Appendix 9.1 The Quays Data Review, WSP 2012

UNITED BY OUR DIFFERENCE

WSP

THE QUAYS - BARRY WATERFRONT

Review of Existing Site Data and Reports

17/10/2012

Confidentiality: Confidential

Quality Management

Issue/revision	Issue 1	Revision 1	Revision 2	Revision 3
Remarks	Draft for Client Comment			
Date	October 2012			
Prepared by	K Hole			
Signature				
Checked by	S Clennell-Jones			
Signature				
Authorised by	P Dowson			
Signature				
Project number	00033313			
Report number	00033313_Data_Review_v1			
File reference				

The Quays - Barry Waterfront

Review of Existing Site Data and Reports

17/10/2012

Client

Barry Waterfront Consortium:
Persimmon Homes Ltd, Llantrisant Business Park, Llantrisant, Rhondda Cynon Taff, CF72 8YP

BDW Trading Ltd, Oak House, Village Way, Tongwynlais, Cardiff, CF15 7NE

Taylor Wimpey UK Ltd, Building 2, Eastern Business Park, Wern Fawr Lane, St Mellons, Cardiff, CF3 5EA

Consultant

WSP Environmental Limited
Fairway House
Paramount Business Park
St Mellons
Cardiff
CF3 0LW
Tel: +44 (0)11 7930 3770
Fax: +44 (0)11 7929 4624
www.wspgroup.co.uk

Registered Address

WSP Environmental Limited
01383511
WSP House, 70 Chancery Lane, London, WC2A 1AF

WSP Contacts

Simon Clennell-Jones
Simon.clennell-jones@wspgroup.com
Katie Hole
Katie.hole@wspgroup.com

Table of Contents

1 Introduction

1.1 Authorisation

WSP Environmental Limited (WSP) was instructed by the Barry Waterfront Consortium (the Client), to undertake a data review of previously completed third party reports and review of the conceptual site model developed for The Quays, Barry Waterfront Development, Barry, Wales (the Site) in order to enable the development of a remedial strategy for the Site.

A Site location plan and proposed masterplan for the development are presented in **Appendix A** as Figure 1 and Figure 2, respectively.

1.2 Project Background

The Client is seeking to redevelop the Site in several phases to include areas of residential development, retail, public amenity and a school. The redevelopment is anticipated to be undertaken over several years.

Cuddy Group (the Earthworks Contractor) has been appointed by the Client to undertake a programme of earthworks / Site preparation works at the Site, initially on the first phase of residential redevelopment and the retail area. These works are being undertaken by the Contractor on a Design and Build basis.

Once the earthworks/site preparation works are complete, it is intended that the various phases will then be redeveloped by a series of other contractors.

The earthworks includes a surcharging exercise with an anticipated volume of 60,000m^3 of material required. It was originally intended to obtain this material from borrow pits to be excavated on the Site. Once the material had been used for surcharging, it was intended that it would later be incorporated into shallow fill/cover material to be placed within gardens and landscaping.

Following commencement of the works, the Earthworks Contractor identified the presence of asbestos within shallow and deeper excavated materials on the Site which are considered to constrain the potential reuse of Site materials for surcharging and/or clean cover.

In order to facilitate the redevelopment of the Site, a Remediation Strategy is considered to be required to form the basis of works to be undertaken to protect Human Health.

1.3 Scope of Document

This document is intended to provide an overview of the geo-environmental assessment works previously completed by third parties including the assessments completed in 2012 upon the Contractor encountering asbestos containing materials (ACM). The overview has been prepared to inform the production of a Remediation Strategy for the Site to allow the proposed redevelopment to proceed in a safe and sustainable manner for the intended mixed residential and commercial end use.

This overview is focussed on risks associated with Human Health in the context of the proposed redevelopment and excludes an assessment of issues relating to Controlled Waters.

1.4 Limitations

It should be noted that this report presents no new desk study or ground investigation data but provides an overview of the information supplied to WSP by others. This report should be read in conjunction with the historical reports.

This data review and the conclusions developed are based on third party reports for which WSP has no reliance and are unable to comment on the reliability / accuracy of the data provided therein. A full list of reports reviewed is provided in **Appendix B**. It should be noted that contamination may be present at the Site which has not been identified during previous assessments which may be encountered during the development and therefore, a strategy for dealing with unidentified contamination will be included within the subsequent Remediation Strategy.

2 The Site

2.1 Site Details

Table 2.1: Site Details

Site Address	The Quays, Barry Waterfront, Barry, Wales,
Grid Reference	311060E, 167120N
Site Area	Approximately 42 Hectares (Ha)
Site Description	The Site comprises several derelict parcels of land which are either surfaced with hardstanding or currently laid to rough scrubland. The south eastern section of the Site is formed by South Quay which was formerly used as a Tank Farm with a number of former concrete tank bases still present amongst the scrubland. The western, central and northern sections of the Site comprise an area referred to as West Pond. The centre south of West Pond is occupied by the Contractor compound which is situated on former car parking with concrete hard-standing extending to the southwest. The western and northern sections of the Site are bound by Harbour Way (causeway) and railway line and Powell Duffryn Way, respectively. The western and northern sections of the Site were noted to be overgrown with scrub vegetation with a number of overgrown stockpiles and excavations in the west and northwest where material has been excavated for surcharging. The north eastern section of the Site (East Quay) is separated from the main Site by Barry No. 1 Dock and comprises open land which is partially overgrown. Two former graving docks were located within the East Quay area of the Site, Graving Docks No. 1 and No.2. The Graving Dock No. 1 was backfilled as part of remedial works undertaken in the 1990s and now comprises undeveloped scrubland.
Surrounding Area	The southern Site boundary is formed by a cliff upon which is Barry Island comprising a residential development with a fun park to the southwest. The western Site boundary is formed by Harbour Way (Causeway) and railway line, beyond which is Barry Harbour which discharged into the Bristol Channel. The northern Site boundary is formed by Powell Duffryn Way, beyond which are the mainline Barry Railway Station and a new hotel. The eastern Site boundary is formed by David Davies Road, Cory Way and Woodham Road, beyond which is an industrial estate. The centre east of the Site is bound to the east by Barry No.1 Dock which connects to the Bristol Channel to the east.

2.2 Historical Land Use

2.2.1 Development of the Docks

A review of reports produced by Ove Arup and Partners and Earth Science Partnerships on behalf of the Barry Waterfront Development Consortium, Welsh Assembly Government and Associated British Ports (**Appendix B**), indicate that the majority of the Site (West Pond) was occupied by tidal flats associated with the Cadoxton Estuary. The south / southeast of the Site (South Quay) was occupied by fields and cliffs forming the northern

shore of Barry Island which was separated from the mainland by the tidal estuary until the late 1800's when construction of Barry Docks commenced through infilling of the estuary.

An embankment was constructed in the east of the Site within the West Pond area which was used to dam the Estuary as preparatory works for the construction of the Docks to the east. The cliff line of Barry Island in the south / southeast of the Site was also quarried out to provide material for the construction of the Docks at this time.

The Barry Docks opened in 1889. The southern part of the Site (South Quay) was occupied by railway sidings and subsequently coal tips along the dock wall of Barry No. 1 Dock. With the construction of the dam and docks, the centre and west of the Site effectively remained as Barry Harbour (mouth of Cadoxton River) until 1898 when the causeway carrying the railway and Harbour Road was constructed along the southwest and western Site boundaries. This effectively created an isolated pond known as 'West Pond' between Barry No.1 Dock to the east and Barry Harbour to the south and southwest.

Land to the northeast of West Pond formed a quayside providing access to South Quay and The Mole (a stone spur jutting out from the west side of Barry No.1 Dock to provide additional mooring space within the Dock). The Mole and South Quay were occupied by railway sidings and storage areas from late 1800's.

South Quay remained relatively unchanged until the mid 1900's with the construction of a tank farm and associated buildings and infrastructure. A review of the tank inventory undertaken by Ove Arup and Partners indicates that the tank farm predominantly stored organic chemicals including diesel oil, kerosene, mineral oil, chlorinated solvents, methanol, silicone, sodium hydroxide amongst others. The tank farm was decommissioned in the early 2000s with removal of all tanks and buildings. However, the former concrete tank bases, access roads and building foundations remain.

The eastern and northeast parts of West Pond were in-filled early after construction of the Docks and housed a large number of railway sidings and associated storage areas which serviced the Docks. The remainder of West Pond was gradually in-filled from the west between 1915 and 1920's with the size of the pond decreasing. The western portion of the Site was then set to railway land with in-filling continuing to progress to the east.

After a decline in the coal trade in the late 1930's, the staithes, that were used to drop coal directly into the boats, became progressively disused. As a result of this, the west, south and Mole areas of the dock were gradually redeveloped as tank farms. From 1938, the Ministry of Supply operated seven large tanks, mostly used to hold oils for the cosmetic and margarine industries.

During the war, the area was used as storage for military equipment and the docks suffered minor damage from aerial attacks.

Post war, the remainder of the West Pond was filled from sidings along the east and west banks of the pond and from the 1960's, part of the reclaimed pond was used to dismantle railway wagons and store railway engines.

Between 1962 and 1984, the Tank Farm was increased to its maximum development including some pressure storage vessels and during the 1960's and early 1970's, exports of coal continued to decline and by 1976 shipments had effectively ceased, with the last coal tip being demolished in 1981.

Since this time, the Port Authority erected various buildings including a storage shed at the eastern end of the dock.

2.2.2 1990s Remediation

According to a number of reports completed by Arup, the Site was subject to a degree of remediation to address asbestos, heavy metal and hydrocarbon contamination in the mid to late 1990's. The remediation reportedly comprised the excavation of the upper 100mm of material and removal and encapsulation within a former graving dock No. 1 in the northeast (East Quay beyond Barry No. 1 Dock) which was lined and capped.

Between the late 1990's and present, the Site was subject to the importation of material for clean cover which has been stockpiled within the centre and northeast area of West Pond.

2.2.3 Commencement of Redevelopment

In 2012 the enabling works for the proposed development commenced the Earthworks Contractor. Upon excavating soils for the works in the West Pond area, various asbestos containing materials (ACM) were encountered.

The enabling works have since slowed whilst the ground contamination conditions are assessed and a Remediation Strategy is developed and agreed with the regulatory authorities to allow the works to progress.

2.3 Environmental Setting

2.3.1 Topography

West Pond is generally flat ranging from approximately 7.7mAOD in the south, east and north to 11mAOD in the southwest. A number of stockpiles are present within the former West Pond which comprise of materials which were to be utilised for surcharging / clean cover materials which vary from 9 to 11mAOD in elevation.

The topography of South Quay is also relatively flat ranging from 7mAOD in the southeast corner to 8.5mAOD along the southern boundary. The northern / dockside boundary is generally at an elevation of 7.8mAOD.

East Quay (former Graving Dock No.2) ranges from 6.8mAOD in the south to 10.9mAOD in the north.

A cliff is present along the southern boundary of the Site and ranges from 8mAOD (at base adjacent to Site) to 28mAOD in the southeast on Clive Road.

2.3.2 Geology

A review of the British Geological Survey Sheet 263 Cardiff (Scale 1:50,000) Solid and previous assessment reports indicate that the geology beneath and surrounding the Site is complex, resulting from a significant degree of faulting on and south of the Site.

South Quay and the east and north sections of West Pond are underlain by Penarth Group deposits and the south and western sections of West Pond are underlain by St Mary's Well Bay Formation. The northeast section beyond Barry No. 1 Dock (former graving dock) is underlain by Blue Anchor Formation deposits (part of the Mercia Mudstone Group) with isolated outcrops of Lavernock Shale deposits (Blue Lias) on the southern and south western boundary.

The previous assessments have identified that the bedrock/ solid geology is overlain by a considerable thickness of superficial alluvial deposits associated with Cadoxton Estuary and made ground from the former historic use of the Site.

The depth to the upper surface of bedrock was noted to vary considerably across the Site, ranging from 2 metres below ground level (mbgl) in the south (adjacent to Barry Island Cliff) and 24mbgl in the centre of the Site (extent of former Estuary) where the exposed uplifted bedrock has been scoured by the Estuary.

A buried valley was identified trending east-west through the centre of the Site.

2.3.3 Hydrogeology

Previous assessments by Earth Science Partnership and a review of the Environment Agency (EA) website indicate that the geological strata beneath the Site have been classified as the following by the EA:

Strata	Aquifer Classification
Made Ground	Unclassified
Alluvium	Secondary B
Lavernock Shales	Secondary B

Strata	Aquifer Classification
Penarth Group	Secondary B
Blue Anchor Formation	Secondary B
Mercia Mudstone	Secondary B
St Mary's Well Bay Formation	Secondary A

One abstraction well was recorded within 1km of the Site which is licensed to Barry Island Pleasure Park (license number: 21/58/31/0031) for industrial, commercial and public supplies – holiday sites, camp sites and tourist attractions. It was assumed that the borehole was abstracting from Carboniferous Limestone which is brought closer to surface by faulting rather than the Mercia Mudstone Group which outcrops in this area.

The Site is underlain by a Secondary B Aquifers, which coincides with the Penarth Group, an interbedded limestone and mudstone formation and the Blue Anchor Formation, a mudstone formation. A principal aquifer is located approximately 600m to the south of the Site and coincides with Friars Point Limestone Formation, which outcrops to the west of Barry Harbour.

A review of the ESP 2010 Report indicates that groundwater strikes were encountered in Made Ground deposits at depths of between 4 to 6metres below ground level (mbgl) and within Alluvium at depths of between 8 and 15mbgl. Subsequent rest groundwater levels were recorded at depths of between 4 and 6mAOD within both Made Ground and Alluvium which were suggestive of connectivity between the Made Ground and Alluvium, although may be partially confined in some areas.

The assessments also concluded that groundwater flow was generally in a northeast to southwest direction towards Barry Harbour, with a gradient of 0.005. However, locally the groundwater elevations plunge in the centre of the Site where the in-filled estuary channel and greatest thickness of alluvium is encountered. The groundwater flow along the southern Site boundary (adjacent to Barry Island Cliffs) is likely to be heavily influenced by faulting and generally will flow north and southwest along the cliff margins.

2.3.4 Hydrology

The Site is located adjacent to the west of Barry No. 1 Dock and to the northeast of Barry Harbour which discharges into the Bristol Channel. The Site is underlain by the in-filled former Cadoxton River which still discharges, although at much lower volumes / seepage to the southwest of the Site.

Previous assessments completed by Arup and ESP concluded that groundwater flow from the Site to Barry No. 1 Dock was likely to be limited and actual flow was likely from the Dock into the Site, as rest water levels within the dock were recorded at 1 to 1.5m higher than rest water levels recorded within Made Ground and Alluvium on the Site.

A slow flow / seepage of groundwater was considered likely to occur at periods of low tide when a small stream discharges beneath the causeway to the southwest of the Site and flows into Barry Harbour. It is anticipated that during high tides, tidal inundation occurs beneath the Site through more permeable alluvial layers.

A review of the EA River Basin Management Plans indicate that the coastal waters surrounding the Site are classified as good for both chemical and ecological parameters; and are expected to remain good in 2015.

2.3.5 Flooding

A review of the Arup Strategic Earthworks and Drainage Strategy produced for the proposed development in 2009 indicates that the Site roads will need to be raised to a minimum of 8.868mAOD; and the south / southwest boundary of West Pond to 9.34mAOD in order to provide protection from flooding and flood surge events. Consequently, a raise in current Site roads of approximately 1 -2m would be required across the majority of the Site.

The EA website indicates that the Site is located on the edge of areas which are at risk of extreme flooding from rivers without flood defences.

3 Contamination Sources

3.1 General

As discussed in Section 1.3, a number of geo-environmental assessments have been undertaken by various parties across various parts of the Site between 1991 and 2012.

The primary objective of this Data Review was originally focused principally on asbestos contamination. However, since commencement, the scope of works has been extended to include a wider assessment to consider the potential for contamination on the Site to pose a risk to human health and/or controlled water receptors to enable an appropriate Remediation Strategy to be developed.

This section therefore, summarises both asbestos and any other residual sources of contamination which have been identified during previous assessments.

3.2 Historical Contamination Sources

As discussed briefly in Section 2.2, the Site has had a long history of industrial operations from the late 1800's to the mid to late 1990's which may have given rise to soil and groundwater contamination. Previous assessments of the Site have identified a range of contamination and a short summary is provided below.

3.2.1 West Pond

West Pond was formed by the damming of the Cadoxton Estuary when Barry No. 1 Dock was constructed and subsequently, by the construction of a causeway to the south and west of the Site. Following this the pond was gradually backfilled with tipped waste, typically believed to comprise waste generated from the surrounding docks and associated industries, including slag, furnace ash, engine ash, waste coal and now understood to include waste asbestos containing materials. The Phase I Infrastructure – West Pond report, prepared by Earth Science Partnership in 2010, indicated a varied thickness of infill material to be present within this section of the Site, with thicknesses ranging from 1m to 12m within the centre of the Site, in the location of stockpiled material.

The south and eastern sections of West Pond are known to have housed a significant number of railway sidings and associated industrial operations including coal tips. From the mid 1930's, the eastern section of West Pond was utilised as a tank farm which housed a number of above ground storage tanks which were used to store fuels, oils, solvents, soap, vegetable oils (cashew nut oil) which were utilised in surrounding industries.

The western side of the Site was gradually in-filled, with the centre and west section of West Pond latterly being used as a railway engine and wagon refurbishment and dismantling yard, which is believed to have given rise to a degree of asbestos contamination within West Pond.

Upon removal of the railway sidings in the south, east and west of West Pond, the derelict areas in the south and southwest were utilised as car parking.

The Remediation Strategy Review issued by Ove Arup and Partners in January 2007, indicates the majority of the area of the West Pond had been remediated in accordance with the remedial strategy from the mid 1990s, although North Quay is the only area noted to have been appropriately capped and re-profiled.

3.2.2 South Quay

Upon construction of the Docks, South Quay was initially occupied by a series of railway sidings and low level coal tips. As the demand for coal decreased, a number of the sidings were removal and a tank farm and associated infrastructure and operations buildings were constructed. The South Quay tank farm stored a variety

of chemicals which included hydrocarbons (kerosene, diesel, lube oil, solvents) and vegetable oil and buffering / cleaning agents. The tank farm was decommissioned in the late 1990's and has remained derelict since. To date it is understood that no remedial works, other than removal of former tanks, infrastructure and buildings have been completed.

3.2.3 East Quay

The East Quay initially comprised two graving docks (No. 1 and No.2) and a quay side of Barry No. 1 Dock which housed a number of buildings and associated infrastructure. Graving Dock No. 1 was in-filled as part of remedial works completed by Associated British Ports in the mid to late 1990's. The No. 1 Graving Dock was dredge, lined and subsequently in-filled with waste material generated from West Pond, North Quay and East Quay remedial works. The works were completed under license from the EA. Upon completion of the works, the in-filled graving dock was covered with clean cover and the license has since been surrendered. It is understood that the Client has a 'pie crust' agreement with Associated British Ports which enables the development of East Quay for public open space, but no works are permitted into the former graving dock which may breach the landfill protection measures installed.

3.2.4 Summary

Based on the history of the Site, it is considered that the Site is likely to have been impacted by a wide variety of contaminants predominantly metals, polycyclic aromatic hydrocarbons (PAHs), hydrocarbons and asbestos associated with the former railway sidings and engineering works; and organic contaminants (chlorinated hydrocarbons, solvents, diesel, kerosene, lube oil) and metals associated with the former tank farms.

As noted previously, the Site has been subject to a series of intrusive assessments which have identified a degree of contamination which is summarised in the following sections.

3.2.5 Asbestos Containing Materials (ACMs)

An asbestos assessment was undertaken by Berridge Environmental in 1991 on behalf of Halcrow on the West Pond area. This report is referred to and referenced in Arup 1992 Dock 1 Geotechnical and Contamination Report. The ACM assessment comprised the collection of 97 No. samples for asbestos testing:

- 62 No. from surface;
- 16 No. from 0.1m;
- 16 No. from 0.5m;
- 3 No. from depths >0.5m.

Of the 97 No. samples tested, 61 No. samples reported positive identification for asbestos. 44 No. samples (66%) from the surface recorded asbestos, predominantly chrysotile, but also some amosite and crocidolite. 11 No. (69%) of samples from 0.1m recorded asbestos at concentrations at <5%w/w which were considered trace concentrations at this time (it is noted that this is no longer considered to be a 'trace' concentration).

Fifty percent of samples from 0.5m recorded the presence of asbestos and one sample from >0.5m recorded trace asbestos (<5%w/w). The report concluded that the majority of asbestos contamination was present within the upper 100mm and recommended a surface strip of the upper 100mm to be disposed of off-Site or within an appropriately managed facility; and the incorporation of a 100mm thick layer of clean cover.

It should be noted that a large proportion of samples recorded asbestos concentrations in excess of 30%w/w with some as high as 95%w/w.

In March 1994, Arup undertook further intrusive investigations within West Pond and East Quay and whilst no formal asbestos analysis was undertaken on the majority of samples collected, potential ACMs were noted within field logs in trial pit V16, where a piece of corrugated cement bounded sheeting was observed at surface and trial pit W30 at 0.3-0.5m where possible asbestos is noted. A soil sample from V16 noted chrysotile asbestos sheeting but no fibres were detected. No soil sample was analysed for asbestos from trial pit W30.

A further report produced by Arup in July 1994 (No. 3b Phase II Reclamation works for Dock No. 1 (West Pond and East Quay) – Phase II Infrastructure Site) summarises the previous Berridges Asbestos Survey from 1991, as discussed above. The Arup report states that 7 No. additional soil samples to those obtained in 1991 were collected from 0m to 0.6m and screened for asbestos. None of the additional samples were recorded as containing asbestos. However, the factual report produced by Structural Soils notes chrysotile present, but no fibres identified. Recommendations were made within the report of removal of 0.05 – 0,10m of soil from the contaminated area and for a 0.10m layer of clean soil to be spread over the Site. The report also notes that the Site is badly contaminated with asbestos containing materials.

A further report produced by Arup in October 1994 for Phase III – Site A and Mole contains no discussion of asbestos and focuses on metal and hydrocarbon contamination.

Arup undertook further intrusive assessment works in January 1997 within West Pond Car Park and North Quay which were inaccessible during the 1994 assessment works. The report states that the eastern side of the Site is known to be impacted by ACMs mainly at surface resulting from previous dumping and the former railway wagon recovery and dismantling works. The report goes on to state that chrysotile, amosite and crocidolite fibres were encountered at 0.5m along the north eastern boundary; and further fragments of asbestos rope and gaskets were encountered across the Site at 0.5m and occasional fragments at depth >2.5m. The presence of asbestos at depth is considered to be associated with the former in-filling of West Pond during the early to mid 1900's.

A review of field logs included within this report (Note: Area 1 refers to the car park within the southeast section of the West Pond), indicates that possible ACMs were encountered at the following locations:

- Area 1, TPCP6 – Old gasket encountered within made ground at 2.0m;
- Area 1, TPCP8 – Occasional steel bars and empty shell casings;
- Area 1, TPCP10 – Iron ore waste and gasket at 0 to 0.55m;
- Area 1, TPCP10 – Asbestos gasket at 2.5m;
- Area 1, TPCP12 – Loose brown fibrous material, possible ACM at surface;
- Area 1, TPCP15 – Piece of old gasket at 0.3m;
- Area 1, TPCP16 – Piece of gasket at 1.2m;
- Area 1, TPCP17 – 2 No. possible asbestos pipes at 4.0m;
- Area 1, TPCP17 – 2 No. gaskets at 0.2 to 0.5m;
- Area 1, TPCP20 – Several gaskets and pipes found. No depth given;
- Area 1, TPCP25 – Fragments of material, possible asbestos encountered at 0 to 0.25m;
- Area 1, TPCP26 – Possible asbestos at 0.9m;
- Area A, TPNQ1 – Comment: Where asbestos found sample taken from surrounding soil, but does not mention where asbestos was observed. Additional comment: tubs taken from 0.2-0.5m; 0.5-2.0m, 3.6m and surface.
- Area A, TPNQ3 – Asbestos sheeting at surface.

No laboratory testing certificates are provided within the report. The results are tabulated from previous factual reports. The visual observations noted within the field logs for the potential presence of ACMs, do not appear to correspond to where samples have been submitted for chemical analysis and therefore, the presence of suspected ACMs cannot be confirmed by chemical analysis.

The report additionally states that broken cement bonded (asbestos) sheeting was also encountered to the north of the T&A building in the vicinity of East Quay. Asbestos was encountered at greater depth beneath the West Pond Car Park due to land raising of the car park with the incorporation of hard-standing and blinding layer.

The report concluded that there were no fibres associated with ropes of gaskets analysed and therefore, careful hand picking of these and other ACMs should be sufficient to render the material / soil suitable as fill. However, should fibres be encountered during validation testing then the material should be taken to the on-site disposal

facility (former graving dock located in the north-east corner of current Site). The report suggests that a contingency of 5% of soils (1,500m^3) being impacted by ACMs should be allowed for. In the area of the T&A Building the report recommends a 100mm soil strip, with material being deposited within on-site waste facility.

Additional contamination sources in the form of blue granules and grease / resin within the T&A Building to be deposed of off-Site or within on-site waste facility, subject to licence conditions. A steel chamber to the rear of the T&A Building should be investigated, excavated and backfilled.

Between completion of the 1994 assessments and subsequent reports by Arup in 1997, it is understood that the remediation / reclamation works proposed were undertaken and comprised the excavation of the upper 100mm of soil across 70% of West Pond and disposal within a waste disposal facility on-site. The waste facility was licensed by the Environment Agency and comprised the former graving dock in the northeast of the Site. The dock was fully lined and capped with inert material and landscaped to be utilised as public open space.

Arup produced a Technical Issues Report for the Barry Waterfront in May 1997 which summarises the works completed and the validation works to demonstrate that the Site was suitable for intended mixed residential and commercial end use.

The report states that the North Quay was impacted by low levels of heavy metals and mobile contaminants (tars and oils) and West Pond was impacted by low level asbestos contamination at surface.

Contaminated material was removed from North Quay, West Pond and East Quay, but only North Quay was re-profiled and clean cover layer installed. The material deposited within the on-site waste treatment facility was tested prior to disposal to ensure it complied with the disposal licence conditions.

The former Woodham's Yard (scrapyard / railway engine dismantling) within West Pond was subject to a 600mm soil strip which was disposed of within the on-site treatment facility.

A 600mm clean cover layer was stated as being installed within the development plateau and road verges, with 300mm over road areas within a valley present through the centre of the Site. However, later reports suggest that the full incorporation of clean cover across the Site was not completed due to insufficient material available at the time.

The report stated that within residential and public open space, the formation level and clean cover were suitable for a residential end use based on ICRCL criteria at the time and within commercial / retail areas the formation level predominantly met commercial criteria, whereas the clean cover layer typically met residential standards with some isolated areas only meeting commercial criteria. However, based on the masterplan and guidance at the time, the Site was considered suitable for use.

In 2007, Arup were commissioned by the Barry Waterfront Consortium to undertake a reappraisal of the previous assessments completed to reflect changes in the regulatory frameworks and determine whether additional works were required to support a planning application for the Site.

The remedial strategy review concluded that whilst reclamation works were completed in the mid to late 1990's that the works would require re-assessment against current Contaminated Land Exposure Assessment (CLEA) criteria and revised remedial target may be required.

Further supplementary assessment works were completed by Arup in 2008, which comprised the excavation and drilling of 123 No. trial pits, 29 No. cable percussion boreholes and 5 No. rotary boreholes. The assessment works predominantly focus on validating the previously identified metal and organic contamination but also analysed 132 No. soil samples for asbestos. Visual evidence of asbestos was noted in the form of asbestos sheeting in WPTP41 between 0.6-1.6m and 3.3-3.7m, in the southern part of the West Pond. However, no free fibres were detected during subsequent chemical analysis at this location. Laboratory analysis did record free fibre asbestos (chrysotile) in WPTP114 at 0.3m. However, no visual evidence of potential ACMs was noted during the field observations. No other asbestos was encountered during this phase of investigation.

In 2012, following commencement of the earthworks, ASM Compliance Limited at the request of Cuddy Group completed an Asbestos Material Investigation of Soil, after the identification of potential asbestos containing materials at surface during initial enabling works at the Site. The investigation comprised the excavation of up to 40 No. trial pits excavated to a maximum depth of 4.0mbgl and a surface walkover to assess the extent of asbestos contamination within soil across parts of the West Pond area. Selected soil samples and visual asbestos samples were submitted for laboratory testing.

The investigation identified the presence of asbestos (predominantly chrysotile, although some crocidolite and amosite were also encountered) from surface to at least 3.5mbgl. The assessment identified that asbestos was present in both solid and free fibre form and was more prevalent in the west of West Pond, than the eastern side.

The report concluded that appropriate measures needed to be implemented in accordance with the Control of Asbestos Regulations (CAR) 2012, which include the completion of a risk assessment to determine whether any proposed works meet the criteria for Licensed Asbestos Works. Given the nature of the asbestos identified (highly fibrous and /or of low density) it was considered that most of the work would require a Licensed Asbestos Removal Contractor (LARC). It was also recommended that due to the incompleteness of previous investigations and limitation of the 2012 assessment, that additional assessment works were completed in the vicinity of the rising main to confirm the area was free of asbestos.

In summary, the assessment works to date have primarily been focused on the West Pond area with limited assessments focused upon the Mole, East Quay and South Quay.

Targeted asbestos surveys conducted in 1991 and 2012 identified widespread asbestos across the development area, although asbestos was noted to be more prevalent in the western half of West Pond. It is considered that ACMs may be more prevalent in the western half of West Pond, as this area was the last to be in-filled and subject to use as a railway engine breakers yard and scrapyard. However, it should also be considered that the assessment works have been more focused on the West Pond than other areas of the development.

A summary email from Earth Science Partnership in August 2011 to John Wilson, failed to take into account the volume of asbestos discovered in the 1991 survey, instead focusing only on information gathered by Arup in 2008, where only one sample submitted for asbestos recorded a positive result. From this information ESP and Arup have suggested that asbestos is extremely limited throughout the Site and that capping to landscaped areas and gardens would be sufficient to mitigate against the risks posed by asbestos to the future site users; and no consideration of the potential for the suitability of material for re-use as surcharging material / clean clover or the requirement for special control measures to mitigate potential risks during construction.

3.2.6 Organic Contamination

The Arup 2008 Geo-environmental Assessment of the West Pond identifies visual and olfactory evidence of hydrocarbon contamination within 18 No. locations ranging from hydrocarbon odours, sheens, pockets of free phase liquid and creosote odours. Total petroleum hydrocarbon (TPH) and polycyclic aromatic hydrocarbon (PAH) analysis was completed on 244 No. samples and volatile and semi-volatile organic compounds (VOC/ SVOC) analysis was completed on 37 No. samples.

In summary, TPH was discovered throughout the West Pond, with concentrations ranging from <10mg/kg up to 5,755mg/kg. Total PAH concentrations ranged from below the detection limit to a maximum of 660mg/kg. With regards to VOCs and SVOCs, many of the samples analysed did not detect levels above limits deemed acceptable for a residential end use. However, a number of exceedences above the acceptable screening criteria were noted particularly in the southern area of the West Pond.

Earth Science Partnership was commissioned to undertake a Controlled Waters Risk Assessment in 2010 in order to assess the potential risks associated with the soil and groundwater contamination identified at the Site. The report identifies that potential sources of contamination comprised infill materials within West Pond, historic contaminative uses including former railways, docklands, railway repairs / breakers yard / scrap yard; and former use of the east and southeast as an above ground tank storage depot.

The assessment considered potential detrimental impact to the Secondary A, B and Secondary Undifferentiated Aquifers via vertical and lateral migration contamination and subsequent migration to Barry No.1 Dock and the Barry Harbour / Bristol Channel.

The majority of organic contamination was identified in the southeast of the West Pond in the vicinity of the former South Quay and Old Tank Farm and was centred around BH25, BHE5, BHE6 predominantly at depths >3mbgl within reworked alluvium / made ground. A number of intense and very strong hydrocarbon odours were also recorded in TPE8, TPE10 – TPE13 and TPE16 and creosote odours were recorded in BHE15 and BHE16.

A review of the rest groundwater levels indicated that regional flow within the alluvium is from northeast to southwest (Barry Harbour). Made Ground was considered likely to hold perched water which has the ability to interact with the underlying Alluvium and bedrock at the margins, with the majority of rest water levels from both Made Ground and Alluvium recorded between 4 and 6mAOD. The report notes that the rest water levels in the adjacent Barry No. 1 Dock and recorded groundwater elevations on-site are higher by 1 to 1.5m and kept artificially high by the lock gates. It was therefore, considered that the potential for groundwater migration to the dock was minimal and more likely of discharge from the dock into the Site. It was considered that discharge of groundwater from the Site to Barry Harbour may occur during periods of low tide when a small discharge can be seen to the southwest of the Site by the Causeway. However, the rate of discharge was considered low due to the low permeability of the made ground and alluvial deposits.

The recorded permeabilities for the deposits appear to vary within the reports and are inconsistent, but range between 1.7×10^{-4} to 9.1×10^{-6} m/s in Made Ground and 1.9×10^{-4} to 8.42×10^{-9} m/s for alluvium. Overall, a hydraulic gradient of 0.005 was recorded from northeast to southwest within the alluvium, although groundwater was noted to plunge in the centre of the Site along the axis of the former Cadoxton River Estuary and where the greatest thickness of alluvium was encountered.

The report identified that groundwater within the Made Ground and Alluvium has been impacted by phenols, TPH and PAHs. Elevated concentrations of manganese and iron were also recorded and were considered indicative of natural attenuation of hydrocarbons occurring. Contaminant concentrations within bedrock were noted to be considerably lower than those recorded in the overlying Alluvium / Made Ground suggesting that vertical migration of contamination to bedrock is limited.

The hydrogeological model and contaminant distribution within groundwater was considered to indicate a two stage contaminant plume with the most elevated concentrations centred around BH25, E5 and E6 and levels decreasing sharply to the north and west. Boreholes E4 and SQBH1 located between the plume and Barry No.1 Dock recorded no significant contaminant levels and the contaminant plume migration is inferred to be in a northwest direction. The concentrations were noted to reduce within 100m of plume core and the plume terminates 300m from the Site boundary. However, whilst not observed to date, it was considered that breakthrough of contamination to groundwater within bedrock, Barry Harbour and Barry No. 1 Dock could occur in the future.

A Tier 3 Detailed Quantitative Risk Assessment (DQRA) was completed using the EA Remedial Targets Methodology & Remedial Target Worksheet: Release 3.1, October 2006 for Level 3 Groundwater, assuming a shrinking / exhausted plume. Degradation of contamination was considered in all phases due to lines of evidence of natural attenuation from field and laboratory data.

The risk assessment derived a number of remedial clean up targets for key Contaminants of Concern (CoC) (naphthalene (PAH), benzene, toluene, ethylbenzene and toluene (BTEX), phenol and total petroleum hydrocarbons (TPH)), with the exception of Aromatic TPH C8-16 and benzene, no contaminants were observed to exceed their respective remedial clean up targets. However, it should be noted that a number of the remedial targets were near or in excess of the saturation limits for the contaminant and therefore, suggestive that the presence of free phase product does not pose a risk to identified receptors.

The report concluded that a degree of remediation would be required to address TPH and benzene contamination and that pump and treatment of groundwater on-site via a water treatment system (carbon filter) was likely to be the most cost effective and appropriate method of remediation with on-going monitored natural attenuation. The report recommends that a precise methodology is agreed with the EA in advance.

The scope of the review works presented herein does not include an assessment of the proposed works in relation to controlled waters and it is understood that the Client has submitted the proposed approach above to the Environment Agency via the Planning Authority.

The presence of the organic contamination on-site represents a potential source of volatile vapours in relation to human health impacts via indoor and outdoor vapour pathways as well as the potential for direct contact risks to be present.

3.2.7 Inorganic Contamination

Arup's Geotechnical and Contamination Report conducted on the Site in November 1992 identified a number of areas that were affected by inorganic contaminants. Within the West Pond and surrounding area, several

contaminant hotspots were identified for arsenic, cadmium, lead, zinc and copper. No further details with regards to concentrations of identified inorganic contaminants were provided within the report. The South Quay was reported as likely to be affected by inorganic contamination due to the historical presence of the tank farm. Samples were collected during this investigation throughout the South Quay area. However, no samples were scheduled for chemical analysis. The East Quay was not investigated by Arup during this time.

In 1994, Arup conducted further intrusive investigations on the Site, the results of which are presented in the Phase II Site Reclamation Report. Within this phase of investigations, arsenic was the primary inorganic contaminant assessed. Within the West Pond, 78% of the soil samples which were tested, were found to be above the Interdepartmental Committee on the Redevelopment of Contaminated Land (ICRCL) threshold trigger level for domestic gardens, although only two of the samples (3%) were above the tentative action trigger level of 50mg/kg (level at the time which required remedial action). Within the East Quay, all of the samples exceeded the ICRCL threshold trigger level for domestic gardens and 14% of samples exceeding the tentative action trigger level. The greatest levels of arsenic were noted within the area surrounding the graving docks (East Quay). It is important to note that ICRCL levels have been superseded by the Contaminated Land Exposure Assessment (CLEA) Soil Guideline Values (SGVs). The South Quay was not investigated within this report.

The Site Investigation Report on Site 'A' and the Mole from October 1994, Indicates Site 'A' (eastern most part of West Pond) is largely uncontaminated with regards to ICRCL values for domestic gardens for Group A contaminants such as arsenic, cadmium, chromium, lead and zinc, with only low levels of cadmium found at levels above the domestic housing trigger level in 2% of the samples. The East Quay, South Quay and West Pond were not investigated within this report.

Within Arup's West Pond car park and North Quay Geotechnical and Contamination Report (January 1997) assessed the suitability of soils at the Site based on inorganic contaminants. The materials were classified as follows:

- Type 1 – material to be taken to the on-site waste disposal facility, i.e. the No. 1 Graving Dock;
- Type 2/3 – material may only be used as a general fill below the capping;
- Type 3 – material can be used for capping where the end use of the Site is non-domestic, i.e. retail, leisure, or commercial; and
- Type 4 – material can be used for capping where development with domestic housing is planned.

The assessment concluded that within the western part of West Pond47% of the samples taken were classed as Type 4 Fill, 32% were classed as Type 3 Fill, 5% were classed as Type 2/3 Fill and 16% were classed as Type 1 Fill. Within Area 4 (East Quay), 73% of samples were classed as Type 4 Fill, 20% were classed as Type 3 Fill and 7% were classed as Type 2/3 Fill.

Table 3.1 below indicates some of the inorganic contamination levels within each fill type.

Table 3.1: Summary of Fill Classifications

Parameter	**Type 4**	**Type 3**	**Type 2/3**	**Type 1**
Arsenic (mg/kg)	40	50	500	500
Cadmium (mg/kg)	3	15	50	50
Chromium (Total) (mg/kg)	600	1000	2500	2500
Copper (mg/kg)	1000	19000	19000	19000
Lead (mg/kg)	500	2000	10000	10000
Zinc (mg/kg)	2000	33000	33000	33000

The Arup 2008 West Pond Geo-environmental Report undertaken to validate the soils at the site to current CLEA guidance criteria concluded that both clean capping and formation level soils were impacted by inorganic contaminants. Antimony, cadmium, copper, lead, mercury, zinc and beryllium were considered to pose a

potential unacceptable risk to human health within the eastern most section for West Pond. Whereas arsenic, antimony, copper, chromium, lead, nickel, mercury and zinc were considered to pose a potential unacceptable risk to human health within the wider West Pond area. It should be noted that a number of elevated concentrations were recorded as outliers to the data sets within the statistical analysis and therefore, may be indicative of hotspots as opposed to site wide contamination; or an underlying data set and more refinement of the data analysis is required. Either way it is considered likely that mitigation works (incorporation of clean cover or hard-standing) would be required to address the potential risks identified.

3.2.8 Ground Gas

No gas monitoring took place during any of the investigations in 1994 and in 1997. Within Arup's Technical Issues Report, it was concluded that due to gas concentrations being found at levels well below acceptable limits when tested during works in 1992, landfill gas was not an issue that needed to be addressed within the Site.

In the Arup 1992 Dock 1 Geotechnical and Contamination Report it was mentioned that soft ground boreholes were monitored for explosive gases during drilling, no exceedences of lower explosive limit (LEL) were recorded (5% of the LEL). Eight of the boreholes were installed with gas standpipes. The mean oxygen content was low in BH5, BH2, BH8, and BH18 (4.2 – 18.9%), while BH 20, BH21 and BH25 have mean values between 19.6-20.8%. The LEL had a maximum of 2.0 % LEL in BH5 and the CO2 ranged between 8% and 0%, the maximum being in BH2.

Four of the boreholes (BH2, BH5, BH8 and BH21) were sampled in July 1992, the original four plus an additional four were sampled in August 1992 (BH12, BH18, BH20 and BH25). BH5, BH8, BH12, BH21 and BH25 were sampled in September 1992. All samples were analysed for methane, carbon dioxide, oxygen, nitrogen and hydrogen sulphide.

The methane concentrations were mostly <0.02 with a maximum concentration of 5.8 % in BH18 in the September 1992 round. Carbon dioxide ranged from 0.19% - 11%, maximum in BH18 during the September sampling round. The oxygen content was very low in all rounds for BH2 and BH5, BH12 was low for the August and September gas sampling rounds. In BH18 the oxygen levels dropped from 21% in August to 11% in September 1992. The nitrogen content was fairly consistent with a minimum value of 72% in BH18 September round and a maximum of value of 94% in BH12 during the August sampling round. The hydrogen sulphide levels were consistently below the limit of detection.

The Arup 2008 intrusive assessment included the assessment of ground gas risk in accordance with CIRIA 665 and NHBC. The assessment comprised the monitoring of 39 No. monitoring wells, 29 No, of which were installed within the Made Ground; 8 No. within the alluvium and 2 No. within the bedrock. Six monitoring visits were completed between May and July 2008.

Methane concentrations ranged from 0%v:v to 18%v:v and carbon dioxide from 0%v:v to 12.0%v/v. The highest methane concentration of 18%v:v was recorded in WPRBH4 installed within the underlying bedrock and therefore, the assessment for the residential site (western section of West Pond) was completed using the highest recorded methane concentration from the Made Ground (12.5%v:v in WPBH26). Similarly, the highest flow reading (>20l/hr) was recorded in WPRBH4 within the bedrock and a flow rate of 5.7l/hr recorded in alluvium in WPBH20 was utilised. The assessment concluded that the residential development area was predominantly CIRIA Characteristic Situation (CS) 2 or NHBC Amber 1.

A gas assessment for the commercial land (eastern section of West Pond) was completed using the gas readings from the underlying bedrock on the assumption that a piled solution may be required, which resulted in a classification as CIRIA CS3.

The 2008 report also states that the Site is located in an area where full radon protection measures are required in all new residential properties.

3.3 Contamination Summary

3.3.1 West Pond

The West Pond has been the subject of numerous intrusive investigations by Ove Arup and Partners since 1992 as well as being the subject of two asbestos investigations, one in 1991 and the latter in 2012. Throughout the reports, conflicting conclusions have been presented, particularly over the levels of asbestos and the risk which they pose. Both targeted asbestos surveys have shown asbestos to be present throughout the West Pond area, both within the soil to depths >3.5m and as sheeting, lagging and gaskets at surface; and a report by Arup in 1997 indicates the area is a known to be impacted by asbestos contamination. However, many of the other reports did not detect many traces of asbestos or test for asbestos and therefore, do not class asbestos as a risk within this area.

With regards to organic contamination, visual and olfactory evidence has been noted during the varying assessments and particularly in 2008. The majority of organic contamination was identified in the southeast of the West Pond in the vicinity of the former South Quay and Old Tank Farm and was centred around BH25, BHE5, BHE6 predominantly at depths >3mbgl within reworked alluvium / made ground. A number of intense and very strong hydrocarbon odours were also recorded in TPE8, TPE10 – TPE13 and TPE16 and creosote odours were recorded in BHE15 and BHE16.

The organic concentrations were noted to reduce within 100m of the plume core and the plume terminates 300m from Site boundary. However, whilst not observed to date, it was considered that breakthrough of contamination to groundwater within bedrock, Barry Harbour and Barry No. 1 Dock could occur in the future.

The risk assessment derived a number of remedial clean up targets for key Contaminants of Concern (CoC) (naphthalene (PAH), benzene, toluene, ethylbenzene and toluene (BTEX), phenol and total petroleum hydrocarbons (TPH)), with the exception of Aromatic TPH C8-16 and benzene, no contaminants were observed to exceed their respective remedial clean up targets. However, it should be noted that a number of the remedial targets were near or in excess of the saturation limits for the contaminant and therefore, suggestive that the presence of free phase product does not pose a risk to identified receptors.

The report concluded that a degree of remediation would be required to address TPH and benzene contamination risks to controlled water receptors.

Metal concentrations within West Pond have also been recorded in excess of current CLEA SGVs or generic assessment criteria (GACs) and are considered to pose a potential risk to human health receptors.

A ground gas assessment completed in 2008 concluded that the residential development area was CIRIA CS2 or NHBC Amber 1; and the retail area was CIRIA CS3 due to the elevated methane concentrations and flow rates within the underlying bedrock and appropriate gas protection measures would be required. Furthermore, West Pond is considered to fall within an area at risk from radon gas and therefore, radon protection will be required within the construction of all new dwellings and extensions.

It is considered that there has been sufficient investigation within West Pond to assess the degree of contamination present; and appropriate mitigation and validation works can be completed as the development works progress.

However, no assessment of the risks from vapour inhalation outdoors has been completed which is considered a potential exposure pathway; and therefore, further assessment works may be warranted to fully quantify potential risks which could be completed in conjunction with the works outlined for South Quay, below.

3.3.2 South Quay

The South Quay has been subject to limited intrusive investigations between 1991 and 2012. This area has historically been the location for a number of storage tanks containing a variety of organic and inorganic compounds which has likely led to the impact of underlying soils and waters. Previous assessments, whilst limited in scope and extent have identified elevated metals and organic contamination likely to be associated with the former use as a tank farm, railway lines and associated coal stores. The extent of potential ACMs within this area is relatively unknown as only limited testing has been conducted within the area. However, it is

considered likely that some ACMs may be present associated with former pipe lagging, switchgear and railway works.

South Quay is located within an area where there is a risk to humans from radon gas and therefore, radon protection measures are required within the construction of all new dwellings and extensions.

A previous assessment completed in 2008 identified elevated concentrations of hydrocarbon contamination in the southeast of West Pond and the contamination plume within groundwater was noted to be migrating in a north to northwest direction which is suggestive of a source of contamination within South Quay and eastern section of West Pond.

Limited ground gas assessments have been completed and no assessment for potential risks from vapour inhalation (indoor outdoor) has been completed. Therefore, it is considered that further intrusive assessment works are required to fully quantify the degree and extent of asbestos, metals and organic contamination and associated constraints to the proposed residential development.

The scope of the assessment works will be agreed with the regulatory authorities, but likely to include the excavation of a series of trial pits and the advancement of rotary boreholes to enable the collection of representative soil, groundwater and ground gas samples; vapour and groundwater monitoring, as required. The findings of the assessment works will be utilised to refine and develop the remedial / mitigation strategy for South Quay.

3.3.3 East Quay

The East Quay was subject to minor investigative works in 1994 during which one area was noted to be impacted by asbestos (vicinity of former T&A building). Following this assessment Graving Dock No. 1 was dredged, lined and in-filled as part of the remedial works for the wider development area completed in the mid to late 1990s. Material which was considered unsuitable for retention within the wider development area was deposited within the graving dock and subsequently covered with clean cover to enable use as public open space.

It is therefore considered that East Quay is likely to have been adversely impacted by inorganic, organic and asbestos contamination both from its former industrial use, but also as a receiving landfill for wider site contamination. However, the Client has a ‘pie crust’ agreement with Associated British Ports which restricts the use and potential investigations within this area.

It is considered that further assessment / validation works are required to confirm the suitability of East Quay for public open space. Given the potential restrictions with regards to the former landfill (in-filled graving dock), it is proposed that within the graving dock area the investigations are restricted to shallow / surface validation and gas / vapour assessment only, unless the regulatory authorities require further clarification of residual soil concentrations.

The areas external to the graving yard should be subject to validatory testing as above, however, intrusive works will not be limited to shallow soils.

As no buildings or basement structures are proposed in this area, the risk from ground gas is considered low, however, a risk from vapours in outdoor air may still exist and appropriate assessment should be completed to confirm whether a risk exists.

4 Conclusions and Recommendations

4.1 Summary of Contamination

A review of previous reports and recent investigations indicate that the majority of West Pond has been impacted by asbestos contamination as a result of previous in-filling and historical operations (railway, railway engine repair / breakers yard, scrapyard and former tank farm). Based on the data reviewed, the western section of West Pond appears to be the worst impacted with asbestos and asbestos fibres recorded from surface to depths in excess of 3.5mbgl. The eastern section of West Pond has recorded few positive identifications of asbestos, which may stem from the fact that the eastern section of West Pond was in-filled earlier and was occupied by railway lines and a tank farm whilst the western section was gradually in-filled by local waste and utilised as a railway engine breakers yard.

The presence of ACMs has also been recorded within East Quay (including in-fill material in Graving Dock No. 1) and the southwest of South Quay and therefore, it is considered that ACMs are present across the development site, although potentially to a lesser degree.

Inorganic and organic contamination has been noted throughout the Site from chemical analysis and visual and olfactory evidence at varying concentrations. Limited information has been provided with regards to this contamination within the East Quay and South Quay areas and, as a result, there is a need for further investigations within these areas. Whilst a degree of remediation / reclamation was undertaken in the mid to late 1990s, the works only involved the excavation and removal to an on-site waste disposal area (Graving Dock No. 1) of the upper 100mm and in some areas 600mm to remove asbestos and organic contamination. The remedial works completed were considered satisfactory to enable the Site to be suitable for a residential and commercial end use at the time. However, the proposed 600mm of clean cover was not incorporated within some areas of the Site (namely south and southeast of the Site), as insufficient volumes of material were available at the time. Subsequent validation works in 2008 have identified that surface and near surface soils across the Site are in excess of current SGVs for residential end use and therefore, are considered to pose a potential unacceptable risk to human health receptors.

Recent assessments undertaken by Earth Science Partnership identified unacceptable levels of organic contamination (phenol, semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs) and TPH) within soils and groundwater in the south and centre south of the Site which posed a theoretical risk to groundwater with Secondary Aquifers, Barry Harbour and Barry No. 1 Dock.

Ground gas monitoring has occurred mainly within the West Pond area, although limited assessment has been completed on South Quay. The results of the 2008 ground gas assessment classified the residential development areas in West Pond as CIRIA CS2 or NHBC Amber 1 and the commercial development as CIRIA CS3. Furthermore, the Site is located within an area where radon protection measures are required within all new residential dwelling and extensions. The East Quay has not been monitored for ground gas issues and as a result more information may be required within this area.

No assessment for vapour inhalations risks in outdoor air has been completed. In light, of the former uses of the Site and level of organic contamination identified, it is considered that a risk from vapour inhalation outdoors may exist and an assessment should be completed to confirm / affirm this potential exposure pathway.

4.2 Summary of Potential Contamination Related Development Constraints

4.2.1 Asbestos

The presence of asbestos will result in the need to amend to proposed remediation strategy and methodology for undertaking the enabling / earthwork phases of the development to ensure that appropriate risk to human health (Site workers, visitors, future Site occupants / users and public) are adequately mitigated. Any works

where soils containing asbestos are to be handled must be completed in accordance with the Control of Asbestos Regulations 2012 and appropriate specialists will need to be utilised to ensure that the control measures are implemented.

Recent discussions with the Vale of Glamorgan Environmental Health Department and the Health and Safety Executive have indicated that in principle these regulatory bodies have no objection to the retention of asbestos containing material on-site, subject to the implementation of appropriate control and mitigation measure which will eliminate potential inhalation exposure risks to human health for the duration of the enabling / earthworks and post development.

The presence of asbestos within Site soils which were proposed to be utilised as clean cover will result in the soil being unsuitable for use and therefore, 'clean' cover will need to be imported from off-site sources to make up the shortfall of clean material. This material will need to meet the criteria of any earthwork or importation of material specification to ensure the material is both geotechnically and chemically suitable.

4.2.2 Organic and Inorganic Contamination

The presence of organic and inorganic contamination has been noted throughout the Site. Further investigations need to be completed throughout the Site in order to determine exact levels of contaminants throughout the Site and an appropriate remediation strategy will need to be formulated in order to reduce these levels deemed acceptable by authorities.

As with the asbestos, organic and inorganic contamination with asbestos, Site soils which were proposed to be utilised for clean cover across the Site, will now be deemed as unsuitable for use and therefore 'clean' cover will need to be imported to make up the shortfall of clean material.

4.2.3 Ground Gas

The potential for ground gas to cause a constraint has been classed as unlikely within the West Pond as sufficient gas monitoring has occurred on this area of the Site. The risk within the South Quay and East Quay however, is unclear and therefore plans for additional ground gas monitoring within these areas will need to be formulated to ensure any risks can be properly mitigated against.

A radon risk has been determined as likely throughout the Site. As a result of this, basic radon precautions will need to be incorporated into any design plans for the Proposed Development.

4.3 Recommendations

4.3.1 General Site Wide

A revised remediation strategy will need to be submitted to and approved by the Local Planning Authority to facilitate the progression of the enabling works in light of the asbestos contamination identified in 2012 at the commencement of the enabling works. This is currently being completed under a separate cover and will be issued in October 2012.

The Principal Contactor will need to develop a safe system of work and ensure that all works are completed in accordance with the CAR 2012 and appropriate documentation and notifications are issued to the Health and Safety Executive and other regulatory authorities.

A ground gas assessment completed in 2008 concluded that the residential development areas was CIRIA CS2 or NHBC Amber 1; and the retail areas was CIRIA CS3 due to the elevated methane concentrations and flow rates within the underlying bedrock. Therefore, appropriate gas protection measures will be required within all new buildings. Furthermore, the Site is located within a radon affected area and therefore, radon protection measures are required within all new dwellings and extensions.

No assessment of vapours to human health both indoor or outdoor has been undertaken and whilst vapour exposure pathway from indoor air can be adequately mitigated by the incorporation of appropriate vapour / gas

protection measures, it is considered that an appropriate assessment of risk from vapours in outdoor air should be completed.

4.3.2 West Pond

It is considered that there has been sufficient investigation within the West Pond to assess the degree of contamination present; and appropriate mitigation and validation works can be completed as the development works progress.

However, no assessment of the risks from vapour inhalation outdoors has been completed which is considered a potential exposure pathway; and therefore, further assessment works may be warranted to fully quantify potential risks which could be completed in conjunction with the works outlined for South Quay

Part of the assessment of organic contamination within South Quay may encroach onto the southeast / east of West Pond in order to full delineate the contamination plume. However, these works can be combined with the assessment works for South Quay and in conjunction with the current enabling works.

4.3.3 South Quay

It is considered that further intrusive assessment works are required to fully quantify the degree and extent of asbestos, metals and organic contamination and associated constraints to the proposed residential development.

The scope of the assessment works will be agreed with the regulatory authorities, but likely to include the excavation of a series of trial pits and the advancement of rotary boreholes to enable the collection of representative soil, groundwater and ground gas samples, vapour and groundwater monitoring, as required. The findings of the assessment works will be utilised to refine and develop the remedial / mitigation strategy for South Quay.

4.3.4 East Quay

It is considered that further assessment / validation works are required to confirm the suitability of East Quay for public open space. Given the potential restrictions with regards to the former landfill (in-filled graving dock), it is proposed that within the graving dock area the investigations are restricted to shallow / surface validation and gas / vapour assessment only, unless the regulatory authorities require further clarification of residual soil concentrations.

The areas external to the graving yard should be subject to validatory testing as above, however, intrusive works will not be limited to shallow soils.

As no buildings or basement structures are proposed in this area, the risk from ground gas is considered low, however, a risk from vapours in outdoor air may still exist and appropriate assessment should be completed to confirm whether a risk exists.

Appendix A - Figures

Appendix B – List of Reports Reviewed

- The Quays, Barry Waterfront, Evidence of Asbestos found by ASM. Dated w/e 20th July 2012. Summary of information provided by the Client;
- Joint Venture Partnership of Associated British Ports and Welsh Development Agency, Barry No. 1 Dock, Redevelopment Geotechnical and Contamination Report, November 1992. Volume 1 of 2 Main Text. Ove Arup & Partners Consulting Engineers;
- Joint Venture Partnership of Associated British Ports and Welsh Development Agency, Barry No. 1 Dock, Redevelopment Geotechnical and Contamination Report, November 1992. Volume 2 of 2 Appendices. Ove Arup & Partners Consulting Engineers;
- Associated British Ports Holdings PLC, Barry No. 1 Dock, South Glamorgan, Phase 2 Reclamation – Site Investigation Factual Report, May 1994. Integral Geotechnique (Wales) Limited;
- Joint Venture Partnership of Associated British Ports and Welsh Development Agency, Site Investigation Report No. 3b, Phase II Reclamation, July 1994. Ove Arup & Partners Consulting Engineers;
- Associated British Ports. Reclamation of Tank Farm and Mole at Barry No. 1 Dock, Factual Report on Ground Investigation. August 1994. Exploration Associates.
- Joint Venture Partnership of Associated British Ports and Welsh Development Agency, Site Investigation Report No. 5 (Phase III) – Site 'A' and Mole. October 1994. Ove Arup & Partners Consulting Engineers;
- Joint Venture Partnership of Associated British Ports and Welsh Development Agency. Geotechnical and Contamination Report – West Pond Car Park & North Quay Areas – Revision B. January 1997. Ove Arup & Partners Consulting Engineers;
- Joint Venture Partnership of Associated British Ports and Welsh Development Agency. The Waterfront Barry – Technical Issues Report. May 1997. Ove Arup & Partners Consulting Engineers;
- Joint Venture Partnership of Associated British Ports and Welsh Development Agency. Waterfront Barry – Remediation Strategy Review. January 2007. Ove Arup & Partners Consulting Engineers;
- Barratt, Persimmon and Taylor Wimpey. Barry Waterfront – South Quay and West Pond Desk Study. February 2008. Ove Arup & Partners Consulting Engineers;
- Barratt, Persimmon and Taylor Wimpey. Barry Waterfront – Geo-environmental Site Investigation Report – West Pond. September 2008. Ove Arup & Partners Consulting Engineers;
- Barratt, Persimmon and Taylor Wimpey. Waterfront Barry – Geo-environmental Site Investigation Report – West Pond. September 2008. Ove Arup & Partners Consulting Engineers;
- Barratt, Persimmon and Taylor Wimpey. Factual Report on Ground Investigation at Waterfront Barry, West Pond. October 2008. Structural Soils Limited;
- Barratt, Persimmon and Taylor Wimpey. Waterfront Barry – Strategic Earthworks, Highways and Drainage Report. September 2009. Ove Arup & Partners Consulting Engineers;

Author	Date	Title
Earth Science Partnership	October 2010	Barry waterfront development west pond BWD consortium controlled water RA
Earth Science Partnership	No date	General Notes
CL/SE442 122374/KPI	January 2010	Letter from EA dated 25 January 2010
Ove Arup & Partners Ltd	February 2008	Barrat, Persimmon and Taylor Wimpey, Barry Waterfront, South Quay and West Pond, Desk Study.
EA (Sally Thompson)	19/12/2008	EA response to West Pond Report (SE/CL/442-ML1)
Ove Arup & Partners Ltd	September 2008	Geoenvironmental Site Investigation report - West Pond Barratt, Persimmon and Taylor Wimpey Waterfront Barry
Ove Arup and Partners International Ltd and Structural Soils Limited	October 2008	Factual Report on Ground investigation at Waterfront Barry, West Pond (721317)
Ove Arup & Partners Ltd	28/08/2009	Response to EA letter dated 19122008 re Geo-environmental Site Investigation Report - West Pond (SE/CL/442-ML1 122374/KPI, 6-34)
Earth Science Partnership	December 2010	Barry Waterfront Development Phase I Infrastructure - West Pond (Geotechnical Remediation)
ASM Compliance Ltd	July/August 2012	Asbestos Material Investigation - Barry Waterfront (A0712/030)
Ove Arup and Partners International Ltd	April 2002	Waterfront, Barry. Preparation and Disposal of Development Plots on East Quay, West Pond and South Quay - Draft 2. Engineering progress report
Ove Arup & Partners Ltd	1 March 2007	Barry Waterfront Engineering Issues and Quantities/Costs for Abnormals (122374/JS)
Ove Arup & Partners Ltd	6 March 2007	Barry Waterfront Constraints and Issues affecting Development (122374/JS)
Ove Arup & Partners Ltd	No Date	Barry Waterfront Technical Pack
Ove Arup & Partners Ltd	January 1998	Associated British Ports, The Waterfront, Barry West Pond Replacement Sewer Contract 3C
Giles Sommerwill (Earth Science Partnership)	25 August 2011	Email to John Wilson
White Young Green	No Date	The Waterfront, Barry Contract 3C West Pond Replacement Sewer, Health and Safety File

WSP Environmental Limited
Colston 33
Bristol
www.wspgroup.co.uk