

Knowsley
Redevelopments Ltd
Former Contract
Chemicals, Knowsley

Remediation Strategy and
Verification Plan

April 2025



Document Control

Project: Former Contract Chemicals, Knowsley – Remediation Strategy and Verification Plan

Site Address: Penrhyn Road, Knowsley, L34 9HY

Client: Knowsley Redevelopments Ltd

Author: G&J Geoenvironmental Consultants Ltd

Report Reference: GJ224-03-R003-RSVP-V1

Brief Description of Contents Review of available information to develop a preliminary remediation strategy to address identified contamination. Provision of recommendations for remediation and validation works as required.

Document Checking:

Date	Issue	Comments	Prepared by:	Checked by:	Issued by:
April 2025	V1	-	Chris Hepworth Managing Director	Andrew Bedford Senior Environmental Consultant	Chris Hepworth Managing Director

CONTENTS

1.0	INTRODUCTION	1
1.1	Sources of Information	1
1.2	Scope of Works.....	2
1.3	Terms and Conditions	2
1.4	Limitations.....	2
1.5	Policy Context – Land Contamination	3
2.0	SITE SETTING	5
2.1	Site Location and Description.....	5
2.2	Site Description.....	5
2.3	Site History.....	6
2.4	Geology and Hydrogeology	8
2.5	Hydrology.....	8
2.6	Proposed Development.....	9
3.0	CONCEPTUAL SITE MODEL	10
3.1	Sources	10
3.2	Receptors.....	12
3.3	Contaminant Pathways	13
3.4	Pre-Remediation Conceptual Site Model.....	14
4.0	REMEDIAL TARGETS AND OBJECTIVES	16
4.1	Remedial Targets.....	16
4.2	Remedial Objectives.....	17
5.0	REMEDICATION OPTIONS APPRAISAL.....	19
5.1	Introduction.....	19
5.2	Remedial Technical Assessment Process	19
5.3	Remediation Outline Assessment	19
5.4	Detailed Evaluation of Remedial Technologies.....	23
5.5	Preferred Remediation Solution for the Site	23
6.0	REMEDICATION STRATEGY AND IMPLEMENTATION	26
6.1	Introduction.....	26
6.2	Remedial Targets / Criteria	26

6.3	Remediation of Contaminated Soils and Groundwater.....	26
6.4	Monitoring Wells	28
6.5	Implementation Plan	29
6.6	Materials Management Plan	29
6.7	Potential Risks to Remediation & Construction Workers	29
6.8	ACMs	30
7.0	VERIFICATION OF THE WORKS.....	31
7.1	Verification Plan	31
7.2	Verification Report	33
8.0	CONCLUSIONS	34
9.0	REFERENCES	35

APPENDIX CONTENTS

A	GROUNDWATER CONTAMINATION DISTRIBUTION PLANS
B	REMEDATION OPTIONS APPRAISAL

1.0 INTRODUCTION

G&J Geoenvironmental Consultants Ltd (G&J) was commissioned by Knowsley Redevelopments Ltd to prepare this Remediation Strategy and Verification Plan to outline the works required to address contamination at the former Contract Chemicals site in Knowsley, which is proposed to be redeveloped for commercial / industrial use.

The purpose of this report is to interpret information pertaining to the site in order to develop an appropriate and sustainable remediation strategy to ensure the effective remediation of the identified contamination.

1.1 Sources of Information

Previous investigations, by G&J and others, have identified potentially significant contamination in the soil and groundwater at the site associated with the past site use, primarily in the form of 1,2-dichlorobenzene, although other contaminants are present.

A Detailed Quantitative Risk Assessment (DQRA) has been undertaken by G&J to evaluate the risks and develop appropriate remedial targets. The findings of the previous ground investigations and the DQRA are detailed in the following reports:

- '*Former Contract Chemicals Ltd, Knowsley – Interpretative Desk Study*', G&J Geoenvironmental Consultants Ltd, Report Ref: GJ224-DTS-V1, February 2021.
- '*Former Contract Chemicals Ltd, Knowsley – Site Investigation Interpretative Report*', G&J Geoenvironmental Consultants Ltd, Report Ref: GJ224-SI-INT-V1, January 2022.
- '*Former Contract Chemicals Ltd, Knowsley – Detailed Quantitative Risk Assessment*', G&J Geoenvironmental Consultants Ltd, Report Ref: GJ224-03-R002-V1, April 2025.

The desk study included a review of a number of previous ground investigations that were undertaken at the site between 1993 and 2012. The findings are described in the following reports;

- '*Preliminary Contaminated Site Investigation Contract Chemicals Ltd, Knowsley*', Cremer & Warner Ltd, Report ref: C397/1, April 1993.
- '*Integrated Pollution Prevention and Control, Pre-Authorisation Desk Study of Contract Chemicals Ltd*', AIG Consultants Ltd, Report ref: UK99/A1421, July 1999.

- '*Contract Chemicals Ltd, Trade Effluent Overspill Sampling, Final Interpretive Report*', Entec Uk Limited, Report ref: 11002il, January 2011.
- '*Bromododecane Spillage Investigation, Contract Chemicals Site, Knowsley*', AMEC Environment & Infrastructure UK Limite, Report ref: 32144, September 2012.

1.2 Scope of Works

The scope of this report is as follows:

- To summarise general site information such as location, environmental setting, ground conditions and contamination status, based on the results of the previous investigations;
- To assess viable remediation options to be protective of human health and the water environment;
- To provide viable and feasible remedial options that are most appropriate given the site constraints and opportunities;
- To provide an outline Remediation Implementation Plan for the site (including suggested remediation oversight and validation reporting protocols).

The remedial works are to be undertaken to support the future redevelopment of the site, based on a proposed commercial / industrial development.

1.3 Terms and Conditions

This report has been prepared for Knowsley Redevelopments Ltd in consideration of the current use of the site and the proposed future development. Much of the environmental information relates to the site in its present state and should not be used in a different context without reference to G&J.

1.4 Limitations

The findings and opinions conveyed in this report are based on the current information available to G&J. This report is based on the available information for the site and interpretative comment in terms of current contaminative status of the soil and groundwater at the site.

Although every effort has been made to ensure the accuracy of the information contained herein, no checks have been carried out to ensure the accuracy of information obtained from and collated by third

parties and no liability can be accepted for any errors or misinterpretation of the third party information where it has been incorporated into this report.

Future changes in legislation and advances in current best practises or provision of more detailed design proposals or additional investigation data, may result in this report requiring review and possible further assessment after the date of issue.

1.5 Policy Context – Land Contamination

The primary legal and policy mechanisms for managing contaminated land are Part IIA of the Environmental Protection Act 1990 and the National Planning Policy Framework.

Part IIA provides a statutory definition of Contaminated Land and supporting guidance which defines how to decide whether or not land meets this definition. For land to be determined as contaminated land, the onus is on demonstrating with sufficient certainty that land is in such condition, by reasons of substances in, on or under the ground that;

- a) Significant harm is being caused or there is a significant possibility of such harm being caused; or
- b) Significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused.

Significant harm and how to determine if a significant possibility of such harm exists is defined in the statutory guidance which accompanies Part IIA. The guidance also defines **four categories** of land with respect to the risks to human health and the water environment and how the degree of risk relates to the statutory definition of contaminated land, as summarised in the following figure:

Figure 1.1 Part IIA Categories

Land Category	Human Health	Water	
1	Unacceptably high probability that Significant Harm would occur if no action taken	Strong case that a Significant Possibility of Significant Pollution exists	Part IIA Contaminated Land
2	The risks are sufficient that a Significant Possibility of Significant Harm exists	Of sufficient concern to present a Significant Possibility of Significant Pollution	
3	Not low risk but does not pose a Significant Possibility of Significant Harm	The risks are not sufficient to constitute Significant Possibility of Significant Pollution	Not Part IIA Contaminated Land
4	Low risk to human health and no possibility of meeting the statutory definition	No/low risk to controlled waters and would not meet the statutory definition	

In terms of planning policy, a precautionary approach is adopted whereby it is necessary to demonstrate with sufficient confidence that the site cannot meet the statutory definition of contaminated land. Although the above categorisation is not explicitly applicable to planning decisions, a site classed as Category 4 should be considered suitable for development in accordance with planning policy. While a Category 3 site could be considered suitable, the reduced level of confidence associated with such a site means this is less likely.

2.0 SITE SETTING

2.1 Site Location and Description

The site is located off Penrhyn Road, Knowsley, approximately 1km east of Junction 4 of the M57 motorway. The site is approximately centred on National Grid Reference 342970, 396725; the site location and current layout are shown in Figure 2.1.

Figure 2.1 Site Location and Layout



Contains Ordnance Survey data, © Crown copyright 2025

2.2 Site Description

The site covers an area of approximately 3.5ha and is approximately rectangular in shape. Prior to the demolition and clearance works the central and eastern portions of the site comprised disused chemical processing plants and tank farms, with warehousing and storage in the west and office space and car parking in the south. The details of the former layout and specific features are presented in G&J's previous desk study (and summarised in Section 2.3, below).

The site has now been cleared and comprises predominantly rough open ground, with stockpiles of crushed demolition rubble. Some of the site roads remain in place.

The site slopes very gently down to the south, with ground levels of approximately 32mAOD in the north and 30mAOD in the south, a gradient of approximately 1 in 90.

To the immediate north of the site is the embanked A580 'East Lancashire Road' with the Brintonwood Trading Estate beyond. The southern boundary is formed by Penrhyn Road, with an area of rough ground beyond. To the west of the site is a distribution warehouse where a number of businesses operate. To the east is a chemical works operated by Algal Omega 3 Ltd, including an electricity sub-station.

2.3 Site History

The site was largely undeveloped agricultural land/rough ground until around 1980, when development of the current site commenced. Knowsley Brook was shown to run east to west across the site but was culverted when the site was developed. Since then the site has seen some development between 1988 and 2003, the most significant being the construction of a building (the Bonner building) in 1997.

Anecdotal evidence suggests that during the Second World War period the site was occupied by Nissan Hut accommodation for workers at the Royal Ordnance Factory Kirby, which was located to the north of the A580.

The history as a chemical works and the wide variety of chemicals and processes used during its operation resulted in several potential contamination sources. The most prominent of these were the main processing areas such as the Surfactant Hall, Bonner building, Diol Plant, Technical Development Centre (TDC) and adjacent tank farms. In addition, other sources such as fuel tanks, electricity substations, IBCs and smaller chemical containers were identified during the site walkover.

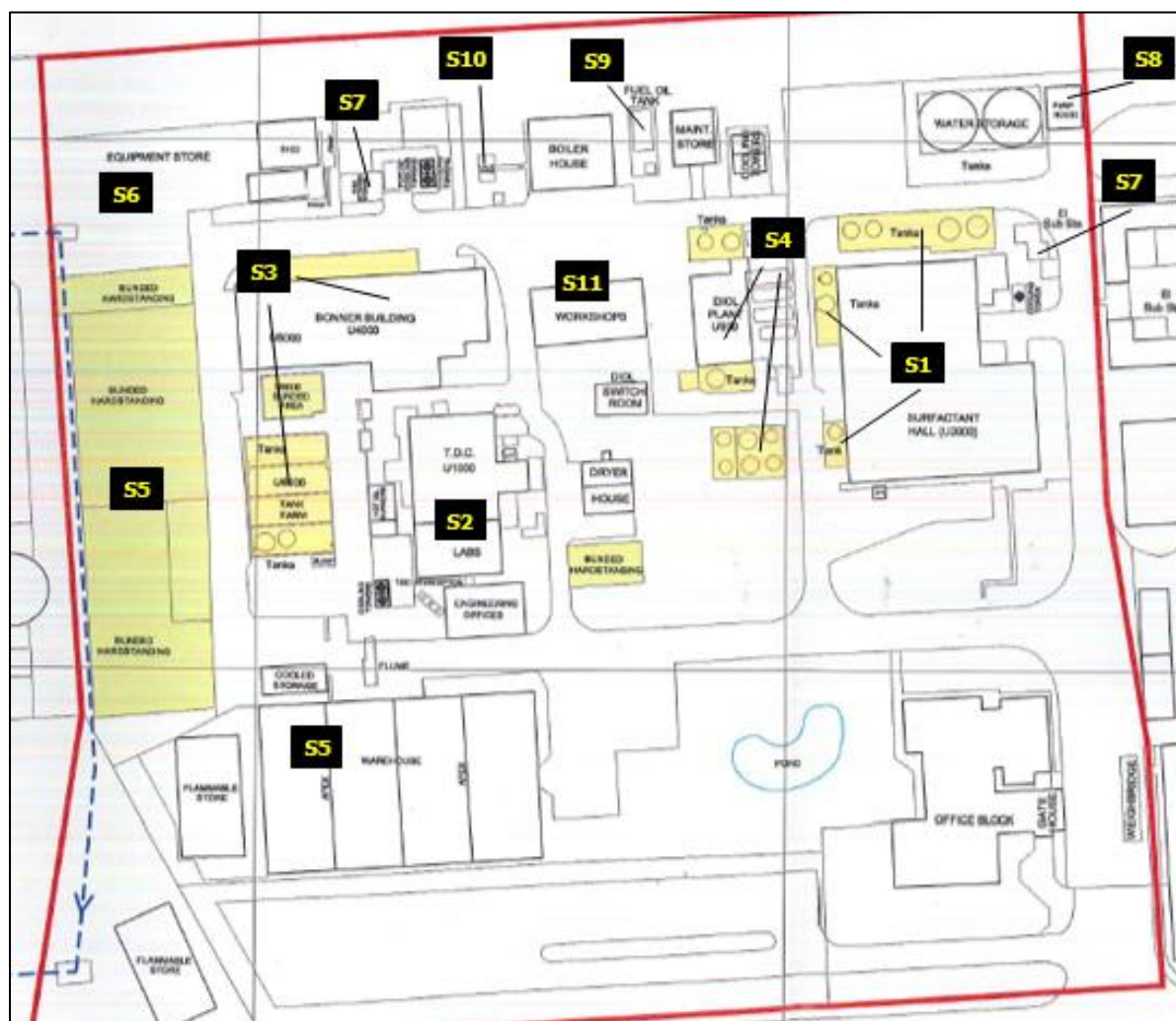
Table 2.1 presents a summary of the main potential sources and the primary contaminants of concern associated with each. Figure 2.2 is a plan of the former works and shows the locations of these sources.

Table 2.1 Summary of Main Potential Contaminant Sources

Source	Potential Contaminants
Surfactant Hall and Tank Farm (S1)	Sodium cyanate; Sodium thiocyanate; Hydrochloric Acid; Acetic Acid
Technical Development Centre (TDC) (S2)	Various organic and inorganic contaminants
Bonner Building and Tank Farm (S3)	Bromine; Butyric acid; Hydrochloric acid; Ethanol
Diol Plant and Tank Farm (S4)	Dimethyl amine (1, 2) propane diol; Hydrochloric Acid; Sodium Hydroxide

Source	Potential Contaminants
Warehouse & Bunded Hardstanding (west) (S5)	Hydrochloric acid wastes; Hydrobromine acid wastes; Sulphur Dioxide absorber waste; Alkaline wastes; Solvent wastes; Diol wastes; Ammonium Sulphate wastes
Equipment Store (S6)	Hydrocarbons; Inorganics
Substations (S7)	Hydrocarbons (including PCBs)
Pump House (S8)	Biocides; Bromgard 420 (zinc based water hardness treatment)
Fuel Tanks (S9)	Fuel Oils; Petroleum Hydrocarbons
Valve House (S10)	Gas Condensates
Workshops (S11)	Petroleum Hydrocarbons
General Contaminants associated with the buildings and Made Ground (S12)	Metals; PAHs; Asbestos

Figure 2.2 Main Potential Contaminant Source Locations



2.4 Geology and Hydrogeology

The site is shown to be underlain by Devensian Till in the north and the Shirdley Hill Sand Formation in the south, and then a bedrock consisting of the sandstone of the Chester Formation. A surficial layer of Made Ground is anticipated due to the past uses and development of the site.

The Shirdley Hill Sand Formation is classed as Secondary (A) Aquifer by the Environment Agency (EA), and the Devensian Till deposits as a Secondary (undifferentiated) Aquifer. The underlying Chester Formation is classed as Principal Aquifer. The site is within Zone 3 (total catchment) of a Groundwater Source Protection Zone. The closest active groundwater abstraction is a potable abstraction approximately 980m to the east of site, where water is taken from a number of boreholes. Another potable abstraction is present approximately 2km to the west.

The G&J investigation found Made Ground throughout the site to depths of between 0.4m and 3.0mbgl, but typically between 1.0m and 2.0mbgl. The material typically comprised reworked natural soils, with entrained man-made materials such as brick and concrete fragments, and was predominantly cohesive, although granular horizons were also present. Organic odours were noted in some locations within the Made Ground.

Beneath the Made Ground, predominantly cohesive deposits considered to be Glacial Till were encountered with thicknesses from 0.3m to >4.75m where present (Glacial Till was not recorded in several locations, predominantly in the north-east of the site).

Beneath the Glacial Till, or directly beneath the Made Ground where the Till was absent, strata considered to represent the Chester Formation were encountered, at depths of between 0.4m and 6.5mbgl. Both sandstone and mudstone were encountered, with the weathered strata being both granular and cohesive.

Perched groundwater was encountered within the Made Ground / Glacial Till, generally as minor seepages. The surface of the deeper groundwater within the Chester Formation was recorded at between approximately 1.0 – 5.5mbgl. The highest groundwater levels were recorded close to the centre of the site, from where flow appears to be strongly towards the south-west, and to a lesser degree to the north. Regional groundwater flow is expected to be towards the west, but locally this may be affected by the potable groundwater abstraction to the east of the site.

2.5 Hydrology

Knowsley Brook is understood to flow within a culvert beneath the site, having historically flowed east to west at the surface across the site. Available plans show the culvert to run beneath the western

margin of the site, while anecdotal evidence suggests it flows beneath the northern and western edges of the site.

2.6 Proposed Development

It is proposed to redevelop the site for commercial use, as shown in the potential layout in Figure 2.3.

Figure 2.3 Proposed Development Layout



3.0 CONCEPTUAL SITE MODEL

The contamination identified during the ground investigations is described in detail in the G&J Ground Investigation and DQRA reports referenced in Section 1.1. The following is a summary of the main contamination sources identified in soil and groundwater.

3.1 Sources

Potentially significant contamination has been recorded in both soil and groundwater.

3.1.1 Soil

During the investigation works, organic odours were noted in a number of locations, generally associated with the Made Ground within the former process area, which covers much of the northern half of the site. However, while contamination has been identified within the soil from a number of organic compounds, none of the recorded concentrations were above the human health GAC for a commercial land use (although it should be noted that for many contaminants the commercial GACs represent very high concentrations, and obvious odours / staining can be present without the GAC being exceeded). Therefore, the risks from soil contamination are considered only in terms of the potential impact on the groundwater (although there remains potential for concentrations above the GAC to be encountered during future works).

As such, at this stage, the only contaminant of concern in the soil is considered to be **1,2-dichlorobenzene**, as this has been recorded at significant concentrations in both the soil and groundwater. While other contaminants have been recorded at significant concentrations in the soil (e.g. 1,2,4-trimethylbenzene), they have not been recorded in the groundwater.

1,2-dichlorobenzene has been found to be widespread in the soil, having been detected in 25 out of 30 samples tested over the course of both phases of investigation, although primarily at low concentrations.

3.1.2 Groundwater Contamination

Contamination has been identified in both the shallow groundwater within the Made Ground and cohesive superficial deposits, and in the deeper groundwater within the Chester Formation. Although the groundwater may be considered a receptor (or pathway) rather than a source of contamination, the aim is to ensure that the contamination does not present an ongoing risk to the wider water environment, such as the Chester Formation Principal Aquifer and the nearby potable water abstractions.

Again, the most notable contaminant is 1,2-dichlorobenzene which was recorded at its highest concentration in the deep groundwater from the centre of the site but was generally more widespread in the shallow groundwater.

While other organic contaminants have been identified, they are generally either at low concentrations and / or very localised, or are otherwise only associated with the elevated concentrations of 1,2-dichlorobenzene. The only possible exception is chlorobenzene, which was recorded at its highest concentration in a location (GJR04) where the concentration of 1,2-dichlorobenzene was much lower.

Cyanide and bromide have both been identified at significant concentrations in both the shallow and deep groundwater, but these are generally localised.

3.1.3 Contaminants of Concern

Based on the findings of the 2021 ground investigation and the supplementary investigation works undertaken as part of the DQRA, the following table details what are considered to be the primary contaminants of concern, and whether they are considered to represent a potential risk to human health and / or the water environment.

Table 3.1 Contaminants of Concern

Substance	Potential Risk to Human Health?	Potential Risk to Controlled Waters?
1,2-dichlorobenzene	No*	Yes
chlorobenzene	No*	Yes
Cyanide	No	Yes
Bromide	No	Yes

*based on a commercial land use

Table 3.2 presents a high level summary of the distribution of the above contaminants in soil (where relevant) and groundwater, in terms of maximum and average concentrations over both phases of investigation by G&J. With regards groundwater contamination, the summary is based on results from all the boreholes (both shallow and deep), again over both phases of investigation.

Table 3.2 Summary Distribution of Contaminants of Concern

Substance	Summary of soil concentrations (mg/kg)				Summary of Groundwater Concentrations (ug/l)			
	Max	Mean*	Median	No of locations detected (out of /X)	Max	Mean*	Median	No of locations detected (out of /X)
1,2-dichlorobenzene	512	19	0.051	25/30	62490	3729	25	20/27
Chlorobenzene	0.1	N/A	<0.005	8/30	9583	485	<5	11/27
Cyanide	ND	ND	ND	0/30	250	N/A	<5	8/27
Bromide	No tests			-	500	80	28	17/17

*Where results are below the LoD, a figure of 0.5 x LoD is used in the calculation of the mean

ND-Not Detected. **N/A**-Insufficient data

Table 3.2 gives a high-level overview of the distribution of the contaminants of concern and their overall concentrations. 1,2-dichlorobenzene is shown to be commonly present throughout the soil and groundwater, although in the majority of locations this is at low concentrations. Chlorobenzene is present in only very low concentrations in soil and in only in localised significant concentrations in groundwater.

Cyanide is not present at all in the soil, but has been detected in approximately one-third of the groundwater samples, while bromide is present in all groundwater samples (although low concentrations may be naturally expected).

The plans in Appendix A show the distribution within the groundwater of 1,2-dichlorobenzene, chlorobenzene and bromide.

3.2 Receptors

3.2.1 Human Health

In terms of human health, the receptors will be the users of the remediated site. It is proposed to redevelop the site for commercial / industrial use, so the receptors will be employees and visitors to the site.

Those involved in any remediation, earthworks and / or construction would also be potential receptors for the identified contamination. However, such risks would usually be managed in accordance with appropriate health and safety risk assessments and the use of suitable work procedures and personal protective equipment (PPE).

3.2.2 Controlled Waters

There are considered to be two controlled waters receptors that are relevant in terms of potential impact from contamination originating on the site. Firstly, there is the underlying groundwater, represented by the Secondary Aquifer(s) of the superficial Shirdley Hill Sand Formation and the Devensian Till, and more significantly by the Principal Aquifer of the Chester Formation. Secondly, there is Knowsley Brook, which is understood to flow within a culvert beneath the site.

The most sensitive controlled waters receptor is considered to be the groundwater within the Chester Formation, which is present at depths of around 3-5mbgl beneath the site. There are specific receptors in the form of potable groundwater abstractions, which take water from the Chester Formation approximately 1km to the east and 2km to the west.

The shallow groundwater which has been identified within the Made Ground and superficial deposits may be considered to be a contaminant pathway rather than a receptor in its own right, given that it has no resource potential.

Knowsley Brook is likely to be largely isolated from the groundwater by the culvert in which it flows, and it may be located above the water table (although the depth of the culvert is not currently known).

The groundwater table associated with the Chester Formation aquifer has been monitored at a level between approximately 1 – 5.5mbgl, although is considered to be confined beneath the overlying cohesive deposits in some areas. These deposits will provide some protection, but the presence of contaminants within the Chester Formation aquifer suggests it is not completely hydraulically isolated from the shallow groundwater.

3.3 Contaminant Pathways

Contamination has been identified within both the soil (primarily the Made Ground) and the groundwater. As such, the pathways described below could potentially link the contamination sources with the receptors.

3.3.1 Site Users (Human Health)

The active pathways for the exposure of site users will likely comprise the following, based on the proposed site use;

- Direct contact with contaminated soils, followed by ingestion and / or dermal absorption;
- Inhalation of soil derived dusts and particulates;

- Inhalation of gases and vapours originating from contaminated soil or groundwater;
- Consumption of water supplied through pipes laid in contaminated soil.

3.3.2 Controlled Waters

- Leaching of contaminants within the Made Ground and superficial deposits, followed by migration through the unsaturated and saturated zones to the Principal Aquifer within the Chester Formation. This will likely occur via more permeable horizons in the generally cohesive Made Ground and superficial deposits;
- Migration of contamination in any shallow groundwater to the culverted Knowsley Brook and seeping through any cracks or other penetrations in the culvert;
- Migration of dissolved contamination (resulting from the above) within the Chester Formation,

3.4 Pre-Remediation Conceptual Site Model

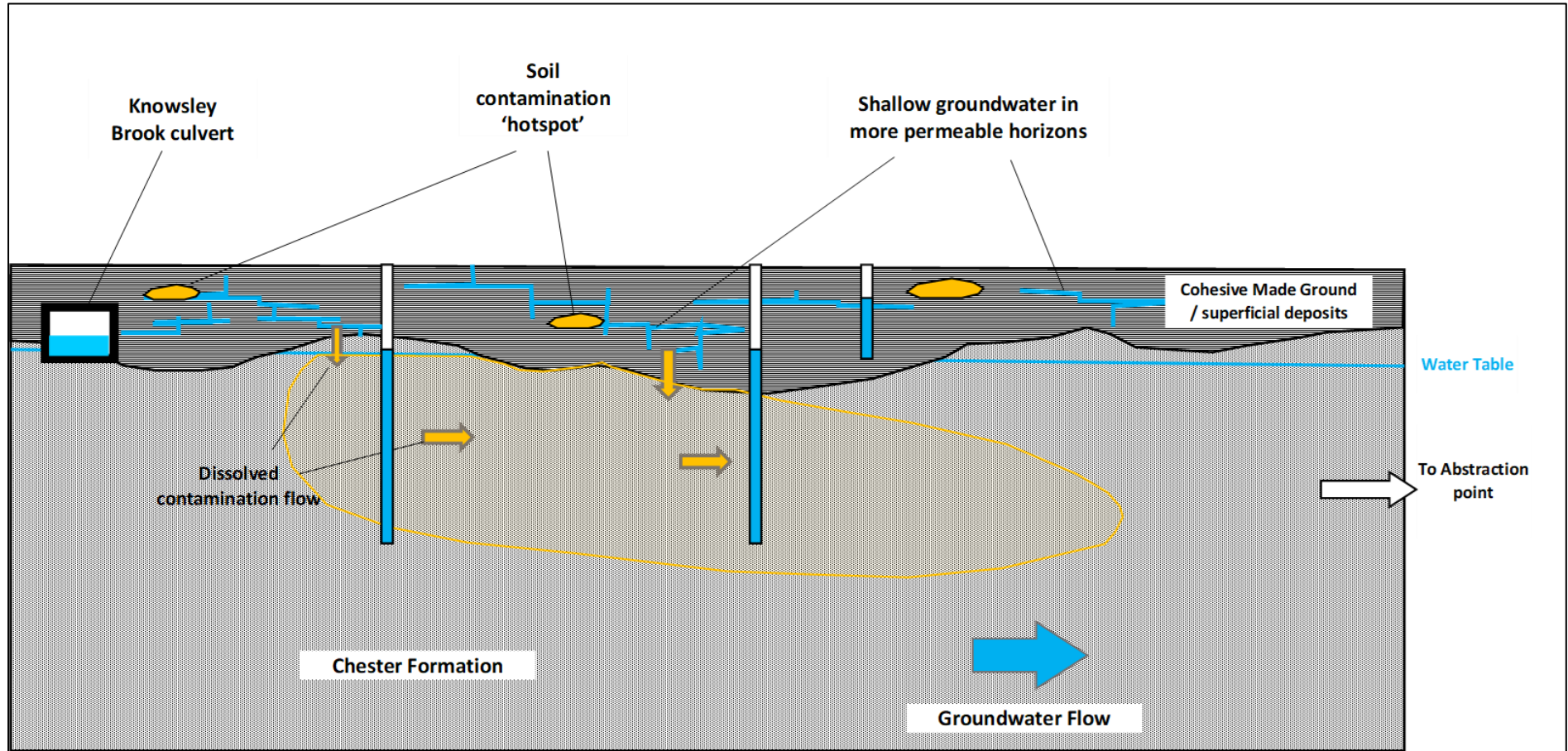
The potentially significant pollutant linkages are summarised in Table 3.3, while Figure 3.1 presents a schematic of the site ground conditions, contaminant sources, receptors and pathways based on the current site use and the information collected during the ground investigations.

Table 3.3 Pollutant Linkages

Reference	Source	Pathway	Critical Receptor
PL1*	Organic contamination, specifically 1,2-dichlorobenzene throughout the Made Ground	Ingestion	Humans (Future site users)
PL2*		Dermal Contact	
PL3*		Inhalation of soil derived dusts	
PL4*		Inhalation of vapours	
PL5		Leaching and migration via the unsaturated zone to the underlying groundwater	Chester Fromation Principal Aquifer
PL6*	Dissolved contamination within the Chester Formation (1,2-dichlorobenzen, chlorobenzene, cyanide, bromide)	Migration via saturated zone	Wider groundwater environment (Chester Formation Principal Aquifer)
PL7*			Potable Water Abstractions
PL8*#			Knowsley Brook

*PL1 to 4 not significant based on currently available information and PL6 to 8 may not be significant based on results of the DQRA. #Linkage may not be complete.

Figure 3.1 Conceptual Site Model



4.0 REMEDIAL TARGETS AND OBJECTIVES

4.1 Remedial Targets

Remedial targets have been derived for the main contaminants of concern which are protective of human health and the water environment. The details of how the targets were derived are provided in the DQRA report. The targets are designed to ensure future users of the site are not exposed to unacceptable levels of contamination and that there are no unacceptable risks to the water environment (specifically the potable water abstractions and the wider Chester Formation Principal). The human health targets are based on Generic Assessment Criteria for a commercial land use.

4.1.1 Soil Remedial Targets

No contaminants have so far been recorded at concentrations in the soil that are in excess of the human health GAC for a commercial land use. The only contaminant of concern identified in the soil was 1,2-dichlorobenzene, as this was the only contaminant that was present at significant concentrations in both the soil and groundwater. However, GAC / benchmark concentrations are included for other organic contaminants that have been found to be present, but so far not at concentrations that would be considered to present a significant risk.

The remedial targets for soil are detailed in Table 4.1.

Table 4.1 Soil Remedial Targets and Benchmark Concentrations

Substance	Human Health Targets - Commercial GAC (mg/kg)	Controlled Waters Targets (mg/kg)	
		Remedial Target Derived Using Consim	Maximum Recorded Concentration*
1,2-dichlorobenzene	2000	41	512
chlorobenzene	56	-	0.1
1,2,4-trimethylbenzene	42	-	5.7
1,3,5-trimethylbenzene	-	-	1.3
n-propylbenzene	4100	-	0.6
Toluene	56000	-	0.11
Ethylbenzene	5700	-	0.25
p-&m-xylene	5900	-	0.49
o-xylene	6600	-	0.30
Bromoform	760	-	0.9
Organic Contamination	Absence of evidence of significant organic contamination, such as free phase contamination, heavy staining or strong odours		

*to be used as a benchmark to determine if further assessment of the risks to the water environment is required
Bold are anticipated targets for remediation works based on the current information

Based on currently available information, the main drivers of the remediation works in terms of soil contamination are ensuring concentrations of 1,2-dichlorobenzene are below the remedial target of 41mg/kg and that any significant visual or olfactory evidence of contamination is addressed.

All contaminants have been recorded at concentrations that are well below the GAC for a commercial land use, and it is considered unlikely that concentrations exceeding the GAC will be encountered during the remediation and verification works.

Table 4.1 includes the maximum recorded concentrations of the most significant organic contaminants identified during the previous investigation works. These are not remedial targets, but it is suggested that these concentrations are used as an initial benchmark to determine if any further assessment is required of the risks to controlled waters. In reality, a potential risk is only likely to be present if the verification works identify much higher concentrations. As **chlorobenzene** was the only one of these contaminants (other than 1,2-dichlorobenzene) to be recorded at significant concentrations in the groundwater, then this is realistically the only contaminant that will require any further assessment should it be encountered at significantly higher concentrations than it has been previously.

4.1.2 Groundwater Remedial Targets

The DQRA did not determine any site-specific remedial target concentrations for groundwater that are protective of the wider water environment, as the assessment concluded that the identified contaminants in groundwater (specifically 1,2-dichlorobenzene, chlorobenzene, cyanide and bromide) will not present a significant risk to the wider groundwater with no impact predicted for the nearby abstraction points.

Remediation of soil sources and natural attenuation processes, such as dilution, dispersion and degradation should result in improvement in groundwater over time. As such, the following target is therefore considered appropriate for groundwater contamination;

- As a minimum, no observed increase in concentrations or expansion of the plume(s), but with an overall aim for betterment (i.e. reduced concentrations and a declining plume).

4.2 Remedial Objectives

The overall objective is to ensure that none of the Pollutant Linkages detailed in Table 3.3. are complete after remediation. Remediation works should be undertaken at the site to ensure that concentrations of the contaminants of concern are below levels that would represent a risk to human health or controlled waters (i.e. the sources are eliminated), with reference to the remedial targets detailed above.

Remediation works should aim to achieve the soil remedial targets and to demonstrate that contamination in groundwater is improving, or at the very least not deteriorating.

5.0 REMEDIATION OPTIONS APPRAISAL

5.1 Introduction

The aim of the remediation options appraisal is to assess technologies, processes and design measures available that have the potential to address the primary soil sources and, where practical, existing groundwater contamination in accordance with remedial objectives described above, given what is known regarding the ground conditions and any constraints associated with the site layout and setting.

The available remedial options have been considered with the objective of:

- Providing certainty that the remediation solution meets the remedial criteria for the site;
- Providing a pragmatic and sustainable remedial option;
- Providing an economical and viable remedial solution.

The remedial options appraisal will be assessed in terms of addressing the relevant pollutant linkages detailed in Table 3.3, which currently represent a potentially unacceptable risk.

Given the past site use, the intensity of the previous investigations and the presence of large stockpiles preventing access to some areas, the presence of previously unidentified contamination hotspots is considered likely and verification of soils across the site is therefore considered necessary. Verification inspection, sampling and analysis is described in Section 7.

5.2 Remedial Technical Assessment Process

A remediation options appraisal has been carried out to determine the most appropriate remedial solution. The appraisal consisted of the following key stages:

- An initial identification of available and feasible technologies for use at the site;
- An evaluation of the suitability of technologies to meet remedial objectives;
- A summary of technologies or combination of technologies that are considered suitable for the site.

5.3 Remediation Outline Assessment

The purpose of this section is to identify technologies which are feasible for the remediation of the identified contamination sources at the site and consistent with the remedial objectives. The following

treatments and treatment combinations currently available in the United Kingdom are considered to be suitable for the geological and hydrogeological conditions of the site and the nature of the contamination:

- Segregation of affected soils / materials;
- Off-site Treatment at a Soil Treatment Facility;
- Off-site Disposal;
- Ex-situ Bioremediation;
- Soil Vapour Extraction;
- In-situ Chemical Reduction / Oxidation;
- In-Ground Barriers;
- Pump and treat / dispose;
- Natural Attenuation;

5.3.1 Segregation of Affected Soils / Materials

The separation of soils affected by contamination from those that are suitable for use and / or the separation of deleterious materials.

Advantages: Prevents suitable soils from being excavated for treatment or disposal; Considered a form of pre-treatment in terms of waste disposal; Reduces disposal costs.

Disadvantages: Only suitable for identifiable 'hotspots' of contamination or obvious deleterious materials, such as visible fragments of asbestos containing materials.

5.3.2 Off-site Treatment at a Soil Treatment Facility

Excavation of soils impacted by contamination, followed by removal from site for treatment at an off-site facility.

Advantages: Absolute removal of all contaminated material; Rapid timescales; Avoids the need to handle large volumes of soil on-site; Cheaper than landfill.

Disadvantages: Moderately costly; Generates local traffic; Requires import of clean fill material.

5.3.3 Off-site disposal of soils

Excavation of soils impacted by contamination, followed by removal from site for disposal at an appropriately licensed waste management facility (e.g. landfill).

Advantages: Absolute removal of all contaminated material; Rapid timescales.

Disadvantages: Extremely costly; Generates local traffic; Requires import of an equivalent quantity of “clean” fill material; Not sustainable due to large amount of lorry movements; Not considered best practice by regulators.

5.3.4 Ex-situ Bioremediation

Bioremediation processes may be operated under aerobic and/or anaerobic conditions to restore contaminated soils to a state suitable for use. Excavated soil is placed in an above ground treatment area and stimulated to enhance the natural biodegradation by exploiting the ability of soil microbial populations to biodegrade or biotransform contaminants present in the soil.

Advantages: Easy to monitor; Effective with most organic contaminants; Cost effective; Sustainable; Improves soil structure.

Disadvantages: Requires large treatment area; May not be suitable for all organic contaminants; Can be a relatively slow process; Soils with high clay / silt content can be difficult to treat.

5.3.5 Soil Vapour Extraction

Soil vapour extraction (SVE) is used to remove volatile and some semi-volatile contaminants from soil. A vacuum is applied to the soil which in turn induces a controlled flow of air driving off more volatile contaminants in the soil phase. Membranes are usually placed over the surface of the soil treatment beds to increase the effectiveness of treatment. The off-gases will usually be treated to recover or destroy the contaminant.

Advantages: Removes halogenated and non-halogenated organic compounds; Can be tailored to maximise VOC removal; Sustainable.

Disadvantages: Requires large treatment area; Relatively slow process; Moderately expensive; Off gas treatment may require special permits for operation in built up areas; Ineffective for less volatile contaminants.

5.3.6 In Situ Chemical Oxidation / Reduction

Chemical Oxidation / Reduction involves introducing substances to groundwater that destroy or transform contaminants or enhance microbial degradation. For example, zero valent iron can drive reductive dechlorination, while various oxidants can drive degradation of chlorinated solvents, BTEX and fuel oils.

Advantages: Effective on suitable organic source zones; Sustainable;

Disadvantages: Expensive when employed over large areas; Relatively slow process; Groundwater treatment may not offer significant benefits given results of DQRA.

5.3.7 In Ground Barriers

In ground barriers can take the form of impermeable walls formed in the ground to prevent the migration of contaminated groundwater, or permeable barriers that allow contaminated groundwater through, but which contain a reactant that removes or immobilises the contaminants from the groundwater.

Advantages: Relatively simple to implement; PRBs can treat a variety of contaminants depending on the reactant.

Disadvantages: Ongoing maintenance required; High initial costs; Large volumes of soil require disposal or re-use; Generally need an impermeable strata to key into; PRBs may need replacement; Physical barriers do not treat contamination; Benefits may be limited given results of DQRA.

5.3.8 Pump and Treat / Dispose

Removal of contaminated groundwater by pumping from extraction wells or open trenches / excavations. Once removed, the groundwater undergoes treatment before being discharged to a sewer, watercourse or back to ground, or is taken off-site for disposal.

Advantages: Easy to monitor; Can be used in conjunction with soil treatments which involve excavations; Removes all contaminants; Cost-effective;

Disadvantages: Requires disposal or treatment of extracted groundwater; Rate of progress depends on recharge rate and volume of groundwater / product; Extracting from depth requires detailed plume / source characterisation and numerous extraction wells.

5.3.9 Natural Attenuation

Natural attenuation occurs where ground conditions allow natural processes such as biodegradation, dispersion and dilution to reduce contaminant concentrations without significant intervention (usually in groundwater). This usually requires a programme of monitoring to be undertaken to demonstrate that ground conditions are conducive and that attenuation is occurring.

Advantages: Low Cost; Sustainable; No ground disturbance.

Disadvantages: Requires suitable ground conditions; Requires primary sources to be removed; Long timescales; Can require alternative technique if no progress.

5.4 Detailed Evaluation of Remedial Technologies

The preliminary remediation technologies described above have been evaluated for suitability by assessing each against the remediation objectives. A point scoring system has been adopted to provide an objective view of the evaluation. The scoring system is as follows:

- **4 Points** - Highly suitable, easily meets the remedial objectives with a high degree of certainty
- **3 Points** - Generally suitable but not necessarily the best option or there may be some uncertainty
- **2 Points** - Moderately or possibly suitable, or there may be some significant uncertainty
- **1 Point** - Unsuitable or high degree of uncertainty regarding suitability
- **0 Points** - Very unsuitable or contrary to objective

A table showing the detailed options appraisal is available in Appendix B.

5.5 Preferred Remediation Solution for the Site

Based on the results of the options appraisal, the preferred remedial solution uses the following technologies to treat the identified soil and groundwater contamination, as follows;

1. Selective excavation, segregation and ex-situ bioremediation of soils affected by significant organic contamination, most notably from 1,2-dichlorobenzene (to address Pollutant Linkages PL5 and possibly PL1 to PL4 (Table 3.3));

2. Pumping of any contaminated shallow groundwater from excavations (where encountered) for treatment and / or disposal (indirectly address PL6 to PL8);
3. Monitoring of attenuation of groundwater as a result of the remediation works and natural processes (PL6 to PL8);

The above options are considered the most appropriate based on the options appraisal detailed in Appendix B. These options are considered the most appropriate in terms of cost and sustainability to address the contamination identified at the site, given the site constraints and opportunities, and the identified risks.

5.5.1 Soil Remediation

Excavation and bioremediation is considered appropriate to address localised areas of organic contamination, which should be susceptible to bioremediation processes. The affected soils will be identified through olfactory and visual evidence of contamination and the results of laboratory analysis undertaken as part of a robust programme of inspection and verification (see Section 7.1). The two areas of significant contamination identified during the previous investigation works will be considered as 'hotspots' and addressed during the remediation works. These areas are centred on the investigation positions detailed below and their locations shown in Figure 5.1.

- BH104 (342900E -396738N) – 1,2-dichlorobenzene 41mg/kg
- BH105 (343028E -396786N) – 1,2-dichlorobenzene 512mg/kg

Figure 5.1 'Hotspots' Identified by Previous SI



Although the concentration recorded in BH104 does not exceed the remedial target, it is considered to represent an area where higher concentrations may be present and therefore should be treated as a hotspot at this stage.

Other hotspots are likely to exist in locations not covered by the previous investigation works which will need to be identified and addressed through the inspection and verification programme.

5.5.2 Groundwater Remediation

Active treatment of the groundwater within the Chester Formation is not proposed at this stage, given the results of the DQRA suggest that existing groundwater contamination does not present a significant risk to the wider groundwater environment including the potable water abstractions. Groundwater treatment is considered likely to be of limited benefit when compared to costs and practicalities of undertaking such remediation works.

Any contaminated shallow groundwater (i.e. perched groundwater with the Made Ground / Glacial Deposits) will be pumped and treated / disposed of where encountered in excavations during the remediation works.

Groundwater monitoring will be undertaken (see Sections 6.4 and 7.1) to demonstrate that there is no deterioration of groundwater quality, with the overall aim of demonstrating betterment, and continues not to present a significant risk to controlled waters receptors. The removal of significant soil sources (plus pumping of any contaminated shallow groundwater), together with natural attenuation processes, should mean that no significant ongoing sources of contamination remain within the Made Ground / Glacial Deposits and that groundwater quality will improve over time.

6.0 REMEDIATION STRATEGY AND IMPLEMENTATION

6.1 Introduction

The remedial works at the site are designed to address the identified contamination and manage any associated potentially significant pollutant linkages. The following sections present an outline approach and strategy for the remedial works. The approach will need to be agreed with the regulators prior to the remedial works commencing and detailed method statements will need to be prepared by the contractor.

6.2 Remedial Targets / Criteria

Remedial target concentrations for soil are detailed in Section 4.1 and the remedial works will aim, as a minimum, to achieve these concentrations across the site.

The main aim with respect to groundwater contamination should be to prevent future deterioration and where practical provide betterment in terms of groundwater quality.

6.3 Remediation of Contaminated Soils and Groundwater

6.3.1 Soil

The soil remedial works will comprise the excavation of soils from any significant organic contamination 'hotspot' locations, identified through visual / olfactory evidence of contamination or where concentrations in validation samples are found to exceed the remedial target. The 'hotspots' will include those identified during the previous G&J investigation, as shown in Figure 5.1. The soils will be excavated until there is no obvious visual or olfactory evidence of contamination, at which point verification samples will be taken from the base and faces and the excavation.

The excavated soils displaying evidence of contamination, or from areas where laboratory testing has shown concentrations above the remedial targets, will be separated and transported to a stockpile located in a designated treatment area within the site.

Verification samples will be taken from trial pits excavated at 10m or 20m centres across the site as described in Section 7.1. Together with inspections undertaken during the trial pitting (and any other earthworks), this will ensure the Made Ground and upper Glacial Deposits are suitable for use and that contaminated soils are sent for treatment (or removed from site).

The soils affected by significant organic contamination will be transported to the treatment area and formed into windrows / biopiles. The soils will be periodically turned and nutrients added as appropriate to enhance the bioremediation process. Representative samples will be taken at regular intervals to monitor the progress of bioremediation and determine when soils are suitable for re-use.

The contractor will be responsible for determining the most appropriate frequency of turning, nutrient addition etc, required to achieve the remediation objectives, which will include undertaking any bioremediation trials as necessary. Should bioremediation prove unsuccessful, then any soils that are deemed to remain a potential risk will be removed from site for disposal, or subject to an alternative form of remediation.

Should any other obvious evidence of contamination be identified anywhere on the site during remediation or future earthworks / construction (suspicious materials, staining, odours), the affected soils / materials will be separated and characterised, and subsequently treated or disposed of.

6.3.2 Groundwater

Groundwater contamination will be addressed by removing sources of contamination in the soil, as described above, and by pumping any contaminated water from excavations for either treatment or disposal, depending on the volume.

Minor shallow groundwater is expected to be present associated with the Made Ground and natural Glacial Deposits, as was previously noted in standpipes with response zones within these strata. Where encountered, contaminated shallow groundwater will be pumped from excavations created as a result of remedial works.

Groundwater will be pumped out of the excavations, either to a treatment plant where it will be passed through appropriate filters of sand and activated carbon to remove contaminants, before being either discharged under consent to the sewer or removed from site, or to holding tank for off-site treatment / disposal.

The volume of groundwater extracted from the excavations will depend on the rate of recharge and pumping from the excavations.

6.3.3 Natural Attenuation

It is considered that natural attenuation will likely play a part in the remediation of groundwater, particularly after the soil remediation works have been completed. A programme of monitoring will be undertaken during and after the remediation works. This is to demonstrate that there continues to be

no significant risks to controlled waters receptors, and ideally that the overall groundwater quality improves after completion due to natural processes.

6.4 Monitoring Wells

Monitoring wells are required to allow ongoing monitoring of groundwater quality during and after the remediation works in order to demonstrate that the overall quality of the groundwater is improving. Where possible, existing wells will be used, but it is considered likely that some new wells will be required to replace any lost / destroyed during the remediation or other earthworks or that need to be relocated nearby due to construction activities.

There are currently 6 useable monitoring wells that target the Chester Formation. One of these (GJR03) is located close to the centre of the site, with the rest around edges, as shown in Figure 6.1. Each of these standpipes extends to approximately 12m.bgl

Figure 6.1 Standpipes within the Chester Formation



GJR03 is located close to the centre of the proposed building, and therefore it will need to be decommissioned at some point during the construction works, and there will no possibility of relocating a new standpipe nearby. GJR03 will be maintained for as long as possible, until such a time as construction works require its removal.

Monitoring will be undertaken on a monthly basis during the remediation and until 3 months after completion, and thereafter on a quarterly basis for at least 6 months.

6.4.1 Decommissioning of Standpipes

There are numerous other standpipes present of the site in addition to those shown in Figure 6.1, the majority of which are shallow and do not extend into the Chester Formation. All redundant standpipes should be decommissioned in accordance with EA guidance to ensure they do not act as preferential contaminant pathways. This also applies to the standpipes in Figure 6.1 after completion of the monitoring period if they are no longer required.

6.5 Implementation Plan

Following agreement of the remedial strategy, the contractor will need to supply method statements and all relevant documentation to stakeholders detailing the proposed implementation / phasing plan. Relevant documentation will include all relevant environmental permits, waste and treatment licences.

6.6 Materials Management Plan

A Materials Management Plan will likely need to be prepared (in accordance with the CL:AIRE document "The Definition of Waste: Development Industry Code of Practice Version 2") for the reuse of excavated materials on the site. If required, a declaration will need to be prepared by a Qualified Person to confirm that the materials are suitable for use and therefore not classified as waste.

6.7 Potential Risks to Remediation & Construction Workers

During site remediation and other works being undertaken at the site, the potential exposure to soil contaminants by site remediation and construction workers should be addressed as part of the contractor Site Specific Working Plan and within a Health and Safety Plan (HASP) for the works to be compliant with CDM requirements.

6.8 ACMs

No obvious significant ACMs were identified during the previous investigations, and it is unlikely (but not impossible) that such materials may be encountered during remediation or other earthworks.

However, all site operatives should be at least 'asbestos aware' and if any potential ACMs are encountered during future works, the works should be paused and a geo-environmental engineer or asbestos specialist consulted to determine an appropriate course of action.

Any work with ACMs must be in accordance with the Control of Asbestos Regulations 2012 and the site-specific asbestos risk assessment, and only be undertaken by personnel with appropriate training and licences, as applicable.

7.0 VERIFICATION OF THE WORKS

7.1 Verification Plan

The works will be verified in accordance with the Environment Agency document: 'Verification of Remediation of Land Contamination' (Report: SC030114/R1) and other relevant industry good practice guidance including The Environment Agency's Land Contamination Risk Management (LCRM) framework.

In summary, the following work will be undertaken on site by the geo-environmental consultant and the contractor:

- Attendance on site during the remediation works (including verification trial pitting and hotspot excavation) by an experienced geo-environmental engineer to inspect the soils, take samples, supervise excavations and maintain a site diary of activities;
- Site wide verification will be undertaken through the excavation of trial pits at a frequency of 10m centres within the former process area and 20m centres across the rest of the site (as shown in Figure 7.1, below). Trial pits will be excavated to depths of between 2.5 – 3.0m.bgl to allow identification of any obvious hotspots and the collection of representative verification samples. At least one sample will be collected from each pit;
- Samples taken from the verification trial pits will be submitted to a UKAS/MCERTS accredited laboratory and analysed for VOCs (including 1,2-dichlorobenzene and chlorobenzene);
- Verification of soil contamination hotspot excavations will be by inspection of the soils for visual and olfactory evidence of contamination, and the collection of verification samples from the base and faces of the excavation. Samples will be submitted to a UKAS/MCERTS accredited laboratory and analysed for the contaminants of concern;
- Verification samples from remedial excavations will be taken at a minimum frequency of 1 per 10 x 10m from the base and every 10m along the sides of excavations, with a minimum of one sample per face and base;
- Treated soils will be tested at a rate of one sample per 250m³, with a minimum of five samples taken from each windrow / biopile. Samples will be submitted to a UKAS/MCERTS accredited laboratory and analysed for the contaminants of concern;
- Any imported material used on the site (for example if required to achieve the desired site levels) will be tested at a rate of one sample per 250m³ for the first 5000m³ reducing to 1

sample per 500m³ thereafter if materials are reasonably consistent. A minimum of three samples will be taken from each different soil source. Samples will be analysed for a full suite of contaminants that will include, as a minimum: metals, pH, asbestos, PAHs, Petroleum Hydrocarbons, plus any others that may be relevant based on the source of the material;

- All samples will be screened against the remedial targets for the site, or otherwise Generic Assessment Criteria for a commercial land use, and there should be an absence of any visual or olfactory evidence of contamination;
- A topographic record will be kept by the contractor, as appropriate, to show the excavations locations and depths;
- A photographic record and description of the excavations will be kept by the geo-environmental engineer / contractor;
- The volume and locations of contaminated soils excavated, treated, disposed and re-used will be carefully recorded by the contractor, along with all other material movements;
- The volume of water removed from the excavations, treated and discharged / tankered off-site will be recorded by the contractor;
- Samples of groundwater will be taken from the monitoring wells and submitted to a UKAS/MCERTS accredited laboratory and analysed for cyanide, bromide and VOCs;

Figure 7.1 Verification Sampling Frequencies



7.2 Verification Report

A post remediation verification report will be produced in line with LCRM and other relevant contaminated land guidance. It will contain all site data including analysis results, approvals, licences and drawings to show the effectiveness of the remediation.

The verification report will include the following information:

- Details of the objectives for the remediation strategy selected;
- Details of the remediation methodologies employed;
- All background information, referencing key supporting documents including this report;
- A clear description of the remediation work undertaken with details of the sequence of events and verification sampling undertaken;
- Details of the methodology for verification, data collection and interpretation;
- Details of the final volumes and nature of materials excavated, pumped, treated, disposed of and imported. Supporting documentation (lorry tickets) will be included as an appendix where appropriate;
- A plan which shows the extent of the excavations and location of validation sampling points;
- The results of testing undertaken on all verification samples;
- The results of testing on all groundwater samples taken during the remediation works;
- Any works that have not been undertaken / remain outstanding;
- Conclusions regarding the success of the remedial works based on all available information.

A subsequent report detailing the results of post-remediation groundwater monitoring will also be produced on completion, which will include interpretation of the results, conclusions and recommendations for any further action as necessary.

8.0 CONCLUSIONS

Previous ground investigations have identified organic contamination (most notably from 1,2-dichlorobenzene) within Made Ground and natural Glacial Deposits, while organic contaminants (most notably 1,2-dichlorobenzene and chlorobenzene), bromide and cyanide have been identified in groundwater. Following the DQRA (described in a separate report) and the remediation options appraisal, the preferred remedial solution comprises the excavation and bioremediation of organic soil contamination hotspots, and the pumping of any contaminated shallow groundwater from excavations for treatment or disposal.

This will be supplemented by a monitoring programme to assess natural attenuation of groundwater after removal of significant sources of contamination within the soil.

Remediation verification samples, and samples of any treated, site won or imported material will be analysed and screened against the site remedial targets or generic assessment criteria, as appropriate.

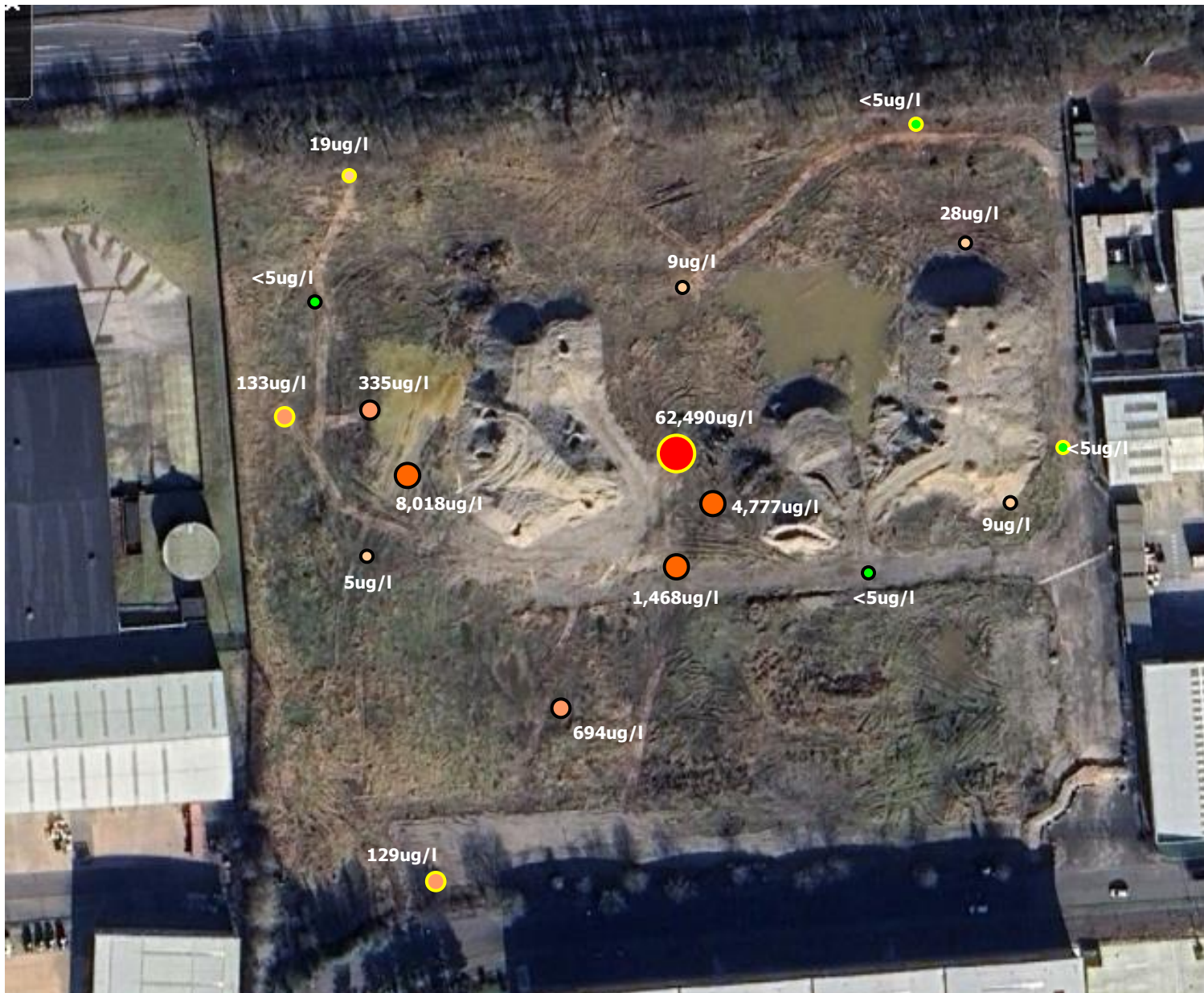
The remediation work will be supported by the production of a verification report.

9.0 REFERENCES

1. BS 5930: (2015): Code of Practice for Site Investigation. British Standards Institution
2. BS 10175: (2011): Code of Practice for the Investigation of Potentially Contaminated Sites. British Standards Institution
3. LCRM (2020): Land Contamination Risk Management. Environment Agency
4. CL:AIRE (2014): SP1010 – Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination
5. Land Quality Press (2015): The LQM/CIEH S4ULs for Human Health Risk Assessment (S4UL3312)
6. Environment Agency (2002): The Effects of Contaminant Concentration on the Potential for Natural Attenuation
7. Environment Agency (2008): Science report SC050021/SR7 Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values
8. CL:AIRE/AGS/EIC (2010) - Soil Generic Assessment Criteria for Human Health Risk Assessment
9. Howard and Aronson (1997): Anaerobic Biodegradation of Organic Chemicals in Groundwater: A Summary of Field and Laboratory Studies
10. SoBRA (2017): Development of Generic Assessment Criteria for Assessing Vapour Risks to Human Health from Volatile Contaminants in Groundwater

APPENDICES

A – Groundwater Contamination Distribution Plans



DO NOT SCALE

NOTES:

- Deep groundwater
- Shallow groundwater



G&J Geoenvironmental Consultants Ltd
35-37 High Street,
Barrow upon Soar, Loughborough, LE12 8PY
Tel: 01509 410372
info@gjgeoenvironmental.com

CLIENT:

Knowsley Redvelopments Ltd

PROJECT:

**Former Contract Chemicals,
Penrhyn Road**

TITLE:

**1,2-dichlorobenzene
distribution in groundwater –
March 2025**

SCALE@SIZE :

NTS

ISSUE:

FINAL

DESIGN/DRAWN by :

CMH

DATE:

April 2025

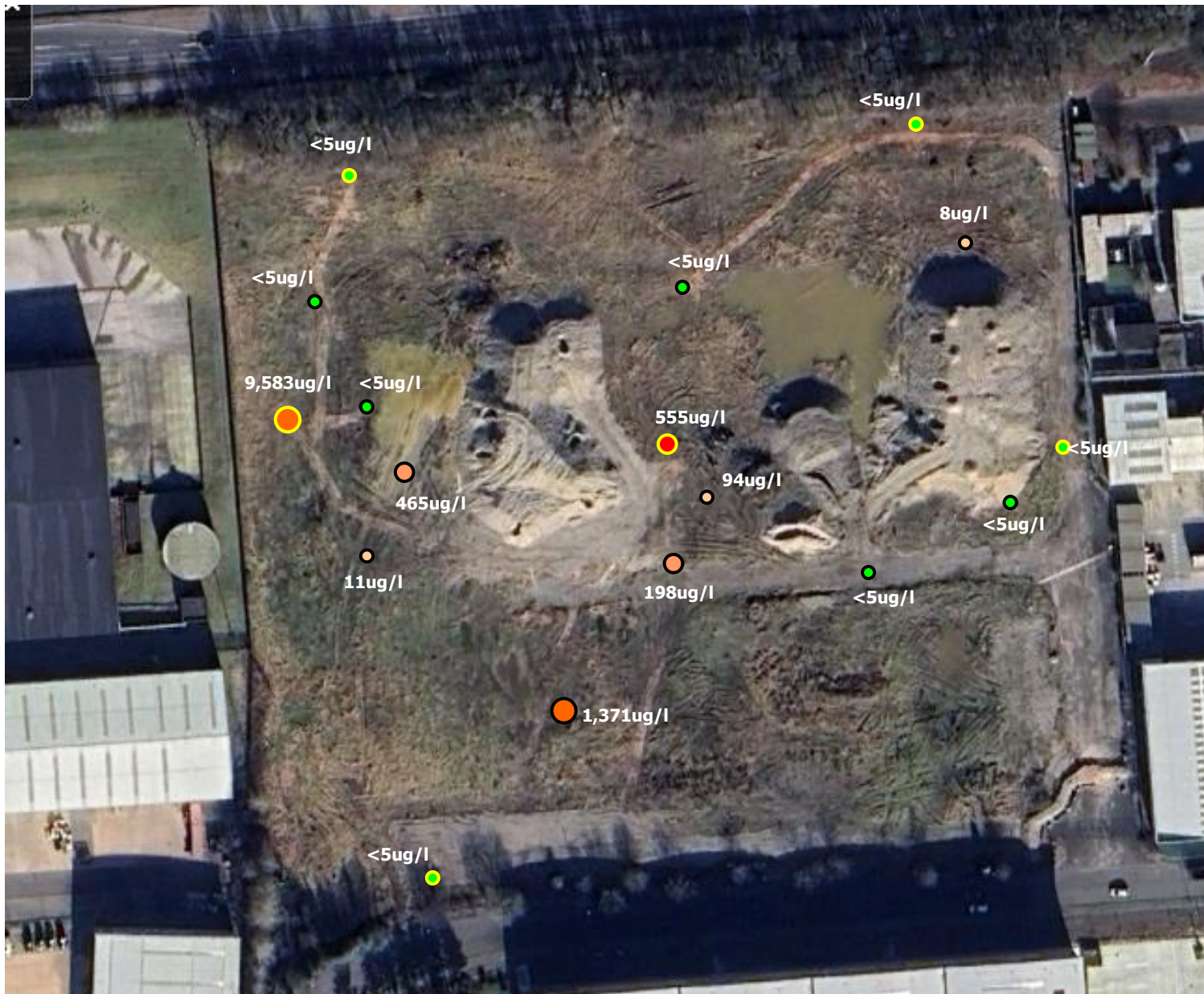
PROJECT No:

GJ224

DRAWING No:

Photos01

© G&J Geoenvironmental Ltd



DO NOT SCALE
NOTES:

- Deep groundwater
- Shallow groundwater



G&J Geoenvironmental Consultants Ltd
35-37 High Street,
Barrow upon Soar, Loughborough, LE12 8PY
Tel: 01509 410372
info@gjgeoenvironmental.com

CLIENT:
Knowsley Redvelopments Ltd

PROJECT:
**Former Contract Chemicals,
Penrhyn Road**

TITLE:
**Chlorobenzene distribution in
groundwater – March 2025**

SCALE@SIZE :	ISSUE:
NTS	FINAL
DESIGN/DRAWN by :	DATE:
CMH	April 2025
PROJECT No:	DRAWING No:
GJ224	Photos01

© G&J Geoenvironmental Ltd



DO NOT SCALE

NOTES:

- Deep groundwater
- Shallow groundwater



G&J Geoenvironmental Consultants Ltd
35-37 High Street,
Barrow upon Soar, Loughborough, LE12 8PY
Tel: 01509 410372
info@gjgeoenvironmental.com

CLIENT:

Knowsley Redvelopments Ltd

PROJECT:

**Former Contract Chemicals,
Penrhyn Road**

TITLE:

**Bromide distribution in
groundwater – March 2025**

SCALE@SIZE :

NTS

ISSUE:

FINAL

DESIGN/DRAWN by :

CMH

DATE:

April 2025

PROJECT No:

GJ224

DRAWING No:

Photos01

© G&J Geoenvironmental Ltd

B – Remediation Options Appraisal

Remedial Method	Remedial Objectives			Score	Pros	Cons
	a	b	c			
Segregation	4	4	4	16	1) Avoids disposal of unaffected soils 2) Form of pre-treatment for waste disposal 3) Reduces disposal / treatment costs	1) Only suitable for identifiable hotspots and obvious deleterious materials
Off-site disposal	4	1	1	6	1) High degree of certainty of meeting criteria 2) Can address a wide range of contaminants, including those which may not be economical viable to remediate by other methods 3) Remediation timescales are fast in comparison to other techniques	1) Less sustainable option 2) Generates traffic around the local community and beyond 3) Import required to fill the void unless the site can be regarded to a lower level 4) High costs of disposal
Off-site Treatment at a Soil Treatment Facility	4	2	1	7	1) Removal of a full range of contaminants 2) Suitable for large amounts of treatment when the site cannot accommodate volumes in the available space 3) Cheaper than landfill	1) Higher cost than treating materials on site 2) Requires import of clean fill material 3) Generates traffic around the local community and beyond
Ex-situ Bioremediation	3	3	4	10	1) Easy to monitor and control procedure 2) Effective with organic contaminants 3) Relatively low cost technique using readily available plant 4) Very Sustainable treatment process 5) Chemical and geotechnical homogeneity of soil is improved	1) Relatively time consuming / labour intensive 2) Soils with a high clay or silt content can be difficult to treat. 3) Requires large treatment area 4) May not be suitable for all organic contaminants
Soil Vapour Extraction	2	3	2	7	1) Effective for volatile contaminants 2) Sustainable	1) Not effective on less volatile contaminants 2) Expensive over large areas 3) Relatively slow process 4) Off-gas treatment may require permit
In-Situ Chemical Oxidation / Reduction	2	1	2	5	1) Effective for organic contaminants 2) Sustainable	1) Expensive over large areas 2) Relatively slow process 3) Groundwater treatment may not offer significant benefits given results of DQRA
In Ground Barriers	2	1	2	5	1) Relatively Simple 2) Can work for a range of contaminants	1) High initial costs 2) May require ongoing maintenance 3) Requires appropriate geological conditions 4) Large volume of soils require re-use / disposal 5) Benefits may be limited given results of DQRA
Pump and Treat / Dispose	2	2	2	6	1) Easy to monitor and control from excavations 2) Effective for all groundwater contaminants 3) Relatively low cost 4) Can be used in conjunction with ex-situ bioremediation	1) Progress will depend on geology and rate of recharge 2) Requires disposal or treatment of extracted groundwater / product 3) Extracting from depth requires detailed plume / source characterisation and numerous extraction wells 4) Difficult to extract significant quantities of free phase contamination from depth
Natural Attenuation	2	4	3	9	1) No ground disturbance 2) Low cost technique 3) Sustainable	1) Slow process 2) Requires suitable ground conditions 3) Requires primary sources to be removed

Remedial objectives:

Providing certainty that the remediation solution meets the remedial criteria (a)

Providing a pragmatic and sustainable remedial option (b)

Providing an economical and viable remedial solution (c)

Scoring:

Highly suitable, easily meets the remedial objectives with a high degree of certainty – 4 points

Generally suitable but not necessarily the best option or some uncertainty may be present – 3 points

Moderately or possibly suitable, some significant uncertainty may be present – 2 points

Unsuitable or high degree of uncertainty regarding suitability – 1 point

Very unsuitable or contrary to objective – 0 points