to both the current use of land and to any proposed future use. When considering the current use of land, Part IIA of the Environmental Protection Act 1990 (EPA 1990) provides the regulatory regime, which was introduced by Section 57 of the Environment Act 1995, and came into force in England and Wales on 1 April 2000. The main objective of the Part IIA regime is to provide an improved system for the identification and remediation of land where contamination is causing unacceptable risks to human health, controlled waters, or the wider environment given the current use and circumstances of the land.

Part IIA provides a statutory definition of contaminated land under Section 78A(2) as:

> *"any land which appears to the Local Authority in whose area it is situated to be in such a condition, by reason of substances in, on, or under the land, that:*
>
> *(a) Significant harm is being caused or there is a significant possibility of such harm being caused; or*
>
> *(b) Pollution of controlled waters is being, or is likely to be, caused."*

Part IIA provides a statutory definition of the pollution of controlled waters under Section 78A(9) as:

> *"the entry into controlled waters of any poisonous, noxious or polluting matter or any solid waste matter."*

Controlled waters are defined in Section 104 of the Water Resources Act 1991. In summary, these comprise relevant territorial waters, coastal waters, inland freshwaters and groundwater, including groundwater used for public and private drinking water supplies.

Natural Resources Wales (NRW) has powers under Part 7 of the Water Resources Act 1991 to take action to prevent or remedy the pollution of controlled waters, including circumstances where the pollution arises from contamination in the land. This is reinforced in The Contaminated Land (Wales) Regulations 2012 and the Contaminated Land Statutory Guidance for Wales (Welsh Government, 2012). NRW guidance places particular emphasis on the protection of groundwater resources, including safeguarding both public and private water supplies.

Part IIA introduces the concept of a contaminant linkage; where for potential harm to exist there must be a connection between the source of the hazard and the receptor via a pathway. Risk assessment in contaminated land is therefore directed towards identifying the contaminants, pathways and receptors that can provide contaminant linkages. This is known as the contaminant–pathway–receptor (CPR) linkage.

In Wales, responsibility for identifying and addressing contaminated land under Part IIA rests primarily with local authorities, with specialist advice and support provided by NRW where controlled waters may be affected or where significant risks are present. Within the planning process, land contamination is addressed through the requirements of Planning Policy Wales (PPW), supported by technical guidance such as the Welsh Government's Land Contamination Guidance and relevant Technical Advice Notes. PPW requires that development is carried out in such a way that the land is suitable for its intended use and is not capable of being determined as "contaminated land" under Part IIA once developed. Therefore, appropriate risk-based investigation is required to identify potential contaminant linkages, which can then be assessed and, where necessary, mitigated using methods agreed with the planning authority and with reference to NRW advice.

Source Protection Zones

Source Protection Zones (SPZs) are delineated to protect groundwater sources—such as wells, boreholes and springs—used for public drinking water supply. In Wales, SPZs are defined and managed by Natural Resources Wales (NRW). In England they are defined by the Environment Agency (EA), in Scotland by SEPA, and in Northern Ireland by the Northern Ireland Environment Agency (NIEA).

SPZs illustrate the relative risk that activities at the ground surface could pose to a groundwater abstraction. The size and shape of each zone reflect subsurface hydrogeological conditions, abstraction rates and methods, and other local environmental factors.

SPZs are classified into four categories:

- **Zone 1 – Inner Protection Zone:** Areas from which groundwater can travel to the abstraction point within 50 days, at and below the water table. A minimum 50 m radius around the abstraction is also applied. This provides protection against the rapid transmission of pollutants and water-borne pathogens.
- **Zone 2 – Outer Protection Zone:** Areas contributing water that may take up to 400 days to reach the abstraction point, or that comprise 25% of the total catchment area (whichever is greater). This period is the minimum over which the relevant regulator (NRW in Wales; EA in England) considers pollutants are likely to be attenuated, diluted or delayed before reaching the abstraction.
- **Zone 3 – Total Catchment:** The full catchment area needed to sustain the abstraction and any associated discharges.
- **Zone of Special Interest (ZoSI):** Defined in special cases where local conditions mean that potential contamination sources outside the normal catchment could still affect the groundwater source (e.g., karst features, mine workings, or significant industrial sites).

Where development is proposed within or near an SPZ, risk assessments and mitigation should reflect the zone designation and local hydrogeological context, with early engagement with NRW advised for Welsh sites.

Groundwater Vulnerability Assessments

Since 1 April 2010, groundwater protection policy in England and Wales has used aquifer designations consistent with the Water Framework Directive (WFD). In Wales, these designations are applied and managed by Natural Resources Wales (NRW). The classifications reflect the importance of aquifers both as a resource for drinking water supply and in their role supporting surface water flows and dependent wetland ecosystems.

Aquifer designation data is derived from geological mapping provided by the British Geological Survey (BGS). This dataset is updated regularly to reflect improvements to geological understanding. Two broad types of aquifer designation are recognised:

- Superficial (Drift) Aquifers – permeable unconsolidated (loose) deposits, e.g. sands and gravels.
- Bedrock Aquifers – solid permeable formations, e.g. sandstones, chalk and limestones.

The aquifer classifications are as follows:

Table 1. Aquifer Classification ("Geological Classification").

Classification	Definition
Principal Aquifers (Highly Permeable)	These are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.
Secondary A Aquifers	Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.
Secondary B Aquifers	Predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.
Secondary Undifferentiated Aquifers	This has been assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type.
Unproductive Strata	These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

NRW uses this aquifer classification system, alongside groundwater vulnerability mapping, when assessing risks from land contamination and proposed developments. This ensures consistency with the Water Framework Directive objectives to protect groundwater both as a drinking water source and as a key ecological component.

Natural Resources Wales Guidance

Groundwater Protection: Policy Context And Tiered Tools (Wales)

Natural Resources Wales' approach to groundwater protection is to prevent pollution and protect groundwater as a resource for current and future generations, and NRW has adopted the Environment Agency's approach to protecting groundwater (formerly GP3) for use in Wales. This sets out aims, regulatory positions, tools and technical guidance used in planning and permitting decisions.

Whilst the legislation and guidance framework can be complex, the core objectives are consistent: prevent deterioration, manage risks, and secure sustainable use of groundwater under the Water Framework Directive regime and associated regulations. In Wales this sits alongside primary legislation such as the Water Resources Act 1991 (as amended) and the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017.

Historically, the National Rivers Authority (NRA) published the Policy and Practice for the Protection of Groundwater (PPPG) in 1992 (revised 1998). Subsequent European directives—the Groundwater Directive (80/68/EEC) and the Water Framework Directive (2000/60/EC)—drove major updates, culminating in the Environment Agency's Groundwater Protection: Principles and Practice (GP3, 2012). NRW now uses the EA approach in Wales as its decision-making framework.

NRW's Risk-Based, Tiered Toolkit (Wales)

NRW applies a tiered, risk-based set of tools to protect drinking-water sources and groundwater more widely. From broad strategic designations through to highly targeted controls, these include:

- Aquifer designations and groundwater vulnerability mapping – Principal, Secondary (A/B/Undifferentiated) Aquifers and Unproductive Strata, derived from BGS mapping and used to understand sensitivity and vulnerability.
- Source Protection Zones (SPZs) – Zones 1–3 and Zones of Special Interest around potable groundwater abstractions to manage activities by travel-time and catchment risk. In Wales, SPZs are defined and published by NRW.
- Drinking Water Protected Areas (DrWPAs) and Safeguard Zones (SgZs) – WFD protected areas for drinking-water sources; Safeguard Zones are non-statutory catchments designated where a DrWPA is at risk, focusing action to prevent deterioration and reduce treatment needs.
- Water Protection Zones (WPZs) – Statutory controls used only in exceptional circumstances; in Wales, this currently applies to the River Dee Water Protection Zone, where specific substances and activities require consent across the catchment.

These tools are applied in combination according to site-specific risk and hydrogeological context; they are not a formal hierarchy. For developments in Wales, findings should inform planning and permitting, with early engagement with NRW where higher sensitivity is identified.

Controlled Waters Risk Assessment

In Wales, developers are expected to assess and manage risks to controlled waters (groundwater and surface waters) so that land is suitable for use and does not cause pollution. Natural Resources Wales (NRW) applies a risk-based approach consistent with the Water Framework Directive and the groundwater protection approach adopted from the Environment Agency (EA). Site assessment should identify potential risks and, where necessary, derive appropriate remedial targets to protect controlled waters.

Key tools and datasets (as relevant to Wales): aquifer designations and groundwater vulnerability mapping (BGS/NRW), Source Protection Zones (SPZs), Drinking Water Protected Areas (DrWPAs) and Safeguard Zones (SgZs), and (where applicable) Water Protection Zones (WPZs). These inform sensitivity and screening.

Stages of assessment

1. **Risk screening / Conceptual Site Model (CSM)**

- Define sources–pathways–receptors for controlled waters.
- Review site setting and hydrogeology, aquifer classification, SPZ status, proximity to surface waters, DrWPA/SgZ context, abstractions and private water supplies.
- Identify plausible contaminant linkages and data needs.

2. **Generic (Tier 1) Risk Assessment**

- Compare groundwater and surface-water data against appropriate generic screening criteria, e.g. relevant Environmental Quality Standards (EQS), UKTAG standards, Drinking Water standards/PCVs, and other accepted benchmarks.
- Apply conservative assumptions to screen out low-risk linkages.
- Where applied in Wales, use the Remedial Targets Methodology (RTM) Tier 1 (as adopted by NRW from EA practice) or equivalent accepted methods to derive protective targets.

3. **Detailed Quantitative Risk Assessment (DQRA)**

- Where Tier 1 indicates potential concern, refine the assessment using site-specific hydrogeological parameters (hydraulic conductivity, gradients, thickness, dilution/attenuation, source mass, degradation).
- Consider RTM Tiers 2 & 3 (as adopted by NRW) and/or recognised fate-and-transport models to derive site-specific remedial targets for groundwater and relevant surface-water receptors.
- Evaluate compliance at appropriate points of compliance (e.g., receptor boundary, abstraction, surface-water compliance point) consistent with receptor sensitivity and NRW expectations.

Outcome:

The assessment should conclude whether controlled-waters risks are acceptable or whether mitigation/remediation is required, setting clear remedial targets and monitoring needs. Early engagement with NRW is recommended where sites lie within SPZs, DrWPAs/SgZs, or otherwise sensitive hydrogeological settings.

Risk Screening

In Wales, risk screening begins with the development of a robust Conceptual Site Model (CSM). The CSM is a critical tool for assessing potentially contaminated sites and provides the framework for identifying and evaluating plausible source–pathway–receptor linkages.

At this stage, available information (e.g. desk study data, geological and hydrogeological mapping, aquifer designations, Source Protection Zones, Drinking Water Protected Areas, abstractions, and surface water features) should be reviewed to establish whether sensitive controlled water receptors may be present. Where evidence supports the absence of a particular receptor, the associated linkage can be screened out at an early stage.

The CSM is a living document and should be refined as more information becomes available, including findings from intrusive investigation and monitoring. This iterative process ensures that risk screening reflects site-specific conditions and is consistent with NRW's expectation that risk assessments are proportionate, transparent, and updated as uncertainty is reduced.

Generic Risk Assessment - England and Wales

When undertaking the Generic Hydrogeological Risk Assessment, the Remedial Targets Methodology (RTM) Tier 1, as adopted by Natural Resources Wales (NRW) from the Environment Agency approach, is commonly applied. Comparison of chemical analytical results is made with appropriate screening criteria.

In accordance with Part 2A of the Environmental Protection Act 1990, Tier Environmental has had regard to all of the Water Quality Standards (WQS) relevant to the site, and a judgment has been made against the most stringent of those relevant standards, including:

- EQS Directive 2008/105/EC
- Priority Substances Directive 2013/39/EU
- Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015
- UK Drinking Water Standards (UK DWS)
- World Health Organisation (WHO Guidelines) for Drinking Water Quality
- Council Directive 98/83/EC on the quality of water intended for human consumption (Drinking water directive)

In some instances, the laboratory method detection limit is greater than the appropriate EQS/UKDWS value. In these instances, only measured concentrations in excess of the laboratory method detection limit have been considered likely to potentially represent a possible significant risk to controlled waters.

Please note that there is no quantitative criterion for total petroleum hydrocarbons (TPH), or speciated TPH fractions. Historically, standards provided for petroleum hydrocarbons ranges from 10µg/l (Private Water Supply Regulations 1991, removed from the 2009 regulations) to 50µg/l-1000µg/l (Surface Waters (Abstraction for Drinking Water) Regulations 1989) which related to the degree of treatment of water prior to use as drinking water. Over time, the legislative standards have been rescinded and no alternative standard provided, although the Environment Agency planned to release speciated TPH criteria (Fretwell et al., 2009).

In order to assess whether there is a potentially unacceptable risk of pollution of controlled waters, the results of the groundwater chemical analysis for TPH and BTEX were evaluated against Water Quality Standards (WQS) appropriate to the conceptual model for the site:

Table 2. Summary of Selected TPH and BTEX Water Quality Standards Selected for Tier 1 Screening

Determinand	Units	WQS Selected	Source of WQS
Aliphatics >C5-C6	µg/l	15000	Table 5.4 of CL:AIRE 2017#
Aliphatics >C6-C8	µg/l	15000	Table 5.4 of CL:AIRE 2017#
Aliphatics >C8-C10	µg/l	300	Table 5.4 of CL:AIRE 2017#
Aliphatics >C10-C12	µg/l	300	Table 5.4 of CL:AIRE 2017#
Aliphatics >C12-C16	µg/l	300	Table 5.4 of CL:AIRE 2017#
Aliphatics >C16-C21	µg/l	-	Table 5.4 of CL:AIRE 2017#
Aliphatics >C21-C35	µg/l	-	Table 5.4 of CL:AIRE 2017#
Aromatics >C5-EC7	µg/l	10	Table 5.4 of CL:AIRE 2017#
Aromatics >EC7-EC8	µg/l	700	Table 5.4 of CL:AIRE 2017#
Aromatics >EC8-EC10	µg/l	300	Table 5.4 of CL:AIRE 2017#
Aromatics >EC10-EC12	µg/l	100	Table 5.4 of CL:AIRE 2017#
Aromatics >EC12-EC16	µg/l	100	Table 5.4 of CL:AIRE 2017#
Aromatics >EC16-EC21	µg/l	90	Table 5.4 of CL:AIRE 2017#
Aromatics >EC21-EC35	µg/l	90	Table 5.4 of CL:AIRE 2017#
Benzene	µg/l	10	Priority Substance Water Framework Directive 2015 and Table 5.3 of CL:AIRE 2017#
Toluene	µg/l	74	Table 1 Water Framework Directive 2015 and Table 5.3 of CL:AIRE 2017#
Ethylbenzene	µg/l	20	R&D Technical Report P2-115/TR4, 2002
Total xylenes	µg/l	30	DoE (1997c) Hedgecott S. and Lewis S, An update on proposed environmental quality standards for xylenes in water, final report to the Department of the Environment. Report No. DoE 4273/1. Medmenham: WRc; and; Table 5.3 of CL:AIRE 2017#

Notes - # = CL:AIRE document 'Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies' (ISBN 978-1-905046-31-7, dated 2017),

Table 5.3 was referenced in the first instance from the CL:AIRE document 'Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies' (ISBN 978-1-905046-31-7, dated 2017), the to select appropriate Freshwater EQS values for benzene, toluene and total xylenes. The selected value for Ethylbenzene was derived from the proposed EQS value of 20µg/l from the Environment Agency R&D Technical Report P2-115/TR4, 2002. This represents a more conservative value than the 300µg/l value in Table 5.3.

With respect to speciated TPH CWG fractions, Table 5.3 states and refers the reader to 'See Table 5.4'. On this basis, Tier Environmental selected the World Health Organization (WHO) guide values for TPHCWG fractions in drinking water that are presented in Table 5.4 which may be considered appropriately protective of the controlled waters environment based on the conceptual site model.

Generic Risk Assessment is generally undertaken via comparison of reported leachate and/or groundwater concentrations against selected assessment criteria for the potential contaminants of concern identified for the site from a preliminary desk based assessment.

The selected Generic Assessment Criteria (GAC) derived from a Water Quality Standard (WQS) for any specific substance may not necessarily be a simple number and can often be found to be expressed as:

- Annual mean concentration;
- Maximum allowable concentration;
- 95th percentile concentration for *n* samples;
- Total concentration;
- Dissolved concentration (applicable to filtered samples)

The values may sometimes be expressed for individual substances (e.g. arsenic or for groups of substances e.g. total xylenes or sums of certain PAHs).

Environmental Quality Standards (EQS) have been used where available for Priority Substances and Priority Hazardous Substances set at a European level:

- Priority Substances Directive 2013/39/EU;
- (amending 2008/105/EC)

In addition, EQS values derived for Specific Pollutants have been used as presented in The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

For assessing risks to potable water abstraction supplies, UK Drinking Water Standards presented in the Water Supply (Water Quality) Regulations 2000 (SI/2000/3184) (as amended) have been applied.

In selecting a GAC for a particular site, Tier Environmental considers the following factors:

- Current use/function of the groundwater (e.g. drinking water, irrigation water, industrial use, base-flow to rivers and streams);
- Plausible, proposed or planned future uses of the water and nearby waters;
- Sensitivity of the critical receptor (e.g. human health, aquatic life); and,
- Requirements to trigger action under the legal context.

In accordance with Part 2A:

> *"in deciding whether pollution of controlled waters is occurring, the assessor will have regard to all of the water quality standards that are relevant to the specific site and make a judgment against the most stringent of those relevant standards."*

If the Tier 1 or 2 assessments indicate exceedances of threshold levels, then the options are to:

- To devise suitable remedial solutions;
- To carry out more investigation, sampling and analysis;
- To conduct a site-specific Detailed Quantitative Risk Assessment (DQRA) to whether or not the soil materials are suitable for their site-specific intended use or to devise a site-specific clean-up level.

Detailed Quantitative Risk Assessment (DQRA)

The decision to carry out a DQRA will be informed by the initial qualitative and generic assessment. The scope of any such assessment will be accurately defined by the outcomes of the former two stages. The robust CSM will be sufficiently refined by this stage that only certain contaminants of concern, certain pathways and certain receptors will require further assessment.

Additional site specific data is normally required for this stage of assessment, as explained above, more processes that are capable of affecting contaminant concentrations are considered (such as dilution and attenuation).

Remediation criteria derived will therefore be specific to each site and will be based on a detailed assessment of the potential impact at the identified receptor or compliance point. A greater level of confidence can be placed on the predicted impact on the compliance point following a DQRA.

Compliance Points

As part of the DQRA, you must define one or more compliance points. These are locations (such as receptor boundaries, abstraction points or other relevant locations within the plume or pathway) where concentrations will be checked against the derived target concentration / remedial target. The selection of compliance points should reflect the refined CSM, receptor sensitivity, hydrogeological setting, and pollutant transport pathways, and should be agreed with Natural Resources Wales. Monitoring or verification at these points is required as part of any remedial strategy to demonstrate whether objectives are being met and whether further action is needed.

Hazardous and Non Hazardous Substances

The Groundwater (England and Wales) Regulations 2009 transpose the Groundwater Directive (2006/118/EC) and control the discharge of potentially polluting substances to groundwater. The regulations apply in Wales and are enforced by Natural Resources Wales (NRW).

Substances are divided into two categories: Hazardous Substances and Non-hazardous Pollutants (broadly equivalent to the former List I and List II substances).

- **Hazardous Substances**
  These are the most toxic and damaging substances and must be prevented from entering groundwater, directly or indirectly. Examples include mineral oils and other hydrocarbons, pesticides, biocides, herbicides, solvents, and certain metals. Discharge of Hazardous Substances to controlled waters is not permitted.
- **Non-hazardous Pollutants**
  These are other contaminants which, while generally less toxic than Hazardous Substances, can still pose significant risks. Their direct discharge to groundwater is generally prohibited, and any indirect discharge must be limited and controlled by technical precautions to prevent pollution. Examples include ammonia, nitrites, a range of metals, and fluorides.

Permitting note (Wales): In practice, controls on inputs to groundwater are regulated through the Environmental Permitting (England and Wales) Regulations 2016. Activities posing a risk to groundwater (e.g., discharges to ground/groundwater, certain infiltration systems, or operations within SPZs) typically require an environmental permit or a specific regulatory position from NRW. Early engagement with NRW is recommended where Hazardous Substances or higher-risk Non-hazardous Pollutants could be present.

APPENDIX F - CHEMICAL TEST SAMPLING

Samples were selected by a representative of Tier Environmental during the site investigation works in accordance with the sampling approach described elsewhere in this report.

Samples for chemical analysis

All samples for chemical analysis were placed into clean new containers as summarised in Table 1. Unless explicitly stated elsewhere in this report, no preservatives were used to eliminate the risk that preservatives cause contaminant dissolution or analytical interference. Containers for VOC analysis were fully filled to exclude headspace.

Soil samples were dispensed as soon as possible after collection using reusable stainless steel spatulas, trowels, or similar implements.

Ground water samples were collected from boreholes using single-use Teflon bailers or dedicated Waterra tubing with foot valves, except as otherwise noted within this report. Caution was taken to avoid excessive agitation during collection

New disposable gloves were used by the engineer for the collection of each sample.

Reusable equipment was washed down with distilled or deionised water between samples, except where tarry or similarly sticky materials were present. In such cases specific cleaning procedures were adopted as specifically described elsewhere in this report.

All sub-samples taken for chemical analysis were placed into refrigerators or cool boxes containing frozen ice packs immediately after aliquoting. All samples were transferred in cool boxes containing frozen ice packs to the relevant UKAS/MCERTS accredited laboratory as soon as possible. Recommended maximum holding times before analysis are summarised in Table 1.

Table 1. Sample containers and holding times.

Analysis	**Container/special requirements**	**Max. holding time at 4°C before analysis**
Soil and sediment samples		
VOCs	30-60 g brown or green glass jar with VOC-resistant cap and inert cap liner. Must be fully filled.	14 days
TPHCWG	30-60 g brown or green glass jar with VOC-resistant cap and inert cap liner **PLUS** 250-500 g brown or green glass jar with unwaxed cap liner.[1] The former must be fully filled.	14 days
All other organics	250-500 g brown or green glass jar with unwaxed cap liner.	7 days
Inorganics	Air-tight 0.5-2.0 kg plastic container (250-500 g brown or green glass jar may also be used).	14 days[2]
Water samples		
VOCs	40-50 ml glass vial with VOC resistant screw cap and inert liner. Must be fully filled.	14 days
TPHCWG	40-50 ml glass vial with VOC resistant screw cap and inert liner **PLUS** 500-1000 ml brown or green glass bottle with screw cap and unwaxed liner.[1] The former must be fully filled; the latter should be filled if possible.	14 days
All other organics	500-1000 ml brown or green glass bottle with screw cap. Fill if possible.	7 days
Inorganics	500-1000 ml translucent or opaque screw cap plastic *or* brown or green glass bottles. Fill if possible.	14 days[3]

1 The smaller vessel is used for analysis of the volatile components within the TPH mixture and the larger one is for the non-volatile components.

2 14 days is set as a reasonable limit for all routine analyses of soil for those inorganic components vulnerable to chemical and/or biological breakdown. Samples for sulphate analysis are vulnerable to biological sulphate-reduction but can be held for up to 28 days. For total metals, a holding period of up to 6 months is acceptable.

3 14 days applies for all routine analyses of most inorganic components that may be vulnerable to chemical and/or biological reactions. In the specific cases of sulphide, nitrite, nitrate and phosphate analyses, storage time must not exceed 48 hours. For total metals, a holding time of up to 6 months is acceptable.

Tier Environmental standard analytical suites

The analyses included with Tier Environmental's standard analytical suites for soil, soil leachate and water samples are presented in Table 2. Other individual analyses were specified as described within this report.

Table 2. Tier Environmental Standard Analytical Suites.

Parameter	**Sample type**					
	Soil		**Leachate[1]**		**Water**	
		LoD[2] (mg/kg or as stated)		**LoD (µg/l or as stated)**		**LoD (µg/l or as stated)**
Metals and metalloids						
Arsenic	✓	1	✓	10	✓	10
Cadmium	✓	1	✓	5	✓	5
Chromium	✓	1	✓	5	✓	5
Mercury	✓	1	✓	1	✓	1
Lead	✓	1	✓	4	✓	4
Selenium	✓	2	✓	10	✓	10
Copper	✓	1	✓	1	✓	1
Nickel	✓	1	✓	50	✓	50
Zinc	✓	1	✓	8	✓	8
Other inorganics						
Ammonia (as NH_4-N)					✓	15
Total sulphate	✓	100			✓	50 mg/l
Water-soluble sulphate	✓	0.1 g/l				
Hardness (as $CaCO_3$)					✓	1 mg/l
Organics						
Monohydric phenol	✓	1	✓	0.5	✓	0.5
Speciated PAHs (USEPA 16)	✓	0.1	✓	0.01	✓	0.01
Total Organic Carbon	✓	0.1 wt%				
Others						
Electrical conductivity					✓	NA
pH	✓	NA	✓	NA	✓	NA

NA - Not applicable

1 Leachate preparation according to NRA (1994), 10:1 liquid to solid ratio.

2 The table presents the desired limit of detection for the analysis. Higher LoDs may be reported on analytical data sheets due to interference between analytes within specific samples or if the laboratory needed to dilute samples to achieve results within the calibrated range for that instrument.

Analytical QA procedures

Introduction

Quality Assurance (QA) is a system of review and audit that assesses the effectiveness of that product and assures the producer and user that defined standards of quality have been met. If we consider site investigation and chemical analysis, QA is the management system that ensures these measures are in place and working as intended.

QA within the laboratory form part of relevant certification programmes (such as UKAS and MCERTS) and, indeed, will be undertaken in some form by any reputable analyst, whether for a certified technique or not. Laboratory QA/QC is beyond the control of Tier Environmental and will not be considered further in this document, although the relevant laboratory documentation can be obtained upon request. QA must also form part of the design and execution of a site investigation.

Two parameters often used to assess measurement quality objectives are bias and precision. Bias is a systematic deviation in the data. For example, a positive bias (concentrations higher than in reality) would be introduced if sampling bottles were a source of the analyte and this fact was unknown. Precision is the variation in the measurements around a central 'expected' value. This could be due both to real variability in the environmental medium being measured and random errors in the analytical process. Both precision and bias can be assessed by the use of appropriate blanks and replicates within the site investigation programme.

The objectives of the QA activities undertaken in this present site investigation were to recognise and quantify systematic bias within the analytical dataset and to obtain an indication of precision. In environmental samples, much of the observed variability is likely to result from heterogeneity in the sampled medium, particularly for soil and sediment samples.

Such QA practice within the sampling programme is required by current guidance (e.g., Environment Agency report P5-065/TR (2000); Environment Agency LFTGN02 (2002); BS 10175:2001).

Alternative QA procedures to the generic approach presented in this appendix may be specified for a project, provided case-specific justification is given.

QA checking procedure (data validation)

The responsible Engineer and Project Reviewer are required to undertake data validation and provide comment on data quality within the main body of the report(s) issued, when noteworthy matters arise. This QA checking should involve:

Confirming that data reported by the laboratory have achieved the standards specified by the certification scheme (MCERTS or UKAS). This will be indicated on the analytical certificates issued by the laboratory.

Checking that the limit of detection (LoD) and limit of quantification (LoQ) achieved by the laboratory for an individual analyte is appropriate for the purposes of the report. LoD and LoQ will vary dependent upon analyte concentrations, sample matrix properties and interference from co-contaminants.

A check that the reported range of concentrations are reasonable for the analyte. For example, the dissolved concentration of an analyte in a water sample should not exceed saturation. If it does, then this merits further consideration (e.g., was colloidal organic matter or other solid-phase material present or could there have been unobserved free-phase organic liquid?) and explicit comment. At its simplest, there may be a unit error.

Where analysis involves reporting of Tentatively Identified Compounds (TICs; normally by mass spectrometry), the reviewers should check that these might reasonably be expected at the site under consideration. The uncertainties in identification by MS mean that it is not uncommon that TICs are incorrectly assigned. In cases of doubt, the analytical laboratory can re-check the raw data and confirm.

A review of the analytical precision by comparing data obtained for duplicate samples. There is no absolute threshold - variability is entirely dependent upon the sample matrix and manner in which the contaminant has entered the sample. Variability that cannot reasonably be assigned to such factors (for example a very high apparent variability in data for sediment-free water samples) should be reviewed with the laboratory. Variability that is attributable to the sample matrix can nevertheless provide important pointers to improve understanding of contaminant transport pathways and the risks posed by pollutant linkages (e.g., soil heterogeneity, the association of contamination with particular soil fractions, the presence of residual NAPL within soil pores or the role of suspended sediments in contaminant transport).

Confirmation that no errors have been introduced by data transcription, unit conversion or corrections between preliminary and certificates issued by the laboratory. The reviewer should audit a proportion (typically 5-10%) of all data from the original (final) certificates of analysis through to the equivalent values in the report for those specific samples.

In is important to consult the analytical laboratory if apparent QA issues arise. Many apparent concerns can be adequately resolved on the basis of revisiting the raw analytical data or by obtaining a better understanding of the inherent limitations of the analysis for a particular matrix or sample type.

APPENDIX G - COMPLYING WITH CONTROL OF ASBESTOS REGULATIONS 2012

Complying with Control of Asbestos Regulations (CAR): Risk Assessments, Licensing and Training

This appendix outlines CAR risk assessments and where they should be applied in relation to assessing and remediating brownfield sites. The information below details the different classifications of work with asbestos under CAR, summarises the legal requirements for asbestos awareness training for all involved in the investigation and management of asbestos containing soil (ACS), and details the potential requirements for suitable proficiency training relating specifically to ACS.

CAR RISK ASSESSMENTS

A CAR Risk Assessment is required for any work which may expose employees to asbestos. It is recommended that a precautionary approach is adopted if there is any doubt about risks associated with asbestos.

There are three main activities for potential asbestos exposure during work on brownfield sites:

- Site reconnaissance visits;
- Site investigation works; and
- Site remediation.

CAR risk assessments are needed at each stage but may be incorporated during the site investigation stage into the overarching health and safety risk assessments.

The CAR risk assessment must:

- Identify the type of asbestos to which employees are liable to be exposed, where possible, or assume it is present in different forms;
- Determine the type and extent of exposures to asbestos that may occur during the work
- Identify the steps to be taken to prevent exposure or reduce it to the lowest level reasonably practicable; and,
- Consider the effects of control measures that have been or will be taken.

The CAR risk assessment should include any information used to inform the risk assessment such as asbestos reports or desk study information. In the event that this information is not available, the assessor should be assumed that all forms of asbestos may be present on site.

For all investigation and remediation of ACSs, a detailed written work plan should he produced and followed as detailed on the HSE website and in the CAR.

The CAR risk assessments for specific investigations or remediation projects, will determine whether or not work is 'licensable work' (LW)**,** notifiable non-licensable work' (NNLW) or 'non-licensed work' (NLW). In addition, training requirements are also defined by the CAR risk assessment.

Some examples of control measures that apply during site reconnaissance, site investigation works, and site remediation are given below and should be applied depending on the asbestos risks identified for the site at each stage of investigation:

- Avoiding stirring up dust;
- Cleaning footwear after site works;
- Removing and bagging any overalls for disposal/laundering;
- Respirators and hygiene facilities for high risk sites;
- Segregated welfare units;
- Wetting ground
- Minimising soil disturbances;
- Implementation or retention of capping/break layers;
- Implementation of awareness training;
- Air monitoring;
- Managing stockpiles;
- Area segregation;
- Wheel washing
- Road washing/cleaning

It is important to note that during site reconnaissance visits, site investigation works and site remediation that asbestos should not be considered in isolation and control measures are likely to form part of a wider health and safety precautions.

Respiratory protective equipment (RPE)

RPE is the last line of defence and its requirement would be defined by the CAR risk assessment. HSE (2013b) advises that RPE should have an assigned protection factor of 20 or more for all work with asbestos. In certain instances, full face-piece, positive pressure respirators with a protection factor of 40 are necessary (to EN 12942:1998, TM3).

Suitable types of RPE for most ***short*** duration non-licensed asbestos work:

- Disposable respirator to standards EN149 (type FFP3) or EN1827 (type FMP3)
- Half mask respirator (to standard EN140) with P3 filter
- Semi-disposable respirator (to EN405) with P3 filter

These filters are not suitable for people with beards/stubble or for long or continuous use.

LICENSING

CAR defined certain types of activities involving asbestos as 'licensable work' (LW) or as 'notifiable non-licensable work' (NNLW). All other work would be 'non-licensable work' (NLW).

LW is defined as:

- work where exposure is not 'sporadic and low intensity'
- work where the risk assessment cannot demonstrate that the control limits (four hour and 10 minute limits) will not be exceeded
- work on asbestos coating
- work on AIB or insulation where risk assessment is either of first two points above or not of short duration (where short duration is defined for any work liable to disturb asbestos as taking less than two hours per week (including ancillary work) and no one person carries out that work for more than one hour').

NNLW includes work with:

- AIB or asbestos insulation of short duration that is not licensable
- fire-damaged asbestos cement or asbestos cement damaged so as to create significant dust and debris
- asbestos ropes, yarns, woven cloths in poor condition or handling cutting or breaking up the materials
- asbestos papers, felts and cardboard in poor condition, unencapsulated or not bound into another material.

Work with weathered asbestos cement, air monitoring and collecting samples of ACM in buildings would not normally be notifiable.

It is impossible to specify definitively what activities will and will not be licensable. This decision should be made as part of the CAR risk assessment. CAR is not primarily aimed at work with ACSs and there is little published information on airborne asbestos concentrations during work with ACSs. Nevertheless, CAR will require some remediation projects, and occasionally site investigations, to be LW. Investigations on other sites may involve NNLW. The decision as to whether work is LW or NNLW should be made during the CAR risk assessment by those in charge of the brownfield site investigations and remediation projects.

TRAINING REQUIREMENTS

Asbestos health and safety courses are offered by a number of providers in the UK. Training courses that include the problem of identifying ACMs in soil should be undertaken at regular intervals by those involved in the investigation, assessment and management of sites where ACs are known or suspected. It is the role of the employer to identify the level of training required for an employee based on their role, experience and duties. Reference to Regulation 10 of CAR should be referred to for more information on training requirements.

Recognising asbestos within soils is challenging due to the heterogeneity of such soils and the discolouration of asbestos by smeared soil. Specific training for ground workers should include understanding fibre release potential, potential control measures in the field, how to take representative ACSs safely, sample labelling and what analytical tests are available and when the y should be implemented.

Health and safety training required under CAR includes asbestos awareness, non-licensable work (including notifiable non-licensable work) and licensable work with asbestos.

In addition to health and safety training, some staff involved in the technical identification on site of ACMs, sampling and analysis may require technical proficiency training (competency training).

Training vs. Competence

HSE (2005) identifies that ‘training alone does not make people competent. Training must be consolidated by practical experience so that the person becomes confident, skilful and knowledgeable in practice on the job’. It is critical that ACS surveyors demonstrate competency with details of relevant field experience alongside training and examples of previous works/references.