Remediation Strategy
In accordance with CL:AIRED Industry Code of Practice
Stobart Park, Widnes

Prepared on behalf of:

Stobart Group

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1 Introduction

1.1 Background

The Stobart Group recently (July 2011) submitted an Environmental Statement to accompany an outline planning application for the proposed redevelopment of land at the Merseyside Multi Modal Gateway (3MG) site in Widnes. Earth and Marine Environmental (EAME) Limited have been retained by The Stobart Group to assist with the development of a Remediation Strategy for this development as the works involve the management and re-use of contaminated material. The development will involve the re-adjustment of site levels on parts of the site to be achieved by the excavation, treatment and re-use of substantial volumes of potentially contaminated soil (heavy metal contaminated LeBlanc waste being the key contaminant of concern). The outline application has subsequently been revised and re-submitted in January 2012 to include an amended site boundary, change of building layout and earthworks quantities. In addition a proposed Biomass facility was removed from the application, to be pursued under separate application. A reserved matters submission for the Phase I Earthworks and Infrastructure is now being submitted pursuant to the current Outline Planning Application (11/00266/OUTEIA). Thus the Remediation Strategy that was prepared and submitted in October 2011 has been updated in light of the revised outline application, information received and works identified for the Phase I reserved matters submission. This revised version, Rev02 has been prepared in compliance with the Contaminated Land: Applications in Real Environments (CL:AIRE) ‘Definition of Waste: Development Industry Code of Practice’ (CoP), Version 2, as issued in March 2011.

Previously, another part of Stobart Park (Project Eagle) was remediated under Version 1 of the CL:AIRE Code of Practice (the former Tessenderlo chemical works site) but there have been a number of changes in the CL:AIRE CoP between Version 1 and Version 2 (current version). The changes are largely procedural but nonetheless need to be recognised. These are:

1. Increased scope to include Direct Transfer of naturally occurring soil materials (including elevated natural contaminants). The new updated Code now enables the direct transfer and re-
use of clean naturally occurring soil materials between sites. It also creates the conditions to support the establishment and operation of fixed soil treatment facilities, which have a key role to play in the future of sustainable materials management. As with earlier versions it also enables the reuse of both contaminated and uncontaminated materials on the site of production, and between sites within defined Cluster projects;

2. Explanation about the use of a fixed Soil Treatment Facility within Cluster Projects.

3. A Materials Management Plan (MMP) template. There is no extra documentation required as part of the new version, however in order to give extra guidance and simplify any future audits the steering group have decided to introduce a template for a standardised Materials Management Plan (MMP).

4. Declaration specific to project scenarios (Qualified Person registration number must be quoted to confirm registered at time of completion).

5. Declaration submitted prior to use (not prior to excavation).

6. Declaration not required for the transfer from Donor to Hub site (Duty of Care still applies).

7. Role of Qualified Person updated and further clarity provided, including Qualified Person checklist, and who can appoint them. The role of QP in ensuring that best practice is consistently and demonstrably applied is key to the success of the CoP. It is therefore essential that all QP’s update and maintain their knowledge. Current QPs are required to be chartered with a professional institute; CL:AIRE will expect to see evidence of Continuing Professional Development (CPD) logs showing an individual has registered the method they have employed to update their knowledge, for example through the new training course or through private study.
8. Interaction of CoP with Site Waste Management Plans, Defra CoP and SEPA guidance tabulated in Appendix 7.9. Frequently asked questions regarding construction activities that do not require an Environmental Permit.

The CL:AIRE CoP allows for such projects to take place without the need for formal Environmental Permitting of the deposit of such materials, provided that certain requirements are met and that certain protocols are observed and that there is an auditable process verified by an independent “Qualified Person”. The key requirements of the CL:AIRE CoP are:

- that there is an appropriate Materials Management Plan (MMP) that details fully how the materials are to be managed and used on the site, including setting assessment and validation criteria;

- that the MMP forms part of a Remedial Strategy based on thorough investigation and risk assessment;

- that there is appropriate documentation and record keeping of all activities undertaken under the programme;

- that the activities do not cause pollution; and

- that the works are verified as meeting the above criteria by an appropriately qualified person who has not been involved in the design, management or execution of the project.

This document sets out the remedial strategy, risk assessments and Materials Management Plan in accordance with the CL:AIRE requirements, in relation to this project.
1.2 Project Description

The Stobart Group is planning to undertake the second stage of development works at Stobart Park, Widnes. This follows Project Eagle, which comprised Phase 1 and included the development of a refrigerated logistics centre and car park on the former Tessenderlo works, upgrading Marsh Brook and site roads. The second stage comprises the redevelopment of the brownfield land to the west of Desoto Road, see Figure 1. The site has had a long history of mixed uses (chemical works, timber treatment, warehousing, etc), and is now largely demolished awaiting redevelopment. The site can effectively be split into three distinct areas, the former AHC land (West Bank Dock), the Reclamation Mound and the Foundry Lane site. The current layout of the site and the respective areas that will be discussed in this document are set out in Figure 1a and 1b. The extent of the Phase I earthworks is provided in Fairhurst Drawing 80692 -0014 (Isopachyte Proposal), appended to this document.

The completed development will be a multi modal distribution hub comprising warehousing and intermodal transfer of freight. The project will involve wholesale regeneration of a very large and in places contaminated brownfield site and will create around 2400 new jobs. The proposals will be implemented in phases and will comprise a number of successive reserved matter submissions pursuant to the outline consent, which dependent on the final customer may be altered.

The first stage was the re-development of brownfield land to the east of Desoto Road, known as Project Eagle, which comprised the development of a refrigerated logistics centre, car park and HGV yard on the former Tessenderlo and Eddarbridge land to the east of Desoto Road.

Due to the scale of the proposal and requirement to secure occupiers to determine the final details of each building the scheme is being developed in 6 phases. The phases are not proposed as the construction programme and may not occur in the sequence set out. Each phase can progress independently which is defined on the Infrastructure Phasing Plan Ref: 11026/23 and Phasing Masterplan Ref: 11026/22 Rev A. The following strategy relates to the current proposal, on the proposed development on land to the west of Desoto Road, which can be summarised as follows:
STOBART PARK (In progress)

Phase 1 – Stage 1 Earthworks and Infrastructure (current proposal)

- the area (9.5 hectares) east of Stewards Brook comprising construction of spine road, roundabout at Desoto Road and earthworks and infrastructure to the south of the proposed Spine Road, to provide a serviced site for Unit 3, HGV parking and car parking, strategic landscaping and works to Stewards Brook and road bridge.

Subsequent Phases

- Phase 2 – Stage 2 Earthworks and Infrastructure to provide a new roundabout to serve units 1 and 2, serviced sites for unit 1 and 2, strategic landscaping and completion of the cycleway/footway to also form emergency access to Foundry Lane.
- Phase 3 – New Rail Siding;
- Phase 4 – Unit 1;
- Phase 5 – Unit 2; and
- Phase 6 – Unit 3.

It is intended that the development will be completed in the separate phases, with the initial Phase I works comprising development of a new roundabout at Desoto Road, a central spine road through the site to Stewards Brook, a road bridge crossing the brook and provision of a development plot (Unit 3) to the south of the new road. This will involve excavation and treatment of galligu contaminated material. This material is to be used to create the spine road and a developable platform to the south of the spine road, see Fairhurst Drawing 80692 – 0014, at the end of this report.

Following this phase, the works comprise the excavation and treatment of further galligu material to realise the potential of the remainder of the site (within the Reclamation Mound and Foundry Lane area). The quantities may change as detailed proposals come through for each of the business units but, the general order of quantum will remain similar. The precise volumes will be detailed in the Materials Management Plans (MMP) and will be updated throughout the project.
The site once fully developed will be an integrated intermodal logistics centre, building upon the existing rail and freight handling capabilities, but, given the scale of the development and funding mechanisms must be implemented in the Phases described above as illustrated on Fairhurst Drawings 80962/22a (Phasing Masterplan) and 80962/23 (Infrastructure Phasing Masterplan). A previous Remedial Strategy was provided to support Project Eagle and a similar approach is proposed for this development – namely where possible and achievable under acceptable environmental conditions site derived materials will be re-used and off-site disposal will be minimised.

1.3 Overview of the Earthworks and Site Preparation

In simple terms, the plan is to use bulk earthworking techniques (cut and fill) to re-level the land to create a consistent, geotechnically stable formation level for the entire development area, see Fairhurst Drawing 80962/0014. In broad terms there will be a net loss of material from the Reclamation Mound and corresponding deposit of material on the former AHC and Foundry Lane land.

In total it is anticipated that around 350,000 m$^3$ of soil will need to be used in the overall development, which will largely be obtained from the Reclamation Mound, whilst the Phase I works incorporate a cut of around 24,000 m$^3$, see Section 4.3.6. A large proportion of this engineering fill will come from the Reclamation Mound which comprises an area of Made Ground and chemical waste contaminated soil known locally as “galligu”. Galligu is, in essence, waste from the Le Blanc process associated with the Widnes Soap and Alkali manufacturing industry. Where the material to be removed from the Reclamation Mound is clay, top soil and sub-soil there is considered to be no need for treatment of the material for environmental protection reasons and its re-use is not problematic other than the scale of the operation and materials management issues. There will also be additional material arising from the foundations, drainage, concrete bases, former buildings etc., which will be detailed in the MMPs.

The principal material of concern from a contamination perspective is “Galligu”. This is a colloquial generic term for alkali and soap industry residues from the Widnes area dating back to the early days of the UK chemical industry. On the whole the material encountered is effectively Le Blanc process residues (sodium and calcium sulphide cake) but is often contaminated with heavy metals and most
notably arsenic. It should be noted, however, that these highly elevated arsenic levels which are characteristic of Widnes galligu are related to the earliest manufacturing periods of the soap and alkali industry (1800’s). The *Le Blanc* process and production activities were subsequently modified and later production campaigns did not generate arsenic metal rich *LeBlanc* residues. Consequently, whilst galligu is used as a generic term in the area, it can be highly varied in nature appearing in a variety of colours from white through to purple and consistencies from a dry powdery cake to a thixotropic mass.

For the sake of clarity, the most pressing need in terms of agreeing a remedial strategy and ensuring that all of the necessary permits and approvals are in place is thus the cut and fill operation associated with the development of the Phase I works, which is due to commence in May 2012.

The environmental benefits that accrue from enabling the full site wide scheme to proceed are as follows:

- Physical treatment and chemical stabilisation of hundreds of thousands of cubic metres of contaminated soils (galligu);

- Capping and sealing of around 32 hectares of, in places, heavily contaminated land that is mostly permeable to rainwater infiltration (and thus leaching) at present;

- Substantial chemical improvement of Steward’s Brook which presently has low ecological value and very poor water quality (heavily chemically contaminated);

- A comprehensive site wide landscaping scheme creating substantial opportunities for enhancing the biodiversity of the entire site and providing ecological corridors traversing the site and connecting with the wider environment. The current site is largely hardcore with isolated pockets of low grade landscaping of little ecological value;

- The entire site will be provided with a comprehensive, managed, sealed drainage system that will serve all areas of the site and convey clean stormwater to the local watercourses, eliminating
infiltration and providing much needed clean water flow and dilution water to the contaminated watercourses. The current drainage system is incomplete, decrepit and ill-defined in places and likely to interact substantially with the contaminated soil and groundwater on the site and convey contaminants to the local watercourses. The redundant drainage systems will be removed and/or capped as part of the initial infrastructure works to prevent future migration pathways. It is understood that a collapsed United Utilities sewer traversing the Foundry Road site will also be investigated and remediated; and Replacement of a currently run down and visually “derelict” site with an integrated, landscaped and well maintained site comprising high quality buildings and infrastructure.

For this scheme to be physically viable there is a requirement for re-levelling of the site around the Reclamation Mound. Whilst this would be technically feasible by disposing of the overburden material off-site and importing the necessary infill material, this would be environmentally and commercially unsustainable. Consequently the only practicable option is to have a cut and fill balance using site derived materials but to ensure that an appropriate level of treatment is applied to ensure that the re-used materials and newly exposed materials do not pose an increased or unacceptable environmental risk. Within the areas of excavation (cut), these will be overdug where necessary and replaced with the solidified treated galligu to a depth to be agreed. The current proposed phase of the earthworks and site preparation is illustrated in Fairhurst Drawing 80962/0014, at the end of this report.

1.4 Regulatory Implications of the Proposed Works

The recent redevelopment project (Project Eagle) which involved the excavation and treatment of around 400,000 m³ of material excavated from the Reclamation Mound and re-deposited at the former Tessenderlo and Eddarbridge areas to create a developable platform for the erection of the Tesco Chilled Distribution Warehouse was undertaken successfully using the CL:AIRE Code of Practice. A previous Remedial Strategy (Ref 67C1938) was produced which outlined the mechanism for these works. This was undertaken using the original version of the CL:AIRE Code of Practice, Definition of Waste Version 1 2008. This Code of Practice has since been superseded with Version 2, released in March 2011.
In essence, the previous Remedial Works were considered to be undertaken as follows:

- Uncontaminated soils and clay will be dealt with as a simple materials movement exercise without the need for any permits or consents (other than allowed for by planning);

- Soils and galligu with low contaminant levels (e.g. below CLEA Industrial SGV’s or GAC equivalent for metals) were originally planned to be dealt with under an Environmental Permit exemption (Paragraph 9), which was submitted and approved by the Environment Agency prior to works commencing, but due to time scales and the additional benefits of stabilising the re-used material, the works were actually completed under the CL:AIRE CoP; and

- This was undertaken, completed and a Verification Report issued on completion.

The second phase of works, addressed by this Remedial Strategy document, is deemed to essentially be a continuation of the previous works. The previous Remedial Strategy indicated that some of the galligu contaminated material contained contaminant levels (especially arsenic) that were higher than the CLEA Soil Guideline Value for Industrial End Use and leach at significant levels. Thus for Project Eagle it was decided that stabilisation treatment would be required and this approach is to be continued in the next phase of works.

Whilst it is acknowledged that each case for remediation is site specific and has to be justified on its own individual merits, it is considered that this is largely a continuum of the same site. The conditions therein are very similar in terms of groundwater regime and the fact the majority of the area is made of galligu (the principal contaminant of concern). The capping of the Tesco DC site was with the same material (and hence the same source conditions) of material proposed for capping in the current development proposals. In other words, both developments will use the same site derived material from the reclamation mound as a stabilised engineered cap.
The CL:AIRE CoP is designed to set out a formal framework and independent verification system to allow developers to make use of site derived materials whilst ensuring that there is no harm to the environment and that there is an auditable trail of data, risk assessments, reports, procedures and material characteristics that can be inspected at any time to ensure that the procedures have been complied with and the environment protected. The EA’s approach to this is set out in *Remediation Position Statement 006 – Definition of Waste – Development Industry Code of Practice*. A substantial volume (but not all) of the soils involved in the cut and fill is contaminated with galligu.

Where the developments differ is in their historical usage as the Project Eagle site (current Tesco DC site) had a much more intensive usage of the land for chemical activities (notably the Tessenderlo chemical works) and there was a chemical contamination legacy on that site that does not exist on the proposed Stobart Park development site. In that regard the environmental conditions and pollution source on the Tesco DC site were considerably worse than exist in the subject area.

In addition to the earthworks described above, it is also necessary to undertake some works affecting the crossing of Steward’s Brook which is presently a corrugated tunnel culvert and deemed to be structurally and aesthetically insufficient. As part of the development of the spine road The Stobart Group are proposing to build a new road bridge over the Brook at this point which will also require consent from the EA.

Finally there will be clean stormwater runoff discharges to the Brook(s) which also will be required to meet environmental objectives and obtain the consent of the EA.

To summarise the regulatory position therefore, for the scheme as a whole, a number of regulatory approvals are required, namely:

- Land Drainage Consent for the new crossing of Stewards Brook;
- Surface & Wastewater Discharge Consents for outfalls from the site into the Brook(s)
Mobile Treatment Licence (MTL) for soil stabilisation plant;

Deployment Form for use of MTL on site; and

Remediation Method Statement in accordance with the CL:AIRE Code of Practice.

It is this latter bullet point to which the remainder of this report mainly applies although the other aspects will be touched upon where relevant.

The outline planning application has been submitted and is currently under consideration. This remediation strategy forms part of the Phase I reserved matters submission which provides detailed information relating to the appearance, landscaping, layout and scale of the proposed development to the east of Stewards Brook as illustrated by Fairhurst Drawing 11026/23.

However, the fundamental principle of all works will be that there is no deterioration in water quality as a result of the development and no additional pollution loading or pollutant linkages created. Moreover, the scheme, whilst primarily delivering commercial and socio-economic benefits, will also lead to environmental betterment of the site overall.

1.5 Remediation Overview

In developing the remedial strategy the following sustainability and environmental protection principles have been considered and will be applied as fully as practicable. This is a re-iteration of the principles provided previously and follows best practice:

- where possible all materials generated by the works should be dealt with on site and preferably re-used in a beneficial way to reduce the need to import make-up materials;

- where off-site removal is unavoidable, preference should be given to re-use and recycling of materials (with pre-treatment if required) over landfill disposal;
where such off-site treatment and disposal is necessary the proximity principle shall be applied (namely the materials will be dealt with at competent facilities as close to the site of generation as possible);

- existing significant pollutant linkages (identified source-pathway-receptor scenarios as defined in the *Environmental Protection Act 1990 (Part IIa)* should be eliminated or reduced to a level of insignificance;

- the overall carbon and vehicle emission potential of the remedial options shall be considered in developing an appropriate strategy (*i.e.* off-site transport and materials import must be balanced against on site solutions);

- the construction activities must not lead to increased environmental impact from the site and must be managed to prevent pollution and nuisance incidents arising; and

- opportunities for bio-diversity enhancement within the Stobart land-holding should be sought.

In addition the following will be adhered to during the course of the development (as it was during the Project Eagle development):

- where the excavated material is uncontaminated (*e.g.* clay, crushed concrete and top-soil) this will be re-used around the site for levelling and landscaping;

- the galligu material will be tested and treated with a stabilisation technique operated under a Mobile Plant Licence;

- the treated (stabilised) galligu will be emplaced in layers across the area to form a structurally and chemically stable building platform, but will also seal the underlying land from percolation of rainwater into contaminated sub-soils and eliminate vapour, ingestion and dermal contact human health risks to site occupiers, this will be undertaken in areas of cut as well as upfill;
where material is encountered during excavations that cannot be stabilised, this material will be quarantined (either in-situ or ex-situ) pending identification of appropriate treatment and disposal options, with preference given to on-site treatment and re-use over off-site disposal. This may for example involve bio-remediation or the engineered capping of materials which would be agreed with the EA and HBC at that time;

- any groundwater/perched water encountered during the earthworks will be assumed at the outset to be contaminated and impounded accordingly. Pending characterisation analysis, the water will preferentially be treated on site and discharged to surface water (subject to EA approval) but where this is not feasible it will be tankered away for off-site treatment; and

- all the construction activities (including groundworks) will operate under a Construction Environmental Management Plan (CEMP) that will set out measures to be applied to prevent pollution, nuisance and to be protective of the environment. The CEMP (appended to this report) will be produced and managed by The Stobart Group and all site contractors will be expected to comply with it.

It should be noted that the site, in parts, contains many metres thickness of contaminated soils to significant depths and it is not considered practicable or warranted in terms of risks to the site occupiers and neighbours to remediate these deeper materials (which would effectively only be achievable by bulk removal of millions of tonnes of soil). As such these will remain largely undisturbed by the proposed development works, other than where piling or deeper excavations intercept them (which has been considered in this document). The remedial options appraisal is further outlined in Section 3.
1.6 Roles and Responsibilities

There are a number of key parties that will be involved in the remediation works and site development. For the sake of completeness these are described below:

- **Stobart Engineering and Infrastructure Limited** is the Client and Main Contractor for the project and will ultimately fund, sanction and approve all works. Stobart will implement the design, manage the site and procure and manage all sub-contractors (including the remediation works).

- A remediation contractor has not yet been appointed for the development works. Once chosen, they will be charged with the design, management and execution of the stabilisation/treatment works (especially stabilisation and management of the on-site laboratory). This contractor will provide the Mobile Plant and associated Mobile Treatment Licence and Technically Competent Person(s).

- **Earth Tech Solutions (ETS)** is the company responsible for undertaking the testing regime to determine appropriate mixes to treat the galligu to achieve the appropriate geotechnical and environmental qualities of the stabilised material.

- **Fairhurst** is the Consulting Engineer responsible for providing technical design input and overall strategic design of the earthworks (and subsequent construction) including the cut and fill levels across Stobart Park.

- **Earth and Marine Environment (EAME) Limited** is the Environmental Consultant to the design team and contractors and will verify that the remediation works have been carried out to the satisfaction of the authorities and client. Following completion of the works, EAME will prepare a verification report (including plans, analytical results, waste transfer notes etc., as provided by the Contractor) and undertake all liaison with the regulatory authorities (with the exception of obtaining appropriate permits and licences required by the remediation contractor, in which case EAME will provide an advisory role as required).
1.7 Remediation Strategy Report

The remainder of this document sets out the remedial strategy in more detail as follows:

- **Section 2 – Ground Conditions and Contaminative Status** - this provides an overview of the ground conditions and contamination status associated with the site.

- **Section 3 – Risk Assessment and Options Appraisal** – this provides an overview of the qualitative and detailed quantitative risk assessments provided previously regarding the perceived and identified risks to sensitive receptors.

- **Section 4 – Remediation Scope and Methodology** – this sets out in detail how the remediation works are to be implemented, managed, monitored and verified.

- **Section 5 – The Re-use of Excavated Materials On-Site as a Non-Waste** – this provides details necessary to confirm that the proposals to re-use the material comply with the factors set out in the CL:AIRE Code of Practice enabling the material to be regarded as non-waste, namely:
  
  - Factor 1 – Suitability for Use;
  - Factor 2 – Certainty of Use;
  - Factor 3 – Quantity of Use;
  - Factor 4 – Protection of Human Health and the Environment;
  - a summary of the Materials Management Plan (MMP); and
  - a summary of the Construction and Environmental Monitoring Plan (CEMP).

The report sections are supported by a series of figures, drawings and technical appendices and are referenced in the text where appropriate.
2 Ground Conditions and Contaminative Status

2.1 Introduction

The site has been extensively investigated over many years by various companies and most recently by Fairhursts in order to determine the ground conditions for the proposed development. EAME undertook an environmental investigation as part of the outline planning submission for the proposed Stobart Park Extension (11/00266/OUTEIA) in April 2011. Thus in terms of site characterisation there is a large body of information pertaining to the site’s environmental setting including soil, groundwater and surface water conditions. A previous Remedial Strategy was formulated for the Phase 1 works (Project Eagle) which included detailed risk assessments for the site and the proposed works, which is essentially the same as proposed for this phase of development, i.e. mass earth moving, stabilisation of contaminated material and re-deposition of the treated material. The key findings on the ground conditions have been obtained from the extensive ground reports and assessments that have been completed on the site previously, which are available for consultation and have all been provided to the EA and HBC prior to this document being prepared. The various reports and studies which collectively make up the investigation of the development area are:


- The Stobart Group, Multi Modal Distribution Centre, Waste Management Permitting – Exempt Activities, 67C13948-1, Environ October 2008 (WML Para 9 Exemption Report);


- Chapter 12 & 13 of Environmental Statement, Stobart Park/3MG, Widnes prepared by EAME on behalf of Stobart Developments for W A Fairhurst and Partners, Ref 89429, July 2011 (11/00266/OUTEIA) and within the revised application submitted in January 2012.

In addition, a report was supplied entitled ‘Verification Report, In accordance with CL:AIRE Industry Code of Practice’, Intermodal Distribution Centre, Ditton, Widnes prepared by Environ in July 2009. The report comprises the findings and assessment of the treatment of the stabilised galligu that was deposited across the Project Eagle site.

Collectively these studies and in particular the assessment of the material in the Reclamation Mound provide a robust characterisation of the site conditions and the nature and treatability of the materials being considered for re-use. In addition a geotechnical investigation has recently been completed and reported in Draft Factual Report on Ground Conditions, Ref. W11/40935, dated January 2012 by Ian Farmers Associates (1998) Limited on behalf of Fairhursts.

2.2 Geology, Hydrogeology and Hydrology

Geology

According to the British Geological Survey (BGS) Solid and Drift Map for Runcorn (Sheet 97, scale 1:50,000) and confirmed using the BGS online Geology of Britain viewer, the site is directly underlain by recent Tidal Flat Deposits (the River Mersey is tidal within this area). Tidal Flat Deposits commonly
comprise soft dark grey clays, silts and occasionally sands, which may be organic and contain shelly material.

The superficial deposits are underlain by the Wilmslow Sandstone Formation (formerly known as the Upper Mottled Sandstone) of the Triassic Sherwood Sandstone Group at depths ranging from 12 to over 35m below ground level (bgl). The Sherwood Sandstone Group is underlain by Permian sandstones and further underlain by Carboniferous Coal Measures to depth. The Wilmslow Sandstone Formation is a fine to medium-grained, red-brown to brick red, generally pebble-free, with sporadic siltstones.

According to data issued by the National Radiological Protection Board (2002), the land is located in an area where less than 1% of residential properties are above the action level for Radon set by the National Radiological Protection Board. No radon protection measures are considered necessary by the British Geological Survey.

**Palaeo-Channel**

The current course of the River Mersey flows to the south of the site and upstream [east] through an obvious geological gap between Runcorn and Widnes, the Runcorn gap can be seen annotated based upon approximate rock head contours. Previous discussions held with the Contaminated Land Officer at HBC indicated that it is conjectured that a previous channel (palaeo-channel) lies to the north of the Runcorn promontory and was subsequently naturally infilled with fluviatile [possibly fluvio-glacial] deposits. This stratum may either be the result of deposition from glacial melt waters during the Devensian [last Ice age], a recent infilled meander of the River Mersey or a combination of both. A review of the Drift edition BGS Sheet 97 - Runcorn indicates that the depth to rock head in this area is in the region of 20 to -40m relative to Ordnance Datum.

**Published Hydrogeology**

The aquifer classification system was updated on 1st April 2010 which provided new aquifer designations to replace the old system of aquifer classifications, such as Major, Minor and Non-Aquifer. This new system is in line with the EAs Groundwater Protection Policy (GP3) and the Water Framework Directive.
(WFD) and is based on British Geological Survey mapping. A review of the maps produced on-line indicates the site is located on the following:

<table>
<thead>
<tr>
<th>Table 2.1: Aquifer Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Formation</strong></td>
</tr>
<tr>
<td>Tidal Flat Deposits</td>
</tr>
<tr>
<td>Wilmslow Sandstone Formation</td>
</tr>
</tbody>
</table>

Details of hydro-geological field observations and field evidence of contamination observed during the EAME 2011 site investigation and subsequent monitoring rounds are discussed in Section 2.3.

**Hydrology**

The two nearest main surface watercourses to the development area are Ditton Brook and Stewards Brook. There is also a small watercourse known as Marsh Brook adjacent to the eastern boundary of the development site. This is effectively a local drainage channel that leads to the River Mersey.

Both Ditton and Stewards Brook are tidal. The normal tidal limit for Ditton Brook is upstream of the bridge, near the northern entrance to the Foundry Lane site. The normal tidal limit for Stewards Brook is approximately half way between the access road connecting the Reclamation Mound with the West Bank Dock Site and the confluence of Ditton Brook and Steward’s Brook.

Marsh Brook is also tidally influenced but unlike Stewards and Ditton Brook, Marsh Brook is an artificially engineered channel that, outside of periods of tidal inundation, has little if any flow. Also this brook is hydraulically lined with a low permeability geotextile and whilst it receives surface water run-off periodically, is not expected to receive groundwater baseflow.
Stewards Brook flows in between the area to the north of the Reclamation Mound and Stobart Park 3MG, before flowing through a culvert under the access road and then alongside the eastern boundary of the Reclamation Mound and the western boundary of the HEDCO landfill site (also known as Hutchinson’s Hill). The base substrate of Steward’s Brook has been observed to be white in colour and it has been assumed that it is substantially comprised of galligu. Domestic refuse and debris has been observed within the brook on occasions and the water is often opaque and prone to notable changes in colour. A strong hydrogen sulphide smell is often noted emanating from the Brook and also from the bankside when disturbed. Steel piles, installed approximately 17m below ground level (m bgl), were placed along the eastern boundary of the Reclamation Mound in the early 1990s to prevent the leaching of contaminants from the subsoils into the shallow groundwater from the Mound into the brook.

Ditton Brook is quite substantially larger than Stewards Brook and is located on the western boundary of the site, thereby flowing adjacent to the western side of the Reclamation Mound. Ditton Brook is faster flowing and deeper than Steward’s Brook particularly downstream of its confluence with Stewards Brook. The steel piles were also placed alongside the western side of the Mound to prevent the movement of contaminants from the sub-soils and shallow groundwater into Ditton Brook. Domestic rubbish and debris have been observed during the sampling exercises here, but the water appears visually to be more natural and there is no evidence of the odours that are associated with Steward’s Brook.

2.3 Discussion of Previous Site Investigations

The previous site investigations have by their nature necessitated the collection of soil, groundwater and surface water samples over many years to build up a detailed knowledge of the site. These various studies provide a substantial data set of the chemical characteristics of the ground conditions and in particular the material to be moved and the condition of the land where the treated material would be used. The relevant aspects of this are discussed below in relation to the various areas of the site.

In addition to the site wide investigations, targeted testing of galligu material obtained from the Reclamation Mound was undertaken, and has been reported previously in the Remediation Strategy.
report, CL:AIRE ‘Definition of Waste: Development Industry Code of Practice, Version 1, September 2008, 67C13948 Environ January 2009. This report also included detailed quantitative modelling of the treated and untreated galligu in respect of risks to controlled waters and these assessments were thus used to formulate the remedial options available. The following reports and sampling events have been used to provide the relevant data to inform the remedial strategy for the site:

- Chapter 14 of the Environmental Statement Report (Project Goldfinger 67C12665 – ES Volume 2) that was submitted as part of the planning submission (planning reference HBC Ref 07/00815/FULEIA) in November 2007 (approved on 10 March 2008);
- sampling of galligu and soil from the Reclamation Mound for cementation trials and monolithic leaching tests (2008);
- collection of 30 samples of “pure” galligu from the Reclamation Mound to enable full characterisation of the contaminant levels in the various forms of galligu and the leachability of those substances (2008); and
- collection of 175 “exemption” samples from the Reclamation Mound at intervals of 1 sample every 250m$^3$ (2008).

The above data has also been supplemented by information obtained from the recent site investigation undertaken by EAME in 2011 and the additional testing of samples obtained from the Mound in December 2011. The locations were focussed on areas where the previous studies were limited and to provide data to update and build on previous ground investigation studies in order to develop a conceptual site model and allow sufficient characterisation of the site to adequately identify risks and develop appropriate mitigation measures. These findings were reported in the following chapters of the Environmental Statement and should be consulted for more detail:
• Chapter 12 & 13 of the recent Environmental Statement Report submitted by W A Fairhurst on behalf of The Stobart Group, as part of the planning submission (planning reference HBC Ref 11/00266/OUTEIA) in July 2011; and

• collection and testing of 31 samples from the Reclamation Mound (December 2011) to provide further confirmation of the characterisation of the contaminant levels in the various forms of galligu and the leachability of those substances. This was reported in Chapter 12 of the revised planning application for Stobart Park, Ref 11/00266/OUTEIA as submitted in January 2012.

In addition, further trial pits have recently been undertaken and soil samples collected from the reclamation mound and in the Phase I area (proposed Unit 3). These samples were obtained by Earth Tech Solutions (ETS) to assist in determination of suitable mix for the solidification specification. The samples were subjected to testing for a wide range of contaminants, leachability testing and monolithic testing. The results of this testing by ETS are currently outstanding at the time of preparation of this document.

2.4 Review of Verification Report, in Accordance with CL:AIRE Code of Practice - July 2009

The above report was prepared by Environ to provide appropriate verification that the material excavated from the Reclamation Mound (to the west of the proposed development site) was treated and re-used under the Contaminated Land: Applications in Real Environments (CL:AIRE) Definition of Waste: Development Industry Code of Practice (CoP), as issued in September 2008. The CL:AIRE CoP allows for such treatment and re-use of material to take place without the need for formal Environmental Permitting, provided certain requirements are undertaken and appropriately verified. The main four items enabling the reuse of material under CL:AIRE CoP are: 1) Suitability for Use, 2) Certainty of use, 3) Quantity for Use, and 4) Protection of Human Health and Environment. The report sets out the justification and verification through a series of risk assessments, testing and verification of the process by an independent person (Qualified Person).
To summarise the main issues provided in the report regarding risks to controlled waters comprise the following:

- Leachable chemical analysis from treated Galligu material was modelled using ConSim (a quantitative groundwater risk assessment modelling package), for risks to the River Mersey and the underlying Principal Aquifer. Although only treated and stabilised material was to be placed on site in order to provide a worst case scenario, untreated (i.e. pure Galligu) was also modelled;

- the treated material would be emplaced in compacted engineered layers and thus the site would essentially comprise hardstanding surface, essentially sealing in the treated Galligu. The suitability and placement of the treated material identified that the opportunities for leaching are extremely limited and the material is placed above the groundwater level; and

- the ConSim modelling assessment recorded that should leachate be generated from treated and untreated Galligu, this would pose a negligible risk to the River Mersey and the Principal Aquifer.

2.5 Site Observations of Potentially Contaminated Material (April 2011)

A site investigation was undertaken by EAME in 2011 to provide additional data on the ground conditions at the site and to complement previous investigations. The geology at the site was found to be broadly consistent with former investigations and with published information and can be summarised as follows:

- **Made Ground** was encountered in all sampling locations. This generally comprises hardstanding (concrete or tarmac) or unsurfaced ground comprising a grass/soil, soil/clay matrix or a gravel/silt/sand/clay matrix of varying thickness over fill material such as brown/grey/black sand, silt or clay with variable quantities of brick, gravel cobbles, ash, fragments of coal and slag, timber, metal, wire, glass plastic, ceramic tile and polystyrene overlying galligu chemical waste material. All trial pit locations and window sample holes excavated on the West Bank Dock site were terminated within the made ground deposits.
- **Natural Strata** was encountered in all the borehole locations and window sample holes excavated on the Foundry Lane site. The natural deposits encountered comprised:
  - *Alluvial Deposits*: consisting of soft to firm grey/brown/black silty clay, silt, clayey silt or sands. Alluvial deposits were not encountered in all exploratory hole locations; and
  - *Glacial Till*: consisting of soft to stiff, brown silty or sandy clay with occasional fine fragments of gravel. Glacial Till deposits were not encountered in all exploratory hole locations.

Variances within each of the geological stratifications were noted between the three distinct areas of the site comprising the Foundry Lane site, the Reclamation site and the West Bank Dock site. Therefore, a more detailed discussion of the geology encountered at each of the site areas is outlined below:

**Foundry Lane Site**

The material in this area comprised tarmac hardstanding or unsurfaced ground comprising a gravel/silt/sand/clay matrix over fill material such as sand, silt, clay with variable quantities of gravel, brick, cobbles, ash and fragments of coal. Glacial Till deposits were encountered at depth.

- Galligu chemical waste was encountered in three of the exploratory hole locations (WS8 and WS10-WS11) and generally comprised either a clayey or silty material which ranged in colour from green/orange/white, green/grey, orange/white to white.

- The depth of made ground was proven in all exploratory hole locations to depths ranging from 0.8m bgl (BH6) to a maximum depth of 2.20m bgl (WS11).

- The made ground was underlain by alluvial deposits generally comprising soft to firm grey/brown silty clay or grey clayey silt, which were encountered in all of the exploratory hole locations, with the exception of WS11, of up to 6.9m (BH6) in thickness.
Low permeability drift deposits of Glacial Till were encountered beneath the Alluvium/made ground, which comprise soft to stiff, brown, silty or sandy clay with occasional fine fragments of gravel. The clay deposits within the Glacial Till were encountered at depths ranging from 1.8m bgl (WS10) to 7.7m bgl (BH6), however, the depth (base) of the Glacial Till drift deposits was not proven in any of the exploratory hole locations.

Reclamation Site and Area to the North

Made ground was encountered at each of the exploratory hole locations, the depth of which was proven only in the borehole locations. Alluvial and Glacial deposits were encountered at depth within the boreholes.

- Within the reclamation mound, the made ground horizon comprised unsurfaced material comprising grass/soil or a sand/clay matrix over fill material such as sand, silt, clay with variable quantities of gravel. The surfacing layer at BH3 comprised concrete hardstanding, which is considered to be the original concrete plinth, as identified in the Health and Safety file for the Reclamation site compiled by Cheshire County Council, on to which waste material (predominantly galligu) was deposited. Underlying the concrete hardstanding at BH3 was a discrete dense black ash layer with fine to coarse gravel.

- Galligu chemical waste was encountered in two (BH2-BH3) of the four exploratory hole locations within the reclamation mound and generally comprised a clayey silt, silty clay or a solidified material either white, black, grey or mottled in colour ranging from black/grey/white, black/grey/green/yellow, brown/black, brown/yellow, to yellow/red.

- The made ground horizon, which was encountered to depths ranging from 3.2m bgl (BH5) to a maximum depth of 9.2m bgl (BH2), was underlain by alluvial deposits generally comprising soft to firm grey/black silty clay, sandy silty clay, black silt or grey/black silty sand. The depth of Alluvium was proven in two exploratory hole locations (BH3 and BH5) and was
encountered to depths of 6.8m bgl (BH3) and 8.15m bgl (BH5) with a thickness of up to 4.95m.

- The Alluvial deposits within BH3 and BH5 were further underlain by Glacial Till deposits comprising firm to stiff, brown/mottled brown, silty or sandy silty clay. The depth (base) of the Glacial Till drift deposits was not proven in either of the exploratory hole locations.

- Within the area to the north of the reclamation mound, the exploratory hole locations comprised an unsurfaced layer of clay/sand/gravel and soil directly underlain by fill material such as sand, silt, clay with variable quantities of gravel, brick and inclusions of metal, plastic, glass and timber (BH1) or galligu chemical waste.

- The galligu chemical waste comprised a silty, clayey silt, friable or solidified material, varying in colour from yellow, grey, yellow/grey, yellow/grey/black, yellow/brown, blue/white, white/yellow/orange to white.

- The made ground horizon was encountered within BH1 to a depth of 6.8m bgl and underlain by Glacial Till deposits comprising soft, brown silty clay to an undetermined depth.

**West Bank Dock Site**

Made ground within this area generally comprised a surfacing layer of either hardstanding (concrete or tarmac) or unsurfaced material of grass/soil, sand/clay matrix or limestone chippings overlying either brown/grey/black sand, silt or clay with variable quantities of brick, gravel, cobbles, ash, timber, plastic, wire, organic matter and fragments of coal and slag with occasional inclusions of polystyrene (TP17), glass and ceramic tile (TP3). A discrete dense black ash layer was also encountered within nine (WS4-WS7, TP5 and TP10-TP13) of the twenty-one locations and was generally encountered in locations positioned within the western portion of the West Bank Dock area.

Galligu chemical waste was encountered in all of the sampling locations, with the exception of TP7 and TP12, comprising a silt, clayey/sandy/gravelly silt or a powdery or solidified material ranging in colour
from yellow, grey, green, orange, white to mottled colours such as yellow/orange, yellow/green, yellow/green/brown, yellow/grey, yellow/black/white, black/orange, black/grey, grey/black/yellow, grey/black/white, green/grey, white/grey, green/white, brown/white/orange, black/brown/orange/white, brown/black/yellow and blue/white.

All exploratory hole locations within this area were terminated within the made ground deposits, thus, the depth (base) of this horizon was not proven.

### 2.6 Summary of Soil and Groundwater Chemical Status

#### Previous & Current Soils Analysis from Stobart Park

The potential sources of soil contamination are extensive as the site has been under industrial usage from at least the mid 1800s and is made up, in large parts, from historic chemical waste deposits (galligu) that also dominates the surrounding area.

Field evidence of potential contamination was noted during the recent investigation undertaken by EAME (April 2011) and accords with previous studies conducted at the site; identifying the widespread deposits of galligu chemical waste and a high frequency of inert materials such as brick, gravel and cobbles that were encountered across the site together with discrete granular ashy layers. Fragments of coal, slag, wire and variable quantities of clinker, plastic, timber metal and tile were also encountered particularly within the West Bank Dock area of the site; with occasional unidentifiable odours noted generally within the made ground horizon and occasional sulphide odours noted within the natural alluvial drift deposits.

The chemical testing of soils during the EAME investigation has not revealed significant concentrations of contaminants across the site in relation to screening criteria, where available. Of the sixteen USEPA PAH compounds, only one compound, benzo(a)pyrene, was detected above its screening value in one sample recovered from the made ground horizon. A significantly elevated concentration of lead (6,400mg/kg) was recorded above its respective screening value (750mg/kg) in one sample recovered from the made ground horizon; and a sample consisting of galligu chemical waste recorded an arsenic...
concentration slightly in excess of the screening criteria. Given the size of the site and the sporadic limited findings, these are not considered significant. In addition, the elevated metals are considered to be relatively immobile, especially as soil conditions are neutral to alkaline.

The other key contaminants that have been identified during the EAME investigation were sulphate and sulphide. There are no screening criteria for either of these parameters. Sulphate is relatively benign in environmental terms and is considered to be an issue in engineering terms only. However, sulphide compounds can be potentially hazardous by liberating hydrogen sulphide gas under certain conditions. Significantly elevated levels of sulphate and sulphide were recorded within the galligu chemical waste deposits, which accords with documented material that states that waste (galligu) arising from the Leblanc process (manufacture of sodium carbonate) was rich in sulphur compounds. Significantly elevated sulphide levels were also recorded in two samples recovered from the natural alluvial deposits where hydrogen sulphide odours were noted during the investigation.

Organic contamination is not prevalent at the site within either the made ground or underlying natural deposits, nor are any complex organic (hydrocarbon) species typically associated with the galligu chemical waste. This has been demonstrated through the petroleum hydrocarbon, polycyclic aromatic hydrocarbon and VOC (targeting aromatic compounds) testing and supported by the Total Organic Carbon (TOC) levels which showed very low levels of organic matter present; the absence of any notable visual and/or olfactory evidence of contamination; and low headspace (PID) test results.

The Environ 2007 EIA (67C12665 – ES Volume 2) concluded that chemical testing of the soils revealed that the site was contaminated to varying degrees. Following a review of the chemical data by EAME, in respect to current screening criteria, where available, the results from the previous Environ investigations accord with the recent EAME investigation in that lead and arsenic are generally the key contaminants associated with the site. Elevated levels of these metals were generally associated with the presence of ash and the galligu chemical waste deposits. Furthermore, leachability testing undertaken by Environ concluded that the metals within the made ground were not in a readily soluble and thus leachable form.
Elevated sulphate and sulphide concentrations were also recorded within the Environ investigations with significant levels of both contaminants identified within samples consisting of galligu chemical waste.

The 2004 Environ investigation identified hydrocarbon contamination within the shallow soils located within the area of the West Bank Dock site that formerly comprised the tank farm. It was noted that the tanks were poorly bunded; surface staining was noted around the base of the breeze block bund; the concrete hardstanding was noted to be cracked in places and to generally be in a poor state of repair; the drainage system did not appear to be functioning properly i.e. oily water present on the surface; and field evidence of hydrocarbon contamination was noted in both the soil profile, in the form of a hydrocarbon odour and the perched water, which was discoloured and comprised a significant oily sheen. Hydrocarbon contamination was also identified in a trial pit location situated on the area of land located to the north of the Reclamation site however, no visual or olfactory evidence of contamination was noted during the excavation of the location. It was concluded that results were indicative of localised hotspots of TPH contamination rather than widespread contamination of the site by hydrocarbons. Following a review of the hydrocarbon chemical data, by EAME, in relation to current screening criteria, results from the previous Environ investigation accord with the recent EAME findings that organic contamination is not prevalent at the site.

Asbestos presence was only identified within the shallow soils at one exploratory location within the West Bank Dock site during the 2004 Environ investigation and the 2011 EAME investigation. However, given the known historic landfilling within the West Bank Dock area, the presence of other asbestos containing materials present on the site cannot be ruled out.

Previous & Current Soils Analysis from Reclamation Mound
In 2008, Environ completed a targeted trial pitting exercise within the area of the reclamation mound destined for removal and subsequent re-use in the development of the Tesco distribution centre located to the east of Stobart Park (referred to as Phase 1). A total of 30 samples of ‘pure galligu’ chemical waste were recovered from various depths and locations within the mound, which were analysed for a range of chemical parameters (metals, water soluble sulphate, chloride, fluoride, pH and
organic carbon) and leaching tests in order to try and characterise the full range of pollution potential of the galligu. These results were assessed in relation to the prevailing contaminated land guidance (CLEA Industrial SGVs), which have now largely been withdrawn and showed that only arsenic and lead (and only in a few cases) exceeded the relevant criteria (CLEA Industrial SGV) and thus these were considered to be the principal contaminants of concern from an environmental risk perspective. The Total Organic Carbon (TOC) levels in the galligu characterisation analysis showed very low levels of organic matter present. For continuity and the purpose of this assessment, the results have also been reviewed in relation to current screening criteria (2009 SGVs published by the Environment Agency and the CIEH values (second edition, 2009) with the exception of the former 2002 lead SGV which has been used in lieu of any other criteria). Results are comparable with the 2008 assessment; with only three arsenic exceedances (maximum concentration of 900mg/kg) above its relevant screening value and one exceedance (1,200mg/kg) for lead.

In 2008, as part of the application for a Waste Management Exemption for material to be moved from the reclamation mound to the former Tessenderlo area, that was being redeveloped as the Tesco distribution centre, a further 174 samples were obtained from the reclamation mound by Environ. The targeted analytical suite comprised total arsenic and lead and in addition, every tenth sample was submitted for a comprehensive suite of analysis (pH, range of metals, total sulphate and sulphide). An assessment was made of the Hazardous Properties of the material sampled (representing the first 43,500m$^3$ to be moved under the Phase 1 works (Project Eagle)). The assessment demonstrated that none of the samples would exceed the relevant hazardous property threshold for metals and thus the material would not be classified as hazardous waste due to metal content. For continuity and the purpose of this assessment, the results were reviewed in relation to the current screening criteria based on the 2009 SGVs published by the Environment Agency and the CIEH values (second edition, 2009) with the exception of the former 2002 lead SGV which has been used in lieu of any other criteria. The results indicated that the arsenic criteria was exceeded nine times with a maximum concentration of 1,200mg/kg, recorded, which is only slightly above its relevant screening value (640mg/kg) and only two exceedances (maximum concentration of 1,000mg/kg) for lead with one sample returning a concentration equal to the screening value of 750mg/kg. Sulphate concentrations ranged between 270 mg/kg and 52,000mg/kg and sulphide concentrations ranged from below the laboratory analytical MDL.
to 1,100mg/kg. No other chemical contaminants were identified above respective screening criteria.

The investigation works undertaken by Beach Stabilisation in 2008 within the Mound also confirmed that the material encountered is predominantly galligu overlain by a substantial thickness of soil and clay (this was confirmed by further investigation and analysis performed by Environ in 2008).

In December 2011, a targeted trial pitting exercise was completed within the area of the Reclamation Mound by mechanical excavation of twenty (20) trial pits (TP23–TP42) to a maximum depth of 4.8m bgl (TP34 and TP37). The locations of the trial pits are provided within annotated on Figure 1b. Forty seven samples were obtained and 31 tested for chemical compounds, with 10 subjected to leachability testing. The investigation was undertaken to provide additional data on the galligu material within the reclamation mound and to build on previous investigations/sampling exercises.

All trial pit locations were terminated within the made ground deposits, which comprised unsurfaced material of grass/soil or a sand/clay matrix over fill material such as sand, silt, clay with variable quantities of gravel, brick, concrete, ash, fragments of clinker, slag and timber, metal, wire, glass, clay pipe, plastic and plastic bags, and ceramic tile and galligu chemical waste material. The Galligu chemical waste was encountered in all trial pit locations and generally comprised a clayey/sandy silt or a solidified material either white, grey, green or blue, or mottled in colour ranging from grey/green, green/white, blue/white, yellow/orange and yellow/brown. Visual evidence of contamination was noted in the form of the galligu chemical waste and variable quantities of ash, fragments of clinker, slag and timber, metal, wire, glass, clay pipe, plastic and plastic bags, and ceramic tile that were encountered throughout the made ground deposits. Suspected asbestos-containing materials were noted within TP37 at a depth of 2.10m bgl. This was subsequently screened for laboratory asbestos identification however, no asbestos was detected.

A total of forty seven samples were recovered from the trial pit locations; of which, a total of thirty one samples were submitted for laboratory chemical testing. All samples were recovered from the made ground. Fifteen samples were recovered from the various guises of galligu chemical waste; five samples were recovered from galligu contaminated soils; and eleven samples from the general fill material.
The key contaminants of concern in relation to galligu chemical waste are considered to be lead, arsenic, sulphate and sulphide. However, each sample was submitted for a comprehensive analytical suite comprising a range of metals (including arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc), pH, water soluble sulphate, total sulphate, sulphide and ammonium. Ten samples were also subject to leaching tests in order to further characterise the leachability of the galligu. One sample was submitted for laboratory asbestos identification as asbestos containing materials (ACMs) were suspected within the field. One trial pit indicated potential organic species and was thus tested for TPH CWG and speciated PAHs.

The results for this recent mound investigation have also been reviewed in relation to current screening criteria (2009 SGVs published by the Environment Agency and the CIEH values (second edition, 2009) with the exception of the former 2002 lead SGV which has been used in lieu of any other criteria).

Of the thirty one samples submitted for the range of metals, as identified above, the majority of the metals analysed recorded concentrations below the relevant screening criteria with the exception of lead. Two samples recorded lead concentrations (830 mg/kg and 2,300mg/kg) in excess of the current screening criteria (750mg/kg); the highest concentration was detected in a sample recovered from the fill material within TP41. The pH values ranged from neutral to alkaline in the range of pH 7.0 - 12.1. Water soluble sulphate concentrations ranged from 0.064g/l to 8.9g/l and total sulphate concentrations ranged from 120mg/kg and 150,000mg/kg. Sulphide concentrations ranged from 2.3mg/kg to 1,300mg/kg (TP33, 1.8m bgl). The elevated levels of sulphide were generally recorded within the galligu chemical waste deposits, which accords with previous analytical data for galligu and documented material. Ammonium (as NH₄) (ammonia generally exists in soils as NH₄ + which binds to soil particles) concentrations ranged from below the laboratory analytical MDL to 150mg/kg respectively, with the highest concentration recorded in TP38 within sample recovered from the general fill material. There is no appropriate screening criterion. Total Organic Carbon (TOC) levels showed very low levels of organic matter present. PAH (USEPA Priority 16 PAHs) and TPH CWG analysis was undertaken on one sample recovered from the general fill material in TP35, which exhibited a strong hydrocarbon odour in the field. All detectable PAH and TPH CWG compounds were either below the laboratory analytical MDLs or below respective screening criteria. No visual evidence of contamination
was noted on the sample and the headspace PID) test result was negligible. Asbestos screening was undertaken on a made ground sample recovered from the general fill material in TP37, which was considered to potentially contain ACMs within the field. However laboratory identification confirmed that no asbestos was detected.

Leachability testing did not record concentrations of cadmium, chromium and mercury above the method detection limit. Nickel was recorded in 4 samples, but was well below the relevant EQS. Only one galligu sample recorded an arsenic concentration above the EQS (TP25); lead was detected above the EQS in one galligu sample (TP24); zinc was detected in four galligu samples above the relevant EQS (TP24, TP25, TP37 and TP39); and the majority of copper concentrations exceeded its EQS value. However, this leachability is observed under laboratory conditions for untreated “pure” galligu.

The above findings, observations and test results are similar in nature to previous investigations within the mound i.e. there does not appear to be significant variance of the material encountered in this recent investigation, compared with results identified previously.

**Groundwater Conditions**

In addition to soil contamination, it was apparent from the various works at the site that contamination of the groundwater was recorded. The hydrogeology is complex as multiple groundwater bodies have been identified and can be summarised as follows:

<table>
<thead>
<tr>
<th>Table 2.2: Groundwater Bodies Identified by Intrusive Investigations</th>
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</thead>
<tbody>
<tr>
<td><strong>Water Body</strong></td>
</tr>
<tr>
<td>I – Perched Water</td>
</tr>
<tr>
<td>II – Sand/Silt Lenses (alluvial)</td>
</tr>
</tbody>
</table>
Table 2.2: Groundwater Bodies Identified by Intrusive Investigations

<table>
<thead>
<tr>
<th>Water Body</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>groundwater levels across the site area, within this stratum, which is dependent on the presence of sand/silt lenses within the clay deposits. It is believed that the thickness of the clay reduces in the eastern section of the site;</td>
</tr>
<tr>
<td>III – Glacial Till Water</td>
<td>Sand and gravel deposits encountered within the Glacial Till. These sands and gravels are likely to be a good indicator of potential contamination risk to the deeper major aquifer. In other words, if this horizon is relatively uncontaminated it is likely that the major aquifer will not have been affected by site based contaminants;</td>
</tr>
<tr>
<td>IV – Sherwood Sandstone Aquifer</td>
<td>The Sherwood sandstone aquifer which underlies the area regionally is a major groundwater bearing stratum and Principal Aquifer.</td>
</tr>
</tbody>
</table>

- From the investigations, the groundwater within the alluvial/glacial till horizons appears to be flowing in a south-westerly direction, towards the river basin, which is not unexpected. There appears to be no discernible trend or dynamic to the perched water within the Made Ground.

- It is also considered likely that the groundwater levels are influenced by the tide, which is not to be unexpected given the proximity to the estuary. Previous studies have used automatic hydraulic level loggers, which were undertaken in 2004 and 2011 and were placed in boreholes representative of differing groundwater bodies and also within Stewards and Ditton Brooks. The results obtained in 2011 concurred with the findings of 2004 in that it appears that there is a tidal influence on the water bodies within the Alluvium and Glacial Till, but not within the perched water within the made ground. This cyclical fluctuation in the natural groundwater implies that in the natural strata at least there is some connectivity between the surface waters and groundwater.

- The groundwater regime is also complicated due to the influence of other factors including for example, the installation of the sheet piled wall along the length of Stewards Brook adjacent to the Reclamation side of the site and the Ditton Brook (in part), which was installed approximately 17 m below ground level. Furthermore, the hydrostatic pressure exerted by the Reclamation
Mound and the adjacent HEDCO site is also likely to be an influencing factor together with the granular glacial deposits within the palaeo channel, which may affect the overall groundwater regime.

The sample analysis from retrieved groundwater samples identified that the groundwater is contaminated to varying degrees by various substances but that these need further assessment to ascertain the overall impact on the groundwater and surface water regime in the area.

**Groundwater Quality (2011)**

There are no statutory UK guidelines for chemical contamination of groundwater at present. The UK Water Supply (Water Quality) Regulations 2010 are often used to assess the results of groundwater investigations. However, since they are drinking water standards, they generally represent conservative reference values and they should not be applied prescriptively for all situations, particularly where water is not abstracted for drinking water supplies as is the case on this site. Where Environmental Quality Standards (EQS) exist these have also been considered.

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<thead>
<tr>
<th>Determinant</th>
<th>No. Analysed</th>
<th>Max. Conc. Detected (Sample Ref.)</th>
<th>Guideline Values (µg/l)</th>
<th>No. Equal to or exceeding Guideline</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inorganic Parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>6</td>
<td>11.7 (BH1)</td>
<td>6.5 – 10^4</td>
<td>1 (BH1)</td>
</tr>
<tr>
<td>Total cyanide</td>
<td>6</td>
<td>&lt;10 – 160 (BH3)</td>
<td>50^1</td>
<td>1 (BH3)</td>
</tr>
<tr>
<td>Sulphate as SO₄</td>
<td>6</td>
<td>2,700,000 (BH1, BH3)</td>
<td>250,000^1</td>
<td>6 (all)</td>
</tr>
<tr>
<td>Sulphide</td>
<td>6</td>
<td>310,000 (BH4)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chloride</td>
<td>6</td>
<td>3,000 mg/l (BH3)</td>
<td>250 mg/l^2</td>
<td>6 (all)</td>
</tr>
<tr>
<td>Ammonia as NH₃</td>
<td>6</td>
<td>19,000 (BH4)</td>
<td>15^2</td>
<td>6 (all)</td>
</tr>
<tr>
<td>Ammonium as NH₄</td>
<td>6</td>
<td>20,000 (BH4)</td>
<td>500^1</td>
<td>6 (all)</td>
</tr>
<tr>
<td>Nitrate as N</td>
<td>6</td>
<td>5.2 mg/l (BH1)</td>
<td>50 mg/l^1</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 2.3: Summary of Groundwater Analytical Results (2011)

<table>
<thead>
<tr>
<th>Determinant</th>
<th>No. Analysed</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Nitrite as N</td>
<td>6</td>
<td>ND</td>
<td>500&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>6</td>
<td>930 (BH5)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dissolved oxygen</td>
<td>6</td>
<td>6.2 mg/l (BH1, BH4)</td>
<td>&lt;6 mg/l</td>
<td>3 (BH3, BH5, BH6)</td>
</tr>
<tr>
<td>Hardness</td>
<td>6</td>
<td>488 – 2180 mg/l (BH3)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Heavy Metals**

<table>
<thead>
<tr>
<th>Determinant</th>
<th>No. Analysed</th>
<th>Max. Conc. Detected (Sample Ref.)</th>
<th>Guideline Values (µg/l)</th>
<th>No. Equal to or exceeding Guideline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic (dissolved)</td>
<td>6</td>
<td>88 (BH4)</td>
<td>10&lt;sup&gt;3&lt;/sup&gt;</td>
<td>5 (BH1 – BH5)</td>
</tr>
<tr>
<td>Boron (dissolved)</td>
<td>6</td>
<td>810 (BH6)</td>
<td>1,000&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0</td>
</tr>
<tr>
<td>Cadmium (dissolved)</td>
<td>6</td>
<td>ND</td>
<td>5&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0</td>
</tr>
<tr>
<td>Chromium (dissolved)</td>
<td>6</td>
<td>5.9 (BH4)</td>
<td>50&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0</td>
</tr>
<tr>
<td>Copper (dissolved)</td>
<td>6</td>
<td>5.8 (BH6)</td>
<td>2,000&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0</td>
</tr>
<tr>
<td>Iron (dissolved)</td>
<td>6</td>
<td>2.8 mg/l (BH6)</td>
<td>0.2 mg/l&lt;sup&gt;1&lt;/sup&gt;</td>
<td>3 (BH2, BH4, BH6)</td>
</tr>
<tr>
<td>Fe&lt;sup&gt;2+&lt;/sup&gt;</td>
<td>6</td>
<td>2.35 mg/l (BH1)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fe&lt;sup&gt;3+&lt;/sup&gt;</td>
<td>6</td>
<td>2.76 mg/l (BH6)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lead (dissolved)</td>
<td>6</td>
<td>9.6 (BH2)</td>
<td>25&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0</td>
</tr>
<tr>
<td>Manganese (dissolved)</td>
<td>6</td>
<td>3,300 (BH3, BH5)</td>
<td>50&lt;sup&gt;1&lt;/sup&gt;</td>
<td>5 (BH2 – 5)</td>
</tr>
<tr>
<td>Mercury (dissolved)</td>
<td>6</td>
<td>ND</td>
<td>1&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0</td>
</tr>
<tr>
<td>Nickel (dissolved)</td>
<td>6</td>
<td>10 (BH5)</td>
<td>20&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0</td>
</tr>
<tr>
<td>Selenium (dissolved)</td>
<td>6</td>
<td>ND</td>
<td>10&lt;sup&gt;1&lt;/sup&gt;</td>
<td>-</td>
</tr>
<tr>
<td>Zinc (dissolved)</td>
<td>6</td>
<td>33 (BH3)</td>
<td>5,000&lt;sup&gt;1&lt;/sup&gt;</td>
<td>0</td>
</tr>
</tbody>
</table>

**Major Ions**

<table>
<thead>
<tr>
<th>Determinant</th>
<th>No. Analysed</th>
<th>Max. Conc. Detected (Sample Ref.)</th>
<th>Guideline Values (µg/l)</th>
<th>No. Equal to or exceeding Guideline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium (dissolved)</td>
<td>6</td>
<td>610 mg/l (BH3)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Magnesium (dissolved)</td>
<td>6</td>
<td>160 mg/l (BH3)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
## Table 2.3: Summary of Groundwater Analytical Results (2011)

<table>
<thead>
<tr>
<th>Determinant</th>
<th>No. Analysed</th>
<th>Max. Conc. Detected (Sample Ref.)</th>
<th>Guideline Values (µg/l)</th>
<th>No. Equal to or exceeding Guideline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium (dissolved)</td>
<td>6</td>
<td>78 mg/l (BH4)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sodium (dissolved)</td>
<td>6</td>
<td>1,100 mg/l (BH5)</td>
<td>200 mg/l$^1$</td>
<td>6 (all)</td>
</tr>
<tr>
<td><strong>Phenols</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total monohydric phenols</td>
<td>6</td>
<td>ND</td>
<td>7.7$^2$</td>
<td>0</td>
</tr>
<tr>
<td>Total phenols (HPLC)</td>
<td>6</td>
<td>ND</td>
<td>7.7$^3$</td>
<td>0</td>
</tr>
<tr>
<td><strong>Hydrocarbons</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total EPA-16 PAHs</td>
<td>6</td>
<td>1.8 (BH1, BH3)</td>
<td>0.1$^1$</td>
<td>4 (BH1, BH3, BH5, BH6)</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>6</td>
<td>&lt;0.01 – 0.2 (BH1)</td>
<td>1.2$^2$</td>
<td>0</td>
</tr>
<tr>
<td>Acenaphthylene</td>
<td>6</td>
<td>&lt;0.01 – 0.07 (BH1)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Acenaphthene</td>
<td>6</td>
<td>&lt;0.01 – 0.3 (BH1)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fluorene</td>
<td>6</td>
<td>&lt;0.01 – 0.17 (BH1)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Phenanthrene</td>
<td>6</td>
<td>&lt;0.01 – 0.58 (BH3)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Anthracene</td>
<td>6</td>
<td>&lt;0.01 – 0.17 (BH3)</td>
<td>0.4$^4$</td>
<td>0</td>
</tr>
<tr>
<td>Fluorantheme</td>
<td>6</td>
<td>&lt;0.01 – 0.42 (BH3)</td>
<td>1$^4$</td>
<td>0</td>
</tr>
<tr>
<td>Pyrene</td>
<td>6</td>
<td>&lt;0.01 – 0.34 BH3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BTEX</td>
<td>6</td>
<td>ND</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>MTBE</td>
<td>6</td>
<td>ND</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>TPH Aliphatic (C5 – C35)</td>
<td>6</td>
<td>630 (BH1)</td>
<td>10$^5$</td>
<td>6 (all)</td>
</tr>
<tr>
<td>TPH Aromatic (C5 – C35)</td>
<td>6</td>
<td>ND</td>
<td>10$^5$</td>
<td>0</td>
</tr>
<tr>
<td><strong>VOCs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VOCs</td>
<td>6</td>
<td>ND</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VOCs TICs</td>
<td>6</td>
<td>ND</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>SVOCs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
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</tr>
</thead>
<tbody>
<tr>
<td>Naphthalene</td>
<td>6</td>
<td>0.2 (BH1)</td>
<td>1.2(^3)</td>
<td>0</td>
</tr>
<tr>
<td>Hexachlorobutadiene</td>
<td>6</td>
<td>0.65 (BH1)</td>
<td>0.1(^3)</td>
<td>1 (BH6)</td>
</tr>
<tr>
<td>2-Methylnaphthalene</td>
<td>6</td>
<td>0.37 (BH4)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Acenaphthylene</td>
<td>6</td>
<td>0.07 (BH1)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Acenaphthene</td>
<td>6</td>
<td>0.3 (BH1)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dibenzofuran</td>
<td>6</td>
<td>0.2 (BH1)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4-Chlorophenyl phenyl ether</td>
<td>6</td>
<td>0.21 (BH1)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fluorene</td>
<td>6</td>
<td>0.17 (BH1)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hexachlorobenzene</td>
<td>6</td>
<td>0.31 (BH1)</td>
<td>0.05(^4)</td>
<td>1 (BH1)</td>
</tr>
<tr>
<td>Phenanthrene</td>
<td>6</td>
<td>0.58 (BH3)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Anthracene</td>
<td>6</td>
<td>0.17 (BH1, BH3)</td>
<td>1(^4)</td>
<td>0</td>
</tr>
<tr>
<td>Fluoranthene</td>
<td>6</td>
<td>0.42 (BH3)</td>
<td>0.1</td>
<td>4 (BH1, BH3, BH5, BH6)</td>
</tr>
<tr>
<td>Pyrene</td>
<td>6</td>
<td>0.34 (BH3)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>SVOCs TICs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>91-pentyloctyl- Benzene</td>
<td>6</td>
<td>BH1</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

All concentrations are in µg/l unless specified.

ND = not detected

\(^1\) = Water Supply (Water Quality) Regulations 2010

\(^2\) = EQS Freshwater Annual Average

\(^3\) = EQS

\(^4\) = MAC EQS – Maximum Allowable Concentration

\(^5\) = Water Supply (Water Quality) Regulations 1989 (SI 1989/1147) as amended
It is important to note that both the Drinking Water Standards are conservative and are generally applied in situations where the groundwater is abstracted for potable water supply, which is not appropriate to the site.

- **The pH values** were found to be neutral to alkaline (in the range pH 7.3 – 11.7). However, only one sample recorded alkaline pH’s greater than 9.0, with the maximum pH value detected in the sample collected from BH1, which was installed within Glacial Till deposits. This high pH value is reflective of the strongly alkaline nature of Galligu and typical for groundwaters in contact with *Leblanc* waste. This would suggest that the groundwater found in BH1 is in connectivity with the groundwater located in the Made Ground.

- **Sulphate (as SO\textsubscript{4})** concentrations ranged from 200,000 µg/l (BH6) to 2,700,000 µg/l (BH1 and BH3). All six samples recorded sulphate concentrations in excess of the UK Drinking Water Quality (DWQ) Guideline of 250,000 µg/l. The significantly elevated concentrations of sulphate indicate that the groundwater bodies across the site have been in contact with Galligu contaminated Made Ground.

- **Total cyanide** concentrations were not observed above the analytical detection limit (<30 in three of the six samples analysed. However, just one sample (BH3) was found to above the UK DWQ standard of 50 µg/l at 160 µg/l.

- Concentrations of **monohydric phenol** were not found above the analytical detection limit.

- Elevated concentrations of **arsenic** were detected in all of the six groundwater samples analysed, all of which exceeded the UK DWQ standard (10 µg/l) and five exceeded the EQS guideline value (25 µg/l). Arsenic is a notable contaminant associated with Galligu.

- All six samples were found to have significantly elevated concentrations, above the EQS value (1 µg/l), of **copper**. A maximum concentration of 5.8 µg/l was detected at BH6.
- Three samples (BH2, BH4 and BH6) were found to be elevated above the relevant guideline value for iron.

- Nickel, chromium, zinc and boron were recorded in several locations; however, all concentrations were below the relevant guideline values.

- Cadmium, lead, selenium or mercury concentrations were not detected above the analytical detection limit in any of the samples and therefore below all relevant guideline values.

- All of the samples submitted for sulphide analysis returned concentrations above the analytical limit of detection. The sulphide concentrations were ranged between 5.1 µg/l (BH3) and 310,000 µg/l (BH4). Although there are no relevant guideline criteria, the sulphate levels recorded in BH1 (12,000 µg/l) and BH4 (310,000 µg/l) are considered to be significantly elevated.

- All six samples were submitted for Total Petroleum Hydrocarbons – Criteria Working Group (TPH CWG) analysis; all samples were found to contain alipha hydrocarbons with the carbon chain of between C10 – C35. None of the samples were found to contain any aromatic hydrocarbon carbon chains. The maximum total aliphatic hydrocarbons (C5 – C35) was found to be 630 µg/l (BH1). The TPH contamination is not considered to be widespread as elevated concentrations of TPH have not been found in the soil or groundwater at nearby locations. This is therefore, likely to be more indicative of localised hotspots associated with oil based activities in this area rather than widespread contamination of the site by hydrocarbons.

- Speciated Poly Aromatic Hydrocarbons (PAHs) were found in four of the six samples submitted for analysis which indicated trace concentrations of individual PAH compounds with a number of the individual compounds detected above relevant guidelines (where available). The highest concentration (1.8 µg/l) of total EPA-16 PAHs was found at BH1 and BH3.

- No VOCs or VOC TICs were not observed above the laboratory analytical detection limit.
Twelve SVOCs and SVOC TICs were detected across the six samples submitted, the highest concentrations of which were mainly found in the sample obtained from BH1.

**Previous Groundwater Data**

Environ were commissioned in 2004 to undertake an intrusive investigation of the site to support the design of the development proposals at that time. Sampling locations were positioned to provide a representative spatial assessment of the ground conditions, to target identified areas of potential contamination (e.g. current storage tanks) and to provide preliminary geotechnical information. The intrusive investigation was carried by Environ over a period of five weeks, from the 8th November 2004 to the 16th December 2004 with subsequent periods of sample analysis, monitoring and assessment of results. This study and its results are presented in the Environmental Statement Report (67C12665 – ES Volume 2) that was submitted as part of the planning submission (planning reference HBC Ref 07/00815/FULEIA) in November 2007 (approved on 10th March 2008).

Groundwater samples were obtained by Environ as part of the 2004 investigation. Analysis was undertaken on fifteen samples of groundwater; eleven of which were obtained from the installed boreholes, two from the installed window samples and two from the excavated trial pits.

The results of the groundwater analysis were assessed in relation to the UK Drinking Water Standards and the Dutch Intervention Values, which were used as assessment criteria to screen the results and provide a baseline assessment of groundwater conditions at that time.

Environ’s results from 2004 are repeated here for completion:

- *slightly elevated concentrations of arsenic* (BH14, BH34, BH9, BH31), *cadmium* (WS6, BH23), *lead* (WS4) and *mercury* (BH43) were recorded. Generally, the elevated metal levels were recorded within the perched groundwater, with the exception of a cadmium concentration detected in BH23 and two arsenic concentrations detected in BH9 and BH31, which were detected within the natural, deeper groundwater;
elevated levels of Total Petroleum Hydrocarbons TPH were recorded in WS6 (6,900 µg/l). The sample was interpreted by the laboratory as being consistent with diesel and lubricating oil, which accords with the on-site field evidence of contamination at that location. Elevated TPH concentrations were also detected in BH12 (1,100 µg/l), which was interpreted as being consistent with gas oil and lubrication oil, BH43 (1,100 µg/l), which was interpreted as being consistent with lubrication oil and TP16 (900 µg/l), which was described as ranging between the C_{10} – C_{40} range. Three (WS6, BH43 and TP16) of the four detected concentrations were recorded in locations installed with the made ground horizon, however, the sample recovered from BH12 comprised groundwater from the silty/sandy clay deposits within the Glacial Till horizon. However TPH contamination is not considered to be widespread as elevated concentrations of TPH have not been found in the soil or groundwater at nearby locations and none has been found in the Reclamation Mound. This is therefore, likely to be more indicative of localised hotspots associated with oil based surface activities in this area rather than widespread contamination of the site by hydrocarbons;

generally, poly-aromatic hydrocarbon (PAH) contamination within the groundwater is not considered significant, as the majority of the recovered groundwater samples detected individual PAHs below their respective analytical detection limits. However, elevated concentrations of some of the individual PAH compounds were detected in perched water recovered from TP16 (fluoranthene, benzo (a) anthracene, chrysene, benzo (k) fluoranthene, benzo (a) pyrene, indeno (1,2,3-cd) pyrene and benzo (g,h,i) perylene) and BH34 (benzo (a) pyrene) together with the natural groundwater within the Fluvio-glacial Sands and Gravels horizon recovered from BH23 (indeno (1,2,3-cd) pyrene and benzo (g,h,i) perylene). The elevated PAHs in the groundwater appear to be indicative of localised hotspots rather than site wide contamination, however, in the context of the site’s environmental setting these levels are not considered to be significant;

sulphide was detected in the groundwater at significant concentrations in the locations of BH43 (7,300 µg/l), BH14 (140,000 µg/l) and TP23 (200,000 ug/l). These locations were in Made Ground. Although sulphide contamination was noted within the shallow soils, comprising galligu, the groundwater does not appear to have been significantly impacted overall by this;
- significantly elevated sulphate levels were recorded on-site within the groundwater, with concentrations ranging from 68 mg/l to 6,380 mg/l. All fifteen groundwater samples analysed, recorded sulphate in excess of the UK DWQ guideline value (250 mg/l), with the highest levels generally recorded within the perched water. The galligu is the most obvious source of these elevated sulphate levels; and

- significant levels of the individual ions were detected within the groundwater beneath the site and were generally found within the shallow perched water, where the maximum concentrations of nitrate, potassium, calcium and alkalinity were recorded. The maximum concentrations of chloride, ammonia, sodium and magnesium were detected in the natural groundwater within the alluvial and glacial clay deposits. Given the significant levels of the individual ions, it could indicate that these chemicals are leaching out of the soils and into the groundwater, but these may also be a result of saline intrusions that are likely to have occurred in the area.

A summary of the noteworthy groundwater analytical results is presented in the table below. Please refer to the Environmental Statement (67-C12665, November 2007) for fuller details of the groundwater regime and quality.

<table>
<thead>
<tr>
<th>Sample Reference</th>
<th>Contaminants</th>
<th>On-Site Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH8 (groundwater)</td>
<td>Cl, Ammonia, SO₄</td>
<td>Unsurfaced area adjacent to Ditton Brook on Foundry Lane site</td>
</tr>
<tr>
<td>BH9 (groundwater)</td>
<td>As, Cl, Ammonia, SO₄</td>
<td>Unsurfaced area adjacent to Ditton Brook on Foundry Lane site</td>
</tr>
<tr>
<td>BH11 (groundwater)</td>
<td>Cl, Ammonia, SO₄</td>
<td>Unsurfaced area adjacent to Ditton Brook on Foundry Lane site</td>
</tr>
<tr>
<td>BH12 (groundwater)</td>
<td>TPH, Cl, Ammonia, SO₄</td>
<td>Northern area of the Foundry Lane site</td>
</tr>
<tr>
<td>BH14 (groundwater)</td>
<td>S₂, As, Cl, Ammonia, SO₄</td>
<td>Unsurfaced area north of the Reclamation site</td>
</tr>
<tr>
<td>BH15 (groundwater)</td>
<td>Cl, Ammonia, SO₄</td>
<td>Adjacent to Excel building on Foundry Lane</td>
</tr>
</tbody>
</table>
### Table 2.4: Groundwater Contaminants (2004)

<table>
<thead>
<tr>
<th>Sample Reference</th>
<th>Contaminants</th>
<th>On-Site Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>BH23 (groundwater)</td>
<td>PAH, As, Cd, Cl, Ammonia, SO4</td>
<td>Unsurfaced area north of the Reclamation site</td>
</tr>
<tr>
<td>BH31 (groundwater)</td>
<td>As, Cl, Ammonia, SO4</td>
<td>Adjacent to ASTs in tank farm area within West Bank Dock site</td>
</tr>
<tr>
<td>BH34 (groundwater)</td>
<td>PAH, As, Cl, Ammonia, SO4</td>
<td>Adjacent to AST located in northern section of West Bank Dock site</td>
</tr>
<tr>
<td>BH43 (groundwater)</td>
<td>TPH, S2, Hg, Cl, Ammonia, Nitrate, SO4</td>
<td>Close proximity to the derv AST within former transport yard on the West Bank Dock site</td>
</tr>
<tr>
<td>BH55 (groundwater)</td>
<td>Cl, Ammonia, SO4</td>
<td>Unsurfaced area in southern section of West Bank Dock site</td>
</tr>
<tr>
<td>WS4 (groundwater)</td>
<td>Pb, SO4</td>
<td>Adjacent to uncontained drums behind Unit 2 on the West Bank Dock site</td>
</tr>
<tr>
<td>WS6 (groundwater)</td>
<td>TPH, As, Cd, SO4</td>
<td>Adjacent to ASTs in the tank farm located on West Bank Dock site</td>
</tr>
<tr>
<td>TP16 (groundwater)</td>
<td>TPH, PAH, SO3</td>
<td>Southern section of Reclamation Mound</td>
</tr>
<tr>
<td>TP23 (groundwater)</td>
<td>S2</td>
<td>Southern section of Reclamation Mound</td>
</tr>
</tbody>
</table>

### 2.7 Summary of Current Information

The recent chemical testing of the soil and groundwater has revealed that the site is contaminated to varying degrees and that this is impacting upon groundwater. It should be noted that the above provides an indication of the presence and general magnitude of contamination at the site and has shown that there may be areas where other contaminants could be identified.

Clearly there is a contamination source on the site that appears to be impacting upon groundwater quality to varying degrees and in turn may also be contributing to poor surface water quality where there is hydraulic connectivity between the surface water and groundwater bodies.
It is also quite clear from the level logging data that the groundwater bodies across the site are tidally influenced, as the level logging data provided by Stewards Brook, Ditton Brook and the boreholes correlate. This implies that the steel sheet piling around the Reclamation Mound, which is intended to provide an effective hydraulic barrier between the groundwater within the sheet piled area and the estuary and Ditton and Steward’s Brook, may not be working effectively. Consequently contaminant transfer is possible and may be occurring, although it is also possible that the synchronicity between tidal cycles and the groundwater level behind the sheet piling is due to changes in pore pressure associated with the rising and falling tide having a related effect on the groundwater regime in the area. In other words, whilst there may be a hydrostatic effect, it does not necessarily mean that the groundwater behind the sheet piling and the estuarine water are co-mixing.

The source of the elevated concentrations of metallic and inorganic contaminants with respect to the various guidelines is likely to be a combination of the potential galligu composition of the stream bed of Steward’s Brook, the galligu composition of the surrounding land and the unlined HEDCO landfill site, which forms part of the eastern boundary of Stewards Brook and was a chemical waste disposal site. The hydrocarbon components of the contaminants identified are less likely to be from the galligu which is a predominantly inorganic pollutant source and more likely to be from surface run-off and other sources of localised contamination and possibly landfill leachate.

It is recognised that although the HEDCO site is likely to be the main contributor to contamination of Steward’s Brook given that it is an unlined chemical waste site, there may also be some infiltration and leaching of contaminants from the development site that is adding to the pollution loading overall. Notwithstanding these two sources, the wider area itself is made up of galligu contaminated soils and there will also be a widespread pollution burden from the general area.

Marsh Brook is not a significant surface water feature and is now a newly hydraulically lined drainage channel receiving surface water discharges from the Tesco Distribution Centre site (Tesco DC) and tidal inundations. Steward’s Brook and Ditton Brook are more substantial water courses and are likely to be receiving groundwater base flow as well as surface water discharges, all of which have some potential to be contaminated at present.
Throughout the numerous investigations and assessments of the site relatively consistent characteristics have been identified which give a good degree of confidence as to the nature and presence of contaminants likely to be encountered on the site. The studies suggest that the site is predominantly underlain by galligu or galligu contaminated soils and the principal soil contaminants are inorganic species. There is little evidence on the site of hydrocarbon based contamination (other than some highly localised hot-spots) and the expectation of finding any is low (but such contingencies are allowed for).

The groundwater shows a more complex pattern of contamination with an increased range of contaminants over the threshold screening values. This is likely to be reflective of the contamination burden from a wider area and exacerbated by the groundwater movement across the site. It is also noted that there are multiple groundwater bodies and there may be interactions between these and the local surface waters (including the Mersey Estuary).
3 Risk Assessment and Options Appraisal

3.1 Background

The redevelopment project provides a significant opportunity for site betterment and will enable a very substantial volume of the galligu contamination to be removed and rendered suitable for use and for new sealed water courses to be created. This will eliminate the impacts on the surface water system and prevent human health exposure to future site users. This section of the Remedial Method Statement discusses the potential risk scenarios and pollutant linkages in more detail.

The regime for contaminated land was set out in Part 2A (ss.78A-78YC) of the Environmental Protection Act 1990 (EPA), as inserted by S.57 of The Environment Act 1995 and came into effect in England on the 1st April 2000 as ‘The Contaminated Land (England) Regulations 2000 (SI 2000/227)’. These regulations were subsequently revoked with the provision of ‘The Contaminated Land (England) Regulations 2006 (SI 2006/1380)’, which came into force in England on 4th August 2006, and consolidated the previous regulations and amendments. Under Part 2A of the EPA Section 78A(2), “contaminated land” is defined as “land which appears... to be in such a condition, by reason of substances in, on or under the land, that

- significant harm is being caused or there is a significant possibility of such harm being caused; or

- pollution of controlled waters (including streams, lakes and groundwater) is being, or is likely to be caused.

“Significant harm” is described in the statutory guidance¹ and relies upon a “pollutant linkage” being present. A "pollutant linkage" requires the following:

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¹ The meaning of “significant harm” can be summarised as follows:
- in relation to humans – death, disease or serious injury;
- in relation to ecological systems and their living organisms – irreversible and/or substantial adverse change in the functioning of the ecological system within any substantial part of its location; and
- in relation to property in the form of buildings – substantial failure, damage or interference with rights of occupation.
A conceptual model is an essential element of any site-specific environmental risk assessment. In this context, they are often simple representations of the hypothesised relationships between sources, pathways and receptors. For the purpose of this report, a basic conceptual model has been developed based on the principles of CLR11 and interpretation of information gathered during the Phase I review and Phase II intrusive investigation. Thus, this allows the identification of potential pollutant linkages and whether these linkages have the potential to comprise significant harm and/or pollution of controlled waters in relation to the site. Based on this interpretation, the implications for potential liability associated with soil or water contamination at the site can be evaluated.

All discussions in this section have been made in relation to the site’s proposed industrial/commercial setting. The following is based upon the generally accepted risk assessment principles set out above. These are discussed in more detail below in the context of this site. It should be stressed these are potential scenarios that could exist. It is not necessarily the case that they do.

Based on the above factors, an initial qualitative assessment of the presence of potential pollutant linkages can be undertaken.

### 3.2 Conceptual Site Model

The ground conditions on the site, obtained through the site investigation process, have been summarised into a Conceptual Site Model (CSM), which defines the key sources, pathways and receptors that have been identified as being relevant to this site. The CSM within this chapter summarises the following:

- a **source** of contamination present at concentrations capable of causing significant harm to the health of humans or other environmental receptors;
- there **must** be a human or environmental receptor present; and
- there must be an exposure pathway by which the contamination can reach the receptor.
- the identification of contaminants within the soil that represent potential pollution sources;
- the identification of the potential exposure pathways between the potential sources;
- the identification of the potential receptors for the contamination; and
- the identification of potential pollutant linkages.

All discussions in this section have been made in relation to the site’s proposed industrial/commercial setting.

### 3.3 Identification of Potential Sources

The potential sources of contamination include:

- the elevated concentrations of lead and arsenic identified within the soils that exceeded the screening criteria together with (to a very limited extent) the elevated benzo(a)pyrene concentration. Any substances that were found to exist at concentrations below the relevant screening criteria are not considered to be environmentally significant;

- there are no screening values for several of the chemical parameters analysed during the EAME investigation, however the only parameters considered to be of significance are the elevated sulphate and sulphide levels generally found with the galligu chemical waste deposits and two samples recovered from the natural Alluvial deposits (relating to sulphide);

- in addition to the elevated levels of contamination identified within the galligu, the presence of galligu chemical waste across the site, is in itself a source of contamination; and

- the asbestos (amosite) presence as identified during the 2004 Environ investigation in one sampling location located within the West Bank Dock area.
In addition to the potential pollution sources that already exist at the site, the following potential sources of pollution that may arise as a result of the construction and operational phases of the proposed development have been identified. Although the site will not contain any chemical bulk storage or be occupied by businesses undergoing chemically intensive activities, there is still the potential for the development to add to the pollution burden as illustrated in Table 3.1 below.

It has already been established that elevated levels of both organic and inorganic contaminants exist on the site, in soils, groundwater and surface water and the long-term presence of these contaminants is assumed. There are mechanisms by which contaminants can transfer to the water bodies (leaching, run-off, etc.) and if the site is not changed in anyway such mechanisms are likely to continue to prevail.

In addition to the potential pollution sources that already exist on and around the site, the following potential sources of pollution that may arise as a result of the construction and operational phases of the proposed development have been identified in Table 3.1 below.

<table>
<thead>
<tr>
<th>Construction Phase</th>
<th>Operational Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sediment-rich and/or contaminated run-off from land to water bodies during earthworks.</td>
<td>Increased surface water run-off (which although should be clean rainwater, could pick up contaminants if housekeeping on the site is poor or spillages have occurred, such as fuel and oil leaks from parked vehicles).</td>
</tr>
<tr>
<td>Spillages of polluting materials during construction activities (e.g. fuel spills during plant refuelling).</td>
<td>Increased wastewater from sanitary usage. In addition, there is the potential for vehicle washing to be undertaken on site.</td>
</tr>
<tr>
<td>Dewatering of contaminated groundwater from excavations and the associated generation of large volumes of potentially contaminated water.</td>
<td>Storage of oils, fuels and maintenance chemicals by new site occupiers.</td>
</tr>
</tbody>
</table>

### 3.4 Receptors

It should be noted that there is little if any potential for the on-site contamination to impact upon human health in the off-site community as no plausible pathway exists, hence this has been discounted.
as a potential receptor. It is recognised, however, that there may be dust emissions during construction works but the air quality impact assessment concluded that as the closest residential receptors to the site are more than 300 m from the edge of the construction site, even without mitigation measures it is unlikely that emissions of dust would cause a nuisance, however it should be noted that mitigation measures will be included as part of the Construction Environmental Management Plan (CEMP) which will reduce the level of impact.

Bearing this in mind the potential receptors that are being considered in the initial conceptual site model are as follows:

- groundwater, encountered within the Made Ground, alluvial drift deposits, Glacial Till horizon and Fluvio-glacial Sand and Gravel drift deposits;

- surface water, Steward’s Brook, which flows between the Reclamation site and the West Bank Dock site (in part) and the Ditton Brook, which flows adjacent to the south-west boundary of the Foundry Lane site and to the south of the Reclamation site);

- Site workers (i.e. current and future employees located at the site);

- Groundworkers (i.e. construction workers, maintenance workers or other personnel who may be directly exposed to contaminated soil in the course of their activities);

- ecological diversity in the receiving waters could also be impacted by certain contaminants that could render the water quality incapable of supporting pollution intolerant species (although Steward’s Brook has limited ecological value as detailed in the Environmental Statement Chapter 8 (Ecology and Nature Conservation);

- although limited, there may be recreational and commercial users of the River Mersey that could be impacted by contaminated waters;
third party land (i.e. the possibility of contamination migrating off-site onto third adjacent land via contaminated surface water and groundwater or run-off); and

Marsh Brook has not been identified as a potential receptor as it is hydraulically isolated from the site and other than during periods of tidal inundation, is not a actively flowing water body of any significance (operating mainly as a surface water drainage channel for the Tesco site).

### 3.5 Identification of Potential Exposure Pathways

Exposure pathways are the potential routes that link the potential on-site sources to the identified potential receptors. However, it should be stressed that these risks have to be considered only through plausible pathways.

The following potential exposure pathways have been identified at the site:

- Inhalation, ingestion or skin contact with contaminated soils (although generally risks to construction workers or maintenance workers should be manageable by standard health and safety procedures);

- Migration of land gases into buildings and service conduits;

- Migration of soil contaminants via transmission along conduits;

- The migration of solid contaminants and leachate into the surface watercourses due to the poor state of the banks;

- Migration of contaminants to shallow groundwater bodies and aquifer and to surface water via leaching and run-off, or transmission along conduits;

- Migration of contaminated horizons with uncontaminated horizons through piling activities; and
- Leaching and capillary rise into landscaped areas.

A conceptual model for the site, presenting the identified sources of contamination, pathways and receptors is detailed in tabular form in Table 3.2 below.

### 3.6 Identification of Potential Pollutant Linkages

In order for there to be a recognised risk that requires some form of remedial action there needs to be an identifiable and likely pollutant linkage. In other words there must be a pollution source, a pathway for migration of or exposure to this source and a receptor that can be harmed or negatively affected by exposure to that source.

EAME has devised a conceptual model based on the information obtained to date through the site investigation and based on current knowledge of the site and the future commercial/industrial redevelopment. This is represented in detailed in tabular form in Table 3.2 according to the following key for the type of risk being considered:

- **HHR** = Human Health Risk
- **ESR** = Ecosystem Risk
- **BER** = Built Environment Risk
- **CWR** = Controlled Water Risk
<table>
<thead>
<tr>
<th>Source</th>
<th>Pathway</th>
<th>Receptor</th>
<th>Potential Pollutant Linkage Likelihood &amp; Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contamination of soils from metals (arsenic and lead), asbestos, PAHs (benzo(a)pyrene), sulphate and sulphide. Widespread presence of galligu chemical waste deposits. Land gas (including volatile hydrocarbons).</td>
<td>Ingestion</td>
<td>Human Health (Current site users)</td>
<td><strong>(HHR1) Likely &amp; Moderate Significance</strong> – Significantly contaminated soils (lead, arsenic, sulphate and sulphide) are present and widespread galligu deposits. The Reclamation site and the majority of the West Bank Dock site are currently unsurfaced, with areas that appear to be upfilled, possibly comprising an amalgamation of made ground from previous earth works.</td>
</tr>
<tr>
<td></td>
<td>Inhalation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dermal Contact</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaching of contaminants from the site into the River Mersey.</td>
<td></td>
<td>Human Health (Recreational &amp; commercial users of River Mersey)</td>
<td><strong>(HHR2) Likely &amp; Low - Moderate Significance</strong> - Potential for inhalation of asbestos fibres. The presence of asbestos was identified in only one isolated hotspot encountered during the 2004 intrusive investigation however, the presence of other asbestos containing materials present on the site cannot be ruled out given the historic landfilling activities within the West Bank Dock area; and the subsequent demolition of the buildings located on the West Bank Dock site.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td><strong>(HHR3) Unlikely &amp; Low Significance</strong>. The dilution factor will significantly reduce the concentration of any site-derived contamination entering the River Mersey to sub human health impact levels and the opportunities for contact with these contaminants via recreational activities on river will be minimal.</td>
</tr>
</tbody>
</table>
### Table 3.2 Conceptual Site Model – Current

<table>
<thead>
<tr>
<th>Source</th>
<th>Pathway</th>
<th>Receptor</th>
<th>Potential Pollutant Linkage Likelihood &amp; Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Migration of soil contaminants via permeable conduits</td>
<td>Built Environment (On-site buildings &amp; services)</td>
<td><strong>BER1 Likely &amp; Low – Moderate Significance</strong> – Given the site’s long industrial usage, there is a possibility that the on-site drainage system may have been impacted by contaminants of concern and any leaking drains may provide a pathway to the aquifer. The identified metal contaminants are considered to be relatively immobile, especially as the soil conditions are neutral to alkaline.</td>
</tr>
<tr>
<td></td>
<td>Direct contact of contaminants with building materials</td>
<td></td>
<td><strong>BER2 Likely &amp; Low - Moderate Significance</strong> – the ground conditions, with respect to the high sulphate content, may be harmful and corrosive to concrete and aggressively attack cement based foundation materials. The majority of the historic buildings located on the West Bank Dock site have subsequently been demolished; the remaining buildings date circa 1960 and 2002/2003. The buildings on the Foundry Lane site date circa 1970 and 2000.</td>
</tr>
<tr>
<td></td>
<td>Land Gas Migration (via fissures, conduits &amp; void space)</td>
<td></td>
<td><strong>BER3 Unlikely &amp; Low Significance</strong> - Risk of land gas to migrate and accumulate in buildings and voids is possible. The gas monitoring undertaken to date has indicated a low overall risk however, further investigation of land gas levels would be required in order to refine the ground gas assessment as per current guidance.</td>
</tr>
<tr>
<td></td>
<td>Organic Vapour Migration (via fissures, conduits &amp; void space)</td>
<td></td>
<td><strong>BER4 Unlikely &amp; Low Significance</strong> – Risk of migration of land gas to off-site buildings and services via permeable conduits/geology. The on-site gas monitoring undertaken to date has indicated a low overall risk however, further investigation of land gas levels would be required in order to refine the ground gas assessment and identify the potential for off-site migration.</td>
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</tr>
</tbody>
</table>
### Table 3.2 Conceptual Site Model – Current

<table>
<thead>
<tr>
<th>Source</th>
<th>Pathway</th>
<th>Receptor</th>
<th>Potential Pollutant Linkage Likelihood &amp; Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct leaching into groundwater from contaminated soils</td>
<td>Controlled Water (On-site groundwater bodies)</td>
<td><strong>(CWR1) Likely &amp; Moderate Significance.</strong> Due to known contamination already in the soil and groundwater.</td>
<td></td>
</tr>
<tr>
<td>Cross contamination between groundwater bodies due to the piling exercise</td>
<td>(Off-site groundwater bodies)</td>
<td><strong>(CWR2) Likely &amp; Moderate Significance.</strong> Likely interconnectivity of water bodies exists so contamination could be migrating away from the site.</td>
<td></td>
</tr>
<tr>
<td>Direct leaching into surface water from contaminated soils.</td>
<td>Controlled Water (Surface Water Quality)</td>
<td><strong>(CWR3) Likely &amp; Moderate Significance.</strong> Due to contamination found in groundwater and proximity of Steward’s Brook and Ditton Brook which may be contiguous with this. In addition, there is also the potential for contaminated run-off drainage to enter surface watercourses. The potential for bankside material to enter Stewards Brook cannot be discounted, although given the brook is seated on similar material this is not considered to be significant.</td>
<td></td>
</tr>
<tr>
<td>Source</td>
<td>Pathway</td>
<td>Receptor</td>
<td>Potential Pollutant Linkage Likelihood &amp; Significance</td>
</tr>
<tr>
<td>--------</td>
<td>---------</td>
<td>----------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Spillage of pollutants into the redundant surface water drainage system, which discharges to surface watercourses, during construction phase</td>
<td><strong>Controlled Water</strong>&lt;br&gt;(Ecology of Steward’s Brook, Ditton Brook and River Mersey)</td>
<td><strong>(CWR4) Unlikely &amp; Low Significance.</strong> Although contamination exists, it is generally at low concentrations and the tidal flushing and high water volumes in the receiving waters will lead to massive dilution factors. So the impact on ecological systems is likely to be insignificant. Steward’s Brook will be more susceptible to changes in water quality but due to decades of severe contamination, is of low ecological status.</td>
</tr>
</tbody>
</table>
3.7 Tiered Approach to Land Contamination Appraisal

The *Model Procedures for the Management of Land Contamination*, CLR 11, published by the EA/DEFRA has been developed to provide the technical framework for applying a risk management process when dealing with land affected by contamination. The process involves identifying, making decisions on, and taking appropriate action to deal with land contamination in a way that is consistent with government policies and legislation within the UK.

This is essentially a three tier process comprising the following stages as shown below and in further detail in the flow chart in *Figure 1* below:

**Stage 1 – Risk Assessment**: identification of potential risks, definition of risks and whether further assessment is required to address identified risks (if deemed significant);

**Stage 2 – Options Appraisal**: which essentially comprises assessing and evaluating options for removing or breaking potential significant pollution linkages through detailed feasibility appraisal; and

**Stage 3 – Implementation of Remedial Strategy**: agreeing the strategy and undertaking the identified solutions to break the pollutant linkage(s) with verification of the process. Where long term monitoring is required, review and assess the data obtained to determine whether acceptable or otherwise.
This process for assessing contamination using the appropriate tiered structure has been followed for the Stobart Park development. The investigation and assessment has been completed and reported in previous documents which provide good characterisation of the site conditions and environmental risks.
therein. Below is a review of feasible techniques that may be applicable to the site and a critique of the potential options is presented in the following sections of this report, based on the above flow chart.

3.8 Stage 1 – Risk Assessment

3.8.1 Summary of Current Information

The previous documents submitted in support of the planning application have identified that the soil and groundwater at the site is contaminated to varying degrees (notably with metal species rather than hydrocarbons) and that potentially this may be impacting upon the surface water through direct run off, drainage discharge and groundwater through flow. It is recognised that there may be areas where other contaminants could be identified, but the numerous investigations and sample locations to date provide a reasonably consistent picture and a departure from what has been observed to date is not expected. It is understood that there is some concern that there may be hydrocarbon contamination, but this is a generic concern on all industrial sites and has not been a significant feature of the conditions on this site.

It is also quite clear from the level logging data that the groundwater bodies across the site are tidally influenced, as the level logging data provided by Stewards Brook, Ditton Brook and the boreholes correlate. This implies that the steel sheet piling around the Reclamation Mound, which is intended to provide an effective hydraulic barrier between the groundwater within the sheet piled area and the estuary and Ditton and Steward’s Brook, may not be working effectively. Consequently contaminant transfer is possible and may be occurring, although it is also possible that the synchronicity between tidal cycles and the groundwater level behind the sheet piling is due to changes in pore pressure associated with the rising and falling tide having a related effect on the groundwater regime in the area. In other words, whilst there may be a hydrostatic effect, it does not necessarily mean that the groundwater behind the sheet piling and the estuarine water are co-mixing. Nonetheless the integrity of the sheet piles cannot be assumed.
The source of the elevated concentrations of metallic and inorganic contaminants with respect to the various guidelines is likely to be a combination of the potential galligu composition of the stream bed of Steward’s Brook, the galligu composition of the surrounding land and the unlined HEDCO landfill site, which forms a substantial part of the eastern boundary of Stewards Brook and was a chemical waste disposal site.

It is recognised that although the HEDCO site is likely to be the main contributor to contamination of Steward’s Brook given that it is an unlined chemical waste site, there may also be some infiltration and leaching of contaminants from the development site that is adding to the pollution loading overall. Notwithstanding these two sources, the wider area itself is made up of galligu contaminated soils used to reclaim the foreshore and there will also be a widespread pollution burden from the general area.

3.9 Stage 2 - Feasibility & Options Appraisal

Following the risk assessment process, which has identified potential pollutant linkages to surface water and groundwater, an appraisal of the potential options to break the potential linkages is required and has been completed. The three main concerns to evaluate at the options appraisal stage are to consider the identified potential pollutant linkages and potential remedial scenarios as follows:

1. Identify feasible remediation options for each relevant pollutant linkage;

2. Carry out an evaluation of feasible remediation options to identify the most appropriate option for any particular linkage; and

3. Produce an outline remediation strategy that addresses all relevant pollutant linkages, where appropriate by combining remediation options.

The following elements have been considered, where necessary, 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;

• durability of the strategy (i.e., will it provide a robust solution over the design life?);

• 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, such as a landfill, 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.

A review of possible feasible options, according to CLR11 (DEFRA/Environment Agency, 2004) has been undertaken and is presented in Tables 3.3 and 3.4. This has effectively evaluated the practicality, effectiveness, durability and sustainability of the potential remedial solutions.
It is considered at the outset that large scale source removal of contaminated soils from the site would not be economical, sustainable or technically feasible and thus do not feature as a realistic remedial option. This would effectively involve removal of the entire land mass (accounting for millions of tonnes of material) that would be financially unsustainable, would have no disposal or treatment outlet and would cause wholesale disruption of a very large area. The very long term presence of large volumes of galligu is a characteristic feature of the area that should be accepted as part of the normal baseline conditions and will not change, regardless of any development proposals or remedial actions by the applicant or others.

The extensive investigations, monitoring, sampling and detailed assessments of the potential pollution linkages at the site (and within the wider land area) has identified six potential significant pollution linkages as follows:

1. Elevated concentrations of compounds (mainly metals and sulphate) in soils migrating to onsite receptors (groundwater);

2. Elevated concentrations of compounds (mainly metals and sulphate) in soils migrating to onsite receptors (surface water);

3. Elevated concentrations of compounds (mainly metals and sulphate) in soils in direct contact with onsite receptors (human health);

4. Elevated concentrations of compounds (mainly metals and sulphate) in surface water migrating to offsite receptors (River Mersey);

5. Elevated concentrations of compounds (mainly metals and sulphate) in groundwater migrating to onsite receptors (Stewards Brook); and

6. Elevated concentrations of compounds (mainly metals and sulphate) in groundwater migrating to offsite receptors (surface water and groundwater).
Table 3.3 below presents a summary of the potential remedial options and their applicability to each identified pollutant linkage and a discussion of the remedial options and practicability is presented in Table 3.4: In addition, the capping of the site with stabilised and treated material will inherently reduce the downwards infiltration of rainwater and subsequent leaching.

<table>
<thead>
<tr>
<th>Remedial Method</th>
<th>Media</th>
<th>Potential Pollutant Linkage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 (GW) 2 (SW) 3 (HH) 4 (SW) 5 (SW) 6 (GW)</td>
<td></td>
</tr>
<tr>
<td>Engineering Based Process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) Solidification and Stabilisation</td>
<td>Soil</td>
<td>✓ ✓ ✓ x x x</td>
</tr>
<tr>
<td>2) Re lining a section of Stewards</td>
<td>Water</td>
<td>x ✓ x ✓ x x</td>
</tr>
<tr>
<td>Brook &amp; regarding bankside</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) Containment – hydraulic barriers</td>
<td>Water</td>
<td>x x x x x x</td>
</tr>
<tr>
<td>Biological Based Process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) In-situ bioremediation</td>
<td>Soil/Water</td>
<td>x x x x x x</td>
</tr>
<tr>
<td>5) Natural attenuation</td>
<td>Water</td>
<td>✓ ✓ x x ✓ ✓</td>
</tr>
<tr>
<td>Chemical Based Process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6) Permeable Reactive Barriers</td>
<td>Water</td>
<td>x x x x x x</td>
</tr>
<tr>
<td>7) In-situ chemical additives</td>
<td>Water/Soil</td>
<td>✓ ✓ x ✓ ✓ ✓</td>
</tr>
<tr>
<td>Physical Based Process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8) Multi and dual phase extraction</td>
<td>Soil/water</td>
<td>x x x x x x</td>
</tr>
<tr>
<td>9) Air sparging</td>
<td>Water</td>
<td>x x x x x x</td>
</tr>
</tbody>
</table>

See Table 3.4 for limitations as some processes may be feasible for some compounds

Notwithstanding the discussion above, for the sake of completeness all potential remedial options for the site were considered by the Applicant and their consultants and substantial capping was deemed to be the most appropriate and effective method of rendering the site suitable for use and for improving the environmental conditions. The remedial options appraisal is discussed in detail below.
## Table 3.4: Summary of Remediation Options Feasibility

<table>
<thead>
<tr>
<th>Option</th>
<th>Summary of Technology</th>
<th>Receptor Protected</th>
<th>Practicability</th>
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<th>Suitability of Treatment Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engineering Based Process</strong>&lt;br&gt;Contaminants - Metals, Hydrocarbons, Inorganics</td>
<td></td>
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</tr>
<tr>
<td>1) Solidification and stabilisation – treatment of contaminated soils to prevent leaching of contaminants to groundwater, surface water and direct contact with human receptors.</td>
<td>Treatment of soils using a lime or cement binder, which effectively locks contaminants in a solid phase. Creates a hard impermeable surface.</td>
<td>Human health, groundwater and surface water</td>
<td>Needs pilot trials to establish correct ratio of binder. Large scale plant to undertake the excavation and treatment. Will require agreement with LA and EA for mobile plant licensing and movement of material under CL:AIRE Code of Practice. The sealing of redundant drainage systems would be required.</td>
<td>Long Term – ongoing monitoring of the surface water and groundwater to ensure that the treatment system is adequately working. No movement of soils off site, or disposal at landfill sites of contaminated soils.</td>
<td>Has been used on similar sites in Widnes with agreement from the regulatory authorities. Does not remove the underlying contaminated soils or groundwater, but will serve as betterment to the overall hydrological regime and seal the site surface.</td>
</tr>
<tr>
<td>2) Re-lining a section of Stewards Brook and re-grading bankside</td>
<td>Lining the brook with an impermeable material to break the pathway between contaminated groundwater and surface water. Re-grading/profiling of the bankside to prevent solid matter entering brook.</td>
<td>Stewards Brook and River Mersey</td>
<td>A suitable medium for the lining would need to be identified and employed. As Stewards Brook is tidal, significant constraints would need to be factored into the process. Re-grading/re-profiling the bankside in identified areas from railway to the north to road bridge crossing practical. There is also a legal practicality in that it The Stobart Group does not own this land and has no right of access.</td>
<td>Long Term solution for the protection of Stewards Brook.</td>
<td>Considered suitable – although will require significant engineering. Would need to be undertaken in conjunction with other remedial options as does not treat contaminated ground water. Re-grading/profiling bankside would improve visually and prevent solid matter entering brook. Would treat Stewards Brook from railway to the north to River Mersey, but not deal with any contaminants between the golf course and Stobart land.</td>
</tr>
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<tbody>
<tr>
<td>3) Hydraulic Barrier - Installation of an impermeable barrier, to control lateral migration of contaminated groundwater and prevention of surface water contamination.</td>
<td>The barrier can be constructed of modified clay, steel piles, non permeable plastic or slurry and can be installed into lower, less permeable layers. Installation of such a barrier results in groundwater buildup behind the structure (i.e. within the site).</td>
<td>Stewards Brook and Ditton Brook</td>
<td>Will need to tie into a continuous underlying low permeability horizon. Variable ground conditions were encountered at the site and sandstone (permeable) exists at various depths. As such a definitive low permeability horizon to key into does not exist and contaminant transfer between the aquifer and shallow contaminant horizons may already be occurring within the site.</td>
<td>Medium Term – But will require periodic pumping to ensure localised flooding or unacceptable groundwater build up is avoided. Sheet piling is already present in places, however the efficacy of the seal is questionable.</td>
<td>Not considered suitable due to variable ground conditions (largely permeable) and hence impracticality of implementation – creating an effective continuous barrier would be highly unlikely. Containment would be required on all sides of Stewards brook and continuous along Ditton Brook - to be effective and would require similar treatment from HEDCO.</td>
</tr>
<tr>
<td>4) In-situ treatment (vapour extraction – MPE (HVE), bio-venting/bio-sparging or similar) – hydrocarbons only.</td>
<td>Insertion of an array of wells with collection and treatment onsite in areas with high concentrations of volatile hydrocarbons.</td>
<td>Surface water and groundwater</td>
<td>Relatively low levels of hydrocarbons are present within the groundwater. Limited effectiveness for ‘weathered’ and heavier residual hydrocarbons (residual tars) and no significant soil source zone has been identified.</td>
<td>Short-term and relatively high maintenance operation.</td>
<td>Not considered suitable for the low levels of hydrocarbons present and it could only achieve limited results (there is no comprehensive source), would be expensive to establish and operate within the site for little benefit.</td>
</tr>
<tr>
<td>5) Monitored Natural Attenuation</td>
<td>Comprehensive monitoring of the groundwater (with possible injection of chemicals to stimulate degradation if not)</td>
<td>Surface water and groundwater</td>
<td>Can be relatively easily implemented (and in effect already is), with little if any disturbance to the site activities but does not in itself provide any active intervention in the contaminant source areas (although</td>
<td>Long-term and defective installations can be replaced relatively easily.</td>
<td>Suitable in conjunction with other form of remedial options, such as stabilisation of contaminated soils.</td>
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</tbody>
</table>
### Table 3.4: Summary of Remediation Options Feasibility

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<tr>
<td></td>
<td>occurring). Undertaken to an established protocol in agreement with the regulatory authorities.</td>
<td>degradation can be accelerated via well injection if the conditions are acceptable – although this relates to organic contaminants which are not an identified feature of the site conditions).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical Based Process</td>
<td>Contaminants: Metals, Hydrocarbons</td>
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<td></td>
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</tr>
<tr>
<td>6) Permeable and Semi Permeable Reactive Barrier - Installation of a semi-permeable barrier, to control an area of contamination and prevent migration.</td>
<td>The barrier can be constructed of modified clay, steel piles, non permeable plastic or slurry and can be installed into lower, less permeable layers. Treatment “gates” will permit controlled groundwater flow in defined areas where targeted treatment can be applied. Other technologies available include semi-permeable barriers that act as reactive filters, trapping the contaminants as the groundwater passes through them.</td>
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<tr>
<td>Surface water</td>
<td>Similarly to physical barriers, such a system needs to be keyed into a substantial low permeability horizon (where a gate and funnel approach is used) and needs to present an effective face to the main cross section of the contaminant plume or receptor to be protected. The length of Stewards Brook (both sides) would be required to effectively protect the surface water course. Given the contamination present in the shallow groundwater in this area of the site is mainly inorganic species including metals, attenuation of these is unlikely via such a system, resulting in an element of the known contamination still migrating through such a barrier.</td>
<td>Medium term but only a partial solution.</td>
<td></td>
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<td></td>
<td>Not Suitable as it would be a major engineering operation to install with only limited if any possibility of success and effectiveness and it would be difficult to key into suitable geology or intercept defined contaminant fronts. Unlikely that all types of contamination present within shallow groundwater (e.g. metals, inorganics and hydrocarbons) would be treated.</td>
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</tbody>
</table>
## Table 3.4: Summary of Remediation Options Feasibility

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</tr>
</thead>
<tbody>
<tr>
<td>7) In-situ Chemical Additives</td>
<td>Injection of chemical compounds via a series of injection wells across a wide area of the site or via down gradient boreholes to promote degradation of contaminant species.</td>
<td>Surface water and groundwater</td>
<td>The drilling wells will need to target the specific areas of highest observed contaminant values, which may not be practicable, but otherwise it is a case of installing suitable depth injection wells. Such a system also requires a degree of dynamism in the receiving groundwater regime to promote distribution of the additive. Only likely to be effective on some hydrocarbon species which are not a significant feature of this site.</td>
<td>Long-term – but may need additional applications over a period of time.</td>
<td>Potentially suitable treatment – and possible to implement in conjunction with other treatment options, but only targets a limited range of contaminants that are present and may be ineffective if applied in source areas due to accessibility issues and inhibition of the localised groundwater regime by the capping mass (and hence limiting the effective mobility of the treatment chemicals).</td>
</tr>
<tr>
<td>8) Multi &amp; Dual Phased Extraction</td>
<td>A vacuum is applied to a series of wells drilled into the contaminated soil, and the air and groundwater drawn off slowly for treatment at the surface using an air/water separator and a gas treatment system such as activated carbon to deal with the volatile organic contaminants in Surface water and groundwater</td>
<td>Can be completed in situ with no need for mass excavation but similarly to other intervention methods, needs to target source areas, which may not be practicable on this site as there are no source areas for hydrocarbons (which would be the main target of this technique). Vapour treatment can be completed on site with use of carbon filter. High permeability soils may not be suitable for phased extraction.</td>
<td>Medium to Long Term as can be tuned and de-activated and re-activated over periods of time.</td>
<td>Not considered suitable requires optimal conditions for extraction and ability to target source areas, both of which are unlikely to exist in the context of this site.</td>
<td></td>
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</table>

**Physical Based Process**

**Contaminants: Metals, Hydrocarbons**
### Table 3.4: Summary of Remediation Options Feasibility

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>the air phase and dissolved and free-phase contaminants in the water phase.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>9) Air Sparging</td>
<td>Air is forced into the ground via installation of wells in an array across the site. The volatile gases are stripped from the soil/groundwater and collected onsite for treatment or destruction.</td>
<td>Surface water and groundwater</td>
<td>Suitable mainly for volatile organic compounds and where air circulation can be achieved effectively. This is not a feature of this site.</td>
<td>Short Term targeted treatment programme.</td>
<td>Unsuitable as it is of very limited effectiveness in low permeability soils and confined aquifers and only targets a limited range of contaminants. The hydrocarbon contamination on the site is low level and several years and in most cases decades old. Consequently, the targetable volatile fraction is probably very limited in extent and recoverability and the effectiveness of treatment would not be justified by the extent of implementation works required.</td>
</tr>
</tbody>
</table>
3.10 Consideration of Potential Remedial Options

Considering all of the remedial options and the practicality and suitability of implementation of each, it is considered that large scale engineered intervention, whether that be barriers of arrays of injection collection systems or source removal, only has a limited if any chance of success (even if affordable or practicable) due to the site conditions and geology or only targets a limited range of the potential contaminants. Notably, most of the inter-active remediation technologies available target mobile or volatile hydrocarbon fractions or free phase liquids. This contamination, whilst common on many industrial sites, is not a feature of this site. The primary contaminant of concern is the ubiquitous galligu and associated metallic species contamination, which is evident in the groundwater and surface water. The selective removal or intervention in these contaminants is not technically feasible which really only leaves barrier methods in place.

The stabilisation and solidification of contaminated soils with the engineered emplacement of them on the site would provide an impermeable platform which would greatly reduce downwards infiltration and leaching (such as it is), thereby improving the overall groundwater quality at the site. It also provides a substantial physical barrier between the site users and the contaminants (eliminating the human health risk).

Redundant drainage channels would need to be identified and capped or sealed off as deemed necessary to prevent future pathways for transmission of contaminated groundwater through these legacy systems. This again breaks a linkage and removes a pollution input.

The new drainage system and site surfacing would impart large volumes of clean surface water run-off (during rainfall events) to Steward’s Brook, which would improve the water quality, if only by diluting the contaminants therein.

Re-lining of Stewards Brook, whilst protecting the surface water course, does not provide betterment of the groundwater quality in the area, nor necessarily reduce the pollutant loading to the estuary overall.
This would, admittedly, serve to break the pollutant pathway between contaminated groundwater on site and the surface water, however the legal, engineering, development and financial constraints of the proposed solution may well necessitate other solutions to be regarded as more suitable and environmentally cost effective. In addition it is considered that in conjunction with the section of re-lining, that some form of re-grading slope stabilisation be undertaken to the banksides (under Stobart ownership) to prevent the release of solid matter into Stewards Brook. Where The Stobart Group has rights of access to the bank these areas will be enhanced and this too will improve run-off quality and provide for some ecological enhancement.

It is considered that long term monitoring of the groundwater and surface water would be required to demonstrate the efficacy of the proposed solutions and the benefits of the extensive capping and of the site.

It is difficult to conclude anything other than the proposed remedial measures of new drainage systems, encapsulation capping and bankside enhancement (within the owned land) associated with the development will improve environmental conditions in the area, progress the water courses towards their WFD objectives, reduce contaminant migration from Stobart land into Stewards Brook and constitute an overall betterment of the environmental status of the site and its environs.

### 3.11 Mitigation

The site’s redevelopment proposals will mitigate the key pollutant linkages of human health exposure and on-site buildings and services by creating a substantial physical barrier (site surfacing) between the contaminants and long-term site visitors and users, but construction workers may be exposed temporarily.

**Construction Phase**

Direct contact with contaminated soils and galligu chemical waste deposits will be encountered during earthworks. However, this impact assessment is not intended to assess transient risks to site workers or
other construction workers during redevelopment. Ground works would be carried out under a controlled programme and these risks would need to be dealt with by other legislation and regulations (such as Health and Safety at Work Act 1974) and be considered through health and safety risk assessments by the appointed construction contractor. All workers will assume from the outset that they are working on a chemically contaminated site and adopt appropriate Personal Protective Equipment.

Due to the type and nature of the development it is envisaged that floor loads will be high, settlement criteria stringent and roof spans large such that foundation loads will be significant. In light of this and the variable nature of the soils encountered across the site, it is considered likely that some of the built structures may be founded upon piles. The contaminated nature of the near surface deposits and the potential for creating pathways to the underlying soils and aquifer as a consequence of the piling operation is recognised and understood. Certain piling methods can bring spoil (some of which may be contaminated) to the surface and other methods may drive contaminated soil down into deeper horizons which were previously uncontaminated. Thus, the specific piling technique that will be used (where piling will be required) will be influenced by a number of factors such as depth to rockhead; required bearing strength; presence or absence of contaminated soil along the Pile profile; the specific nature of the contamination; and the proximity to retained structures. The full details of the ground engineering strategy and techniques will be determined in conjunction with suitably qualified Ground Engineering & Piling Contractors and confirmed with the Regulatory Authorities.

All water supply pipes, where they are to be laid in contaminated ground, will be laid in well excavated and clearly defined trenches and will contain clean imported granular bed, surround and backfill. Advice will be sought from the relevant statutory authorities prior to the design and construction of service runs.

All site works will be undertaken in accordance with the EA’s Pollution Prevention Guidance Note 6 ‘Working at Construction and Demolition Sites’. Construction vehicles will be properly maintained to reduce the risk of hydrocarbon contamination and will only be active when required. Construction
materials will be stored, handled and managed with due regard to the sensitivity of the local aquatic environment and thus the risk of accidental spillage or release will be minimised. Construction contractors will also take full account of the requirements of the EA’s General Guide to the Prevention of Pollution of Controlled Waters (PPG1) and guidance set out in PPG2 (Above Ground Oil Storage Tanks) and PPG3 (The Use and Design of Oil Separators).

Furthermore, mitigation measures will be incorporated into a Construction Environmental Management Plan (CEMP), which will set out measures for the control of site drainage, reducing the risk of accidental spillages and the storage and handling of materials.

No underground storage tanks will be used during the construction phase. Any liquids such as degreasers, oils, diesel, required as part of the construction works will be stored in above ground tanks and located on designated areas of hardstanding. In accordance with the Control of Pollution (Oil Storage) (England) Regulations 2001, any tanks storing more than 200 litres of oil will have secondary bunding. Bunding will be specified having a minimum capacity of “not less than 110% of the container’s storage capacity or, if there is more than one container within the system, of not less than 110% of the largest container’s storage capacity or 25% of their aggregate storage capacity, whichever is the greater.”

There is the potential for asbestos containing materials to be present within some of the buildings on site. The building asbestos survey will aid the assessment of the required asbestos removal works prior to the demolition of the buildings.

**Operational Phase**

Hydrocarbon contamination from vehicles is considered to be a potential source of contamination from the routine operation of the site. The proposed development will provide an internal road and a substantial area of car parking space with oil/water interceptor systems positioned at strategic locations. All installed interceptors will be regularly inspected, cleaned and maintained.
Given the generally benign nature of the occupiers’ activities (storage and logistics), it is considered likely that only small quantities of fuels and oils maybe stored on site by tenants. There will be management and housekeeping protocols to be adhered to by the tenants, which will also meet the EA pollution prevention guidelines.

**Residual Impacts**

All significant pollutant linkages can be eliminated or minimised to an acceptable level by the development proposals due to the low sensitivity end use (commercial in nature); the potential upfilling of the site with low permeability material; and hardsurfacing of the entire area with the exception of controlled drained landscaped areas.

The development proposals will involve substantially increasing areas of hard surfacing on the site which will serve to prevent the infiltration and percolation of incident rainwater through contaminated soils (and thus the flushing and leaching of contaminants) from the unsaturated zone to the saturated zone. This will also provide a “clean” barrier between incident rainfall and the contaminated soils, thus leading to uncontaminated surface run-off.

Taking the pollutant linkage summary above into account it is possible to expand upon the potential risk assessment scenarios that may relate to these development proposals and where there is a high or moderate risk of the linkage existing post development. These are discussed below.

**3.12 Human Health Qualitative Risk Assessment**

The potential risks to future site workers and construction workers has previously been undertaken and reported in the Remedial Strategy for Project Eagle in 2009. Essentially the same conclusions can be drawn as effectively, the works to be undertaken comprise the same operations, *i.e.* excavation, treatment and stabilisation of galligu impacted material. The main significant difference being the quantity and area of deposition. Thus, the previous Remedial Strategy (and subsequent Verification of said strategy) is re-iterated here for completeness, with information provided by Environ in italics.
Potential Risks to Future Site Occupiers

Environ reported essentially that the ‘...proposed development will substantially lessen the risk of exposure of site users to contaminated soils to negligible levels once fully operational as there will effectively be an impermeable physical barrier (hardstanding and managed landscaping) between the contaminants and site users. The site will be capped by a substantial thickness of non-leachable, low permeability, stabilised galligu across the entire site area. This treated material will be subjected to validation testing (direct and leachability) to confirm it is suitable for use. In addition, there will be a site wide facilities management function that will control any future site works that may intrude beyond these surfaced areas, such that it will be done in a controlled and informed manner.’

As such the risk of exposure to site users (outside of construction activities) was considered by Environ to be low. EAME would concur with this statement as noted above no significant deviation from the previous operations have been identified.

Potential Risks to Construction Workers

Environ reported essentially that the ‘...planned redevelopment activities will involve excavation and earthworks (i.e. laying new services, cut and fill operations, maintenance of existing services and piling activities during the construction phase) and may expose construction workers to contaminated ground materials (soils and groundwater) through direct skin contact, inhalation of dust and ingestion of particles. These risks are considered to be low to moderate on the assumption that construction phase environmental protection and health and safety management plans for the site will ensure that appropriate measures are adopted to minimise and control the levels of exposure. Properly managed construction activities that are mindful of the potential exposure risks will ensure that all site workers are adequately informed of the risks to themselves and the environment and where necessary they will adopt the appropriate personal protective equipment (PPE).

It should also be noted that there will be an over arching facilities management function at the site that will control all construction and infrastructure maintenance activities in the future such that no ad-hoc contractor activity (that may disregard the risks) will be allowed. As such uncontrolled intrusion into the
contaminated materials will not be permissible.

A further consideration is that in certain areas of the site the galligu at the near surface will be excavated and stabilised to such an extent that it would be hard (similar to concrete) and a monolithic chemically bound material. As such direct contact with this material would not lead to exposure to the chemical contaminants within and the hardness of the material would make uncontrolled ad-hoc or accidental digging through it to the underlying contaminated material very difficult and highly unlikely.

As such the risk of exposure to site users (outside of construction activities) was considered by Environ to be low. EAME would concur with this statement, as noted previously, no significant deviation from the previous operations have been identified.

### 3.13 Groundwater Qualitative Risk Assessment

The potential risks to controlled water has previously been undertaken and reported in the Remedial Strategy for Project Eagle in 2009. Essentially the same conclusions can be drawn as effectively, the works to be undertaken comprise the same operations, *i.e.* excavation, treatment and stabilisation of galligu impacted material. The main significant difference being the quantity and area of deposition, which is now further distant from the River Mersey. Thus, the previous qualitative and quantitative assessments provided in the Remedial Strategy (and subsequent Verification of said strategy) are considered to still be valid. Nevertheless, further testing of the galligu material from the Reclamation Mound has been undertaken, see Section 2.6 and the findings compared with those obtained previously. This indicated that the test results are similar in nature to previous investigations within the mound *i.e.* there does not appear to be significant variance of the material encountered in this recent investigation, compared with results identified previously. Thus the previous risk assessments undertaken by Environ on essentially similar material with similar characteristics remains valid, and are re-iterated here for completeness.
Potential Risks to the Groundwater - General

Environ previously reported the following ‘...the shallow groundwater encountered beneath the site, appears to be perched within the made ground. The made ground is underlain by alluvial drift deposits, which are further underlain by Glacial Till and then Fluvio-glacial Sands and Gravels, all of which are water bearing and would be sensitive to mobile site derived contamination. Equally, the possibility exists that the underlying major sandstone aquifer is in hydraulic continuity with the groundwater encountered within the alluvial deposits and may thus also be sensitive to site derived contamination. The site investigation (2004) has mainly focused on assessing shallow soil and groundwater conditions and has not been designed to include the assessment of the groundwater within the underlying Sandstone Series (which will not be affected by the development works), although longer term monitoring of these water bodies is ongoing. The glacial clay overlying the sandstone is likely to restrict the vertical migration of mobile contaminants into the sandstone to an extent, although the clay layer is not reported to be continuous across the site. Overall, the risk to groundwater from site derived contamination is considered to be moderate as there is the potential for contaminants to leach from the soils into the groundwater bodies, which may be interconnected. Groundwater sampling at the site thus far has demonstrated that the groundwater is contaminated, mainly with metal species although elevated concentrations of hydrocarbons were detected.

The current unsealed cover on site will not reduce the potential for contaminants to leach from the contaminated soils into percolating rainwater and then migrate downwards and impact upon the quality of the groundwater within the shallow horizons. This will be replaced by a substantial low permeability cap which will form an effective barrier to infiltration of rainwater through the site and prevent further leaching via this route in future.

It is recognised, however, that during the construction phase more soils will be exposed to rainfall than would otherwise have been the case (and particularly where galligu will be uncovered in the area of the Reclamation Mound in preparation for construction works). As such there may be a temporary increase in infiltration rates during this period depending upon weather conditions. A surface water management protocol is presented later in this document that details how potentially contaminated run off and
collected groundwater will be managed.

EAME would concur with this statement as the findings of the more recent investigation undertaken in 2011 have not identified any significant differences to the groundwater regime.

**Potential Risks to the Groundwater – Detailed Quantitative Risk Assessment (ConSim)**

Environ undertook ConSim modelling of the treated galligu to establish whether the material would pose a risk to controlled waters. Two models were undertaken, one to assess the risk posed to the River Mersey and the second to the unsaturated base (aquifer). All the supporting information and model runs were provided within the previous Remedial Strategy and are summarised below.

Environ stated in the Remedial Strategy the following:

The modelling was undertaken on a treated galligu sample using 2% ordinary Portland cement (OPC) which is the least likely binder content addition (and the most workable in engineering terms) thus represents a likely worst case in environmental terms. Where the leachate on each occasion has exhibited eluate concentrations that are below the relevant Environmental Quality Standard (EQS – Estuarine Waters), then this implies that even the raw leachate off the stabilised material would be incapable of exceeding the assessment criteria and so that potential contaminant has been discounted.

Where the eluate displays contaminants above these levels, a quantitative risk assessment has been undertaken (using CONSIM) to determine if, after taking into account migration factors and attenuation, the leachate would present a contaminant risk to the Mersey Estuary or Groundwater.

Based upon a review of the eluate criteria presented the following substances are considered to have warranted quantitative risk assessment using the ConSim model:

- Chromium
- Copper
- Zinc
In simple overview terms, the main source identified for contamination was the cement stabilized Galligu which is being spread and compacted over the source area. The main pathway is considered to be leaching of contaminants from the galligu into the underlying material, this would then leach into the groundwater (shallow or deep) and migrate in the groundwater to the receptor. Two main receptors were identified a) the River Mersey via migration of impacted groundwater from the source area to the river and b) the deeper sandstone aquifer via leaching through the overlying deposits. Two ConSim models were run to identify the risks posed to these receptors, the approach and key assumptions are outlined below.

**Model A (61C13949G01 model)**: the receptor is considered to be the River Mersey and a receptor point was identified downgradient of the treated galligu area at the high water mark. The standards identified for comparison at the River Mersey were the saltwater Environmental Quality Standards. The source area was defined as the treated galligu area and this is assumed to be cement stabilized and will be covered in hardstanding/buildings therefore the infiltration rate used (5% of the predicted rainfall) is considered typical of the infiltration through hardstanding areas. The contaminants modeled have been identified as those that exceed the saltwater EQS in the analytical source leachate results and have been modeled in a range (min/max) of concentrations. The groundwater is estimated at a minimum 0.88m to approx 4m below current groundlevels and the addition of the galligu will raise the ground level by a predicted 2m. The unsaturated zone is a mixture of clay, sand and gravel (note an engineered clay layer will be laid beneath the galligu) and as such has been modeled as a typical range of material from clay to gravel. The shallow aquifer is also a mixture of clay, sand and gravel and as such has been modeled as a typical range of material from clay to gravel. The predicted concentration of the identified contaminants has been modeled at the receptor point (the River Mersey).

**Model B (61C13949G02 model)**, the receptor is considered to be the sandstone aquifer located at depth and the receptor point was identified as the concentration of contaminants at the base of the
unsaturated zone. The standards identified for comparison at the aquifer were the saltwater Environmental Quality Standards, these have been chosen as the sandstone is considered to suffer from saline intrusion. The source area was defined as the treated galligu area and this is assumed to be cement stabilized and will be covered in hardstanding/buildings therefore the infiltration rate used (5% of the predicted rainfall) is considered typical of the infiltration through hardstanding areas. The contaminants modeled have been identified as those that exceed the saltwater EQS in the analytical source leachate results and have been modeled in a range (min/max) of concentrations. The leachate from the galligu is modeled to migrate through the underlying material to the top of the sandstone aquifer which is between 7.9m to 25m below current ground level and the addition of the galligu will raise the ground level by a predicted 2m. The unsaturated zone is a mixture of clay, sand and gravel (note an engineered clay layer will be laid beneath the galligu) and as such has been modeled as a typical range of material from clay to gravel and the data has been skewed towards a clayey sand/fine sand as this is the predominant geology. The predicted concentration of the identified contaminants has been modeled at the base of the unsaturated zone and therefore does not take into account any dilution within the sandstone aquifer itself, which would tend to lessen the impacts.

The results of the modelling undertaken previously by Environ are shown in the tables below:

<table>
<thead>
<tr>
<th>Table 3.5: Results for River Mersey Receptor (Environ 2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Results 61C13949G01 – Concentration at River Mersey receptor (mg/l)</td>
</tr>
<tr>
<td>Years</td>
</tr>
<tr>
<td>percentile</td>
</tr>
<tr>
<td>Chromium</td>
</tr>
<tr>
<td>Copper</td>
</tr>
</tbody>
</table>
### Table 3.5: Results for River Mersey Receptor (Environ 2009)

<table>
<thead>
<tr>
<th>Results 61C13949G01 – Concentration at River Mersey receptor (mg/l)</th>
<th>Years</th>
<th>10</th>
<th>50</th>
<th>100</th>
<th>500</th>
<th>Max</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>percentile</td>
<td>50%ile</td>
<td>95%ile</td>
<td>50%ile</td>
<td>95%ile</td>
<td>50%ile</td>
<td>95%ile</td>
<td>50%ile</td>
</tr>
<tr>
<td>Lead</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Zinc</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

### Table 3.6: Results for Groundwater Receptor (Environ 2009)

<table>
<thead>
<tr>
<th>Results 61C13949G02 – Concentration at base of unsaturated zone (mg/l)</th>
<th>Years</th>
<th>10</th>
<th>50</th>
<th>100</th>
<th>500</th>
<th>Max</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>percentile</td>
<td>50%ile</td>
<td>95%ile</td>
<td>50%ile</td>
<td>95%ile</td>
<td>50%ile</td>
<td>95%ile</td>
<td>50%ile</td>
</tr>
<tr>
<td>Chromium</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Copper</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Lead</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Zinc</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
As can be seen, the modelling predicts that there will be no impact on either the River Mersey or the aquifer from these leachable components. It should also be remembered that this is based on conservative assumptions that are not likely to be realised in the field.

The CONSIM modelling has demonstrated that the leachate that could be generated from this treated material would not cause a breach of the relevant guideline value in either the River Mersey or the Groundwater on site.

Note that arsenic was not modelled as in the treated sample of galligu, the arsenic leachability was below the estuarine EQS (maximum leaching value observed in the stabilised galligu sample was 0.0027mg/l and the EQS is 0.025mg/l). As such it would not represent a pollution source in the treated material.

To provide an additional level of comfort the decision was also taken to assess the leachability and model the impacts assuming that none of the galligu was treated. As stated earlier, 30 samples of “pure” galligu have been excavated from areas of the Reclamation Mound that are destined for excavation as part of the site re-levelling works. These were collected in order to provide a sufficient dataset to characterise the galligu in all its forms and enable a database to be built up of expected soil contaminant values and leachabilities (granular test). The results for the soils and leachates have been summarised in the tables below.

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Minimum Observed Concentration (mg/kg)</th>
<th>Maximum Observed Concentration (mg/kg)</th>
<th>Average Concentration (mg/kg)</th>
<th>CLEA SGV Industrial End Use (No. of exceedances)</th>
<th>GAC Industrial End Use (No. of Exceedances)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>12</td>
<td>900</td>
<td>209.37</td>
<td>500 [3]</td>
<td>-</td>
</tr>
<tr>
<td>Barium</td>
<td>40</td>
<td>660</td>
<td>165.37</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Beryllium</td>
<td>0.5</td>
<td>2</td>
<td>1.18</td>
<td>-</td>
<td>1950 [0]</td>
</tr>
<tr>
<td>Boron (W/S)</td>
<td>&lt;0.5</td>
<td>2.2</td>
<td>1.23</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;0.5</td>
<td>6.7</td>
<td>1.69</td>
<td>1400 [0]</td>
<td>-</td>
</tr>
</tbody>
</table>
### Table 3.7: Galligu Sample Analysis Summary (Solid)- Environ 2009

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Minimum Observed Concentration (mg/kg)</th>
<th>Maximum Observed Concentration (mg/kg)</th>
<th>Average Concentration (mg/kg)</th>
<th>CLEA SGV Industrial End Use (No. of exceedances)</th>
<th>GAC Industrial End Use (No. of exceedances)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromium</td>
<td>&lt;10</td>
<td>25</td>
<td>15.56</td>
<td>5000 (0)</td>
<td>-</td>
</tr>
<tr>
<td>Copper</td>
<td>8.2</td>
<td>1700</td>
<td>200.97</td>
<td>-</td>
<td>45700 (0)</td>
</tr>
<tr>
<td>Lead</td>
<td>79</td>
<td>1200</td>
<td>253.55</td>
<td>-</td>
<td>750 (1)</td>
</tr>
<tr>
<td>Mercury</td>
<td>&lt;0.6</td>
<td>7.3</td>
<td>1.62</td>
<td>-</td>
<td>480 (0)</td>
</tr>
<tr>
<td>Nickel</td>
<td>&lt;4.0</td>
<td>48</td>
<td>14.83</td>
<td>-</td>
<td>5000 (0)</td>
</tr>
<tr>
<td>Selenium</td>
<td>&lt;2.5</td>
<td>7.5</td>
<td>3.86</td>
<td>-</td>
<td>8000 (0)</td>
</tr>
<tr>
<td>W/S Sulphate as SO4</td>
<td>0.33</td>
<td>28</td>
<td>6.74</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vanadium</td>
<td>4.8</td>
<td>3000</td>
<td>244.10</td>
<td>-</td>
<td>4250 (0)</td>
</tr>
<tr>
<td>Zinc</td>
<td>21</td>
<td>4600</td>
<td>624.21</td>
<td>-</td>
<td>1880000 (0)</td>
</tr>
<tr>
<td>W/S Chloride</td>
<td>6.8</td>
<td>220</td>
<td>51.64</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Organic Carbon</td>
<td>0.22</td>
<td>16</td>
<td>6.72</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>W/S Fluoride</td>
<td>1.6</td>
<td>9.7</td>
<td>6.18</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>pH</td>
<td>7.8</td>
<td>12</td>
<td>7.24</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 3.8: Galligu Sample Analysis Summary (Leachate)- Environ 2009

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Minimum Observed Concentration (mg/l)</th>
<th>Maximum Observed Concentration (mg/l)</th>
<th>Average Concentration (mg/l)</th>
<th>Estuarine EQS (No. of exceedances)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>Not Detected</td>
<td>0.74</td>
<td>0.12</td>
<td>0.025 (17)</td>
</tr>
<tr>
<td>Barium</td>
<td>0.006</td>
<td>0.078</td>
<td>0.04</td>
<td>-</td>
</tr>
<tr>
<td>Beryllium</td>
<td>Not Detected</td>
<td>Not Detected</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td>Boron (W/S)</td>
<td>Not Detected</td>
<td>0.13</td>
<td>0.04</td>
<td>7</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Not Detected</td>
<td>Not Detected</td>
<td>N/A</td>
<td>0.0025</td>
</tr>
<tr>
<td>Chromium</td>
<td>Not Detected</td>
<td>Not Detected</td>
<td>N/A</td>
<td>0.015</td>
</tr>
<tr>
<td>Copper</td>
<td>Not Detected</td>
<td>0.023</td>
<td>0.01</td>
<td>0.005 (18)</td>
</tr>
<tr>
<td>Lead</td>
<td>Not Detected</td>
<td>0.035</td>
<td>0.03</td>
<td>0.025 (1)</td>
</tr>
</tbody>
</table>
Table 3.8: Galligu Sample Analysis Summary (Leachate)- Environ 2009

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Minimum Observed Concentration (mg/l)</th>
<th>Maximum Observed Concentration (mg/l)</th>
<th>Average Concentration (mg/l)</th>
<th>Estuarine EQS (No. of exceedances)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>Not Detected</td>
<td>Not Detected</td>
<td>N/A</td>
<td>0.0003</td>
</tr>
<tr>
<td>Nickel</td>
<td>Not Detected</td>
<td>0.029</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>Selenium</td>
<td>Not Detected</td>
<td>0.038</td>
<td>0.02</td>
<td>-</td>
</tr>
<tr>
<td>W/S Sulphate as SO4</td>
<td>52</td>
<td>1700</td>
<td>1181</td>
<td>-</td>
</tr>
<tr>
<td>Vanadium</td>
<td>Not Detected</td>
<td>0.035</td>
<td>0.01</td>
<td>-</td>
</tr>
<tr>
<td>Zinc</td>
<td>Not Detected</td>
<td>0.53</td>
<td>0.13</td>
<td>0.04 (2)</td>
</tr>
<tr>
<td>W/S Chloride</td>
<td>Not Detected</td>
<td>27</td>
<td>27</td>
<td>-</td>
</tr>
<tr>
<td>Organic Carbon</td>
<td>1.5</td>
<td>8.5</td>
<td>3.44</td>
<td>-</td>
</tr>
<tr>
<td>W/S Fluoride</td>
<td>Not Detected</td>
<td>2</td>
<td>0.53</td>
<td>-</td>
</tr>
<tr>
<td>pH</td>
<td>7.1</td>
<td>11.4</td>
<td>8.65</td>
<td>-</td>
</tr>
</tbody>
</table>

As can be clearly seen from the summarised information in the tables above and the galligu, on the whole is not significantly contaminated and in fact most of the material could be moved under an exemption without treatment (which has been approved by the EA).

Environ also undertook ConSim modelling of the untreated galligu, however this is not repeated here as the development proposes to treat all excavated material.

In both ConSim risk assessments (for treated and untreated galligu material) the results showed that it is not likely to lead to significant impacts on the potential controlled water receptors.

Notwithstanding the results of the ConSim assessments, the sequence of treatment will be undertaken as previously i.e. the galligu treated soil will be sandwiched between two substantial low permeability engineered layers and be sat well above the saturated zone in the contaminated Made Ground. This means that in addition to the long term curing of the cement stabilised material, it will not be in contact with water that could leach materials from the surface. Furthermore the permeability of the treated material itself is of the order of $1 \times 10^{-10}$ thus percolation and infiltration through it is highly unlikely.
In addition to the previous sampling of the Reclamation Mound EAME have obtained a further 30 samples of soil/galligu from the Reclamation Mound and subjected them to chemical analysis and 10 samples for leachability testing, see Tables 3.9 and 3.10 below.

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Minimum Observed Concentration (mg/kg)</th>
<th>Maximum Observed Concentration (mg/kg)</th>
<th>Average Concentration (mg/kg)</th>
<th>CLEA SGV Industrial End Use (No. of exceedances)</th>
<th>GAC Industrial End Use (No. of Exceedances)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>4.9</td>
<td>580</td>
<td>120</td>
<td>500 (2)</td>
<td>-</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;0.2</td>
<td>19</td>
<td>1.8</td>
<td>1400 (0)</td>
<td>-</td>
</tr>
<tr>
<td>Chromium</td>
<td>3.2</td>
<td>96</td>
<td>24</td>
<td>5000 (0)</td>
<td>-</td>
</tr>
<tr>
<td>Copper</td>
<td>14</td>
<td>420</td>
<td>147</td>
<td>-</td>
<td>45700 (0)</td>
</tr>
<tr>
<td>Lead</td>
<td>6.4</td>
<td>2300</td>
<td>255</td>
<td>750 (2)</td>
<td>-</td>
</tr>
<tr>
<td>Mercury</td>
<td>&lt;0.3</td>
<td>11</td>
<td>1.04</td>
<td>480 (0)</td>
<td>-</td>
</tr>
<tr>
<td>Nickel</td>
<td>3.1</td>
<td>38</td>
<td>17</td>
<td>5000 (0)</td>
<td>-</td>
</tr>
<tr>
<td>Zinc</td>
<td>10</td>
<td>4000</td>
<td>593</td>
<td>-</td>
<td>1880000 (0)</td>
</tr>
<tr>
<td>Total Sulphate as SO4</td>
<td>120</td>
<td>150000</td>
<td>30435</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>W/S Sulphate as SO4 (2:1)</td>
<td>63</td>
<td>8900</td>
<td>3141</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sulphide</td>
<td>2.3</td>
<td>1300</td>
<td>298</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ammonium</td>
<td></td>
<td>150</td>
<td>17</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>pH</td>
<td>7</td>
<td>12.1</td>
<td>8.37</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Minimum Observed Concentration (ug/l)</th>
<th>Maximum Observed Concentration (ug/l)</th>
<th>Average Concentration (ug/l)</th>
<th>Estuarine EQS (No. of exceedances)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>&lt;1.1</td>
<td>100</td>
<td>24.4</td>
<td>25 (3)</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>N/A</td>
<td>0.2 (0)</td>
</tr>
<tr>
<td>Chromium</td>
<td>&lt;0.4</td>
<td>0.7</td>
<td>0.43</td>
<td>4.7 (0)</td>
</tr>
</tbody>
</table>
The above findings, observations and test results are similar in nature to the previous data reported from investigations within the mound i.e. there does not appear to be significant variance of the chemical composition of the material encountered in this recent investigation, compared with results identified previously.

Additional samples have also been obtained by Earth Tech Solutions (ETS) from trial pits in the mound and area of cut within Phase I (site preparation for Unit 3). These will be subjected to chemical testing, leachability testing and monolithic testing. The results are currently outstanding at the time of writing this report.

### 3.14 Surface Water Qualitative Risk Assessment

**Potential Risks to the Surface Waters**

The closest watercourse to the site is Stewards and Ditton Brooks which flow through the centre of the site and on the western boundary respectively. The emplacement of treated galligu and complete
hardstanding of the entire site will lead to the improvement of the water quality in the Brooks as a result of the development for several reasons:

1. The entire site will effectively become capped by buildings, hard surfacing and landscaping which will (a) prevent rainwater percolating through the soil and dragging contamination into the groundwater;

2. The surface sealing of the site will mean any rain falling on the site will be flowing across a clean uncontaminated surface and putting large volumes of fresh water into the brook thus improving quality;

3. Re-lining a section of Stewards Brook and stabilisation of the bankside through re-grading/profiling will further reduce the potential for contaminant transfer from groundwater to surface water and reduce the potential for solid matter to enter the brook;

4. The stabilisation of large volumes of galligu effectively eliminates a large volume of pollutant so is in effect partial remediation of the site soils; and

5. The capping of the site and prevention of future “topping up” will lead to a less dynamic groundwater regime and less pollutant transfer via groundwater through flow into Steward’s Brook, which is already inhibited to a large extent (although clearly not completely) by the sheet piling.

The combination of these elements will necessitate a definitive improvement in water quality at the site. It is acknowledged that the capping of the site will not prevent the on-going transfer of contaminated groundwater between the development land and the Brooks, however it is considered that the sheet piles, while possibly not working to the maximum extent, do nevertheless provide a barrier. The migration of contaminated groundwater into the brook is thus considered to be relatively low, and with significant capping of the site which will reduce the transfer of further water into the saturated zone. In addition, relining of Stewards Brook from the railway at the north, to the road
bridge crossing will reduce entry of contaminated groundwater into the brook. Re-grading/profiling of the bankside will reduce the potential for solid matter to enter the brook.

The ConSim modelling described earlier demonstrates that the treated (and untreated) galligu in itself does not present a significant pollution source. The findings, observations and test results are similar in nature to previous investigations within the mound i.e. there does not appear to be significant variance of the material encountered in this recent investigation, compared with results identified previously.

3.15 Piling Risk Assessment

Due to the type and nature of the development it is envisaged that floor loads will be high, settlement criteria stringent and roof spans large such that foundation loads will be significant. In light of this and the weak and variable nature of the soils found across the site it is proposed that some of the built structures are founded upon piles. The contaminated nature of the near surface deposits and the potential for creating pathways to the underlying soils and aquifer as a consequence of the piling operation is recognised and understood and piling methods will be chosen on the basis of risk assessment as well as structural performance.

From the information available from the site investigation it is currently anticipated that various piling techniques may need to be employed across the site including both displacement and non-displacement types, in addition to surface based ground treatment (e.g. cement stabilisation). During the detailed design phase it is intended that final ground treatment and/or pile designs will be determined and agreed through discussion and liaison between the EA, the Structural Engineer and the specialist Piling and Groundworks Contractors taking due regard of structural performance and the avoidance of contamination migration.

Ideally, the piling technique will comprise friction piles, which are designed to bed into stiff boulder clay over a sufficient length (depth) to ensure that the frictional forces between the pile and the surrounding clay exceed the downward force of the buildings load, and thus provide a stable support for the
building. Given the size of the buildings and loads that could be involved, the Structural Engineers may need to consider piles in excess of 15m deep which may encounter the sandstone rock head that underlies the made-ground and drift deposits. This may necessitate piles ranging from between 14m to >45m depth across the site due to the sandstone rock head dipping sharply from east to west. This would be clarified during the engineering design phase.

**Environmental Implications of Piling**

In Environmental Impact terms, the principal concerns with piling are:

- piling equipment can generate both noise and vibration that could be evident off-site;

- certain piling methods can bring spoil (some of which may be contaminated) to the surface and other methods may drive contaminated soil down into deeper horizons where it would not have previously existed; and

- any piling method that passes through contaminated ground or groundwater into underlying uncontaminated strata creates a potential pathway for downward migration of contaminants (i.e. can cross-contaminate previously uncontaminated ground or groundwater) by allowing contaminated water to drain along the sides of the pile into deeper strata.

With respect to ground contamination issues, it is recognised that in many locations on the site, the piling locations will coincide with varying degrees of contaminated ground and groundwater. What has not been determined at this stage is the specific piling technique that will be used and where these will be required.

This will be influenced by a number of factors including:

- feasibility of surface cement stabilisation techniques;
- depth to rock head;

- required bearing strength;

- presence or absence of contaminated soil along the pile profile;

- presence or absence of contaminated groundwater along the pile profile;

- the specific nature of the contamination that may be present;

- proximity to retained structures (i.e. structures that could be damaged by vibration), and

- cost.

Once Planning Consent has been granted for this development then the Client will commission further investigation of the proposed pile locations, and commence technical discussions with piling contractors to define appropriate piling methodologies and an overall strategy. It is likely, however, that the piling techniques selected will be a combination of augered piling and displacement piling; each of which has potential impacts associated with it, and these are discussed below. These techniques will be used where surface based ground stabilisation is not feasible.

**Auger Piling**

This involves using a rotary boring (auger) technique whereby a screw auger is slowly progressed through the ground whilst, at the same time, bringing the material it has bored through to the surface. Notwithstanding the obvious implication of the open borehole providing a direct pathway from contaminated horizons into uncontaminated horizons (which applies to any piling technique) there is also the issue of exposure to contaminated soils and vapours (e.g. VOC’s from hydrocarbon contamination or hydrogen sulphide from Galligu). The most sensitive receptor for this being the Piling Rig Operators. Furthermore, this technique creates a waste material requiring management and
disposal (regardless of whether or not it is contaminated). If the material is contaminated then there is also the potential for contaminated run-off from this exposed material draining into on-site drainage systems or previously uncontaminated ground. The technique aim would be to screw an auger into the ground to the required depth and then to pump concrete down the hollow auger stem as the auger is slowly withdrawn. Reinforcement is then pushed into the wet concrete.

**Displacement Piles**

This typically involves physically driving a preformed concrete pile into the ground to the required depth. Again, there is the potential for this to create a cross-contamination pathway from contaminated to uncontaminated horizons, but also this technique can physically drive contaminated soils down into deeper horizons, albeit in relatively small quantities dictated by the cross-sectional area of the pile. Significant advantages of this technique over augered piling, however, are that no contaminated material is brought to the surface, thus Worker exposure and waste disposal problems are avoided, and there is no need for the pouring and setting of concrete.

The relative merits of the piling techniques on their associated environmental implications are summarised in *Table 3.11* below:
<table>
<thead>
<tr>
<th>Piling Technique</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Auger Piling</strong></td>
<td>Does not physically transfer material from contaminated horizons to uncontaminated horizons, and instead brings all materials to the surface where they can be managed/disposed of.</td>
<td>The pile can provide a direct migration pathway between contaminated and uncontaminated horizons. This technique can generate large volumes of waste material, some of which may be contaminated presenting Worker exposure and waste disposal issues. The open hole can provide a direct pathway for potentially hazardous gases (e.g. H₂S and VOC) to migrate to the surface (Worker exposure issue). During periods of heavy rainfall, the open hole can provide a direct pathway for substantial volumes of water to flow into contaminated horizons and carry contamination down to previously uncontaminated horizons.</td>
</tr>
<tr>
<td><strong>Displacement Piling</strong></td>
<td>There is no open hole and the pile can be installed directly without bringing any material to the surface.</td>
<td>The pile can provide a direct migration pathway between contaminated and uncontaminated horizons. This method can drive solid contaminants and contaminated soil directly into underlying uncontaminated strata and groundwater.</td>
</tr>
</tbody>
</table>

It should be noted that, in addition to the piles providing a pathway for contaminated water to seep downwards into underlying strata, there is also the potential to allow underlying uncontaminated groundwater that may be under confined conditions (i.e. sub-artesian) to rise-up into contaminated ground.
Mitigation of Piling Impacts

As a precursor to the Construction project and in conjunction with the proposed further investigation that will take place once planning permission has been granted the Client will undertake a Piling Risk Assessment in accordance with the EA Methodology for such set out in their publication - *Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance of Pollution Prevention*. Based upon the investigation of pile locations and the Piling Risk Assessment, the Client and its Contractors will confirm with the Environment Agency which of the proposed piling locations presents a potentially significant risk of cross-contamination between contaminated and uncontaminated horizons. A detailed Method Statement will be then agreed setting out the piling technique and protection methods that will be employed. It is likely that this will include:

- augered piling to bring the contaminated material up to the surface where it can be managed and controlled;

- pre-emptive or simultaneous advancement of solid casing, which will isolate the material being excavated from the surrounding material and prevent groundwater seepages into the borehole, and

- in-situ casting of the piles with secondary sealing of the made-ground/natural ground interface so that groundwater cannot be transmitted downwards along the outside edge of the formed pile.

Where the proposed piling location does not coincide with significantly contaminated ground and the Piling Risk Assessment demonstrates that there is negligible risk of cross-contamination then it is likely that preformed displacement piles will be used.

The rotary auger piling will bring materials to the surface from each horizon that it passes through. It is proposed that these pile horizons are monitored and periodically sampled to enable them to be characterised and, where possible, segregated. This will enable the contaminated material and
uncontaminated material to be defined and segregated for management and handling in accordance with Site-wide Waste Management Strategy.

The full details of the piling strategy and techniques will be determined in conjunction with suitably qualified Piling Contractors and confirmed with Halton Borough Council and the Environment Agency well in advance of piling works commencing on site.
4 Remediation Scope and Methodology

4.1 Introduction

A discussion of the planned remediation works was provided within the previous Remedial Strategy and is not considered to significantly deviate from the information provided in that report (67C13948), however to summarise the remediation project will involve the following elements:

- A Materials Management Plan (MMP) (Appendix A), developed in accordance with the CL:AIRE CoP, and which forms part of this remediation strategy;

- A Verification Plan, which forms part of this remediation Strategy, to identify how the placement of materials is to be recorded and the quantity of material to be used;

- Asbestos Removal (where this may be encountered in fill material)

- Removal of Redundant/orphaned waste materials & goods

- Building Demolition & Clearance of Site Infrastructure

- Vegetation Stripping

- Soil excavation, stock piling and redeposition/disposal;

- Galligu stabilisation and re-use;

- Excavation and treatment/disposal of hydrocarbon contaminated materials (if present);
- Japanese Knotweed control and treatment;
- Groundwater abstraction/control/treatment/discharge;
- Surface water management/control/treatment/discharge;
- On-site concrete crushing;
- Backfill of excavations;
- Confirmatory monitoring / reporting for the remedial works; and
- Production of a Verification Report upon completion.

‘Construction’ works associated with the remedial works will be undertaken in accordance with British Standard Codes of Practice (where applicable), as well as established construction industry practices.

The Works will incorporate relevant requirements in respect of environmental control, based largely on Environment Agency guidance and industry-accepted standards of ‘good working practice’. The Contractor will, at all times adhere to the provisions outlined in the Construction Environmental Management Plan (see Appendix B).

4.2 Phasing of the Construction Programme

The phasing of the earthworks and infrastructure is based on land to the east then west of Stewards Brook. The previous Remedial Strategy for the site provided in broad terms the basic sequence for all of the main works at the development site, which this project will follow.
- **Preparation of Phase I (land to east of Stewards Brook)** – essentially the area comprising the proposed Unit 3 and roadways.

- **Reclamation Mound Excavation** - The ‘mound’ area is capped off with clay approximately 1.5m deep. The excavation of the material from the mound will be undertaken for the Phase II earthworks, when land to the west of Stewards Brook is developed.

- **The Stabilisation of Galligu** – the material excavated from the areas identified on the plan 80962 – Phase 1 Volumes and 80962/0014 will be treated by the remediation contractor and deposited in engineered layers to form a developable platform.

- **Stewards Bridge Construction** – A new bridge is required for the spine road. This will necessitate the crossing of Stewards Brook – the design will be submitted and agreed with HBC and the EA prior to commencement.

- **Building of Units and Car Parks** – this will be completed once the phasing of the works is identified, dependent on the final customer’s requirements.

- **New Rail Siding** – this will be completed to meet a growth in existing demand for rail freight and/or demand from the proposed units within Stobart Park.

In addition to these building related works there will be infrastructural works associated with the building of the site spine roads, car parks and storage areas. These works will take place in tandem with the main construction works but it is not possible at this stage to state where in the phasing sequence each of these “non-building” aspects of the site development will take place (with the exception of the main site spine road discussed above).

From an environmental and pollution prevention perspective, however, it will be the bulk excavation work and treatment of galligu that has the potential for greatest impact both in terms of management
of the materials excavated and management of potentially contaminated groundwater and surface water run-off. Once the galligu has been excavated, treated and emplaced there is relatively little in the way of potentially polluting activities on the site.

4.3 Preliminary and Enabling Works

4.3.1 Service Utilities

All existing services, whether underground or overhead, including electricity, gas, data networks, product lines will be safely disconnected or diverted.

The mains water supply is available on the site and will be utilised for construction purposes. No water will be taken from surface watercourses for potable supply but the galligu treatment does need relatively large volumes of water which may be derived from surface water sources using temporary pumps.

4.3.2 Permits and Licences

Where required, all applicable permits or licences will be obtained prior to beginning work. It is anticipated that the following permits, licences and approvals may be required for the project:

- Mobile plant licence for galligu stabilisation (waste management activity);
- Site Specific Working Plan (Deployment) for the licensed remediation contractor;
- Groundwater Consent for surface disposal of contaminated waters to sacrificial areas;
- Plant licence for screening/crushing equipment;
- HSE approval for asbestos removal contract and method;
- EA approval of proposed piling methodology and pollution prevention measures;
- EA approval for discharge of clean construction run-off to surface watercourses;
- EA approval for permanent site drainage to surface waters;
4.3.3 Facilities for Design Team Personnel and Authorised Visitors

The following facilities will be maintained on site during the construction works:

- free access to the site (via a signing in procedure);
- a dedicated working office space and access to toilets and other welfare facilities;
- provision of water, electricity and telephone line; and
- cleaning and decontamination facilities for personnel likely to come in to contact with contaminated soil and water.

4.3.4 Security of the Site

Stobart Group will ensure that the site is secure during the entire Works programme, so far as is reasonably practicable. All appropriate Health and Safety signage and contact details will be clearly displayed at the site entrance during the works and access to the site will be controlled. Tenants carrying on business activities during the works will be required to comply with site safety rules and ensure that their operations do not encroach upon construction work areas.

4.3.5 Demolition Works

The demolition of existing buildings will be dependent on the final decision regarding phasing of the works, however where this is anticipated the following elements will need to be considered:

- EA approval for treated sanitary wastewater to surface waters; and
- Appropriately licensed waste carriers and disposers.

Where relevant these are discussed in more detail at the appropriate point in this document.
- asbestos removal prior to demolition of buildings;
- isolation of power;
- strip out of plant / pipe runs / residuals / above ground storage tanks; and
- demolition of buildings.

Residual materials will not be allowed to cross-contaminate re-usable materials (e.g. crushed concrete) arising from building demolition.

### 4.3.6 Excavation, Handling and Off-site Disposal

The remediation of the site will involve the physical treatment and chemical stabilisation of around 350,000 m$^3$ of contaminated soils (galligu) and the capping and sealing of around 32.29 hectares of, in places, heavily contaminated land that is mostly permeable to rainwater infiltration (and thus leaching) at present. Filling and raising of ground levels at the site will use site-derived materials.

The remedial strategy involves substantial re-levelling of the site to provide a net balance across the site, which will involve raising the land and a reduction in levels around the Reclamation Mound. This will involve a cut and fill balance using site derived materials. The first part of this works comprises an area of 9.5 hectares and relates to Phase I as illustrated by, Fairhurst Drawing 80692-0014.

**Material Quantities**

The overall materials management requires the handling of around 350,000 m$^3$ of engineered infill to achieve the desired formation level across the site. In total it is estimated that this will largely be removed from the Reclamation Mound, which will be treated and dealt with under the CL:AIRE Code of Practice as a re-usable material once treated.

The current proposal for the Phase I earthworks and infrastructure comprise the following gross (m$^3$) quantities as indicated on Fairhurst Drawing 80962/0014:
Phase 1

Unit 3, carpark and HGV Parking:  22,221(CUT)   20,058(FILL)

Roadway (and Banking):  1,406(CUT)   7,0770(FILL)

The cut and fill volumes do not account for the bulking of materials arising from the removal of the existing culvert and bridge, material arising from drainage and utilities, nor for the inclusion of stabilised material. It is considered therefore that the above volumes will balance once these have been incorporated. The Materials Management Plan will be updated with the data as it is received.

Following the Phase I works, the remainder of the site will be developed in a phased manner comprising the following:

- Phase 2 – Stage 2 Earthworks and Infrastructure to provide a new roundabout to serve units 1 and 2, serviced sites for unit 1 and 2, strategic landscaping and completion of the cycleway/footway to also form emergency access to Foundry Lane.
- Phase 3 – New Rail Siding;
- Phase 4 – Unit 1;
- Phase 5 – Unit 2; and
- Phase 6 – Unit 3.

The remaining phases (2-6) will be subject to a separate Material Management Plan outlined for each phase. No detailed figures are currently available, but from a previous mass balance exercise this was calculated to be a net balance of around 350,000 cubic meters.

Top Soil, Clay and Non-Conforming Material

- Top Soil will be excavated from the surface of the Mound and stockpiled for re-use in areas of landscaping.
- Clean clay excavated from the surface of the mound will be segregated mainly for direct re-use as a low permeability clay capping/bedding layer.

- Where material is encountered during excavations that cannot be lime/cement stabilised, this material will be quarantined (either in-situ or ex-situ) pending identification of appropriate treatment and disposal options, with preference given to on-site treatment and re-use over off-site disposal.

The exact volumes for each material type are not known at this stage but in essence all but a very minor fraction is expected to be used for the land raising exercise or site landscaping (topsoil & sub soil only).

**Galligu Contaminated Material**

This material will be treated ex-situ with a lime or cement stabilisation technique operated under a Mobile Plant Licence. The treated (stabilised) galligu will then be emplaced in layers to form a structurally and chemically stable cap which provides a building platform and also seals the site from percolation of rainwater into contaminated sub-soils and eliminates vapour, ingestion and dermal contact human health risks to site occupiers.

The proposed stabilisation scheme is discussed in more detail in Section 4.4 below.

**Imported Engineering Materials**

Imported materials will include aggregate, concrete, tarmac, etc. These materials will be imported to ‘top off’ the surface of the site following emplacement of treated and non-treated material. These will not be waste materials.
4.4 Soil Stabilisation Techniques (Galligu Treatment)

Stabilisation/Solidification is a civil-engineering based remediation technique in which contaminated soil is mixed with lime or cementitious materials to improve its engineering properties and immobilise contaminants. The dual action means that it is suitable for both land of poor engineering properties and land affected by contamination. Many derelict and brownfield land sites are made up of poor land containing contaminants so Stabilisation/Solidification is a practical technique that provides cost effective remediation, and was successfully undertaken during Project Eagle.

The objectives of stabilisation/solidification remediation are, in the case of stabilisation, to produce more chemically stable constituents. In terms of solidification the objectives relate to passing on physical and dimensional stability to contain the contaminants in a solid product and reducing the influence of external agents such as air / precipitation therefore rendering the contaminants immobile and virtually unleachable.

The proposals for the site are to excavate the galligu and transfer it to a stabilisation processing area where it will be mixed with lime to produce a stabilised material. A detailed method statement for the galligu stabilisation will be presented by the remediation contractor in due course.

The treated galligu and galligu contaminated soils will be subjected to a substantial post treatment testing regime to ensure that the material is both geotechnically suitable as construction fill and environmentally stable.

4.5 Management of Contaminated Waters

There is a possibility for the need for on-site water treatment of contaminated perched groundwater encountered. This water will require abstraction and disposal, either off-site or by means of spraying on-site under a temporary consent to discharge to land. Disposal to foul sewer will require consent
from the Water Company, and may require pre-treatment, although this is unlikely to be an option given
the absence of such sewers of a suitable size in the area.

The site features shallow groundwater, which in the Works area, is potentially contaminated. The
contractor will ensure that a suitable design is in place to remove, treat and dispose of this water. Treatment options may need to include settlement, oil interception, and other contaminant-specific
technologies in order to gain a consent to discharge to land or the local water courses. If this cannot be approved in a reasonable time frame the material will be sent off site for treatment via road tankers and a registered waste carrier.

During the works surface water run-off from the works area (and any stockpile areas) will be controlled
and assessed prior to consented discharge. The Contractor will implement procedures from published guidance documents for working on contaminated sites, such as following the Control of Water Pollution from Construction Sites CIRIA C532 guidelines (CIRIA 2001).

Particular care will be exercised for work close to the any drainage (surface and foul) water systems and
the Brooks. Measures will be put in place to intercept direct run-off from any disturbed areas or seal off ingress points to the drainage system and thereby stopping any potential impact.

The contractor will undertake selected sampling and analysis for a range of ‘standard’ discharge determinands and any additional parameters requested by the authorities and/or Water Company, at least every 72 hours during any discharge works.

4.6 Japanese Knotweed

Japanese Knotweed has been identified on the site in small stands. The *Wildlife and Countryside Act 1981* makes it illegal to knowingly cause the spread of this plant. Control of the plant is reliant upon the death of the rhizome system, which can take a number of years. Methods of control include cutting/pulling the plant, application of herbicide and excavation of the plant, including its rhizome
system, either for disposal or ex-situ treatment. Any cut and excavated material must be carefully managed. These works will be undertaken in conjunction with Qualified Ecologists by competent contractors to an agreed Remedial Plan.

### 4.7 Further Contamination Discoveries

Should any suspect material be uncovered that is a departure from what is expected (i.e. not demolition rubble, general fill or galligu) all work in that area will stop immediately, and the site manager and EAME will be informed to examine the material and if necessary take samples.

Should there be a possibility of a pollution incident occurring the site emergency response procedures are to be followed and co-ordinated with Stobart’s overall emergency response plan.

It is likely that such “unforeseen” contaminated areas will need to be isolated from the cut operation to prevent cross-contamination and allow the works to continue. All Non-Conforming Contaminating Materials will first be delineated and then isolated from all other materials. A quarantine area is to be designated in an area away from fill material. A heavy duty plastic sheet or membrane will be laid and the material placed upon it and then either covered to prevent contaminated run-off. If that is not practicable, the area will be isolated from the general run-off (temporary bunding) and the contaminated run-off collected and characterised for disposal. As the site works progress the most appropriate temporary quarantine area will change and thus a specific area cannot be nominated at the outset.

Where the discovery relates to drums, physically discrete items and other receptacles, the material(s) will be securely sealed in appropriate containment receptacles and transported to the quarantine area awaiting characterisation and transfer to appropriate waste disposal/ treatment facilities.

EAME will be notified by the Contractor immediately if any such contaminated materials are discovered during the works so that the appropriate assessment of the situation and regulatory notifications (EA and HBC) will be made.
Material will be transported by a licensed waste carrier, under a proper duty of care compliant contract. All documentation relating to the disposal of waste offsite will be retained for five years.

In the unlikely event that the contaminated material is of such a volume that it cannot be handled in the manner above and it requires direct removal to avoid double handling, the works will be suspended in that area until such a time as the material has been tested, a disposal facility identified and the necessary Hazardous Waste notifications have been made.

### 4.8 Off-site Waste Disposal


All material removed and disposed off site will be undertaken in accordance with the Duty of Care requirements of the Environmental Protection Act 1990. In addition the Contractor shall ensure that the disposal operation is carried out in accordance with the requirements of the appropriate Local Authority and Environment Agency.

In accordance with the Duty of Care Regulations (Section 34 of the Environment Protection Act 1990) the Contractor is the producer of waste and the transfer from the site and disposal shall be performed by an approved waste disposal contractor. Loading of vehicles shall be performed in an organised manner so as to prevent the spread of contaminants. All vehicles are to be sheeted and cleaned if required, prior to leaving site. The Contractor shall take all reasonable and applicable measures to prevent the escape of material during transportation.

The Contractor will keep valid copies of the waste transfer certificates for each load of material excavated (and disposed of offsite) during the ground remediation works. This information will be available to the Regulatory Authorities. Copies will also be included in the MMP.
The contractor will develop, implement, monitor and modify as required, a detailed Waste Management Plan for all wastes arising from the Works in accordance with the *Site Waste Management Plans Regulations 2008*.

### 4.9 Backfilling and Reinstatement

Material used for backfilling will include treated (stabilised) galligu contaminated soils, excavated soils not exceeding relevant contamination threshold criteria (to be emplaced via the CL:AIRE CoP), site derived demolition material (crushed) and imported materials (including aggregate, concrete, tarmac, etc.). The areas of cut will be overdug to allow a suitable thickness of treated material to be emplaced to create a developable platform.

All of this data will be compiled into a final Verification Report after the works have been completed. This will be submitted to the EA and Halton Borough Council.

### 4.10 Remedial Targets

The objective of the remediation is to treat any galligu that is excavated in the development area to ensure that the cement stabilised material (which will be re-used on site as an engineering material) is not capable of leaching contaminants at levels that would exceed the WAC for inert wastes or breach the estuarine Environmental Quality Standards (EQSs) at the River Mersey. This has previously been demonstrated during the Project Eagle development. Where appropriate, further laboratory trials, field trials and leaching tests will be undertaken (and in the latter case quantitative risk assessment modeling has been performed previously on trial data to demonstrate the suitability of the proposed method).

Additional testing of the material within the Reclamation Mound has been undertaken and the results of this testing is presented in Section 3.13. The findings, observations and test results are similar in nature to previous investigations within the mound *i.e.* there does not appear to be significant variance of the material encountered in this recent investigation, compared with results identified previously. Further
samples have also been obtained by ETS and will also be subject to leachability testing and the results compared with WAC criteria.

The re-sampling of cured, post emplacement treated galligu and leaching tests will be undertaken. As well as comparing these test results to the WAC criteria, the range of leachability levels will be compared to those used for the original ConSim modeling. If that data shows that leachabilities lie within the range that has already been modeled then the original model stands. If, however, leachabilities are observed above the maximum previously used, the models will be re-run with the new data.

**4.11 Reporting**

On completion of the works, a Verification Report will be provided in accordance with the CL:AIRE CoP. This report will also fulfil the requirements of a contamination remedial works Validation Report. The report will provide an audit trail to demonstrate that the materials and wastes have gone to the correct designations. The Verification Report will include the following information:

- appropriate site plans showing the areas and depths of excavation of contaminated soil;
- a copy of the survey showing the site levels both before and after excavation, and the volume of soil removed;
- experience and qualifications of the person preparing the report;
- project description;
- a description of how that material’s usage links with the remediation strategy;
- reference to site investigation data and risk assessments;
- reference to the MMP and MMP tracking system;
- suitable for use criteria;
- treatment records;
- laboratory analytical results;
- reference to waste transfer documentation;
- inclusion of signed delivery tickets;
- plans showing the location of validation sampling points;
- record of any implemented contingency measures;
- record of the quantity of material used; and
- a signed Declaration by a Qualified person (as per the CoP).
5 The Re-use of Excavated Material on-site as Non-waste

5.1 Introduction

The CL:AIRE Industry Code of Practice (CoP) allows for remediation projects to take place without the need for formal Environmental Permitting of the deposit of excavated materials, provided that certain requirements are met and that certain protocols are observed and that there is an auditable process verified by an independent “Qualified Person”.

There are four main factors in assessing the suitability of excavated materials for classification as a non-waste, namely:

- Suitability for use without further treatment;
- Certainty of use;
- Quantity of material; and
- Protection of human health and the environment

Each of these factors is discussed below.

5.2 Suitability for Use

The CoP states that “suitability for use means that a material must be suitable for its intended purpose in all respects. In particular, both its chemical and geotechnical properties have to be demonstrated to be suitable, and the relevant specification for its use must be met. Suitability of use also includes consideration of the effect that the material may have on the environment”.

Materials to be re-used at the site comprise treated (stabilised) galligu contaminated soils and site derived demolition material (crushed). Their suitability for re-use in terms of chemical and geotechnical
properties and the effect that the material may have on the environment are discussed below. This is similar to the Project Eagle development which successfully demonstrated that the material was suitable for use once stabilised.

**Chemical Properties**

For soils excavated from the Reclamation Mound a set of assessment criteria were proposed in consideration of the material's acceptability for re-use on the Tessenderlo area (Project Eagle). These are detailed in the previous reports as detailed in Section 2.1. These assessment criteria were derived to be protective of human health. During the excavation works there will be an on-going testing regime to validate that the soils excavated from the Reclamation Mound and other areas meet the environmental objectives to qualify for exemption.

The stabilisation process involves the treatment of galligu and galligu contaminated soils using Ordinary Portland Cement (OPC) whereby the contaminated soil is mixed with the selected additive in predetermined proportions. Cement is a pozzolanic binder which when mixed with soils can form a durable monolithic mass in which the contaminants are contained and physically bound and the potential leaching action is greatly reduced as the material cures and hardens with time.

In summary, it can be demonstrated that the material that the Stobart Group wishes to re-use as engineered fill will be chemically ‘suitable for use’.

**Geotechnical Properties**

Given that the intention is to erect warehouses, the in-fill material needs to be structurally competent and meet specific geotechnical criteria. To accommodate the loads to be applied from a geotechnical point of view and to permit suitable placement, the galligu contaminated soils are required to be treated by cement stabilisation. However, it should be noted that stabilisation treatment may also be applied to soils meeting the chemical assessment criteria, simply to make the material better to handle and compact from an engineering perspective.
The stabilisation process is required to provide an increase in strength to a minimum laboratory soaked CBR value of 5%, this also requires the materials to achieve 95% relative compaction to reduce the quantity of voids present within the materials placed and treated, in line with the Specification for Highway Works.

In conjunction with the compactive effort applied and achieved within the treated materials, the permeability is also assessed in order to determine the potential for movement of water within the mass of materials treated.

The stabilised material (for Project Eagle) was subjected to a number of physical tests which have demonstrated that it can meet the specified engineering criteria. The data from the previous testing was provided which indicates that in its natural ‘untreated’ state the galligu achieves relatively poor CBR strengths ranging between 0 and 4% and also displays relatively high moisture contents. Thus different increments of binder were added to samples removed from the site and cured for 7 days prior to testing. Strength gain recorded during laboratory trials shows an increase in strength ranging between 45 and 138% CBR. Furthermore, due to the composition of galligu, 95% compaction is also easily achieved. In terms of permeability, these trials have shown that 1x 10^-9 m/s is achievable and in some instances 1 x 10^-10m/s.

In summary, it can be demonstrated that the material that Stobart Group wishes to use as engineered fill (i.e. the galligu contaminated soils from the Reclamation Mound) can be successfully treated to meet the engineering criteria for the proposed development end use.

**Potential Effect on the Environment**

In order to demonstrate the effectiveness and applicability of the cement stabilisation process a number of laboratory tests have been performed on the galligu contaminated soils previously. Bulk samples of galligu contaminated soils were collected from the Reclamation Mound and cast into monolithic blocks using different percentages of cement (OPC). These “cast” monoliths were then subjected to leach
testing in accordance with EA NEN 7375:2004 – *Leaching Characteristics of Moulded or Monolithic Building and Waste Materials* (the so called 64 day “Tank Test”).

The concentration of leached contaminants (expressed in mg/l of direct concentration in the eluate) was compared to Environmental Quality Standards (EQS) for the Project Eagle development. In most cases the leachability results were below the EQS value and thus the material could not be considered to represent a significant pollutant source. In some cases, however, the leachability was higher than the EQS and thus could be regarded as a potential pollution source. Consequently, a detailed qualitative risk assessment (DQRA) was performed to determine the likely concentration of the key “contaminants of concern” (CoC) in the sensitive receptor (*i.e.* the nearest surface water, The River Mersey) which may interact with the groundwater on the site. It is acknowledged that whilst Stewards Brook and Ditton Brook are now the closest surface water receptors to the site, it should be borne that the distance to the River Mersey in the original ConSim modelling runs was based on 20m to the nearest sensitive receptor and the groundwater below the site.

The following substances were modelled in relation to risk to the River Mersey and risk to groundwater:

- Chromium
- Copper
- Zinc
- Molybdenum
- Lead

The modelling was undertaken on a sample using 2% OPC which is the least likely binder content addition (and the most workable in engineering terms) and thus represents a likely worst case in environmental terms. The modelling results demonstrated that the leachate that could be generated from the treated galligu material would not cause a breach of the relevant guideline value in either the River Mersey or the Groundwater on site. The results of the risk assessment are also described in *Section 3.13* of this report.
In addition, as a consequence of the engineering sequence, the galligu treated soil will, aside from being cement stabilised itself to greatly reduce the leachability, be sandwiched between two substantial low permeability engineered layers. Furthermore the permeability of the treated material itself is of the order of $1 \times 10^{-10}$ thus percolation and infiltration through it is highly unlikely.

5.3 Certainty of Use

In accordance with the CoP, it is necessary to demonstrate with certainty that the material will be re-used and that there is not just a likelihood of them being used. Surplus material that cannot be re-used (either pre or post treatment) will be classified as a waste. Similarly, any out of specification material that cannot be re-used will be classified as a waste.

The work requires around 350,000 m$^3$ of engineered infill in total to achieve the desired formation level. The majority of this will be derived from excavation of the Reclamation Mound. For Phase I, approximately 24,000 m$^3$ will be required for the preparation of the area east of Stewards Brook. It will be necessary to import certain materials, including aggregate, concrete, tarmac, etc. These imported materials will be used to ‘top off’ the surface of the site following emplacement of treated material.

As such, the certainty of re-use of the material can be clearly demonstrated as it is an integral part of the development scheme and there is a demonstrable need for material in these volumes and a demonstrable useable source of suitable material in the Reclamation Mound.

5.4 Quantity of Material

The CoP states that “materials should be used in the quantities necessary for that use and no more. The use of an excessive amount of material will indicate that it is being disposed of and is waste.”

The development requires around 350,000 m$^3$ of engineered infill in total to achieve the desired formation level across the area. A preliminary cut and fill assessment has been undertaken for Phase I which indicates a net balance of material, see Fairhurst Drawing 80692 -0014. Previous assessments
and a mass balance for the entire Stobart Park development site, have been undertaken and as such all material excavated from the site and Reclamation Mound can be re-used on the site, providing it meets the ‘suitability for use’ criteria discussed within this report.

5.5 Protection of Human Health and the Environment

In accordance with the CoP, material can only be considered a non-waste if it can be demonstrated that the use of the material will not lead to pollution of the environment or cause harm to human health.

Protection of Human Health

In consideration of the excavated material’s acceptability for re-use in terms of the potential risk to human health, reference has been made to the former CLEA soil guideline values (SGVs) for commercial use. Although these guidelines have recently been withdrawn they are still considered to be acceptable screening criteria. Where CLEA SGVs are not available, reference has been made to the GAC commercial end use values and to hazardous waste threshold concentrations.

The analytical results for the soil samples obtained from the Reclamation Mound have been summarised in Table 5.1 below in relation to the proposed assessment criteria.

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Minimum Observed Concentration (mg/kg)</th>
<th>Maximum Observed Concentration (mg/kg)</th>
<th>Assessment Criteria Value (No. of exceedances)</th>
<th>Reference (all in relation to commercial end use)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>3</td>
<td>1200</td>
<td>500 (14)</td>
<td>CLEA SGV</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;MDL (0.2)</td>
<td>19</td>
<td>1,400 (0)</td>
<td>CLEA SGV</td>
</tr>
<tr>
<td>Chromium</td>
<td>3.2</td>
<td>96</td>
<td>5,000 (0)</td>
<td>CLEA SGV</td>
</tr>
<tr>
<td>Copper</td>
<td>14</td>
<td>420</td>
<td>45,700 (0)</td>
<td>GAC</td>
</tr>
<tr>
<td>Lead</td>
<td>6.4</td>
<td>2300</td>
<td>750 (4)</td>
<td>CLEA SGV</td>
</tr>
<tr>
<td>Mercury</td>
<td>&lt;MDL (0.4)</td>
<td>11</td>
<td>480 (0)</td>
<td>CLEA SGV</td>
</tr>
</tbody>
</table>
Table 5.1 - Summary of Soil Sample Analysis from the Reclamation Mound – Environ/EAME

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Minimum Observed Concentration (mg/kg)</th>
<th>Maximum Observed Concentration (mg/kg)</th>
<th>Assessment Criteria Value (No. of exceedances)</th>
<th>Reference (all in relation to commercial end use)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nickel</td>
<td>3.1</td>
<td>38</td>
<td>5,000 (0)</td>
<td>CLEA SGV</td>
</tr>
<tr>
<td>Selenium</td>
<td>&lt;MDL (3)</td>
<td>&lt;MDL (3)</td>
<td>8,000 (0)</td>
<td>GAC</td>
</tr>
<tr>
<td>Zinc</td>
<td>10</td>
<td>4000</td>
<td>188,000 (0)</td>
<td>GAC</td>
</tr>
<tr>
<td>Sulphide</td>
<td>&lt;MDL (15)</td>
<td>1,100</td>
<td>3,000 (0)</td>
<td>Hazardous Waste TH</td>
</tr>
<tr>
<td>pH</td>
<td>7.0</td>
<td>12.1</td>
<td>6.5-9.5 (3)</td>
<td></td>
</tr>
</tbody>
</table>

MDL = Analytical Method Detection Limit

As can be seen the material on the whole meets these criteria (i.e. is suitable for use without treatment), notwithstanding that all the material to be excavated will be treated under the CL:AIRE Code of Practice.

During the excavation works there will be an on-going testing regime to validate that the soils excavated from the site and Reclamation Mound meet the environmental objectives set out above to qualify for exemption.

Additional trial pits have been undertaken in the reclamation mound area and the area identified for cut in Phase I (site preparation for Unit 3) by Earth Tech Testing Solutions (ETS) and samples submitted for chemical analysis and leachability testing. The results are currently outstanding, but will be subjected to detailed analysis and modelling as previously, however the material excavated visually appears to be of similar consistency to that identified previously.

All of this data will be compiled into a final Verification Report after the works have been completed. This will be submitted to the EA and Halton Borough Council.
Pollution of the Environment

Leachability testing has been performed on treated (cement stabilised) and untreated galligu and the results have been subjected to ConSim risk assessment to determine if there are likely to be impacts upon the aquifer or River Mersey. In both cases the assessments show that the material whether treated or not is not likely to lead to significant impacts on the potential controlled water receptors. The results of the ConSim risk assessment are described in more detail in Section 3.13 of this report.

Additional modelling will be undertaken on the samples submitted for analysis and reported in due course to support the risk assessments previously undertaken.

5.6 Materials Management Plan

The Materials Management Plan (MMP) is intended to document how materials within the ground at the site are to be managed. Given that the site is to be developed in separate phases, this MMP deals with Phase I as per the CLAIRE CoP Section 3.10. The MMP will be followed and updated throughout the remedial and site preparation works.

The MMP will include the following:

- Description of materials with respect to their potential use and relative quantities of each category (such as material to remain in-situ, material capable of being used in another place on the site, materials that are not capable of being used on the site, etc.) based on an appropriate risk assessment;

- Details of where and how (if necessary) these materials are to be stored;

- Details of the intended final destination and use of these materials;

- Details of how these materials are to be tracked; and
- Contingency arrangements to be put in place prior to movement of these materials.

To ensure the quantity of material to be used on the site is not more than that necessary, a mass balance has been undertaken, referenced to the final levels and compared to the pre-existing contours prior to commencement of the works.

The MMP is presented in Appendix A.

5.7 MMP Tracking

Materials subject to excavation, treatment and/or re-use or disposal will be tracked as part of the MMP. Evidence will be generated to enable an auditable trail.

The materials will be reused within 12 months of being stockpiled or stored, or an agreement with the regulatory authorities to extend the timeframe if necessary.

5.8 Contingency Arrangements

Contingency arrangements have been put in place to ensure:

- Out of specification materials are suitably managed;

- Options are available for the management of surplus materials e.g. disposal or recovery options, etc.;

- There are designated responsibilities for the management of such materials; and

- Contingency for programme slippage and for extended treatment times that may arise (e.g. due to adverse weather conditions).
5.9 Qualified Person

A ‘Qualified Person’, Mr Kevin Eaton of MJ Carter Associates, has been designated for the remedial works. Mr Eaton meets the Qualified Person requirements, as defined in the CoP. He will review the evidence relating to the proposed use of the materials on the site and if satisfied, will sign a Declaration, in the form set out in Appendix 6 of the CoP.

A copy of this signed Declaration will be submitted to the Environment Agency so that there is an auditable trail on completion of the project.

5.10 Verification Plan

The Verification Plan identifies how the placement of materials is to be recorded and the quantity of material to be used. This Plan also includes a statement of how the use of materials relates to the remedial objectives.

5.11 Verification Report

A Verification Report will be produced on completion of the project. The objective of the report is to provide an audit trail clearly indicating that materials and wastes have gone to the correct designations and that the materials have been used as defined in this Remediation Strategy. This report will also document any changes that may have been made in the MMP as a result of formal changes or contingency arrangements.

The Verification Report will be reviewed by the ‘Qualified Person’ (although this is not required under the CoP). The report will be submitted to the Environment Agency so that there is an auditable trail on completion of the project.
Figures
Figure 1 – Site Location Plan
Figure 1a – Sampling Location Plan
Figure 1b – Sampling Location Plan
Fairhurst Plan - 11026/22a – Phasing Masterplan
Fairhurst Plan - 11026/23 – Infrastructure Phasing Masterplan
Fairhurst Plan - 80962/0014 – Phase I Isopachyte Proposals
Annex A: Materials Management Plan
Annex B – Construction and Environment Management Plan