



Tidal Lagoon (Swansea Bay) Plc

Tidal Lagoon Swansea Bay Onshore Works

Ground Conditions Desk Study Report

19th April 2016



Document Control

Document: Ground Conditions Desk Study
Project: Tidal Lagoon Swansea Bay
Client: Tidal Lagoon (Swansea Bay) Plc
Job Number: A095976
File Origin: z:\projects\A095973 - Tidal Lagoon Swansea Bay\Report\A095973 - Tidal
Lagoon DTS Final Issue V3.docx
Revision: Final V3
Date: 19th April 2016

Prepared by

Checked by

Approved By

Luzia Kathriner
Geo-environmental Engineer

Simon Johnson
Associate

Ian Viney
Associate Director



Contents

1	Executive Summary	5
2	Introduction	6
	2.1 Instruction	6
	2.2 Brief	6
	2.3 Report Scope	6
	2.4 Limitations	7
3	Site Information	8
	3.1 Location	8
	3.2 Site description	8
	3.2.1 Area 2 Dockyard Area North	8
	3.2.2 Area 1 Dockyard Area South	8
	3.2.3 Area 3 Cable Route – Fabian Way and Cable Terminus - Baglan	9
4	Geology, hydrogeology, hydrology and radon	11
	4.1 Geology	11
	4.1.1 Made Ground	11
	4.1.2 Superficial Geology	11
	4.1.3 Solid Geology	11
	4.1.4 Historical Borehole logs	11
	4.1.5 Geological information from previous site investigations	13
	4.2 Hydrogeology	15
	4.2.1 Aquifer designations	15
	4.2.2 Source protection zones	15
	4.2.3 Hydrogeological information from previous site investigations	16
	4.3 Hydrology	17
	4.4 Radon	18
	4.5 Coal Mining Reports	18
5	Site history	19
	5.1 Summary of site history	19
	5.1.1 Area 1	19
	5.1.2 Area 2	20
	5.1.3 Area 3	20
	5.2 Detailed analysis of site history	20
	5.2.1 Area 1	21
	5.2.2 Area 2	22
	5.2.3 Area 3	23
6	Review of previous site reports	25
	6.1 Reports	25
	6.2 Transit Site	25
	6.2.1 Remediation Performance Specification, Atkins, June 2010	25
	6.2.2 Ground Investigation Works Transit Site Swansea, REC, August 2010.	27
	6.2.3 Remediation Validation Report for Former BP Transit Site, Hydrock, May 2011	27
	6.2.4 Technical Note : Geotechnical and Geoenvironmental Desk Study – Onshore, Atkins November 2014	29
	6.2.5 Swansea Bay Tidal Lagoon Access Road Ground Investigation Report, Atkins, September 2015	30
	6.3 Baglan Bay	33
	6.3.1 Proposed Solar Photovoltaic Park, Baglan Energy Park – Contamination Assessment, Atkins, January 2011	33
	6.3.2 PV Farm Geo-environmental Assessment Report, Atkins, May 2011	34



6.3.3	Technical Note : Baglan Bay Land Contamination, Atkins, October 2014	34
6.4	Whole Site	35
6.4.1	Explosive Ordnance Threat Assessment in respect of Swansea Docks to Baglan Burrows, Bactec, September 2014.	35
6.5	Summary	35
7	Environmental Database Search	36
8	Regulatory Consultation	38
8.1	Overview	38
9	Preliminary ground contamination assessment	39
9.1	Overview	39
9.2	Conceptual site model	39
9.2.1	Conceptual site model 1	39
9.2.2	Conceptual site model 2	41
9.2.3	Conceptual site model 3	42
9.3	Ground contamination risk assessment	43
10	Gap Analysis	57
10.1	Identified Data Gaps	57
10.2	Proposed Scope of Works	58
10.2.1	Service Location	58
10.2.2	BP Pipelines	58
10.2.3	Groundwater Regime and Tidal Influence	59
10.2.4	Contamination – Docks Area (including western landfall building)	59
10.2.5	Ground Conditions and Contamination – Cable Route	59
10.2.6	Contamination – Baglan Energy Park Area	60
10.2.7	Ground Investigation for the Eastern Landfall haul road	60
10.2.8	Ground Gas Regime	60
10.2.9	Western Landfall Building Centre Geotechnical Conditions	61
10.2.10	CBR Values	61
10.2.11	Horizontal Directional Drilling	61
10.3	Consultation	61
10.4	Additional Works	62
11	Conclusions and recommendations	63
11.1	Conclusions	63
11.2	Recommendations	64
11.3	Summary	67
	References	69
	Figures	70
	Photographic Plates	71
	Appendices	78

Figures

- Figure 1 – Site Location Plan
- Figure 2 – Site Plan
- Figure 3 – (not used)
- Figure 4 – Areas of Previous Site Investigations
- Figure 5 – Historic Summary
- Figure 6 – Conceptual Site Models

Appendices

- Appendix A – Report Conditions
- Appendix B – Proposed Development
- Appendix C – Geology and hydrogeology records



Appendix D – Radon Reports	
Appendix E – Coal Mining Reports	
Appendix F – Historic maps	
Appendix G – Environmental Database Search Records	
Appendix H – Matrix with responses to regulatory comments	
Appendix I – CIRIA C552 Risk Methodology	
Appendix J - Obstructions Plan from Hydrock Report (May 2011)	

Tables

Table 4-1 Summary of Historical Borehole Logs.....	11
Table 4-2 Groundwater Monitoring Data in m bgl (REC 28 th April 2015).....	16
Table 4-3 Groundwater Monitoring Data in m bgl (Atkins June/July 2015)	17
Table 5-1 Summary of Historical Land Uses of Area 1.....	21
Table 5-2 Summary of Historical Land Uses of Area 2.....	22
Table 5-3 Summary of Historical Land Use for Area 3	23
Table 6-1 Soil Remedial Targets (mg/kg unless otherwise stated)	28
Table 7-1 Summary of Environmental Database Search Results	36

1 Executive Summary

The Site	The site comprises land adjacent to Kings Dock and Queens Dock in Swansea Bay and an elongated route (circa 4.5km) for a proposed high voltage electricity cable extending to Baglan near Port Talbot. The majority of the site is currently vacant land and is largely covered by hardstanding. The proposed cable route portion of the site is along the footpath to Fabian Way before passing through the sand dunes at Crymlyn Burrows and then running under the River Neath and connecting into Baglan Energy Park.
Site History	The site has an extensive history of industrial development since the construction of the docks circa 1918. Land uses on the site have included a timber yard, fish meal works, oil storage tanks, various industrial works, gasworks and railway sidings. Adjacent land uses have comprised further industrial processes including a large chemical works and power station at Baglan.
Geology, Hydrogeology, Hydrology and Radon	The geology underlying the site comprises Made Ground deposits in the vicinity of the western docks and around the Baglan Bay end of the cable route. The underlying superficial geology comprises Marine Beach Deposits with Tidal Flat Deposits and alluvium around the River Neath and some Blown Sand deposits along the central portion of the cable route. The underlying bedrock comprises Coal Measures. The Coal Measures and superficial deposits are classed as Secondary Aquifers. There is no appreciable risk from radon gas or coal mining noted for the site.
Site Setting	The site is located within a predominantly industrial and commercial area, though some residential properties are present proximal to the cable route. There are three waste management facilities and one closed landfill recorded within 250m of the site.
Ground Contamination Assessment	Significant sources of contamination have been identified based upon the extensive historic industrialisation of the site and surrounding area and in view of information in existing site investigation reports. Key contaminants of concern include heavy metals, asbestos, petroleum hydrocarbons, BTEX and PAHs. There is also a plausible risk of sulphate, cyanide, PCBs, VOCs and SVOCs being present in some areas. Risks to human health and controlled waters have been identified. These risks are predominantly low to moderate; however, some elevated high level risks have also been identified.
Conclusions	The site has a significant risk from contamination, particularly around the docks and adjacent to former industrial processes such as the BP Transit Site and Baglan Chemical works. It is recommended that a ground investigation is undertaken to further assess and refine the risk assessments in this report.

2 Introduction

2.1 Instruction

WYG Environment Planning Transport Ltd (WYG) were commissioned by Tidal Lagoon (Swansea Bay) Plc (TLSB) to undertake a ground conditions desk study to support the planning application for the construction of a tidal energy lagoon in Swansea Bay.

2.2 Brief

The ground conditions desk study is required for the land based elements of the proposed tidal lagoon only and is to consider issues pertinent to the following permanent and temporary features associated with the development:

- Temporary site offices during the construction phase.
- Haul road for purposes of constructing the eastern landfall seawall / barrier.
- A high voltage (275kV) cable route extending for approximately 7km from the western landfall into Baglan Energy Park. The cable will be installed typically 1.6 to 1.8m below ground level (bgl).
- Cable crossing beneath River Neath to be achieved by means of horizontal directional drilling techniques.
- New access road, car parking, public realm landscaping and modifications to existing roads.
- A new employment use building (boating centre, operations centre and maintenance building etc) at the western extremity of the on-shore works, referred to as the Western Landfall Building.

2.3 Report Scope

This report includes the following key elements:

- A record of a site visit and visual inspection walkover.
- A discussion of the current site status and key associated environmental influences observable by general visual inspection around the site.
- A historical site and area review, primarily referring to past editions of Ordnance Survey Maps.
- A review of available site investigation and remediation reports previously undertaken within the area.
- A discussion of the general expected ground and groundwater conditions within the topographical and area context referring to our own geological and hydrogeological maps library.



- Details of an Environmental database search of key relevant agencies, including Local and Statutory Authorities such as the Environment Agency and Radon gas reports obtained from the British Geological Society.
- Review and assessment of coal mining reports for the site.
- A ground contamination assessment discussing the results of the research above, not only concerning potential on-site conditions/constraints and contamination but also an overview of the potential for migration onto or off-site with respect to the surrounding neighbouring sites.
- Development of a preliminary conceptual site model.
- Qualitative ground contamination risk assessment (compliant with CIRIA 552 methodology).
- Recommendations for intrusive ground investigation.
- An executive summary of the report to allow a rapid, layman's overview.

2.4 Limitations

The recommendations and opinions expressed in this report are based on information obtained as part of the desk study and provided by others. Information provided from other sources is taken in good faith and WYG cannot guarantee its accuracy.

This report is subject to the report conditions contained in Appendix A.

The information contained in this report is intended for the use of Tidal Lagoon (Swansea Bay) Plc. WYG can take no responsibility for the use of this information by any third party or for uses other than that described in this report or detailed within the terms of engagement.

3 Site Information

3.1 Location

The site is located in Swansea Bay and extends to Baglan, South Wales. A site location plan is presented as Figure 1.

3.2 Site description

For ease of reference the site has been divided into three areas as shown on Figure 2. Area 1 covers the site area along Queen's Dock and comprises the western landfall and part of a new access road for the proposed development. Area 2 covers the northern area of the site which will accommodate the construction compound including offices, welfare units, storage areas and access road. Area 3 comprises the eastern section of the site including the majority of the cable route to the power station and the eastern landfall as well as the temporary haul road.

A walkover site inspection was undertaken by WYG on 28th January 2016. A series of photographic plates are presented at the end of this report and are cross referenced in the following section. The general site layout, overlaid upon key historic and current features (as discussed in subsequent sections of this report), is shown in Figure 2.

3.2.1 Area 1 Western Dockyard Area

A smaller site road and limited areas of landscaping extend out along the southern seawall and runs to the western most extremity of the site, at the proposed location of the Western Landfall Building. The seawall is approximately 2m high. Three defensive pill boxes were noted in this area and are understood to date back to the Second World War. A number of areas of stockpiled demolition crushings, soil arisings, general waste and scrap metal are present along the seawall road.

At the western terminus of the road the site is occupied by docks, hardstanding and a derelict building noted to include asbestos cement sheeting in a poor state of repair (Plate 3). There are areas of hardstanding and open ground present which were anecdotally reported by the Client to have been occupied by oil tanks. A recently constructed wind turbine is present (Plate 3).

Surrounding land uses include the Swansea docks and retail premises (restaurants, car showrooms etc) to the west, Fabian Way, industrial premises and a sewage works to the north, St. Modwens development site to the east and Swansea bay to the south.

3.2.2 Area 2 Central Dockyard Area

The dockyard area is in the ownership of Associated British Ports (ABP). Access to the docks is via Baldwins Crescent off the A483 - Fabian Way. A central site access road runs through the docks area. To

the north of the site road and extending up to Fabian Way there is an area of soft, slightly boggy ground (Plate 2).

Further to the west there is an open area of former railway ballast which is intended to be used for site offices during the construction phase (Plate 1). A few items of scrap metal were noted across this area but there was no notable evidence of potential surface contamination. The area is raised approximately 2m higher than the adjacent dockside and shares a boundary, marked by a palisade fence, with the former Swansea Coach works to the immediate north. It is proposed that a new access route for the construction phase offices is made from this area onto Langdon Road to the northwest. This route will in turn become the new access road for the proposed Western Landfall Building.

To the south of this site road the area is predominantly vacant hardstanding surrounded by palisade fencing, though some parts are used for the temporary storage of windturbines.

3.2.3 Area 3 Cable Route – Fabian Way and Cable Terminus - Baglan

It is proposed that the cable will be installed within the footpath / highway verge along Fabian Way (Plate 5-7) for approximately 2km between 1.0 and 1.8m below ground level. The proposed high voltage cable route exits the dockyard area to the east and runs along Fabian Way, adjacent to the on-going St. Modwen / University of Swansea development site (Plate 6). This area is understood to have been formerly occupied by a series of oil storage tanks operated by BP. Further to the east the cable runs alongside Crymlyn Burrows (Plate 8 and 10), a series of sand dunes with SSSI status.

There are a series of swales and drainage ditches (Plate 9) containing some small amounts of litter, running alongside the footpath, though no evidence of contamination was noted in the water present in these features. During the site walkover the presence of a large number of utility service manhole covers was noted in the Fabian Way footpath. Therefore, a potential secondary option of running the cable through Crymlyn Burrows is also being considered to avoid conflict with existing services.

Crymlyn Burrows has an existing access path running parallel to Fabian Way. A number of underground service markers are present and it is understood that a range of buried services, potentially including gas, telecommunication, electric, water and relic BP oil pipelines, are present in the Crymlyn Burrows area. There is evidence of limited former development on the burrows in the form of small ancillary buildings (possible substation, pumping stations or similar) which are understood to be associated with below ground utility services (Plate 11). No evidence of suspected contamination was observed on the cable route or immediately adjacent areas.

The proposed cable route passes under the River Neath and will require horizontal directional drilling. The cable is to emerge and run alongside an existing footpath on the western side of a large paper tissue factory before connecting into Baglan Energy Park (Plate 13 and 14). This area is understood to have been



part of the former BP Chemical plant at Baglan Bay. It is noted that eastern bank of the River Neath in this location is significantly elevated in relation to the ground level at Crymlyn Burrows and includes a built up river wall (Plate 12).

The location of the three principal areas is shown on Figure 2.

4 Geology, hydrogeology, hydrology and radon

4.1 Geology

The site is covered by British Geological Survey (BGS) 1:50,000 (solid and drift) map number 247, Swansea. The online version on GeoIndex has been consulted. Extracts of the geological maps are included in Appendix C.

4.1.1 Made Ground

According to BGS mapping, the western area of the site including Area 1 and the BP transit site (see Figure 2) is underlain by Made Ground comprising both artificial deposits and artificially modified ground. Historical borehole logs indicate that Made Ground extends to depths of up to 3.9 to 7.1m and comprise various types of Made Ground including ashy deposits, gravel and cobbles of slag, clinker, firebrick and concrete.

4.1.2 Superficial Geology

The west of the site and is underlain by Marine Beach Deposits comprising mainly sands. Blown Sand Deposits are recorded along the central section of the site and the far east below the power station. Tidal Flat Deposits and alluvium consisting of clay, silt and sand are indicated across the River Neath.

4.1.3 Solid Geology

The bedrock consists of the South Wales Middle Coal Measures Formation in the north and Lower Coal Measure Formation in the south. Both formations consist of mudstone, siltstone and sandstone.

4.1.4 Historical Borehole logs

A number of historical BGS boreholes records in the vicinity of the site are available. Five records are summarised in Table 4-1 below and their locations are shown on Figure 2.

Table 4-1 Summary of Historical Borehole Logs

Borehole BGS Reference (year drilled)	Location	Strata	Depths (m bgl)	Description
SS69SE138-142 (1993)	NGR: 268805, 192895 to 269140, 192945 Port of Swansea road, south-west of A483 Fabian Way	Made Ground	0-3.9	Loose to medium dense clayey silty GRAVEL and COBBLES of sandstone, clinker, coal, coke, brick and slag
		Upper Alluvium	3.9-7.7	Medium dense to dense silty SAND and GRAVEL with occasional shell fragments
		Alluvium	7.7->30	Interbedded soft to firm occasionally stiff silty CLAY with fibrous peat and medium dense to dense clayey SILT and SAND with peaty fibres. Bands between 0.45 and 0.7m thick of compact fibrous peat recorded

Borehole BGS Reference (year drilled)	Location	Strata	Depths (m bgl)	Description
SS69SE316 (1978)	NGR: 269410, 192960 A483 Fabian Way	Made Ground	0-7.1	Ash, chippings and cobbles
		Sand and Gravel	7.1-9.0	Sand and Gravel
SS79SW106 (1979)	NGR: 272770, 193525	Topsoil	0.0-0.2	Topsoil and turf
		Alluvial Blown Sand	0.2-4.0	Medium dense brown fine to medium grained sand with little shell fragments Lense of grey silty clay with some peat debris at 3.60m bgl
		Alluvium	4.0-6.0	Firm grey slightly peaty clay
		Alluvium	6.0-10.4	Very soft grey brown slightly silty clay with a trace of plant remains
		Alluvium	10.4-12.0	Moderately compact grey brown slightly clayey very fine-grained sandy silt with a trace of plant remains
		Alluvium	12.0-15.0	Medium dense grey brown very silty fine to medium grained sand with a trace of shell fragments and a trace of plant remains
		Alluvium	15.0-20.5	Medium dense grey brown silty fine to medium grained sand with occasional layers and packets of grey silty clay and trace of shell fragments and a trace of plant fragments.
		Alluvium	20.5-23.0	Medium dense grey brown silty angular to sub-rounded fine to coarse grained sand with some shell fragments and sub-angular to sub-rounded fine to coarse grained gravel with some cobbles and occasional layers of clayey silt
		Glacial Deposits	23.0-26.5	Medium dense grey brown sub-angular to rounded fine to coarse grained gravel and cobbles with some very silty angular to sub-rounded fine to coarse grained sand and occasional layers of grey silty clay
		Glacial Deposits	26.5-29.5	Dense to very dense grey brown clayey silty angular to sub-angular fine to coarse grained sand and sub-angular to rounded fine to coarse grained gravel with some cobbles
		Sandstone	29.5-29.7	Angular coarse grained gravel and cobble sized fragments of grey sandstone
SS79SW562 (1998)	NGR: 272351, 192725 Baglan Burrows – adjacent to River Neath	Topsoil	0.0-0.2	Loose gravelly sandy topsoil
		Made Ground	0.2-0.5	Loose orange brown medium grained sand with some cobbles of broken concrete
		Made Ground	0.5-1.1	Dense cobbles and boulders of cementitious brown fines with fire bricks and some blue grey vesicular slag

Borehole BGS Reference (year drilled)	Location	Strata	Depths (m bgl)	Description
		Made Ground	1.1-2.1	Loose gravel of black ash with clinker and some cobbles of dark blue grey slag with some carbonation
		Made Ground	2.1-3.0	Loose gravel and cobbles of blue grey vesicular slag. Distinct area of this material with high degree of carbonation.
		Made Ground	3.0-4.3	Medium density gravel to boulders of dark grey vesicular slag with a little carbonation and a few fire bricks.
		Made Ground	4.3-4.4	Firm silty black sand with vegetation. Sulphurous odour
		Sand	4.4-4.9	Loose grey brown medium grained sand
SS79SW619 (1998)	NGR: 273121, 193069 Baglan Burrows, adjacent to River Neath	Topsoil (Made Ground)	0.0-0.2	Loose sand, some gravel of ash and slag rich soil
		Made Ground	0.2-2.2	Loose sand, some gravel and occasional firebrick and shells
		Made Ground	2.2-2.8	Medium dense cobbles and gravel of slag, brown ash and firebrick
		Made Ground	2.8-4.0	Loose dark grey brown clinker and ash, sand and gravel. Little visible slag.
		Made Ground	4.0-5.0	Loose gravel of brown clinker
		Made Ground	5.0-5.7	Loose cobbles/gravel of clinker with minor cobbles of slag
		Sand	5.7-5.9	Loose light brown medium grained sand

4.1.5 Geological information from previous site investigations

4.1.5.1 BP Transit site (August 2010)

The former BP Transit site which is located west of the Swansea Docks encroaches partially on the site (see Figure 2). This area has undergone several phases of site investigation and remediation (see Section 6). The approximate area covered by this investigation is shown in Figure 4. The geological information from (3) is summarised in the following paragraphs.

The sequence of strata encountered below the BP transit site was:

- Made Ground
- Sand and Clay
- Bedrock



Made Ground was encountered in 15 out of 16 borehole positions varying in thickness between 0.1 and 1.6m. The deposits consist of mostly brown fine to medium sand with varying amounts of gravel. The gravel comprised fine to coarse angular to sub-angular sandstone, concrete, brick and some slag.

Underlying the Made Ground sand deposits were encountered to depths of between 8.9 and 24.0m bgl. The sand was fine to medium and contained varying amounts of shell fragments. Below the sand, clay layers of between 0.7 and 7.1m thickness were interbedded with further sand deposits. In some locations the base of the clay was not found and extended to depths of up to 25.1m bgl (11.5m thickness). The clay contained varying amounts of gravel described as fine to medium sub-angular to sub-rounded sandstone, siltstone, mudstone and coal. In two locations peat deposits were encountered at 24.0m bgl of 0.4 and 1.5m thickness.

The bedrock was encountered in three locations at depths of between 17.9 and 25.1m bgl. It consisted of siltstone, sandstone, mudstone and coal. It should be noted that there were ten locations where the boreholes were advanced to between 18.0 and 30.0m bgl and no bedrock was encountered.

4.1.5.2 Tidal lagoon Access Road (August 2015)

A ground investigation was undertaken in the western area of the site (Area 1) in August 2015 by Atkins Ltd with Apex Drilling Services Ltd as the ground investigation contractor (Figure 3 – (not used))

Figure). The results are reported in (1) and (2):

Based on the documents referenced above, the following strata are present in the west of the site:

- Made Ground
- Marine Beach Deposits

Made Ground was found in all of the 44 exploratory positions. The base of Made Ground was only encountered in eight locations ranging between 0.6 and 2.2m bgl. However, boreholes were advanced to up to 4.0m without proving the base of Made Ground. The Made Ground consisted of brown, black and grey sand and gravel with variable amounts of silt, cobbles and boulders. It was described as ashy in places. Information supplied by Natural Resources Wales in previous correspondence provided by TLSB indicates that there are lenses of oil filled ash material commonly encountered in the docks area. The gravel comprised clinker, slag, limestone, siltstone, brick and rare glass and coal. The cobbles consisted of angular to sub-angular tabular slag, foundry debris, limestone, siltstone, brick and some granite, reinforced concrete.

4.2 Hydrogeology

4.2.1 Aquifer designations

The bedrock as well as the Blown Sand Deposits beneath the site are classified as Secondary A Aquifer by Natural Resource Wales (NRW). Secondary A Aquifers are defined as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers.

The Marine Beach Deposits and Alluvium are designated as Secondary Undifferentiated Aquifers. These comprise cases where it was not possible to attribute category A or B to a stratum. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the stratum type.

Secondary B Aquifers are defined as predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. This is generally assigned to the water-bearing parts of the former non-aquifers.

The groundwater vulnerability mapping indicates that the soils across the site have high leaching potential (see Appendix C).

4.2.2 Source protection zones

There are no source protection zones within 1km of the site.

4.2.3 Hydrogeological information from previous site investigations

4.2.3.1 BP Transit site (August 2010)

Following the installation of groundwater monitoring wells on the BP Transit site, the groundwater levels were recorded on the 28th April 2010 by REC (3). The results are presented in Table 4-2. There is no reference to the timing of the measurements and therefore no association to the tide.

Based on this monitoring visit, it can be seen that the groundwater level is dropping towards the sea and a seaward groundwater flow is inferred. However, this conclusion does not allow for tidal influences. The water bearing strata are the sand deposits and thus a relatively high hydraulic conductivity is associated with the aquifer. It may therefore be very responsive to tidal pressures. Due to the close proximity to the sea it is considered likely that there are tidal variations in the groundwater levels beneath the site.

Table 4-2 Groundwater Monitoring Data in m bgl (REC 28th April 2015)

Location	Screen (m bgl)	Groundwater level (m bcl)	Groundwater level (m AOD)
ATSBH001	12.0-15.0	2.615	4.115
ATSBH002	9.0-12.0	1.754	4.756
ATSBH003	5.0-8.0	2.19	4.04
ATSBH004	9.0-15.0	3.841	2.698
ATSBH005	7.0-10.0	3.829	3.301
ATSBH006	7.0-10.0	2.40	4.33
ATSBH007	9.0-12.0	3.547	3.983
ATSBH008	9.0-12.0	3.81	3.58
ATSBH009	6.0-9.0	1.342	5.018
ATSBH010	7.0-10.0	2.193	4.417
ATSBH011	3.0-6.0	5.061	3.999
ATSBH012	3.0-6.0	4.445	4.365
ATSBH013	11.0-14.0	2.836	4.484
ATSBH014	8.0-11.0	1.624	5.236
ATSBH015	7.0-10.0	1.849	5.341
ATSBH016	8.0-11.0	1.655	4.835

4.2.3.2 Tidal lagoon Access Road (August 2015)

The ground investigation undertaken in the western area of the site in August 2015 by Atkins Ltd encountered groundwater in fifteen locations ranging between 1.9 to 3.8m bgl equivalent to 2.97 to 5.50m above Ordnance Datum (AOD)(1). The groundwater observations varied between the arisings being described as damp to medium inflow.

Consistent observations were made in the northern area of the site, where the groundwater was encountered between 3.45 and 3.7m bgl. Across the arsenic area (see Figure 2) groundwater was encountered at shallower depths (2.4-2.5m bgl) and with slow to medium inflows.

Attempts were made to monitor groundwater at eight locations over a month. The results are summarised in Table 4-3. Groundwater could only be monitored in two locations (BH01 and BH09) and was observed to vary between 3.44 and 3.68m bgl. The other borehole installations were too shallow to penetrate the water table. In BH09 the groundwater level was recorded during both low tide and high tide, however only minimal variations were observed (average of 3.5075m bgl for low tide measurements and 3.52m bgl for high tide measurements).

Based on (1) and (2) the groundwater regime cannot be established due to the lack of sufficient groundwater level measurements.

Table 4-3 Groundwater Monitoring Data in m bgl (Atkins June/July 2015)

Location	Screen	22.06.2015	02.07.2015	07.07.2015	08.07.2015	09.07.2015	22.07.2015
BH01	1.00-3.60	3.55 (HT)	3.60 (HT)	3.64 (HT)	3.65 (HT)	3.65 (HT)	3.68 (HT)
BH02	1.00-3.60	Dry (HT)	Dry (HT)	Dry (HT)	Dry (HT)	Dry (HT)	Dry (HT)
BH03	NA	3.55 (HT)	Dry (HT)	Dry (HT)	Dry (HT)	Dry (HT)	Dry (HT)
BH04	1.00-3.30	Dry (HT)	Dry (HT)	Dry (HT)	Dry (HT)	Dry (HT)	No reading
BH05	1.50-2.30	Dry (LT)	Dry (HT)	Dry (HT)	Dry (HT)	Dry (HT)	Dry (LT)
BH06A	1.00-1.90	Dry (LT)	Dry (LT)	Dry (LT)	Dry (HT)	Dry (HT)	Dry (LT)
BH09	1.50-3.45	3.44 (LT)	3.54 (LT)	3.54 (LT)	3.54 (HT)	3.50 (HT)	3.51 (LT)
BH10A	1.50-3.60	Dry (LT)	Dry (LT)	Dry (LT)	Dry (HT)	Dry (HT)	Dry (LT)

NA – No installation details recorded on Borehole log

HT – indicates that the tide was high when the groundwater level was recorded

LT – indicates that the tide was low when the groundwater level was recorded

4.3 Hydrology

The River Tawe flows into the sea immediately west of the site. The western arm of the site is confined by the Queen's dock to the north and the sea to the south. The Queen's Dock is part of a wider dock system



including the King's Dock and Prince of Wales Dock which are located between the Queen's dock and the River Tawe to the north and west of the site. A pond is present within the Sewage works adjacent to the north of the site. Drainage ditches are marked along the A483 along the northern boundary of the site.

The cable route crosses the River Neath in Area 3. There is an inlet reaching into the Crymlyn Burrows from the River Neath towards the west along the site at high tide at approximately 100m S distance. Another one is present to the north of the site. On the eastern side of the River Neath, south of the site, there is a water feature extending in three fingers from the River Neath. Two ponds are present within the industrial estate adjacent to the north of the site, which are considered to be likely attenuation ponds.

4.4 Radon

Radon reports have been obtained from the BGS and these indicate that the site is in an area where between 1-3% of properties are likely to have radon gas at concentrations above the action level. The reports advise that radon protection measures are not required for the site. Copies of the Radon reports are included in Appendix D.

4.5 Coal Mining Reports

In view of the presence of collieries in the area a Coal Mining Report was obtained for the site (including the cable route). The report does not identify any coal mining risks to the site. A copy of the Coal Mining Report is included in Appendix E.

5 Site history

The historical development of the site and surrounding area has been assessed using information available from historical Ordnance Survey (OS) maps which are presented in Appendix F of this report. The dates of specific historical land uses refer to the dates of publication of the maps where that land uses were marked. The actual durations of land uses may be longer and cannot be accurately determined from historical maps.

For ease of reference the site has been divided into three areas and a summary of historical use is shown on Figure . Area 1 covers the site area along King's Dock and comprises the western landfall and new access road of the proposed development. Area 2 covers the northern area of the site which will accommodate the construction compound including offices, welfare units and storage areas. Area 3 comprises the eastern section of the site including the majority of the cable route to the power station and the eastern landfall as well as the haul road. A summary of the historic land use is also presented on Figure .

5.1 Summary of site history

5.1.1 Area 1

The history of Area 1 is dominated by the development and operation of Swansea Docks and the associated industrial activities. Until the construction of the Queen's and King's Dock by 1918-19 the site was undeveloped marsh land and intertidal flats. The industries represented include the following:

- Coal export with associated railway and coaling quays (1921 until 1951)
- Fuel works (1918-19 until 1938 and 1960-66 respectively): Phoenix Patent Fuel Works and Graigola Merthyr Patent Fuel works located at opposite sides of inlet of Queen's Dock approximately 300-400m north of the site
- Oil storage and export (1948-49 until 1992): Two sets of tanks were marked in the far west of the site until 1989. Anecdotal evidence suggests some were associated with flame thrower defence structures during World War II. Oil tanks were present along Queen's Dock by the jetties until 1992.
- Fish meal factory (1921 until 1964) marked 'works' until present is located in the far west of the site between the two sets of tanks.
- Timber yard (1921 until 1938) was recorded between the two westernmost jetties of Queen's Dock.



5.1.2 Area 2

Since the earliest available historical mapping dated 1879, area 2 and its surrounding area accommodated significant industrial activities which are summarised below. Many railways crossed the site, some still present today.

- Immediately adjacent to area 2 in the north was Crown Works (1879 until 1951-56) manufacturing spelter/paint. From 1951-16 it is identified as 'Aluminium Wire and Cable' and not labelled after 1960-62.
- A wagon works called Swansea Works (1879 until 1900) was situated north of Crown works along the railway. In 1947 the site was reclaimed and a factory is visible on aerial photography of that year. On OS mapping of 1948 the factory is identified as 'United Kingdom Chemical Works' with tanks, a water cooling tower and a tar distillery. From 1960-62 the site is labelled 'works'. By 1989 the buildings are demolished.
- A gas works (1979) was present adjacent to the west of Swansea Works.
- A hydraulic power station/works (1919 until 1968-71) was located along the centre of the western boundary of the site.
- An oil depot (1960 until 1980-89) occupied the southern extent of area 2
- Since 2012 a sewage works is recorded adjacent to area 2 to the west

5.1.3 Area 3

The western part of Area 3 was dominated by industrial activities including King's Dock and Elba tin plate works and later a Ford works manufacturing motor components adjacent to the site to the north. A tank farm (BP transit site) occupied part of the site between 1933 and 1980-89. The eastern part (Crymlyn Burrows) remained largely undeveloped intertidal flats and sand dunes. During World War II an anti air craft battery was located in the Crymlyn Burrows and (4) suggests it was used as a training ground by the army. Adjacent to the east of area 3, the Baglan Chemical works were present between 1980 and 2012 including a pipeline leading west.

5.2 Detailed analysis of site history

The tables below provide a detailed account of the review of available OS mapping coverage for the site and general area dating back to 1879.

5.2.1 Area 1

Table 5-1 Summary of Historical Land Uses of Area 1

OS Map Edition and Scale	Within Site boundary	Surrounding area
1879 (1:2,500) and 1884 (1:10,560)	Site area is undeveloped marsh land and intertidal flats	Port Tennant Works (Copper) are recorded approximately 550m north of area 1.
1899 (1:2,500) and 1900 (1:10,560)	No significant changes are recorded within the site boundary	The Prince of Wales Dock has been built approximately 1km north of the site.
1918-19 (1:2,500) and 1921 (1:10,560)	The King's and Queen's Dock have been built. The southern dock wall of Queen's Dock forms area 1. A timber yard is marked west of its centre. A fish meal factory is recorded at the westernmost point of the site.	The Port Tennant Works are no longer marked. However, an electricity generation station is marked in the north-western corner of the former Port Tennant Works site. Coal quays are marked along the north of King's Dock. The Phoenix Patent Fuel Works and Graigola Merthyr Patent Fuel Works are situated on either side of the gate between the two docks.
1938 (1:10,560)	No significant changes are recorded within the site boundary	The electricity generation station is no longer labelled.
1948-49 (1:2,500) and 1949 (Aerial photographs 1:10,560)	The timber yard is no longer recorded. Two tanks are marked west of the fish meal factory and tanks are recorded all along Queen's Dock.	A goods shed is marked at the location of the former Port Tennant Works. The Phoenix Patent Fuel works are no longer marked.
1951 (1:10,560) and 1951-56 (2,500)	No significant changes are recorded within the site boundary	No significant changes are recorded within the surrounding area
1960-66 (1:2,500), 1960-62 (1:2,500) and 1964 (1:10,000)	The fish meal factory is now labelled 'works' and two additional tanks are marked east of it.	The Graigola Merthyr Patent Fuel Works are now labelled 'Disused Works'.
1976 (1:10,000 Russian Military Map)	No significant changes are recorded within the site boundary	No significant changes are recorded within the surrounding area
1962-88 (1:2,500)	No significant changes are recorded within the site boundary	No significant changes are recorded within the surrounding area
1980-89 (1:10,000)	No significant changes are recorded within the site boundary	No significant changes are recorded within the surrounding area

OS Map Edition and Scale	Within Site boundary	Surrounding area
1989 (1:10,000)	No significant changes are recorded within the site boundary	There are tanks recorded on the south-western corner of King's Dock.
2012 (1:10,000)	Both sets of tanks by the former fish factory are no longer present and the tanks along the jetties are no longer recorded.	The tanks on the south-western corner of King's Dock are no longer marked.

5.2.2 Area 2

Table 5-2 Summary of Historical Land Uses of Area 2

OS Map Edition and Scale	Within Site boundary	Surrounding area
1879 (1:2,500) and 1884 (1:10,560)	Crown works (Spelter), Swansea works (Wagon works) and a gas works are located in the northern part of area 2 and adjacent to it. The remainder of the site is undeveloped marsh land and intertidal flats.	An arsenic works is marked adjacent to the north-west of area 2. A colliery is recorded adjacent to the north of area 2. Burrow works (Chemical) situated approximately 250m north of area 2. Port Tennant Works (Copper) are recorded approximately 500m west of area 2.
1899 (1:2,500) and 1900 (1:10,560)	The gas works is no longer labelled and is possibly part of Swansea works	The Prince of Wales Dock has been built approximately 1km north of the site. The colliery adjacent to the site is now labelled 'Old Coal Pit'. The Burrow works is now called Crymlyn Chemical works. Carriage and wagon repairing shops are recorded adjacent to it.
1918-19 (1:2,500) and 1921 (1:10,560)	Swansea works are no longer marked and only the surrounding railway is left. A hydraulic power station is marked by the western boundary of the centre of area 2.	No significant changes are recorded within the surrounding area
1938 (1:10,560)	No significant changes are recorded within the site boundary	The arsenic works is no longer recorded.
1948-49 (1:2,500) and 1949 (Aerial photographs 1:10,560)	No significant changes are recorded within the site boundary	United Kingdom Chemical Works are recorded approximately 100m north of the area 2 including tanks, tar distillery and water cooling.
1951 (1:10,560) and 1951-56 (2,500)	The Crown works are now marked as Aluminium Wires and Cable.	The Crymlyn Chemical works are no longer recorded.
1960-66 (1:2,500), 1960-62	The hydraulic power station is labelled 'work' now. The eastern end of the Queen's Dock has been filled in and	The Aluminium wires and cable are no longer labelled. There are works situated south of the wagon repair shops. The

OS Map Edition and Scale	Within Site boundary	Surrounding area
(1:2,500), 1948-64 (1:1,250) and 1964 (1:10,000)	accommodates an oil depot.	United Kingdom Chemical Works is now labelled 'works'.
1960-71 (1:1,250)	No significant changes are recorded within the site boundary	The works south of the wagon repair shops are now labelled 'lifting gear works'.
1976 (1:10,000 Russian Military Map)	No significant changes are recorded within the site boundary	No significant changes are recorded within the surrounding area
1962-88 (1:2,500 Additional SIM)	No significant changes are recorded within the site boundary	The Carriage and Wagon repair shops are now labelled 'Depot'
1980-89 (1:10,000)	No significant changes are recorded within the site boundary	The former United Kingdom Chemical works is no longer marked.
1989 (1:10,000)	No significant changes are recorded within the site boundary	No significant changes are recorded within the surrounding area
2012 (1:10,000)	The oil depot next to Queen's Dock and the tank farm (BP transit site) are no longer marked.	Adjacent to area 2 (arsenic area) is a sewage works.

5.2.3 Area 3

Table 5-3 Summary of Historical Land Use for Area 3

OS Map Edition and Scale	Within Site boundary	Surrounding area
1879 (1:2,500) and 1884 (1:10,560)	Site area is undeveloped marsh land and intertidal flats. Breakwaters are marked on either side of the River Neath.	No significant changes are recorded within the surrounding area
1899 (1:2,500) and 1900 (1:10,560) and 1900 (1:10,560)	No significant changes are recorded within the site boundary	A tank is marked approximately 150m north of the site on the western bank of the River Neath.
1918-19 (1:2,500) and 1921 (1:10,560)	No significant changes are recorded within the site boundary	King's Dock Works (Tin Plates) are marked along the north of the western part of area 3.
1938 (1:10,560) and 1941 (1:2,500)	No significant changes are recorded within the site boundary	Elba Works are recorded adjacent to the east of King's Dock Works.

OS Map Edition and Scale	Within Site boundary	Surrounding area
1948-49 (1:2,500) and 1949 (Aerial photographs 1:10,560)	A tank farm is recorded in the western part of area 3 extending off site (BP transit site). Oblique aerial photography of 1933 included in (4) shows that the 9 tanks in the west were present then.	No significant changes are recorded within the surrounding area
1951 (1:10,560) and 1951-56 (2,500)	No significant changes are recorded within the site boundary	A Rifle Range is recorded along the south of King's Dock Works.
1960-66 (1:2,500), 1960-62 (1:2,500) and 1964 (1:10,000)	No significant changes are recorded within the site boundary	There is a works marked east of the King's docks works and King's docks works are labelled 'works' now.
1976 (1:10,000 Russian Military Map)	No significant changes are recorded within the site boundary	There Rifle Range is no longer recorded. A line along the pipeline from Baglan Works is marked.
1962-88 (1:2,500), 1968-71 (1:2,500) and 1969-70 (1:2,500)	No significant changes are recorded within the site boundary	The King's Dock Works are now labelled Ford works (Motor Components). There is a Filling Station marked approximately 100m north of area 3 along the A483.
1980 (1:10,000)	No significant changes are recorded within the site boundary	The tank north of area 3 on the western side of the River Neath is no longer recorded. Works including tanks and cooling towers are marked south-east of the site (Baglan works)
1980-89 (1:10,000)	No significant changes are recorded within the site boundary	No significant changes are recorded within the surrounding area
1989 (1:10,000)	No significant changes are recorded within the site boundary	No significant changes are recorded within the surrounding area
2012 (1:10,000)	No significant changes are recorded within the site boundary	The power station adjacent to the west of the site is now marked.

6 Review of previous site reports

6.1 Reports

Previous site reports, technical notes and remediation reports have been reviewed in order to inform the assessment of the site and, where possible, to consider and address comments that have been raised by the regulatory authorities, namely Neath and Port Talbot County Borough Council (NPTCBC) and Natural Resources Wales (NRW). The following reports were reviewed as part of this process:

- Transit Site Remediation Performance Specification, Atkins, June 2010.
- Ground Investigation Works Transit Site Swansea, REC, August 2010.
- Proposed Solar Photovoltaic Park, Baglan Energy Park – Contamination Assessment, Atkins, January 2011
- Baglan Bay PV Farm Geo-environmental Assessment Report, Atkins, May 2011.
- Remediation Validation Report for Former BP Transit Site, Hydrock, May 2011.
- Technical Note : Baglan Bay Land Contamination, Atkins, October 2014.
- Technical Note : Geotechnical and Geoenvironmental Desk Study – Onshore, Atkins, November 2014.
- Swansea Bay Tidal Lagoon Access Road Ground Investigation Report, Atkins, October 2015.
- Explosive Ordnance Threat Assessment in respect of Swansea Docks to Baglan Burrows, Bactec, September 2014.

We understand that TLSB have requested that St. Modwen Developments Ltd (St. Modwen) provide any information that may be available regarding ground conditions and remediation works that St. Modwen have undertaken upon land within their control at the former BP Transit Site and the former BP Chemical Works at Baglan Bay. To date St. Modwen have not provided any pertinent information. We have therefore relied upon publically available information for these areas which has been obtained via the NPTCBC planning portal.

6.2 Transit Site

6.2.1 Remediation Performance Specification, Atkins, June 2010

This report details the remediation objectives (to be achieved by a specialist remediation contractor) for the former BP Transit site in relation to the proposed redevelopment of the area as a university campus. Much of the report is concerned with general arrangements such as health and safety issues. Pertinent



information is provided within the report regarding the contamination impacts identified on the Transit site and the remediation requirements.

The report states that contamination on the Transit Site is variable but is generally more elevated in the west. Aromatic compounds, especially BTEX and mid-range petroleum hydrocarbons are noted to be of particular concern and are frequently evidenced on site by the presence of grey staining and hydrocarbon odours within the soils. The report notes that there was a significant benzene spill from Tank 856 on the site; however, the location of this tank is not provided within the report. It is stated that a previous phase of remediation, using an air sparging methodology, was undertaken in the vicinity of Tank 856 but no further details are provided.

The report states that remediation of contamination must enable the site to be 'suitable for use' as a university campus in accordance with applicable UK guidance and legislation. The requirements of a Section 106 agreement to achieve this degree of remediation are summarised as Milestones within the report as follows:

1. Removal of any shallow soil source contamination to enable MNA (Monitored Natural Attenuation) for benzene to occur consistent with the lines of evidence approach described in EA R&D Publication 95 (2000).
2. Demonstrate that MNA is occurring for benzene and groundwater quality is suitable for use.
3. Demonstrate that for a further 12 months since the achievement of Milestone 2 MNA is continuing to occur and groundwater quality is suitable for use.

Later sections of the report expand upon the above remediation objectives and required the following to be achieved:

- Prevent and/or mitigate against any current or long term unacceptable contaminant migration through the seaward boundary or any other boundary of the site. Unacceptable contaminant migration is defined as any migration resulting in unacceptable impacts on human health, pollution of controlled waters, pollution of surrounding land, nuisance or amenity degradation to the beach including visual or olfactory impacts.
- Remediation or mitigation of any cross boundary contamination impacts occurring onto or originating from the site which may plausibly cause harm to human health, pollution to controlled waters or nuisance.
- Remediation of soil and groundwater contamination on the site to 'suitable for use' levels to be agreed with the Regulatory Authorities.

- Removal or treatment of grossly contaminated soils which are defined as soils where substantial oily residues are apparent on the soil particles.
- Remove any separate phase liquids that may be present and measurable within monitoring points at the site.

In view of the above it is understood that the key contaminants of concern at the Transit Site comprised volatile or aromatic petroleum hydrocarbons including BTEX compounds. Remediation of the site should have resulted in the remediation of key contaminant sources (soil, groundwater and free phase) to a level that is suitable with regard to managing risks to human health, controlled waters and nuisance / amenity value for the site. Residual risks are to be further managed by a process of MNA which may still be ongoing.

6.2.2 Ground Investigation Works Transit Site Swansea, REC, August 2010.

This factual report details the results from a ground investigation of the Transit Site. A total of 16no. gas and groundwater monitoring wells were installed by sonic drilling methods and 42no. Cone Penetration Testing (CPT) boreholes were completed using an integral Laser Induced Florescence (LIF) and Membrane Interface Probes (MIP) to detect hydrocarbon contamination. Information from this report has been incorporated into the geological assessment in Section 4.

The results in the report demonstrate the presence of significant hydrocarbon contamination; however, these have since been subject to remediation as detailed below in the Hydrock Validation report.

6.2.3 Remediation Validation Report for Former BP Transit Site, Hydrock, May 2011

This report outlines the remediation work undertaken by Hydrock at the Transit Site and provides verification data to demonstrate that the remedial objectives have been met.

Prior to undertaking remediation works Hydrock undertook two phases of further site investigation. The first investigation targeted areas of contaminants previously identified within investigations undertaken by URS Corporation Ltd and Atkins. The second investigation comprised a 50m grid over the whole site to highlight any areas of gross contamination which may not have already been identified and the results for this are provided within the Hydrock report.

Based upon the results of these investigations Hydrock stated that in general the contamination is most noticeable in the soils at depths between 2 to 5mbgl and decreases markedly with depth. The highest contaminant concentrations are reported to occur in at the groundwater interface or in the smear zone. The report indicates that contamination is often within the sandier soil deposits and concludes that contamination may be prevented from migrating due to less permeable clay or silt layers in some instances.

The report provides details of soil and groundwater remedial targets which were derived by Atkins and Hydrock and agreed with the regulatory authorities. This addressed possible risks from heavy metals, PAHs, various VOCs, BTEX and petroleum hydrocarbons, PCBs and asbestos. The remedial targets for the soils vary according to depth and are reproduced in Table 6-1 below.

Table 6-1 Soil Remedial Targets (mg/kg unless otherwise stated)

Contaminant	Shallow Soils (0.0 to 1.0mbgl)	Deeper Soils (>1.0mbgl)
Benzene	0.451	0.555
Toluene	33,700	>Saturation limit
Ethylbenzene	286	363
Xylene	98.9	125
Aliphatics C5-C6	160	192
Aliphatics C6-C8	1,740,000	>Saturation limit
Aliphatics C8-C10	68.2	82.4
Aliphatics C10-C12	54,800	>Saturation limit
Aliphatics C12-C16	60,200	>Saturation limit
Aromatics C5-C7	0.451	0.555
Aromatics C7-C8	33,700	>Saturation limit
Aromatics C8-C10	80.1	96.9
Aromatics C10-C12	9,810	>Saturation limit
Aromatics C12-C16	23,6000	>Saturation limit
Aromatics C16-C21	10,000	N/A
Aromatics C21-C35	10,000	N/A
Arsenic	184	N/A
Cadmium	82.2	N/A
Total Chromium	89.9	N/A
Copper	40,400	N/A
Lead	3,280	N/A
Mercury (inorganic)	1,850	N/A
Nickel	473	N/A
Selenium	8,130	N/A
Zinc	568,000	N/A

Remedial targets were not derived for inorganic or low volatility compounds in the deeper soils due to the absence of plausible exposure pathways at these depths.

The remedial targets for groundwater vary according to location across the site to reflect the nature of the proposed campus redevelopment, hardstanding cover etc. Given that groundwater depths are generally in excess of 4m bgl whilst the proposed HV cable excavation is likely to be no deeper than 1.8m bgl, it is

unlikely that any residual groundwater contamination on the Transit Site will be a significant risk to the TLSB scheme.

The report provides details of the benzene leak from Tank 856, stating that this was investigated by URS and found to have resulted in a benzene groundwater plume extending towards Swansea Bay and notably impacting the beach in 1988. Details are provided of the location of this plume and remedial works completed by URS in 2004. In view of the tank and plume location, (approximately 100m south of the proposed cable route) it is considered that this issue is not likely to impact upon the proposed TLSB project.

In summary the remediation works undertaken by Hydrock are stated to comprise:

- The removal and treatment of grossly contaminated soils, principally in the west of the site.
- Removal of all free phase liquids along the southern site boundary in the west of the site (free phase liquids were not identified in other areas of the site).
- In-situ chemical oxidation (using sodium persulphate) of benzene hotspots in the groundwater around Tank 856 and other localised groundwater impacts in the central portion of the site.
- Ex-situ remediation of soils, predominantly from the smear zone immediately above and below the groundwater interface in the west and central parts of the site, using biopiles dosed with nitrogen fertilizer.
- Re-use of treated soils once they were demonstrated to have achieved the agreed remedial targets.
- On-going monitoring to demonstrate that MNA is a suitable technique for long term (up to 30 years) management of the site.

The report states that all site won soils reused on site met the specified remediation criteria and achieved a CBR value of 3% or higher after they were placed down.

It is noted that the works encountered a number of in ground obstructions, the majority of which were removed and concrete crushed for reuse. However, not all of the obstructions encountered during the groundworks were removed and a number of concrete foundations and hardstanding slabs were left in place in the west of the site and adjacent to Fabian Way. These obstructions are shown on a plan which we have extracted and reproduced in Appendix J.

6.2.4 Technical Note : Geotechnical and Geoenvironmental Desk Study – Onshore, Atkins November 2014

This technical note provides a brief overview of anticipated ground conditions for the TLSB site based upon a review of publically available aerial photographs, ordnance survey maps, online historical maps, BGS information and Environment Agency information, predominantly sourced from online searches.



The report identifies the site geology to consist of predominantly of Blown Sand Deposits with Alluvium and Beach and Tidal Flat Deposits proximal to the River Neath. These superficial deposits are in turn underlain by Lower and Middle Coal Measures. Extensive Made Ground and landscaped ground is indicated to be present over the docklands areas.

A wide range of historic activities are noted for the site and surrounding area including (but not limited to); various metal works (arsenic, copper and zinc), railway sidings, wagon works, chemical works, power station, timber yard, coal depot, rifle range, collieries, warehouses, tin plate works, unspecified works, oil storage tanks / depot and sewage works. The historical records used to obtain this information have not been included with the report.

The report notes that there is a predominantly high risk from Unexploded Ordnance (UXO) and makes reference to a UXO Threat Assessment Report prepared by Bactec.

The report notes the presence of landfill sites in the wider area, however, limited data is provided regarding the nature of these sites or their proximity to the TLSB site boundary.

A land contamination assessment and preliminary conceptual site model (CSM) are provided in the report. However, it is considered that the report provides insufficient detail, and a general lack of supporting data, to satisfy regulatory requirements for a desk top study or CSM. Accordingly, the Technical Note is superseded by this report and where applicable we have incorporated information from this Technical Note into pertinent sections.

6.2.5 Swansea Bay Tidal Lagoon Access Road Ground Investigation Report, Atkins, September 2015

This report incorporated a summary of the Technical Note prepared in November 2014 by Atkins and goes on to include and discuss the results of a ground investigation undertaken along the route of the proposed new highways access to the Western Landfall Building for the TLSB scheme. The ground investigation works comprised:

- 13no. dynamic sample boreholes by windowless sampler.
- 116no. trial pits.
- 3no. road cores.
- Recovery of representative bulk and disturbed samples for geotechnical and geo-environmental analysis.
- 10no. groundwater and gas monitoring installations with return monitoring visits undertaken on six occasions for groundwater levels and three occasions for gas concentrations.

- 11no. soakaway tests.
- 5no. plate load tests.

The ground investigation works encountered Made Ground deposits ranging from 0.3 to in excess of 4m thickness across the site. The Made Ground is predominantly granular in nature typically consisting of silt, sand and gravel with some cobbles and boulders present. The exploratory hole logs note the presence of slag materials. Pockets of very soft to stiff clay are also present within the Made Ground. Underlying the Made Ground the works encountered Marine Beach deposits comprising a light brown and orange brown slightly gravelly fine to medium sand. Groundwater levels were monitored at depths of around 3.5 to 3.65m bgl; however, this is based upon relatively few observations as many of the monitoring wells were dry, possibly due to the shallow response zones installed (ranging between 1.9 to 4.2m bgl to base of well). Information relating to ground conditions and geology has been incorporated Section 4 of this report.

Classification tests of the Made Ground indicates that the majority of the samples (approximately 70%) are roughly equal proportions of sand and gravel with small proportions of fines (around 5-6%) and cobbles present (around 0% to 3%). Approximately 30% of the Made Ground samples comprise almost exclusively light brown or brown sand with minimal amounts (3-5%) of fines and gravel present. This may represent dredged material used as fill within the docks area.

Soakaway tests were conducted on the Made Ground soils and recorded infiltration rates ranging between $1.98 \times 10^{-5} \text{m/s}$ to $3.69 \times 10^{-4} \text{m/s}$. The plate load tests were also conducted on Made Ground soils and indicated a CBR value in the range of 20% to 24%.

Ground gas monitoring did not include flow rates and only included relative pressure differential on one occasion. Maximum gas concentrations identified included carbon dioxide at 13.2%, methane at 89.9%, carbon monoxide at 403ppm and VOCs at 220ppm. There is insufficient information available to make a robust assessment of potential ground gas risks based upon these results.

The report contains results for a wide range of geotechnical and geo-environmental testing; however, there is limited discussion of the rationale for the test suites adopted. A total of 187no. samples were analysed for metals (As, Sb, Be, B, Cd, total Cr, Cr_{VI} , Cu, Pb, Hg, Mo, Ni, Se, V and Zn), Total Organic Carbon and asbestos screen. Of these samples 55no. were also tested for total cyanide, speciated TPH-CWG, BTEX and speciated PAHs. It should be noted that a later section of the report states that only 100 samples were analysed for asbestos.

To assess risks to controlled waters, analysis was undertaken on a total of 16no. soil leachate samples and 6no. water samples for metals (As, Sb, Be, B, Cd, total Cr, Cr_{VI} , Cu, Pb, Hg, Mo, Ni, Se, V and Zn), total cyanide, speciated TPH-CWG, BTEX and speciated PAHs. It is generally considered unsuitable to undertake leachate analysis for organic contaminants as the samples preparation methodology (which generally



involves a 24 hour period of agitation of the sub-sample) may lead to misleading results. It is noted that groundwater samples were obtained from the boreholes before allowing sufficient time for equilibrium in groundwater conditions to be achieved after completion of the drilling works.

The report includes a comparison of soil, water and leachate results to Generic Assessment Criteria (GAC) in order to identify potential risks. Risks to human health have been assessed for an open space end use for the access road; therefore, the report does not address risks associated with occupied buildings such as the proposed Western Landfall Building. Risks to controlled waters have been assessed using Environmental Quality Standards (EQS) values applicable for the waters of Swansea Bay or in the absence of such EQS values then Drinking Water Standards were used.

Based upon the generic screening process the report identified elevated concentrations of metals (principally arsenic and lead, but also sporadic occurrences of cadmium and mercury) predominantly within Made Ground soils containing notable amounts of slag material.

Asbestos, comprising 0.001 to 0.004% by volume and a mix of amosite and chrysotile containing materials, was also identified in nine shallow (1m bgl or less) soil samples. No elevated concentrations of PAHs or TPH were reported for the soil samples.

Leachate analysis is reported to have identified elevated concentrations of metals (hexavalent chromium, mercury, antimony, arsenic, cadmium, chromium, copper, lead, selenium and zinc), benzene, xylene and a wide range of various PAH species and TPH fractions. These are noted to be generally associated with Made Ground samples containing slag material. Groundwater analysis indicates broadly the same range and frequency of contaminants as the leachate analysis.

Analysis of 8no. Made Ground samples was undertaken to assess the aggressive chemical environment with regard to buried concrete. This indicated a design sulphate class (DS) of DS-2 and aggressive chemical environment for concrete classification (ACEC) class of AC-2 to apply for the site.

The report concluded that there are moderate to low risks to human health present, generally due to widespread elevated concentrations of metals and shallow asbestos impacts. They recommend that these risks should be mitigated either through the construction of hard cover surfacing or the placement of a break layer and 800mm of 'clean' imported soil in areas of soft ground / landscaping.

Risks to controlled waters were largely discounted in the report due to the proposed extensive hard surfacing proposed for the scheme which will in turn reduce infiltration and leaching of contaminants. The report also acknowledged that poor groundwater quality in the area is likely to reflect the extensive historical activities of the site and surrounding land uses, as such they conclude that mitigating measures to improve groundwater quality are not likely to be effective. This argument fails to consider the potential for sea water ingress to mobilise contaminants into the marine environment and also fails to acknowledge the

fact that the generic screening process considered the sensitive receptor to be the surface waters rather than groundwater.

The report recommended that the majority (74%) of soil arisings would meet the definition of hazardous waste due to human toxicity risks from lead and eco-toxicity risks from zinc. It was considered that soil arisings would be generally unsuitable for re-use on site and should be removed for off-site disposal. WYG do not necessarily concur with this assessment and we consider that further information, including appropriate WAC analysis, should be undertaken prior to determining the suitability of arisings for re-use. We also consider that further consideration of possible pollutant pathways is required before informed decisions can be made regarding potential re-use of arisings.

6.3 Baglan Bay

6.3.1 Proposed Solar Photovoltaic Park, Baglan Energy Park – Contamination Assessment, Atkins, January 2011

This report provides a desk based review of contamination for a proposed solar photovoltaic farm to be located in the approximate centre of the former BP Chemical plant at Baglan Bay. The contamination assessment is superseded by the more detailed assessment undertaken in the subsequent report prepared by Atkins in May 2011 as detailed below, as such we have not reviewed the contamination assessment in the January 2011 report. However, the report does provide a useful overview to elements of the former BP Chemical plant and its history.

Before the chemical works were constructed the area consisted of a sand dune complex. These dunes were levelled and stabilised using imported industrial fill to enable the construction of the chemical works sometime around the 1960s. From this point onwards the site manufactured a range of chemicals including aromatic and chlorinated hydrocarbons until eventual closure of the site in the 1990s and 2000s. The site was acquired by St. Modwen Developments circa 2009.

Many of the plant processes were fed, by a pipeline running under the nearby River Neath, from the BP Llandarcy Oil Refinery some 3km or so to the northwest. A range of ancillary processes, including power generation and effluent treatment were in operation to support the site.

Data provided by BP to St. Modwen is reported to show that there is a range of contamination present across the wider site. Broadly speaking this is stated to include aromatic compounds (benzene, Ethylbenzene and styrene) in the northeast of the site and chlorinated hydrocarbons (vinyl chloride, 1,2 dichloroethane and subsidiary products) in the southwest and west of the site. These are apparently attributed to numerous small, but possibly frequent, leaks and spills that may have occurred.

No specific information is provided for the former power station area upon the route of the TLSB HV cable.

6.3.2 PV Farm Geo-environmental Assessment Report, Atkins, May 2011

This report provides an assessment of ground contamination conditions for a proposed photovoltaic (PV) farm to be located near the centre of the former BP Chemical plant at Baglan Bay. The area covered by this report is approximately 500m south-southeast of the proposed TLSB HV cable route, as such much of the report contents are not necessarily applicable to the ground conditions along the cable route.

The report provides evidence of the geology in the former BP Chemical Plant area. It is understood that slag deposits from other nearby industrial processes in the Port Talbot area were used to stabilise the ground following levelling of the sand dunes that were originally present. Beneath these Made Ground deposits the site is understood to comprise sand deposits with interbedded thin layers of clay and silt horizons. The sand becomes increasingly silty with depth. The uppermost portions of the sand are loose, brown fine to medium sand attributed to the Blown Sand formation whilst the deeper sands, silts and clays are attributed to the Beach or Marine deposits. Glacial Till is reported to be present beneath the Beach deposits as a firm to stiff grey clayey gravely silt, the base of which has not been proven locally.

A preliminary conceptual site model is included which states that the PV Farm area is contaminated by metals, VOCs, BTEX, SVOCs, TPH and PAHs due to the historical use of the area as a chemical works. The reports states that the primary contaminants of concern are considered to be 1,2 dichloroethane with regard to risks to human health for a commercial / industrial land use and 1,2 dichloroethane, vinyl chloride, naphthalene, GRO C6-C8 and TPH aliphatic C6 – C8 with regard to risks to controlled waters. These contaminants will all readily generate vapours and there may be a risk via inhalation of accumulated vapours in confined spaces such as buildings, service ducts or excavations.

Groundwater contour plots for the PV Farm area show a groundwater gradient to the west, as such it is unlikely that migratory groundwater impacts would be expected to affect the TLSB cable route.

6.3.3 Technical Note : Baglan Bay Land Contamination, Atkins, October 2014

This technical note provides a brief summary of land contamination hazards at the former BP Chemical site in Baglan Energy Park. This is pertinent to the eastern most end of the proposed HV cable route which is due to connect into the energy park. The report states that the main contamination risk to the TLSB cable route in this area is from the Arbernedd Power Station which dates back to the 1970's along with the adjacent former BP chlorine production plant.

The report states that the power station is known to be highly contaminated following the closure of the BP Chemicals plant; however it does not provide any further information concerning the type, nature or location of contaminants that are present. The report goes on to consider soil and groundwater contamination which may be present on the wider BP Chemicals site; however this is not likely to be directly pertinent to the proposed cable route as the cable does not extend into these areas.

6.4 Whole Site

6.4.1 Explosive Ordnance Threat Assessment in respect of Swansea Docks to Baglan Burrows, Bactec, September 2014.

This report provides an assessment of the risk from unexploded ordnance (UXO) across the site. The primary potential sources of UXO are considered to include army training activities across Baglan / Crymlyn Burrows and air dropped bombs from the Second World War. The presence of pillboxes on the dock seawalls may also be a source of small arms UXO. The site is generally assigned a high risk rating for UXO, though some small areas of the dockyards are assigned a lower risk based upon post war redevelopment that has occurred.

WYG understands that many sites in the Baglan Bay area were used to dispose of surplus, empty and inert munition casings after the end of the Second World War. As a result it is not unknown for potential UXO items to be found which later turn out to be inert or empty casings. We also consider that the Bactec report is heavily reliant upon generic information for the wider Swansea and Port Talbot area. There appears to be little information or records pertaining directly to the TLSB site. The report does not consider the different types of UXO that may be present in each area of site or how this may require alternative methods of mitigation.

6.5 Summary

Based on the available reports it is considered that there are a number of potential sources of contamination and ground related constraints which may affect the development and these are summarised below:

- Heavy metals and asbestos in the Made Ground soils in the dockyard area.
- High concentrations of carbon dioxide, carbon monoxide and methane within the Made Ground in the dockyard area.
- Residual petroleum hydrocarbons and benzene in the former BP Transit site.
- Relic in-ground concrete structures and pipework, which may also contain further contamination, in the former BP Transit site.
- A wide range of potential contaminants may be present in the former BP Chemicals site at Baglan including metals, VOCs, BTEX, SVOCs, TPH, PAHs and chlorinated hydrocarbons.
- Relic pipeline running from the former BP Chemicals site at Baglan to the former Llandarcy refinery.
- Potential Unexploded Ordnance across the whole site.

7 Environmental Database Search

A search of an environmental database was undertaken and is summarised in the following table. The full report is provided within the Envirocheck report, included as Appendix G of this report. The following summary is generally limited to locations within 250m of the site boundaries unless it is considered that installations or activities beyond that range could potentially have an impact on the site or be affected by the redevelopment of the site.

Table 7-1 Summary of Environmental Database Search Results

	Comments
Discharge Consents	There are 13 active discharge consents within 250m of the site. • Five are related to public sewage, storm sewage overflow • Two are associated with a sewage works discharging final/treated effluent and one to a pumping station discharging sewage • Three consents are given to Associated British Ports for unspecified discharges • One Non Water Company (Private) Sewage • One consent is for Trade effluent from BP Chemicals Ltd
Integrated Pollution Prevention and Controls Local Authority Pollution Prevention and Controls	There is one active Integrated Pollution Control within 250m of the site related to coating processes and printing within miscellaneous industries and one Local Authority Pollution Prevention Control for a petrol filling station.
Pollution Incidents to Controlled Waters	There are 16 Pollution Incidents to Controlled Waters recorded within 250m of the site, four of which occurred on site. One category 1 incident (major) occurred in 1996 approximately 250m north of the site (western extent of cable route, area 3) involving crude sewage. Three category 2 (significant) incidents occurred: • Farm effluent/slurry leaked at the tank farm on site in the west of Queen's Dock area • Unknown pollutant was emitted approximately 100m north of the proposed Western Landfall Building • Crude sewage leaked approximately 150m south of the eastern area of the site on the western side of the River Neath near the pipeline The remaining 11 incidents were classified category 3 (minor). All occurred in the 90s and involved a range of pollutants including foam/soap suds, mining water, sewage, light oil, algae, firewater/foam, cure sewage and rubbish.
Water Abstractions	There is one Water abstraction located within 250m of the site associated with aquaculture and situated at the north-western corner of Queen's Dock.

	Comments
Historical Landfill Sites and Registered Landfill Sites	There is one record of a Local Authority Recorded landfill site within 250m by Baglan Bay Works; however no details of type of waste or operation are supplied. It is assumed that this record refers to the industrial waste landfill within the Baglan Chemical Works (see below). There are two landfills recorded approximately 400 and 450m north of the central portion of the site, Tir John landfill and Arsenic Tip. The Tir John landfill has been recorded since 1953 and accepted industrial and commercial waste. Records show that it was categorised as landfill site taking special waste in 1985. The latest Licence issued in 2000 shows that it accepts between 75,000 and 250,000 tonnes of waste per year including the following types of waste: • Degradable commercial waste • Degradable household waste • Degradable industrial waste • Inert materials • Metal waste, scrap metals There are no records giving details of the operation or wastes deposited at the Arsenic tip.
Licensed Waste Management Facilities Registered Waste Treatment Site	There are four active Licensed Waste Management Facilities recorded within 250m of the site. • A metal recycling site (mixed) adjacent to the proposed Western Landfall Building area of the site • A physico-chemical treatment facility approximately 120m north of the BP transit site • A material recycling treatment facility approximately 250m north of the BP transit site • An industrial waste landfill within the Baglan Chemical Works, approximately 200m southwest of the terminus of the cable route. The licence was issued in 1977 and its status is now 'transferred'. It is understood that St. Modwen's now own this site.
Sensitive Land Uses	Crymlyn Burrows is a site of special scientific interest (SSSI) covering the area between the River Neath to the east and the BP transit site to the west.



8 Regulatory Consultation

8.1 Overview

Previous consultations with the regulatory authorities (Swansea Council, Neath and Port Talbot Council and Natural Resources Wales) have been undertaken by TLSB. A number of comments or concerns have been received in letters, e-mails and meeting notes as listed below.

- E-mail from Emma Harding NPTBC 12th August 2105
- Meeting note 28th September 2015
- Letter from NRW dated 1st September 2015 in response to application for construction of underground cable.
- E-mail from Leah Clark, NPTBC in response to Technical Note 26th October 2015
- NRW letter response to Planning Application for Western Landfall Building and Access Roads 4th November 2015

We have endeavoured to address these comments as far as we are able as detailed in the matrix in Appendix H. Issues pertaining to desk top research, conceptual site models and risk assessments have been addressed within this report, whilst issues pertaining to ground investigation works are noted and will need to be addressed during subsequent phases of site investigation.

9 Preliminary ground contamination assessment

9.1 Overview

In general, ground contamination can occur through several causes, particularly from historical operations and activities. Contamination can result from either on site sources or from on-site migration from off-site sources, leading to long term liabilities under recent legislation for any site owner.

The Environment Act 1995 (Section 57) makes provisions for a risk based framework for the identification, assessment, management and redevelopment of contaminated land within the UK. The provisions of the Act came into effect in England and Wales in July 2001 and are aimed at ensuring that actions taken with respect to contaminated land are directed by a technically well founded assessment of risk.

The process of risk assessment is an evaluation of the probability of harm, and comprises the identification of sources of contamination, receptors that may be affected by the contamination and pathways by which the receptors may be harmed.

9.2 Conceptual site model

A preliminary conceptual model for the site has been developed based on the information presented in the preceding sections. Considering the large area of the site and multiple sources of contamination, the conceptual site model (CSM) has been produced along three sections as shown on Figure A. Graphical representations of the models are presented as Figure B-D.

The CSMs form the basis for the qualitative assessment of ground contamination risks associated with the site and presented in section 9.3. The key sources, pathways and receptors are outlined below within the context of the proposed development of the site.

9.2.1 Conceptual site model 1

The first CSM covers the western area of the site along the Queen's Dock including the proposed Western Landfall Building, access road and part of the construction compound. See Figure A for the location and extent of the section and Figure B for a drawing of CSM 1.

9.2.1.1 Sources

The sources of potential contamination stem from the historical industrial use of the site. The individual sources are outlined below:

- Potential contamination associated with storage tanks (leak or spillage of petroleum hydrocarbons, GRO/DRO and BTEX);
- Potential contamination with asbestos at surface associated with derelict factory building (former fish meal factory);



- Potential contamination associated with Made Ground containing slag and clinker likely to be sourced from surrounding industrial processes (heavy metals, PAHs, sulphate and cyanide);
- Potential contamination associated with timber yard (metals and metalloids, inorganic compounds, acids/alkalis, organic solvents, preservatives);
- Evidence of hydrocarbon contamination (oily sheen, strong hydrocarbon odour, PID readings between 205 and 730 ppm) found in TP39 during site investigation in August 2015 (1), (2);
- Evidence of hydrocarbon contamination (strong hydrocarbon odour, PID reading 212 ppm) found in TP35 during site investigation in August 2015 (1), (2);
- Evidence of hydrocarbon contamination (oily sheen, strong hydrocarbon odour, PID readings between 45 and 300 ppm) found in TP22 during site investigation in August 2015 (1), (2), and
- Ground gas from the Made Ground soils (methane, carbon dioxide and carbon monoxide).

9.2.1.2 Pathways

The primary pathways by which sensitive receptors may come into contact with ground contamination are considered to be the following:

- Direct contact of potentially contaminated soil with new built structures (chemical attack of potentially contaminated soil on new built structures)
- Direct dermal contact or ingestion of potentially contaminated soil or inhalation of dust originating from potentially contaminated soil
- Migration and accumulation of gases or vapours through permeable sub-surface materials and/or preferential pathways
- Leaching and horizontal or vertical migration through the unsaturated ground, either through permeable sub-surface materials and/or preferential pathways

9.2.1.3 Receptors

The following are considered to be sensitive receptors:

- Current site users
- Construction workers
- Future site users
- Proposed new structures (Western Landfall Building etc)
- Cable duct

- Controlled waters (Tawe Estuary, Swansea Bay)

9.2.2 Conceptual site model 2

The second CSM covers the area of the proposed construction compound and temporary haul road to the eastern landfall as shown on Figure A. A drawing of CSM 2 is presented on Figure C.

9.2.2.1 Sources

The potential sources of contamination considered in the risk assessment are listed below:

- Potential contamination associated with historical land use off and on site including spelter and paint works, aluminium and cable works, railway wagon repair works and gas works (metals, inorganic compounds, acids/alkalis, organic compounds e.g. aliphatic/aromatic hydrocarbons, halogenated solvents, asbestos, cyanide);
- Potential contamination associated with Made Ground containing slag and clinker from surrounding industrial processes (heavy metals, PAHs, sulphate and cyanide);
- Potential contamination associated with oil depot (leak or spillage of petroleum hydrocarbons, GRO/DRO and BTEX);
- Evidence of hydrocarbon contamination associated with fine sand lenses embedded in Marine Beach Deposits (petroleum hydrocarbons, GRO/DRO and BTEX);
- Potential contamination associated with redundant pipework in relation to BP Transit site (leak of petroleum hydrocarbons, GRO/DRO and BTEX), and
- Ground gas from the Made Ground soils (methane, carbon dioxide and carbon monoxide).

9.2.2.2 Pathways

The primary pathways by which sensitive receptors may come into contact with ground contamination are considered to be the following:

- Direct contact of potentially contaminated soil with new built structures (chemical attack of potentially contaminated soil on new built structures);
- Direct dermal contact or ingestion of potentially contaminated soil or inhalation of dust originating from potentially contaminated soil;
- Migration and accumulation of gases or vapours through permeable sub-surface materials and/or preferential pathways;
- Leaching and horizontal or vertical migration through the unsaturated ground, either through permeable sub-surface materials and/or preferential pathways;



9.2.2.3 Receptors

The following are considered to be sensitive receptors:

- Current site users;
- Construction workers;
- Future site users;
- Proposed temporary structures of construction compound including offices and welfare units and haul road;
- Cable duct;
- Controlled waters (Swansea Bay).

9.2.3 Conceptual site model 3

9.2.3.1 Sources

The potential sources of contamination considered in the risk assessment are listed below:

- Potential contamination associated with redundant pipework in relation to oil depot (leak or fuel or other hydrocarbon);
- Potential contamination associated with Made Ground containing slag and clinker (heavy metals, PAHs, sulphate and cyanide)
- Potential contamination associated with historical land use off and on site including tin plate work and motor component manufacture (metals, metalloids and their compounds, inorganic compounds);
- Evidence of hydrocarbon contamination associated with fine sand lenses embedded in Marine Beach Deposits (petroleum hydrocarbons, GRO/DRO and BTEX;
- Potential contamination associated with army activities in Crymlyn Burrows (UXO, heavy metals, hydrocarbons);
- Potential contamination associated with pipeline (leak of hydrocarbons);
- Evidence of contamination associated with Baglan Chemical works (metals, VOCs, SVOCs, PCBs, PAHs and TPH).

9.2.3.2 Pathways

The primary pathways by which sensitive receptors may come into contact with ground contamination are considered to be the following:

- Direct contact of potentially contaminated soil and new built structures (chemical attack of potentially contaminated soil on new built structures);
- Direct dermal contact or ingestion of potentially contaminated soil or inhalation of dust originating from potentially contaminated soil;
- Leaching and horizontal or vertical migration through the unsaturated ground, either through permeable sub-surface materials and/or preferential pathways.

The risk of these pathways occurring may be increased during construction works if existing surface hardstanding is broken out or the ground is disturbed.

9.2.3.3 Receptors

The following are considered to be sensitive receptors:

- Current site users;
- Construction workers;
- Future site users;
- Cable duct;
- Controlled waters (Swansea Bay, River Neath Estuary).

9.3 Ground contamination risk assessment

The pollution linkages based on the sources, pathways and receptors identified in the previous section are outlined in the following table with a qualitative risk assessment.

CIRIA C552 has been used to define the risk rating presented in the Qualitative Risk Assessment matrix, the methodology for which is presented in Appendix I.



This matrix is based on CIRIA C552 risk evaluation methodology, definitions for risk ratings is presented in Appendix I

Source	Pathway	Receptor	Consequence of risk being realised	Probability of risk being realised	Risk Classification	Potential risk management requirements
Potential contamination associated with oil storage tanks (tanks near former fish meal factory)	Direct dermal contact or ingestion of potentially contaminated soil or inhalation of dust originating from potentially contaminated soil	Current site users	Medium	Unlikely	Low	Site is largely covered by hardstanding so exposure to contamination is unlikely to occur.
		Construction workers	Medium	Likely	Moderate	A site investigation is recommended to confirm the presence/absence of contamination. Residual risks can be managed through appropriate personal protection equipment (PPE) and good working practices. Appropriate procedures should be defined in the construction management plan in case of discovering previously unidentified contamination.
		Future site users (Western Landfall Building)	Medium	Low likelihood	Moderate/Low	A site investigation is recommended to confirm the presence/absence of contamination. If contamination is present unless it is otherwise remediated, any soft landscaping area should include a minimum of 600mm thick layer of clean imported topsoil to break the pollution linkage.

This matrix is based on CIRIA C552 risk evaluation methodology, definitions for risk ratings is presented in Appendix I

Source	Pathway	Receptor	Consequence of risk being realised	Probability of risk being realised	Risk Classification	Potential risk management requirements
Potential contamination associated to storage tanks (tanks near former fish meal factory)	Migration and accumulation of gases or vapours through permeable sub-surface materials and/or preferential pathways	Future site users (Western Landfall Building)	Medium	Likely	Moderate	A site investigation is recommended to confirm the presence/absence of contamination including a gas monitoring programme to assess the presence/absence of VOCs and other ground gases in the ground. If VOCs or other ground gases are present, gas protection measures should be included in the design of the Western Landfall Building.
	Direct contact of potentially contaminated soil and new built structures (chemical attack of potentially contaminated soil on new built structures)	Proposed structures (Western Landfall Building and cable duct)	Mild	Likely	Moderate/Low	A site investigation is recommended to confirm the presence/absence of contamination including soil testing to assess its aggressiveness.
	Leaching and horizontal or vertical migration through the unsaturated ground, either through permeable sub-surface materials and/or preferential pathways	Controlled waters (River Tawe Estuary)	Medium	Low likelihood <i>(assuming the dock walls are intact and prevent migration into the sea)</i>	Moderate/Low	A site investigation is recommended to confirm the presence/absence of contamination including a groundwater monitoring program to assess the groundwater regime and its connectivity with the sea (tidal variations)

This matrix is based on CIRIA C552 risk evaluation methodology, definitions for risk ratings is presented in Appendix I

Source	Pathway	Receptor	Consequence of risk being realised	Probability of risk being realised	Risk Classification	Potential risk management requirements
Potential contamination of asbestos at surface associated with derelict factory building (former fish meal factory)	Direct dermal contact or ingestion of potentially contaminated soil or inhalation of dust originating from potentially contaminated soil	Current site users	Severe	Likely	High	An asbestos survey is recommended to be undertaken by a specialist contractor to confirm the absence/presence and extent of asbestos contamination. If asbestos is present depending on its form (fibres only or asbestos containing materials) and distribution, different risk management measures may be required. An asbestos management plan should be prepared for the construction work. If asbestos is present only suitably trained construction workers should work in the contaminated area with suitable PPE and following good working practices.
		Construction workers	Severe	High likelihood	Very high	
		Future site users (Western Landfall Building)	Severe	Likely	High	
Potential contamination associated with Made Ground containing slag and clinker (Heavy metals)	Direct dermal contact or ingestion of potentially contaminated soil or inhalation of dust originating from potentially contaminated soil	Current site users	Medium	Likely <i>(based on areas of soft ground with no hardstanding)</i>	Moderate	A site investigation is recommended to confirm the presence/absence of contamination. Risks to construction workers can be managed through appropriate personal protection equipment (PPE) and good working practices.
		Construction workers	Medium	Likely	Moderate	

This matrix is based on CIRIA C552 risk evaluation methodology, definitions for risk ratings is presented in Appendix I

Source	Pathway	Receptor	Consequence of risk being realised	Probability of risk being realised	Risk Classification	Potential risk management requirements
Potential contamination associated with Made Ground containing slag and clinker and other fill materials (Heavy metals, ground gases including methane, carbon dioxide and carbon monoxide)	Direct dermal contact or ingestion of potentially contaminated soil or inhalation of dust originating from potentially contaminated soil	Future site users (Western Landfall Building)	Medium	Likely	Moderate	A site investigation is recommended to confirm the presence/absence of contamination. If contamination is present unless it is otherwise remediated, any soft landscaping area should include a minimum of 600mm thick layer of clean imported topsoil to break the pollution linkage.
	Migration and accumulation of gases or vapours through permeable sub-surface materials and/or preferential pathways	Proposed temporary structures (offices, welfare units)	Medium	Unlikely <i>(based on the fact that there is likely to be a space between the units and the ground enabling substantial ventilation)</i>	Low	A site investigation is recommended to confirm the presence/absence of contamination including a gas monitoring programme to assess the presence/absence of ground. If ground gases are present, gas protection measures should be included in the design of the Western Landfall Building.
		Future site users (Western Landfall Building)	Medium	Likely <i>(based on the fact that elevated CO, CH₄ and CO₂ levels have been measured in previous investigations (1))</i>	Moderate	

This matrix is based on CIRIA C552 risk evaluation methodology, definitions for risk ratings is presented in Appendix I

Source	Pathway	Receptor	Consequence of risk being realised	Probability of risk being realised	Risk Classification	Potential risk management requirements
Potential contamination associated with Made Ground containing slag and clinker (Heavy metals)	Direct contact of potentially contaminated soil and new built structures (chemical attack of potentially contaminated soil on new built structures)	Proposed structures (Western Landfall Building, cable duct)	Mild	Likely <i>(based on results of previous investigations (1))</i>	Moderate/Low	A site investigation is recommended to confirm the presence/absence of contamination including soil testing to assess its aggressiveness.
	Leaching and horizontal or vertical migration through the unsaturated ground, either through permeable sub-surface materials and/or preferential pathways	Controlled waters (Swansea Bay)	Medium	Low likelihood <i>(based on limited leaching since the majority of the site is covered with impermeable surfaces)</i>	Moderate/Low	A site investigation is recommended to confirm the presence/absence of contamination including groundwater sampling and monitoring to establish the groundwater regime and its connectivity to the sea (tidal influences).
Evidence of hydrocarbon contamination along Queen's Dock	Direct dermal contact or ingestion of potentially contaminated soil or inhalation of dust originating from potentially contaminated soil	Construction workers	Medium	High likelihood	High	Risks to construction workers can be managed through appropriate personal protection equipment (PPE) and good working practices. The risk should be included in the construction management plan. Excavated soil that is potentially contaminated will have to be disposed of appropriately.



This matrix is based on CIRIA C552 risk evaluation methodology, definitions for risk ratings is presented in Appendix I

Source	Pathway	Receptor	Consequence of risk being realised	Probability of risk being realised	Risk Classification	Potential risk management requirements
Evidence of hydrocarbon contamination along Queen's Dock	Direct contact of potentially contaminated soil and new built structures (chemical attack of potentially contaminated soil on new built structures)	Proposed structures (Western Landfall Building, cable duct)	Mild	Likely	Moderate/Low	Consideration should be given to the materials used for the cable duct and their susceptibility to chemical attack.
	Leaching and horizontal or vertical migration through the unsaturated ground, either through permeable sub-surface materials and/or preferential pathways	Controlled waters (Swansea Bay)	Medium	Low likelihood <i>(based on intact dock walls preventing interaction with sea)</i>	Moderate/Low	A site investigation is recommended to confirm the presence/absence of contamination pathways, hydraulic connectivity to the marine environment and tidal influence.

This matrix is based on CIRIA C552 risk evaluation methodology, definitions for risk ratings is presented in Appendix I

Source	Pathway	Receptor	Consequence of risk being realised	Probability of risk being realised	Risk Classification	Potential risk management requirements
Potential contamination associated with historical land use on and adjacent to site including spelter and paint works, aluminium and cable works, railway wagon repair works, gas works and chemical works (metals, inorganic compounds, acids/alkalis, organic compounds e.g. aliphatic/aromatic hydrocarbons, halogenated solvents, asbestos, cyanide)	Direct dermal contact or ingestion of potentially contaminated soil or inhalation of dust originating from potentially contaminated soil	Construction workers	Medium	Likely	Moderate	A site investigation is recommended to confirm the presence/absence of contamination. Risks to construction workers can be managed through appropriate personal protection equipment (PPE) and good working practices. The risk should be included in the construction management plan. Excavated soil that is potentially contaminated will have to be disposed of appropriately.
	Leaching and horizontal or vertical migration through the unsaturated ground, either through permeable sub-surface materials and/or preferential pathways	Controlled waters (Groundwater)	Medium	Likely	Moderate	A site investigation is recommended to confirm the presence/absence of contamination including groundwater sampling and monitoring to establish the groundwater regime and its connectivity to the sea (tidal influences).

This matrix is based on CIRIA C552 risk evaluation methodology, definitions for risk ratings is presented in Appendix I

Source	Pathway	Receptor	Consequence of risk being realised	Probability of risk being realised	Risk Classification	Potential risk management requirements
Evidence of hydrocarbon contamination associated with fine sand lenses embedded in marine beach deposits (BP Transit site)	Direct dermal contact or ingestion of potentially contaminated soil or inhalation of dust originating from potentially contaminated soil	Construction workers	Medium	Unlikely (<i>due to depth of contamination (>2m) construction workers are unlikely to get into contact with it</i>)	Low	Risks to construction workers can be managed through appropriate personal protection equipment (PPE) and good working practices. Appropriate procedures should be defined in the construction management plan in case of discovering previously unidentified contamination.
	Direct contact of potentially contaminated soil and new built structures (chemical attack of potentially contaminated soil on new built structures)	Proposed structures (cable duct)	Mild	Unlikely (<i>due to depth of contamination typically being >2mbgl; hence cable duct is unlikely to come into contact with contamination</i>)	Very low	A site investigation should be undertaken along the cable route to confirm the extent of Made Ground and assess potential contamination. A precautionary approach should be adopted during the construction of the cable route to react to any encountered unforeseen contamination.
	Leaching and horizontal or vertical migration through the unsaturated ground, either through permeable sub-surface materials and/or preferential pathways	Controlled waters (Groundwater, Swansea Bay)	Medium	Unlikely (<i>Assuming the remediation was successful</i>)	Low	A site investigation should be undertaken along the cable route to confirm the extent of Made Ground and assess potential contamination and potential pathways.

This matrix is based on CIRIA C552 risk evaluation methodology, definitions for risk ratings is presented in Appendix I

Source	Pathway	Receptor	Consequence of risk being realised	Probability of risk being realised	Risk Classification	Potential risk management requirements
Potential contamination associated with redundant pipe work (leak of fuel or other hydrocarbon) (BP Transit site)	Direct dermal contact or ingestion of potentially contaminated soil or inhalation of dust originating from potentially contaminated soil	Construction workers	Medium	Likely	Moderate	A site investigation including a ground penetrating radar (GPR) survey is recommended to confirm the presence/absence of redundant pipes. If redundant services are present a supplementary intrusive investigation is recommended to confirm the presence/absence of contamination. Risks to construction workers can be managed through appropriate personal protection equipment (PPE) and good working practices. Appropriate procedures should be defined in the construction management plan in case of discovering previously unidentified contamination.
	Direct contact of potentially contaminated soil and new built structures (chemical attack of potentially contaminated soil on new built structures)	Proposed structures (cable duct)	Mild	Likely	Moderate/low	A site investigation including a ground penetrating radar (GPR) survey is recommended to confirm the presence/absence of redundant pipes. If redundant services are present a supplementary intrusive investigation is recommended to confirm the presence/absence of contamination.



This matrix is based on CIRIA C552 risk evaluation methodology, definitions for risk ratings is presented in Appendix I

Source	Pathway	Receptor	Consequence of risk being realised	Probability of risk being realised	Risk Classification	Potential risk management requirements
Potential contamination associated with redundant pipe work (leak of fuel or other hydrocarbon) (BP Transit site)	Leaching and horizontal or vertical migration through the unsaturated ground, either through permeable sub-surface materials and/or preferential pathways	Controlled waters (Groundwater, Swansea Bay)	Medium	Likely	Moderate	A site investigation including a ground penetrating radar (GPR) survey is recommended to confirm the presence/absence of redundant pipes. If redundant services are present a supplementary intrusive investigation is recommended to confirm the presence/absence of contamination.

This matrix is based on CIRIA C552 risk evaluation methodology, definitions for risk ratings is presented in Appendix I

Source	Pathway	Receptor	Consequence of risk being realised	Probability of risk being realised	Risk Classification	Potential risk management requirements
Potential contamination associated with historical land use off and adjacent to site including tin plate works, motor component manufacture (metals, metalloids and their compounds, inorganic compounds) (Former King's Dock works)	Direct dermal contact or ingestion of potentially contaminated soil or inhalation of dust originating from potentially contaminated soil	Construction workers	Medium	Likely	Moderate	Risks to construction workers can be managed through appropriate personal protection equipment (PPE) and good working practices. Appropriate procedures should be defined in the construction management plan in case of discovering previously unidentified contamination (robust reactive strategy).
	Direct contact of potentially contaminated soil and new built structures (chemical attack of potentially contaminated soil on new built structures)	Proposed structures (cable duct)	Mild	Likely	Moderate/low	Option A: A site investigation is recommended to confirm the presence/absence of contamination including soil testing to assess its aggressiveness. Option B: Consideration should be given to the materials used for the cable duct and their susceptibility to chemical attack.
	Leaching and horizontal or vertical migration through the unsaturated ground, either through permeable sub-surface materials and/or preferential pathways	Controlled waters (Groundwater, Swansea Bay)	Medium	Likely	Moderate	A site investigation should be undertaken to confirm the extent of Made Ground and assess potential contamination and potential pathways.

This matrix is based on CIRIA C552 risk evaluation methodology, definitions for risk ratings is presented in Appendix I

Source	Pathway	Receptor	Consequence of risk being realised	Probability of risk being realised	Risk Classification	Potential risk management requirements
Potential contamination associated with pipeline (leak of hydrocarbons)	Direct dermal contact or ingestion of potentially contaminated soil or inhalation of dust originating from potentially contaminated soil	Construction workers	Medium	Low likelihood	Moderate/low	Risks to construction workers can be managed through appropriate personal protection equipment (PPE) and good working practices. Appropriate procedures should be defined in the construction management plan in case of discovering previously unidentified contamination (robust reactive strategy).
	Direct contact of potentially contaminated soil and new built structures (chemical attack of potentially contaminated soil on new built structures)	Proposed structures (cable duct)	Mild	Low likelihood	Low	A site investigation including a ground penetrating radar (GPR) survey is recommended to confirm the location and depth of the pipeline.
	Leaching and horizontal or vertical migration through the unsaturated ground, either through permeable sub-surface materials and/or preferential pathways	Controlled waters (Groundwater, Swansea Bay, River Neath Estuary)	Medium	Low likelihood	Moderate/low	A site investigation should be undertaken where any pipelines are suspected to be present on the site in order to confirm the extent of Made Ground and assess potential contamination and potential pathways.

This matrix is based on CIRIA C552 risk evaluation methodology, definitions for risk ratings is presented in Appendix I

Source	Pathway	Receptor	Consequence of risk being realised	Probability of risk being realised	Risk Classification	Potential risk management requirements
Evidence of contamination associated with Baglan Chemical Works	Direct dermal contact or ingestion of potentially contaminated soil or inhalation of dust originating from potentially contaminated soil	Construction workers	Medium	Likely	Moderate	Risks to construction workers can be managed through appropriate personal protection equipment (PPE) and good working practices. Appropriate procedures should be defined in the construction management plan in case of discovering previously unidentified contamination (robust reactive strategy).
	Direct contact of potentially contaminated soil and new built structures (chemical attack of potentially contaminated soil on new built structures)	Proposed structures (cable duct)	Mild	Likely	Low	A site investigation should be undertaken to confirm the extent of Made Ground and assess potential contamination and potential pathways.
	Leaching and horizontal or vertical migration through the unsaturated ground, either through permeable sub-surface materials and/or preferential pathways	Controlled waters (Groundwater, Swansea Bay, River Neath Estuary)	Medium	Likely	Moderate	A site investigation should be undertaken to confirm the extent of Made Ground and assess potential contamination and potential pathways.



10 Gap Analysis

10.1 Identified Data Gaps

It is considered that there are a number of gaps in the existing data that need to be addressed prior to commencement of the construction phase of works. Some of these gaps relate to information primarily required for design purposes or to address health and safety issues whilst other data gaps relate to regulatory and planning issues and will be need to meet the requirements of the regulatory authorities.

In summary it is considered that the following data gaps need to be addressed:

1. The accurate location of existing below services, including relic or redundant services such as the BP pipelines, need to be established.
2. Potential hydrocarbon contamination that may be associated with leaks from the former BP pipelines needs to be assessed in a robust manner.
3. Tidal influences upon the local groundwater regime need to be investigated in order to inform assessment of the contamination risks to both the groundwater and the marine waters. Previous investigation works of the docks area only included boreholes and monitoring wells in the area to the north and immediate east of King's Dock and Queen's Dock. Boreholes were not drilled to the south of Queen's Dock along the access road to the Western Landfall Building. Furthermore the response zones for the boreholes were largely installed at relatively shallow depths (4mbgl or less) above the saturated zone. As a result the monitoring wells are not suitable for providing a robust assessment of the groundwater regime. Insufficient monitoring has been undertaken to establish any tidal influence on the groundwater. The boreholes installed in June 2015 were apparently not left for a sufficient period before monitoring to enable equilibrium to return, and the samples taken may therefore not be representative. Further groundwater sampling and testing should be undertaken.
4. Contamination conditions around the docks area needs to be investigated in more detail to assess potential risks to human health, risks to controlled waters and the suitability of soil arisings for re-use on site. The current investigation data is focussed upon specific areas namely; the proposed access road and the reported former arsenic works area only.
5. Other than for the portion of the route along the former BP Transit Site, there is a general lack of data regarding ground conditions for the cable route. Ground conditions need to be investigated and assessed along the cable route in order to determine the suitability of soil arisings for reuse on

- site, to assess potentially aggressive ground conditions or risks to the health of construction workers and to inform detailed construction design.
6. Contamination at the terminus of the cable route in Baglan Energy Park needs to be investigated and assessed due to the absence of available site specific data in this area.
 7. No ground investigation data is available for the haul road to the eastern landfall.
 8. Ground gas conditions in the vicinity of the Western Landfall Building and proposed construction phase offices / welfare facilities needs to be assessed in compliance with current guidance.
 9. Geotechnical information and an assessment of potentially aggressive ground conditions need to be investigated and assessed for the Western Landfall Building.
 10. CBR values for pavement, road and hardstanding areas needs to be investigated over a wider area of the site.
 11. The geological sequence and ground conditions on either side of the River Neath need to be assessed in order to inform the design of the horizontal directional drilling for the cable route.

10.2 Proposed Scope of Works

It is recommended that the following scope of works is undertaken as an initial phase of investigation in order to address the data gaps detailed above.

10.2.1 Service Location

A Ground Penetrating Radar (GPR) survey should be undertaken along the proposed cable route in order to accurately locate existing services and below ground obstructions. It may also be worthwhile combining additional geophysical techniques (such as magnetometer or electromagnetic methods) with these works in order to determine the possible presence of UXO prior to intrusive works commencing.

10.2.2 BP Pipelines

Any suspected relic pipelines identified by the GPR survey along the route of the cable should be investigated by hand dug or vacuum extraction trial pits in order to expose and assess the condition of the pipeline and to confirm their depth. Soil samples should be taken and analysed for TPH-CWG and BTEX suites from the soil mass on either side of the pipe and at least one sample from the underlying soil.

This assumes that the pipelines are at relatively shallow depths and readily accessible by hand pitting techniques. If the pipelines are present at a greater depth then the investigation techniques may need to be adapted or may not be required at all if it is significantly below the base level of the proposed HV Cable installation (approximately 1.8mbgl).



10.2.3 Groundwater Regime and Tidal Influence

An initial series of 10no. borehole drilled to depths of 10mbgl should be undertaken along the access road (6no. along the southern and eastern edge of Queens Dock and 4no. in the area to the north of Kings Dock). Groundwater monitoring installations should be constructed with a suitable response zone within the saturated soils.

Soil and groundwater samples should be analysed for a suitable suite of contaminants which for the most part will include; heavy metals, asbestos, cyanide, FOC, pH value, sulphate, phenol, TPH-CWG, BTEX and speciated PAHs to reflect the nature of historical site activities and the nature of fill material likely to have been used within the construction of the docks. Groundwater samples should also be analysed for ammonia, ammonium and chloride as indicators of general water quality and saline intrusion.

A suitable regime of regular groundwater monitoring should be undertaken to determine the influence of any tidal effects. This should include the use of automated downhole level loggers to provide continuous groundwater data over at least a 24 hour period. This can then be related back to tide times to identify any evidence of correlations.

10.2.4 Contamination – Docks Area (including western landfall building)

The area of railway ballast to be used for temporary site office should be assessed for potential contamination risks to construction workers. Ground investigations undertaken to date only apply to the proposed access road route through this area. It is considered that a series of trial pits and/or window sample boreholes to depths of between 3-5mbgl should be undertaken on an approximate 50m grid spacing.

Soil samples should be analysed for a suitable suite of contaminants which for the most part will include; heavy metals, asbestos, cyanide, FOC, pH value, sulphate, phenol, TPH-CWG, BTEX and speciated PAHs. Selected samples should additionally be analysed for VOCs, SVOCs and PCBs. This is in view of the wide range of historical activities on and near the site and the nature of fill material likely to have been sourced from nearby industrial process and used in the construction of the docks.

10.2.5 Ground Conditions and Contamination – Cable Route

Much of the proposed 4.5km long cable route is anticipated to lie in close proximity to existing services. In view of this care needs to be taken to avoid damage to these services and to ensure the health and safety of workers during the ground investigation. Even relic or redundant services need to be protected as they may, in some case, contain residual contamination.

It is considered that the most appropriate option of investigation is to undertake hand dig or vacuum extraction trial pits, supplemented with follow-on hand auguring or window sampling techniques to assess the ground conditions to a depth of at least 2mbgl. It is proposed that this work is initially undertaken at 100m centres along the cable route. Additional targeted investigations may subsequently be required if any areas of concern or significant contamination is found. Ideally the works should seek to prove the base of the Made Ground deposits where this is feasible.

Soil samples should be analysed for a broad suite of common contaminants due to the wide range of historical processes in the area and to inform the assessment of options for re-use of the soil arisings on site. As such it is anticipated that the suite of analysis will include; heavy metals, asbestos, cyanide, FOC, pH value, sulphate, phenol, TPH banded and speciated PAHs. Selected samples demonstrating any significant evidence of petroleum hydrocarbon contamination (based on visual, olfactory evidence or elevated PID readings) should additionally be analysed for TPH-CWG and BTEX and this may be expected to occur where the cable passes along the former BP Transit site.

10.2.6 Contamination – Baglan Energy Park Area

The former BP Chemical works and power station is understood to contain a wide range of contaminants and these may be present on the cable route in this area. It is proposed that trial pits and/or window sample boreholes are undertaken on an approximate 50m spacing in this area. Soil samples should be recovered and analysed for a broad range of potential contaminants including; heavy metals, asbestos, cyanide, FOC, pH value, sulphate, phenol, TPH-CWG, speciated PAHs, PCBs, VOCs and SVOCs.

10.2.7 Ground Investigation for the Eastern Landfall haul road

A geotechnical investigation is required to assess ground conditions for the proposed 1km long haul road to enable the construction of the eastern landfall and lagoon seawall. It is proposed that a series of boreholes and trial pits are undertaken with appropriate in-situ geotechnical testing and recovery of samples for laboratory geotechnical analysis. A geotechnical assessment of the haul route should be completed.

10.2.8 Ground Gas Regime

The high gas concentrations identified in previous reports require further assessment. In particular gas flow rates should be recorded as these have not previously been measured for the site. It is recommended that a minimum of three gas monitoring wells are installed into the existing Made Ground in the area of the proposed Western Landfall Building and at least three monitoring wells are installed in the area of the temporary site offices and welfare facilities. Any other areas of temporary or permanent buildings that may be proposed should also be investigated for ground gas.

The gas monitoring wells should be monitored on at least six occasions, to including at least two occasions during falling pressure conditions. Gas monitoring should include measurement of peak and steady concentrations of methane, carbon dioxide, carbon monoxide, hydrogen sulphide, oxygen, PID reading, pressure differential and flow rates. The local climate conditions should be noted along with details of the pressure conditions for the preceding three day period. Monitoring should be undertaken during at least one low and one high tide event to determine if there is any tidal influence upon the ground gas regime.

A ground gas assessment should be undertaken upon the results in compliance with CIRIA C665.

10.2.9 Western Landfall Building Centre Geotechnical Conditions

Geotechnical data for the Western Landfall Building should be obtained from at least two boreholes to be drilled in the area, supported by a further series of four trial pits and/or window sample boreholes due to the potential for highly variable ground conditions in the docks. Samples should be analysed for suitable geotechnical parameters (based upon the soil type) and potential contamination as previously discussed in Section 10.2.4.

10.2.10 CBR Values

CBR values should be established along the full length of the access road and in areas of proposed paving or hardstanding such as the Western Landfall Building car park. Plate load tests supplemented by TRL probe tests in trial pits should be undertaken for this purpose.

10.2.11 Horizontal Directional Drilling

Details of the deeper geology on either side of the River Neath is required to inform the directional drilling method. It is recommended that a borehole should be drilled on each side of the river for this purpose. The location and depth of these boreholes should be agreed with the contractor undertaking the directional drilling works.

10.3 Consultation

A detailed specification and full sampling rationale should be agreed with the Regulatory Authorities, (Swansea Council, Neath and Port Talbot Council and Natural Resources Wales) before any ground investigation works proceed. It is envisaged that this will include consideration of:

- Objectives of the investigation work;
- Access restrictions;
- Permits and Licenses;



- Health and Safety;
- Environmental Management including contamination avoidance and aquifer protection measures;
- UXO risk management;
- Site establishment and security;
- Proposed drilling and exploratory hole excavation methodology;
- Specific investigation measures required to assess ground conditions and assess the depth of the bed of the River Neath where HDD works are proposed;
- Backfilling and re-instatement;
- Drawings showing proposed exploratory hole locations;
- Logging, instrumentation, field testing, monitoring and site supervision requirements;
- Gas and groundwater monitoring standpipe installations;
- In situ geotechnical and permeability testing requirements;
- Sampling, labelling, protection and transport of samples;
- Waste Management;
- Geotechnical laboratory testing;
- Chemical laboratory testing of soil, gas and water samples;
- Data Management;
- Reporting.

10.4 Additional Works

A comprehensive ground investigation report should be prepared that addresses the above works and includes a revised CSM and risk assessment in compliance with all current standards.

It is possible that further targeted ground investigation works may be needed to fully assess any geotechnical or geo-environmental constraints that may be identified by the above works. Any subsequent works should also be undertaken in full consultation with the Regulatory Authorities.



11 Conclusions and recommendations

11.1 Conclusions

The results of the desk based assessment presented in this report have identified the potential for contamination associated with the Made Ground and the wide range of former historical activities that have occurred on the site and adjacent areas. In particular there is evidence within existing ground investigation reports of contamination within the docks, former BP Transit site and the former BP Chemicals site. Investigation of the docks area has also encountered high concentrations of ground gases (carbon dioxide, methane and carbon monoxide) which may represent a significant risk within confined spaces or buildings.

It is considered that the overall risk to human health (current site users, future site users and construction workers) is categorised as low to moderate for the majority of the site. However, there is a localised area of high risk associated with the presence of asbestos materials in the near surface soils proximal to the proposed Western Landfall Building. This impact is present in only a limited area of the site and as such could be mitigated with relative ease using methods such as a cover system and/or removal of unsuitable soils from the site.

There is also a high risk to construction workers from identified hydrocarbon contamination in the Queen's Dock area, though the implementation of typical working protocols, such as working awareness briefings, hygiene controls and PPE, would be sufficient to mitigate and manage this risk. On the basis that the risks can be readily mitigated, using typical working procedures and well established techniques, then it is considered that the limited high risk pollutant linkages that present are unlikely to prevent redevelopment of the site.

Contamination risks to controlled waters (namely groundwater and Swansea Bay) are generally considered to be low to moderate. However, it is acknowledged that there is insufficient information currently available to confirm the degree of potential hydraulic connectivity to the sea or possible tidal influences upon groundwater regime across the site. In absence of confirmatory information the risk assessment has assumed that there is connectivity between the groundwater and the marine environment. Further investigation and monitoring of the groundwater regime would be required in order to confirm if this is in fact the case and in turn to refine the risk assessment.

Risks to structures (including permanent buildings, temporary site cabins and the HV cable) are generally considered to be low to moderate. Previous reports have identified a generally high risk from unexploded ordnance on the site, albeit this appears to be heavily reliant upon generic data for the Swansea area with relatively little site specific information presented in the report.



The site is in an area where published guidance indicates no radon protection measures are required for new dwellings. A Coal mining report also indicates that the site is not at risk from coal mining hazards.

It is anticipated that the geology underlying the site will comprise extensive Made Ground deposits in the vicinity of the western docks and around the Baglan Bay end of the cable route. The Made Ground is likely to be variable in nature due to the apparent use of a range of fill materials, including imported industrial wastes such as slag and clinker, which have been used within the docks and to level land at the former BP Chemicals site. The underlying superficial geology will predominantly comprise Marine Beach Deposits (mainly sand with lesser proportions of silt, clay and gravel) with Tidal Flat Deposits and alluvium (clay, silt and sand) around the River Neath and some Blown Sand deposits along the central portion of the cable route.

It is anticipated that there may be physical in-ground constraints present including underground services, relic services (including former BP pipelines), buried structures (concrete slabs and foundations) and potential unexploded ordnance present on the site. It is understood that a GPR survey will be undertaken to identify the location of utility services and other physical constraints along the cable route.

It is considered that comments and queries previously received from the regulatory authorities have been addressed (as detailed in Appendix H and summarised briefly in Section 8 of this report) to a sufficient degree to inform and support a planning application for the development. In particular key concerns relating to the completeness of the desk top information (such as historical plans, landfill sites, review of existing site reports) have been addressed within this report. Concerns relating to existing ground investigation works have been acknowledged and appropriate measures will be implemented in any future phases of investigation to address these issues.

11.2 Recommendations

In order to support the detailed design of the development (such as establishing appropriate remediation and mitigation measures) at the site it is recommended that a ground investigation is undertaken in order to more fully assess the ground conditions beneath the site and provide greater surety with respect to the potential geo-environmental risks and constraints identified within this report.

This work is not considered to be necessary for purposes of supporting a planning application. It is instead considered that the investigation works would be deferred to a post planning stage. The principal aims of any future ground investigation works should be to; refine the existing risk assessment in specific areas that currently have insufficient data, address anticipated planning conditions and to define suitable mitigation or remediation measures. Key areas for investigation should include the Western Landfall



Building (especially for potential asbestos contamination) and the cable route (especially the portions along the former BP Transit Site and proximal to the former BP Baglan Bay Site).

It is recommended that the ground investigation is designed to include assessment of the following issues and that a detailed scope of works should be agreed in advance with the Regulatory Authorities:

- An assessment of the extent of Made Ground on the site and its composition, depth and distribution. This should include investigations along the cable route to confirm the nature of the ground conditions.
- Investigation works proximal to buried services (including redundant services) should be undertaken by hand pitting and/or vacuum extraction techniques to avoid damaging services.
- Investigations should be undertaken proximal to suspected relic BP pipelines (to be identified by a GPR survey) in order to assess if there is any evidence of contamination due to leaks.
- An assessment of the underlying superficial deposits and their suitability for foundations in areas of proposed new structures.
- Confirmation of the ground conditions on either side of the River Neath to inform the directional drilling for the cable route. Care will need to be taken to ensure that the crossing avoids the location of the former BP pipeline.
- Geotechnical testing of soils (in-situ and laboratory) for foundation and pavement design purposes in the vicinity of the proposed Western Landfall Building and access road.
- Chemical laboratory testing of soils and groundwater chemistry (or leachate analysis if groundwater cannot be recovered) based upon a suitable sampling rationale informed by consideration of the historical site activities in each area. Particular attention should be paid to the Baglan Chemical works, the former BP Transit site and the docks including the near surface asbestos impacts near the western landfall.
- Potentially aggressive ground conditions should be assessed in regard to possible building foundations and services including the HV cable and services required for the Western Landfall Building such as potable water supplies.



- Waste Acceptance Criteria testing should be considered for materials that are likely to require removal to off-site disposal facilities and to inform considerations regarding the possibility of re-using soil arisings on site.
- Suitable monitoring of the groundwater regime, to include installations into the saturated zone, monitoring of tidal variations to groundwater levels and sampling of the groundwater.
- Land gas/ vapour monitoring and risk assessment (compliant with CIRIA 665) in areas of proposed temporary and permanent buildings.
- Interpretative land quality assessment (based on site specific data) to provide a qualitative risk assessment (compliant with UK CLR guidance and CIRIA 552 methodology). Subject to the outcome of this phase it is possible that a Detailed Quantitative Risk Assessment may be required for key contaminants of concern.
- Interpretative geotechnical assessment (based on site specific data) to provide indicative foundation depths and solutions for the Western Landfall Building and to enable outline considerations of earthworks and/ or paved surface design to be developed on a more assured basis.
- An archaeological watching brief is understood to be required for works in the Crymlyn Burrows area. Works in this area will also need to address issues relating to the protection of ecological features, the SSSI status of the burrows and suitable working techniques to minimise impact and reinstate the ground upon completion.
- Suitable measures should be adopted to address the risks from UXO on the site.

Prior to undertaking a ground investigation it is recommended that a GPR survey (or similar geophysical technique) be undertaken along the cable route in order to more accurately identify the location of underground services. This should also be capable of identifying any relic BP pipelines which may also be a potential source of residual contamination or may be a possible preferential pathway for migratory contamination impacts.

A detailed specification establishing the rationale and requirements for ground investigation in each area of the site will be prepared. The scope of work to be undertaken will need to address the data gaps identified within this report.



The re-use of soil arisings should be considered for the scheme in order to minimise off-site disposal and import of 'clean' soil. This will require a regime of validation testing operating under a Materials Management Plan (MMP) or an Environmental Permit (EP). Consultation with the Regulatory Authorities should be undertaken upon completion of further ground investigation works to identify a suitable process for this.

Remediation or mitigation measures may be required in some parts of the site. Without the benefit of a full site investigation it is not possible to confirm the type or extent of such measures that may be required. However, at this stage it is anticipated that a combination of some of the following measures may be necessary:

- Gas and vapour protection measures for buildings.
- Use of hardstanding and/or clean cover layers to break contaminant pathways.
- Use of biopiles or in-situ remediation of soil or groundwater phase organic contaminants.
- Removal of any grossly contaminated material or free phase liquids for off-site disposal.

The UXO risk assessment for the site is considered to be reliant upon generic data for the wider Swansea and Port Talbot area with limited effort to zone the site according to risk or types of UXO hazards that may be present. It is recommended that a peer review of the report is undertaken in order to establish a risk rating and possible mitigation measures on a more site specific basis.

11.3 Summary

A thorough review of a wide range of available data has been undertaken for the site and surrounding area to enable a comprehensive and robust assessment to be made of the potential risks and constraints that are present. In view of this it is considered that there is sufficient knowledge of the site conditions to conclude that in all likelihood the scheme is technically viable and that it is unlikely there will be any unforeseen ground constraints that would prevent the development going ahead.

It is considered that comments and queries previously received from the regulatory authorities have been addressed to a sufficient degree to inform and support a planning application for the development.

In order to support the detailed design of the development it is considered that additional ground investigation works will be required in due course. This work is not considered to be necessary for purposes of supporting a planning application; it is instead considered that the investigation works would be deferred to a post planning stage. The principal aims of any future ground investigation works should be to; refine



the existing risk assessment in specific areas that currently have insufficient data, address anticipated planning conditions and to define suitable mitigation or remediation measures.

Key areas of risk that require further investigation and mitigation include the Western Landfall Building and the cable route (especially the portions along the former BP Transit Site and proximal to the former BP Baglan Bay Site).



References

- (1) Swansea Bay Tidal Lagoon Access Road. Ground Investigation Report. Alun Griffiths Contractors. September 2015. Atkins. (Document reference: Swansea Bay Tidal Lagoon_R001v0)
- (2) Swansea Bay Tidal Lagoon. C133 Onshore Ground Investigation. Factual report. Alun Griffiths (Contractors) Ltd. August 2015. Apex Drilling Services Ltd. (Report No 10318)
- (3) Ground investigation works. Transit Site Swansea. Prosurv Cosult Ltd. August 2010. Resource & Environmental Consultants Ltd (REC Report 43515p1r1)
- (4) Explosive Ordnance Threat Assessment in respect of Swansea Docks to Baglan burrows for Atkins Ltd. 8th September 2014. BACTEC International Ltd. (Report: 5603TA)
- (5) Transit Site Remediation Performance Specification, June 2010, Atkins
- (6) Ground Investigation Works Transit Site Swansea, , August 2010, REC
- (7) Proposed Solar Photovoltaic Park, Baglan Energy Park – Contamination Assessment, January 2011, Atkins
- (8) Baglan Bay PV Farm Geo-environmental Assessment Report, May 2011, Atkins
- (9) Remediation Validation Report for Former BP Transit Site, , May 2011, Hydrock
- (10) Technical Note : Baglan Bay Land Contamination, October 2014, Atkins
- (11) Technical Note : Geotechnical and Geoenvironmental Desk Study – Onshore, November 2014, Atkins



Figures



Photographic Plates



Plate Title

Former Rail Sidings

Plate No

1



WYG Environment

5th Floor, Longcross Court, 47 Newport Road, Cardiff
Tel: 02920 829200

Fax: 02920 455321

Environmental Consultancy
Ground Engineering Services



Project

Tidal Lagoon Swansea Bay -
Onshore Works

Client

Tidal Lagoon Swansea Bay

Plate Title

Boggy Ground - view east
towards Sewage Works

Checked by

SJ

Plate No.

2



Plate Title

Western Landfall - view east

Plate No

3



WYG Environment

5th Floor, Longcross Court, 47 Newport Road, Cardiff
Tel: 02920 829200

Fax: 02920 455321

Environmental Consultancy
Ground Engineering Services



Project

Tidal Lagoon Swansea Bay -
Onshore Works

Client

Tidal Lagoon Swansea Bay

Plate Title

Western Landfall- view
west

Checked by

SJ

Plate No.

4



Plate Title

New Footpath along Fabian Way (Former BP Transit Site)

Plate No

5



WYG Environment

5th Floor, Longcross Court, 47 Newport Road, Cardiff
Tel: 02920 829200

Fax: 02920 455321

Environmental Consultancy
Ground Engineering Services



Project

Tidal Lagoon Swansea Bay -
Onshore Works

Client

Tidal Lagoon Swansea Bay

Plate Title

Fabian Way and New
Campus Buildings

Checked by

SJ

Plate No.

6



Plate Title

Fabian Way - view east

Plate No

7



WYG Environment

5th Floor, Longcross Court, 47 Newport Road, Cardiff
Tel: 02920 829200

Fax: 02920 455321

Environmental Consultancy
Ground Engineering Services



Project

Tidal Lagoon Swansea Bay -
Onshore Works

Client

Tidal Lagoon Swansea Bay

Plate Title

Crymlyn Burrows - view
south

Checked by

SJ

Plate No.

8



Plate Title	Drainage Ditch on South Side of Fabian Way	Plate No	9
-------------	--	----------	---



WYG Environment 5th Floor, Longcross Court, 47 Newport Road, Cardiff Tel: 02920 829200 Fax: 02920 455321 Environmental Consultancy Ground Engineering Services 	Project TidalLagoon Swansea Bay - Onshore Works		Plate Title Crymlyn Burrows- view east	
	Client Tidal Lagoon Swansea Bay	Checked by SJ	Plate No. 10	



Plate Title	Relic Infrastructure Present in Crymlyn Burrows	Plate No	11
-------------	---	----------	----



WYG Environment 5 th Floor, Longcross Court, 47 Newport Road, Cardiff Tel: 02920 829200 Fax: 02920 455321 Environmental Consultancy Ground Engineering Services	Project	Tidal Lagoon Swansea Bay - Onshore Works		Plate Title View West Towards Crymlyn Burrows Over River Neath	
	Client	Tidal Lagoon Swansea Bay		Checked by SJ	Plate No. 12



Plate Title	View Southeast Towards Baglan Energy Park	Plate No	13
-------------	---	----------	----



WYG Environment 5 th Floor, Longcross Court, 47 Newport Road, Cardiff Tel: 02920 829200 Fax: 02920 455321 Environmental Consultancy Ground Engineering Services	Project	Plate Title	
	Tidal Lagoon Swansea Bay - Onshore Works	View West -Baglan Energy Park to the Left	
	Client	Checked by	Plate No.
	Tidal Lagoon Swansea Bay	SJ	14



Figure 1 – Site Location Plan



Contains Ordnance Survey data É
Crown copyright and database right 2016

5th FLOOR
LONGCROSS COURT
47 NEWPORT ROAD
CARDIFF
CF24 0AD
TEL: +44 (0)29 2082 9200
e-mail: cardiff@wyg.com



Client:
**TIDAL LAGOON
(SWANSEA BAY) PLC**

Project: A095973
**TIDAL LAGOON
SWANSEA**

Drawing Title:
SITE LOCATION PLAN

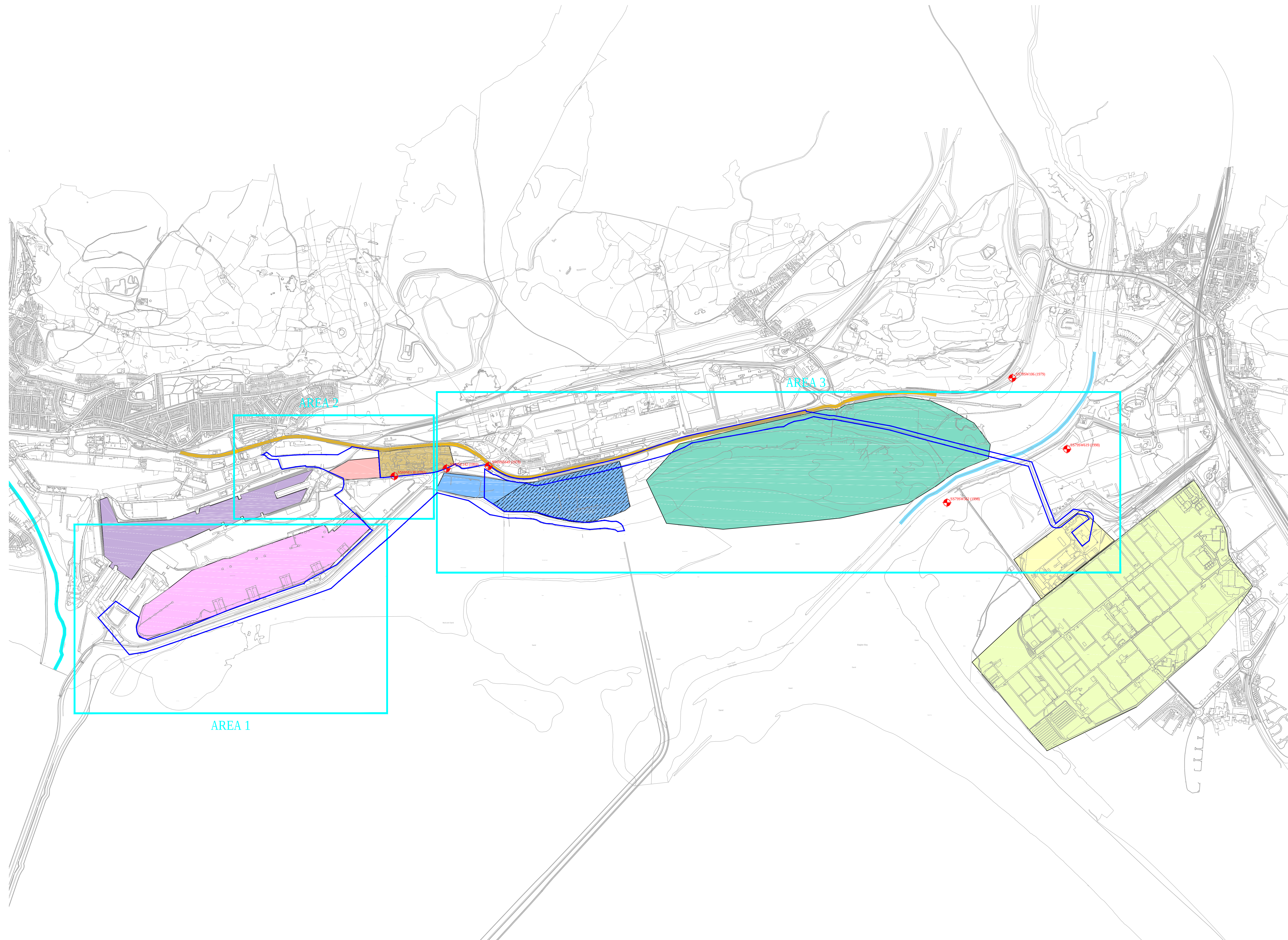
REV	DESCRIPTION				BY	CHK	APP	DATE	
ON PLAN	Scale @ A4		Drawn	Date	Checked	Date	Approved	Date	
	1:50,000		CM	11.02.16	LK	16.02.16	SJ	16.02.16	
	Project No.	Office	Type	Drawing No.				Revision	
	A095973	CDF	N	01					



Figure 2 – Site Layout Plan



DO NOT SCALE: CONTRACTOR TO CHECK ALL DIMENSIONS AND
REPORT ANY OMISSIONS OR ERRORS



	SITE BOUNDARY
	KING'S DOCK
	QUEEN'S DOCK
	ARSENIC AREA
	SEWAGE TREATMENT WORKS
	CRYMILYN BURROWS SSSI
	POWER STATION (NATIONAL GRID BAGLAN BAY SUBSTATION)
	BAGLAN BAY WORKS
	BP TRANSIT SITE
	SWANSEA UNIVERSITY BAY CAMPUS
	A483
	RIVER TAWE
	RIVER NEATH
	HISTORICAL BOREHOLE

REV	DESCRIPTION	BY	CHK	APP	DATE
-----	-------------	----	-----	-----	------

Client:

TIDAL LAGOON (SWANSEA BAY) PLC

5th FLOOR
LONGCROSS COURT
47 NEWPORT ROAD
CARDIFF
CF24 0AD
TEL: +44 (0)29 2082 9200
e-mail: cardiff@wyg.com



Project: A095973

TIDAL LAGOON
SWANSEA

Drawing Title:

SITE LAYOUT PLAN

Scale @ A1 1:12,500	Drawn CM	Date 11.02.16	Checked LK	Date 16.02.16	Approved SJ	Date 16.02.16
Project No. A095973	Office CDF	Type N	Drawing No. 02		Revision	

© WYG Group Ltd

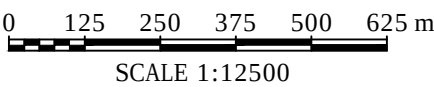




Figure 3 – (not used)



Figure 4 – Areas of previous site investigations



DO NOT SCALE: CONTRACTOR TO CHECK ALL DIMENSIONS AND
REPORT ANY OMISSIONS OR ERRORS

- KEY
- SITE BOUNDARY
- AREAS OF INVESTIGATION
- SWANSEA BAY TIDAL LAGOON ACCESS ROAD,
GROUND INVESTIGATION REPORT, ALUN GRIFFITHS
CONTRACTORS, SEPTEMBER 2015, ATKINS
(DOCUMENT REFERENCE: SWANSEA BAY TIDAL
LAGOON_R001V0) & LAGOON, C133 ONSHORE
GROUND INVESTIGATION, FACTUAL REPORT, ALUN
GRIFFITHS (CONTRACTORS) LTD, AUGUST 2015,
APEX DRILLING SERVICES LTD, (REPORT NO 10318)
SWANSEA BAY TIDAL
- GROUND INVESTIGATION WORKS, TRANSIT SITE
SWANSEA, PROSURY COSULT LTD, AUGUST 2010,
RESOURCE & ENVIRONMENTAL CONSULTANTS LTD
(REC REPORT 43515P1R1)



0 125 250 375 500 625 m
SCALE 1:12500

REV	DESCRIPTION	BY	CHK	APP	DATE
-----	-------------	----	-----	-----	------

Client:
TIDAL LAGOON (SWANSEA BAY) PLC

5th FLOOR
LONGCROSS COURT
47 NEWPORT ROAD
CARDIFF
CF24 0AD
TEL: +44 (0)29 2082 9200
e-mail: cardiff@wyg.com



Project: A095973
TIDAL LAGOON
SWANSEA

Drawing Title:
AREAS OF PREVIOUS INVESTIGATIONS

Scale @	A1	Drawn	Date	Checked	Date	Approved	Date
1:12,500	CM	11.02.16	LK	16.02.16	SJ	16.02.16	
Project No.	Office	Type	Drawing No.	Revision			
A095973	CDF	N	04				

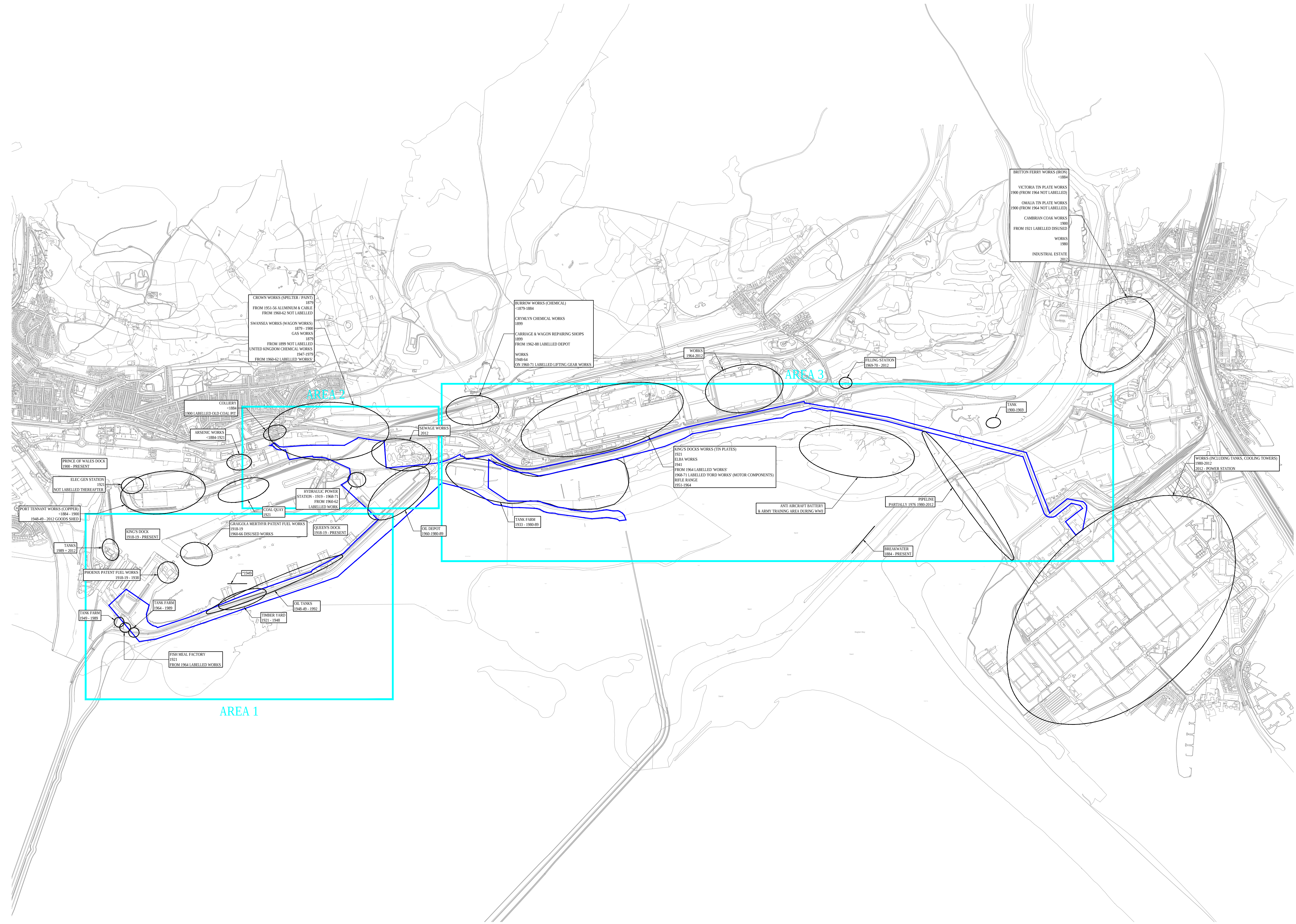


Figure 5 – Historic summary



DO NOT SCALE: CONTRACTOR TO CHECK ALL DIMENSIONS AND
REPORT ANY OMISSIONS OR ERRORS

KEY
SITE BOUNDARY



REV	DESCRIPTION	BY	CHK	APP	DATE
-----	-------------	----	-----	-----	------

Client:
TIDAL LAGOON (SWANSEA BAY) PLC

5th FLOOR
LONGCROSS COURT
47 NEWPORT ROAD
CARDIFF
CF24 0AD
TEL: +44 (0)29 2082 9200
e-mail: cardiff@wyg.com



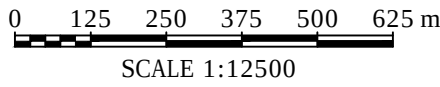
Project: A095973
TIDAL LAGOON
SWANSEA

Drawing Title:
HISTORIC SUMMARY

Scale @	A1	Drawn	Date	Checked	Date	Approved	Date
1:12,500	CM	08.02.16	LK	16.02.16	SJ	16.02.16	
Project No.	Office	Type	Drawing No.	Revision			
A095973	CDF	N	05				



Figure 6 – Conceptual Site Models



REV	DESCRIPTION	BY	CHK	APP	DATE
-----	-------------	----	-----	-----	------

Client:

TIDAL LAGOON (SWANSEA BAY) PLC

5th FLOOR
LONGCROSS COURT
47 NEWPORT ROAD
CARDIFF
CF24 0AD
TEL: +44 (0)29 2082 9200
e-mail: cardiff@wyg.com



Project: A095973

TIDAL LAGOON
SWANSEA

Drawing Title:

LOCATIONS OF CONCEPTUAL SITE MODELS

Scale @	A1	Drawn	Date	Checked	Date	Approved	Date
1:12,500	CM	11.02.16	LK	16.02.16	SJ	16.02.16	
Project No.	Office	Type	Drawing No.	Revision			
A095973	CDF	N	06A				

KEY

- MADE GROUND: Brown sandy GRAVEL with varying cobble content. Gravel and cobbles are of slag, siltstone and occasional clinker.
- MADE GROUND: Light brown fine to coarse grained SAND (possible dredged material)
- MARINE BEACH DEPOSITS: SAND
- BEDROCK - SOUTH WALES LOWER COAL MEASURES FORMATION
- ELECTRICITY CABLE RUNNING ALONG FULL LENGTH OF DOCK
- OTHER SERVICES ARE PRESENT & MAY PROVIDE PREFERENTIAL PATHWAYS

CONTAMINATION

- POSSIBLE CONTAMINATION
- EVIDENCE OF CONTAMINATION FOUND IN PREVIOUS INVESTIGATIONS

SOURCES

- S1

POTENTIAL CONTAMINATION ASSOCIATED WITH STORAGE TANKS LEAK OR SPILLAGE OF FUEL OR OTHER HYDROCARBON)
- S2

POTENTIAL CONTAMINATION OF ASBESTOS AT SURFACE ASSOCIATED WITH DERELICT FACTORY BUILDING
- S3

POTENTIAL CONTAMINATION ASSOCIATED WITH MADE GROUND CONTAINING SLAG & CLINKER (HEAVY METALS)
- S4

POTENTIAL CONTAMINATION ASSOCIATED WITH TIMBER YARD (METALS & METALLOIDS, INORGANIC COMPOUNDS, ACIDS / ALKALIS, ORGANIC SOLVENTS, PRESERVATIVES)
- S5

EVIDENCE OF HYDROCARBON CONTAMINATION (OILY SHEEN, STRONG HYDROCARBON ODOUR, PID READINGS BETWEEN 205 & 730ppm) FOUND IN TP39 DURING SITE INVESTIGATION IN AUGUST 2015
- S6

EVIDENCE OF HYDROCARBON CONTAMINATION (STRONG HYDROCARBON ODOUR, PID READING OF 212ppm) FOUND IN TP35 DURING SITE INVESTIGATION IN AUGUST 2015
- S7

EVIDENCE OF HYDROCARBON CONTAMINATION (OILY SHEEN, STRONG HYDROCARBON ODOUR, PID READINGS BETWEEN 45 & 300ppm) FOUND IN TP22 DURING SITE INVESTIGATION IN AUGUST 2015

PATHWAYS

- A

CHEMICAL ATTACK OF POTENTIALLY CONTAMINATED SOIL ON NEW BUILT STRUCTURES
- B

DIRECT DERMAL CONTACT OF POTENTIALLY CONTAMINATED SOIL OR INHALATION OF DUST ORIGINATING FROM POTENTIALLY CONTAMINATED SOIL
- C

MIGRATION & ACCUMULATION OF GASES OR VAPOURS THROUGH PERMEABLE SUB-SURFACE MATERIALS AND/OR PREFERENTIAL PATHWAYS
- D

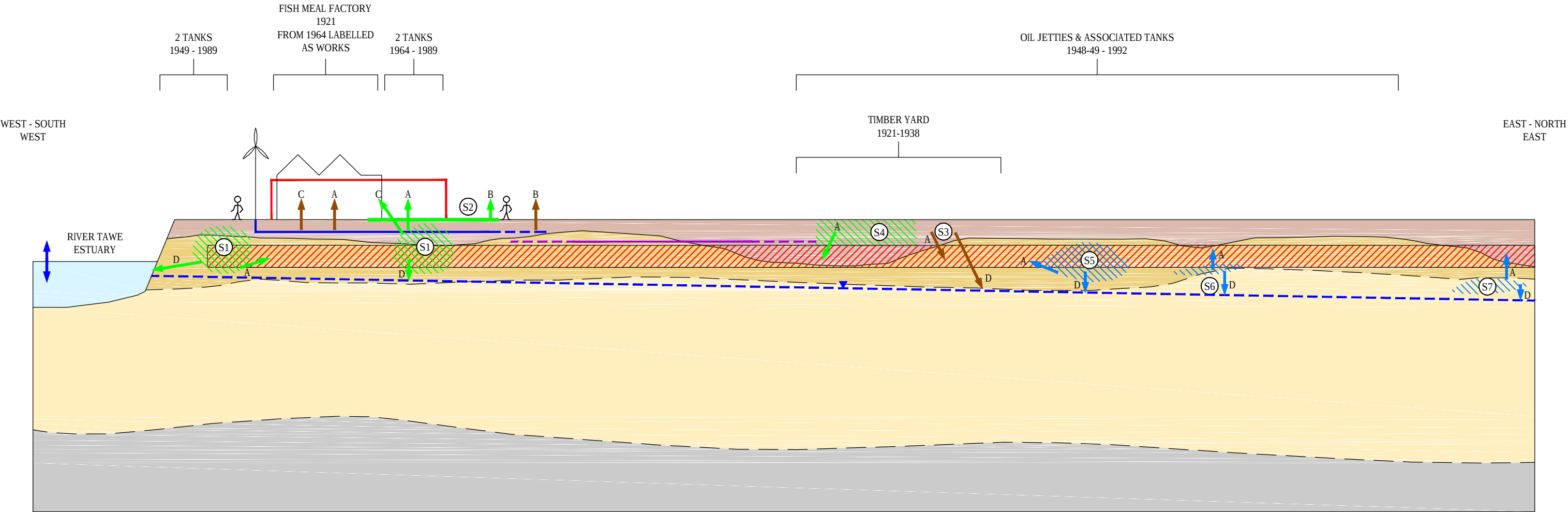
LEACHING & HORIZONTAL OR VERTICAL MIGRATION THROUGH THE UNSATURATED GROUND EITHER THROUGH PERMEABLE SUB-SURFACE MATERIALS AND/OR PREFERENTIAL PATHWAYS

RECEPTORS

- FUTURE SITE USERS
- CABLE DUCT (275kV)
- VISITOR CENTRE
- GROUNDWATER

NOTE: YEAR OF HISTORICAL USE

HISTORICAL USE YEARS REFER TO PUBLICATION OF EDITIONS OF OS MAPS WHERE HISTORICAL USE WAS MARKED. ACTUAL DURATIONS MAY BE LONGER.



5th FLOOR,
LONGCROSS COURT
47 NEWPORT ROAD
CARDIFF
CF24 0AD
TEL: +44 (0)29 2082 9200
e-mail: cardiff@wyg.com



Client:
TIDAL LAGOON (SWANSEA BAY) PLC

Project: A095973
TIDAL LAGOON
SWANSEA

Drawing Title:
CONCEPTUAL SITE MODEL 1

REV	DESCRIPTION				BY	CHK	APP	DATE
	Scale @ A3	Drawn	Date	Checked	Date	Approved	Date	
	N.T.S	CM	11.02.16	LK	16.02.16	SJ	16.02.16	
	Project No.	Office	Type	Drawing No.		Revision		
	A095973	CDF	N	06B				

KEY

MADE GROUND: Brown sandy GRAVEL with varying cobble content. Gravel and cobbles are of slag, siltstone and occasional clinker.

MARINE BEACH DEPOSITS: FINE SAND

MARINE BEACH DEPOSITS: SAND

MARINE BEACH DEPOSITS: CLAY

BEDROCK - SOUTH WALES LOWER COAL MEASURES FORMATION

GROUNDWATER TABLE LIKELY TO VARY WITH TIDE, BOTH HORIZONTAL & VERTICAL MOVEMENT

CONTAMINATION

POSSIBLE CONTAMINATION

EVIDENCE OF CONTAMINATION FOUND IN PREVIOUS INVESTIGATIONS

SOURCES

S1

POTENTIAL CONTAMINATION ASSOCIATED WITH HISTORICAL LAND USE OFF & ON SITE INCLUDING SPELTER & PAINT WORKS, ALUMINIUM & CABLE WORKS, RAILWAY WAGON REPAIR WORKS, CHEMICAL WORKS & GAS WORKS (METALS, INORGANIC COMPOUNDS, ACIDS / ALKALIS, ORGANIC COMPOUNDS e.g ALIPHATIC / AROMATIC HYDROCARBONS, HALOGENATED SOLVENTS, ASBESTOS)

S2

POTENTIAL CONTAMINATION ASSOCIATED WITH MADE GROUND CONTAINING SLAG & CLINKER (HEAVY METALS)

S3

POTENTIAL CONTAMINATION ASSOCIATED WITH OIL DEPOT (LEAK OR SPILLAGE OF OIL)

S4

EVIDENCE OF HYDROCARBON CONTAMINATION ASSOCIATED WITH FINE SAND LENSES EMBEDDED IN MARINE BEACH DEPOSITS

S5

POTENTIAL CONTAMINATION ASSOCIATED WITH REDUNDANT PIPE WORK (LEAK OF FUEL OR OTHER HYDROCARBON). PIPE WORK MAY ALSO PROVIDE PREFERENTIAL PATHWAYS

PATHWAYS

A

CHEMICAL ATTACK OF POTENTIALLY CONTAMINATED SOIL ON NEW BUILT STRUCTURES

C

MIGRATION & ACCUMULATION OF GASES OR VAPOURS THROUGH PERMEABLE SUB-SURFACE MATERIALS AND/OR PREFERENTIAL PATHWAYS

D

LEACHING & HORIZONTAL OR VERTICAL MIGRATION THROUGH THE UNSATURATED GROUND EITHER THROUGH PERMEABLE SUB-SURFACE MATERIALS AND/OR PREFERENTIAL PATHWAYS

5th FLOOR
LONGCROSS COURT
47 NEWPORT ROAD
CARDIFF
CF24 0AD
TEL: +44 (0)29 2082 9200
e-mail: enviro@wyg.com

Client:
TIDAL LAGOON (SWANSEA BAY) PLC

Project: A095973
TIDAL LAGOON
SWANSEA

Drawing Title:
CONCEPTUAL SITE MODEL 2

REV		DESCRIPTION				BY	CHK	APP	DATE
Scale @	A3	Drawn	Date	Checked	Date	Approved	Date		
N.T.S		CM	11.02.16	LK	16.02.16	SJ	16.02.16		
Project No.	Office	Type	Drawing No.		Revision				
A095973	CDF	N	06C						

© WYG Group Ltd.

KEY

- MADE GROUND: Brown sandy GRAVEL with varying cobble content. Gravel and cobbles are of slag, siltstone and occasional clinker.
- TIDAL FLATS DEPOSITS - ALLUVIUM
- MARINE BEACH DEPOSITS: FINE SAND
- MARINE BEACH DEPOSITS & BLOWN SAND DEPOSITS: SAND
- MARINE BEACH DEPOSITS: CLAY
- BEDROCK - SOUTH WALES LOWER COAL MEASURES FORMATION

CONTAMINATION

- POSSIBLE CONTAMINATION
- EVIDENCE OF CONTAMINATION FOUND IN PREVIOUS INVESTIGATIONS

SOURCES

- S1

POTENTIAL CONTAMINATION ASSOCIATED WITH REDUNDANT PIPE WORK (LEAK OF FUEL OR OTHER HYDROCARBON). PIPE WORK MAY ALSO PROVIDE PREFERENTIAL PATHWAYS.
- S2

POTENTIAL CONTAMINATION ASSOCIATED WITH MADE GROUND CONTAINING SLAG & CLINKER (HEAVY METALS)
- S3

EVIDENCE OF HYDROCARBON CONTAMINATION ASSOCIATED WITH FINE SAND LENSES EMBEDDED IN MARINE BEACH DEPOSITS
- S4

POTENTIAL CONTAMINATION ASSOCIATED WITH HISTORICAL LAND USE OFF & ON SITE INCLUDING TIN PLATE WORKS, MOTOR COMPONENT MANUFACTURE (METALS, METALLOIDS & THEIR COMPOUNDS, INORGANIC COMPOUNDS)
- S5

POTENTIAL CONTAMINATION ASSOCIATED WITH PIPELINE (LEAK OF HYDROCARBONS)
- S6

EVIDENCE OF STYRENE CONTAMINATION ASSOCIATED WITH BAGLAN WORKS

PATHWAYS

- A

CHEMICAL ATTACK OF POTENTIALLY CONTAMINATED SOIL ON NEW BUILT STRUCTURES
- D

LEACHING & HORIZONTAL OR VERTICAL MIGRATION THROUGH THE UNSATURATED GROUND EITHER THROUGH PERMEABLE SUB-SURFACE MATERIALS AND/OR PREFERENTIAL PATHWAYS

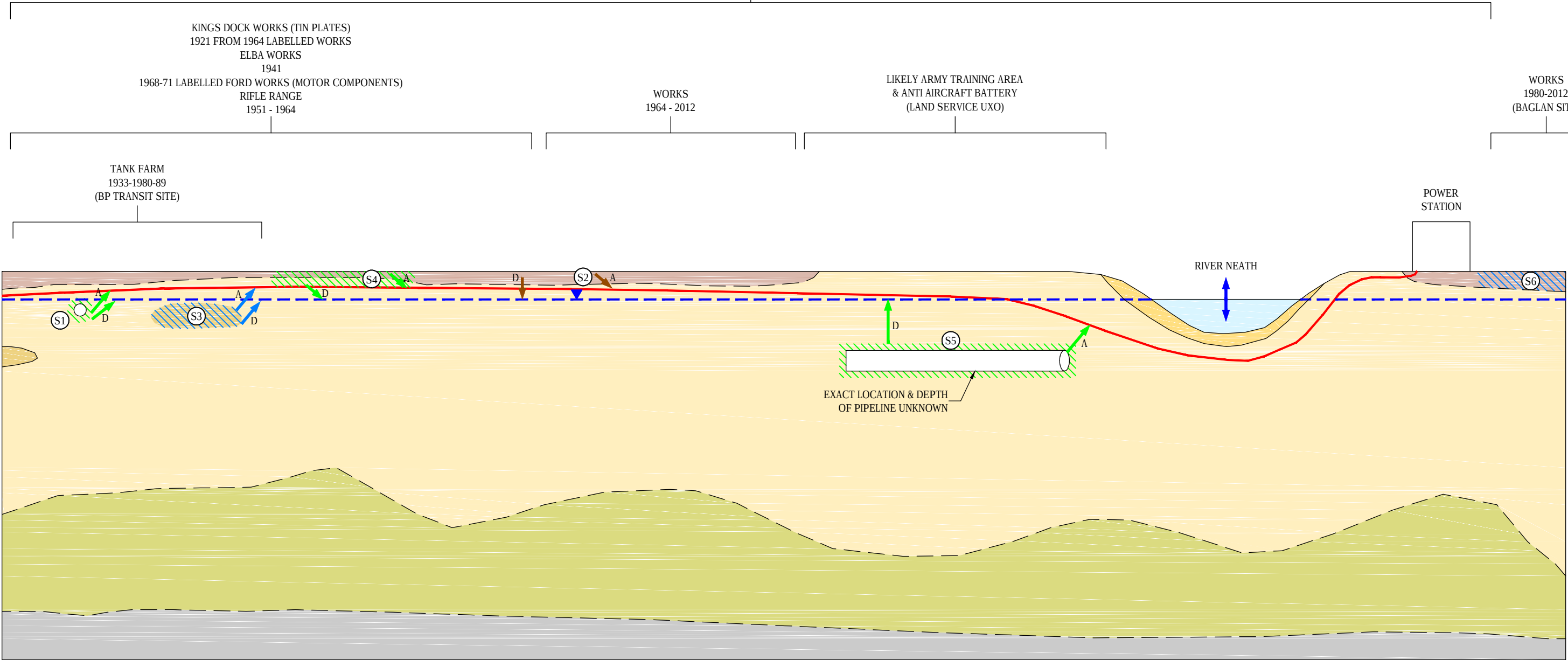
RECEPTORS

- CABLE DUCT (275kV)
- CONTROLLED WATERS (GROUNDWATER, SWANSEA BAY, RIVER NEATH ESTUARY)

WEST

AIR DROPPED UXO

EAST





Appendices