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Barry Waterfront

Environmental Statement
Chapter H

Water Resources, Drainage & Flooding

August 2009

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1.0 Water Resources, Drainage and Flooding

Introduction

1.1 This chapter describes the existing groundwater, surface water, drainage and flood risk and considers how these will be affected by the proposed development during its implementation and on completion. Strategies for mitigating the impacts are described.

1.2 The assessment summarises the legislation, guidance and planning policy and describes the assessment methodology used. The consultation undertaken with the Environment Agency and Vale of Glamorgan County Council is summarised. The baseline conditions are described, based on detailed desk study and ground investigations undertaken in the four distinct areas of the site (Arno Quay, East Quay, West Pond and South Quay) together with a strategic level flood study for all of the site. It draws on the findings of reports undertaken by Arup during 2007, 2008 and 2009. The effect on ground levels is described together with proposals for drainage on site. Mitigation measures are proposed to reduce the impacts on the groundwater and to prevent the site from flooding.

1.3 This chapter is not intended to be read as a stand alone assessment and reference should be made to the “Ground Conditions and Contamination” chapter of this ES (Chapter I), as well as the “Site Description and Proposals” (Chapter C).

2.0 Planning Policy Context

Introduction

2.1 This section describes the legislative, planning and other policy background relating to the water environment of the Application Site.

Legislation

2.2 The assessment has considered the major regulatory legislation outlined below which protect or otherwise apply to water resources. This list is not necessarily exhaustive and in some situations other legislation may apply:

Relevant Legislation:

- Environment Protection Act 1990
- The Water Resources Act (1991)
- The Environment Act (1995)
- Groundwater Regulations 1998
- The Land Drainage Act (1999)
- The Water Environment (Water Framework Directive) (England and Wales) Regulations (2003)
- The Water Act (2003)
- The Private Water Supplies Regulations (1991)
- UK Water Supply (Water Quality) Regulations 2000 and 2001
- Water Resources (Environmental Impact Assessment) Regulations 2003
- Water Resources (Abstraction and Impounding) Regulations 2006
- Pollution Prevention and Control Act 1999
- Environmental Impact Assessment (Land Drainage Improvement Works) Regulations 1999
- Land Drainage Act 1991
- Public Health Act 1848
- Control of Pollution Act 1974
- Control of Pollution Regulations 1996
- Pollution Prevention and Control (England and Wales) Regulations 2000
- Anti Pollution Works Regulations 1999
- EC Dangerous Substances Directive (76/464/EEC)

Relevant codes of practice:

- BS5930: 1990 Code of Practice for site investigations
- BS EN 1997 Eurocode 7 Geotechnical Design
- BS EN 1997-1:2004: General rules
- BS EN 1997-2:2007: Ground investigation and testing
- BS1377-9 (1990) Standard methods of laboratory testing for civil engineering purposes
- ISRM (1985) Rock characterisation methods

- BS6031: 1981 Code of Practice for earthworks
- BS8004: 1986 Code of Practice for foundations
- Policy and Practice for the Protection of Groundwater, 1992, Environment Agency.

Relevant guidance documents:

- Environment Agency Pollution Prevention Guidance Notes (PPG series)
- Good Practice Guide for Handling Soils (MAFF 2000)
- CIRIA 113 Control of Groundwater for Temporary Works,1988
- CIRIA 630 Sustainable water management in land use planning, 2006
- Environmental Good Practice on Site, CIRIA

Planning Policy

National Planning Guidance

2.3 National planning policy is set out in Planning Policy Wales (PPW) (2002) and Technical Advice Note (TAN) 15: Development and Flood Risk. The Development Advice Map for the area indicates that the proposed development is situated within Zones B and C2. As a result, a flood consequences assessment is required by TAN 15. Accordingly, a strategic flood study of the area has been prepared and has been agreed in principle with the Environment Agency Wales.

2.4 With regard to water resources, Paragraph 13.12.1 states that the potential for pollution affecting the use of land will be a material consideration in deciding whether to grant planning permission. Paragraph 13.13.3 of PPW states that development should be designed, wherever possible to prevent adverse effects to the environment, but as a minimum to limit or constrain any effects that do occur. Relevant material considerations include the location of the site, any impact on health and amenity, the risk and impact of potential pollution, prevention of nuisance and the need, where relevant, for restoration.

Development Plan

2.5 The development plan for the area is the adopted Vale of Glamorgan Unitary Development Plan (UDP). Relevant policies include:

- Policy ENV 7 on water resources. This states that water resources will be safeguarded and developments which improve the water environment or help to prevent flooding will be favoured. Development will be permitted where it would not:
  i. Have an unacceptable effect on the quality or quantity of water resources or on fisheries, nature or heritage conservation, recreation or other amenity interests related to such waters; or
  ii. Be potentially at risk from flooding, or increase the risk of flooding locally or elsewhere to an unacceptable level.

- Policy 29 refers to protection of environmental quality. It states that development will not be permitted if it would be liable to have an unacceptable effect on either people's health and safety or the environment by:
  i. releasing pollutants into water, soil or air, either on or off site; or
  ii. from smoke fumes, gases, dust, smell, noise, vibration, light or other polluting emissions.

Emerging Vale of Glamorgan Local Development Plan (LDP)

2.6 The Vale of Glamorgan Council is currently preparing a new LDP for the area. To date, a draft Preferred Strategy was published for public consultation in 2007. The draft strategy sets out the land use and settlement policy for the Vale of Glamorgan and strategic planning polices. The draft strategy aims to ensure that development in the Vale of Glamorgan makes a positive contribution to reducing the impact of and mitigating the effects of climate change and to locate development in areas that are not prone to flood risk.

Consultation

2.7 Consultation with the Environment Agency and the Local Planning Authority has been undertaken and this has been used in the development of the conceptual models outlined in this report.

2.8 In terms of flood risk, Arup started consultation with the Environment Agency in 2007 and agreed the approach of undertaking a Strategic Level Flood Study for the whole site rather than producing individual Flood Consequences Assessments. The Strategic Level Flood Study (Appendix H1) was issued to the Environment Agency in March 2008. The EA responded favourably to the assessment in May 2008, providing specific requirements and proposed planning application condition regarding the minimum development level.

2.9 Arup have also consulted with the Vale of Glamorgan and Environment Agency regarding the geo-environmental conditions at the site and the risk to the water environment. A number of meetings took place in November and December 2007 to discuss the desk study and conceptual models for each site and agree the proposed site investigation. The subsequent Geo-environmental reports were issued to these both the EA and VoG in June, 2008, November 2008 and February 2009, further consultation regarding the technical details with the EA is ongoing. The VoG have stated that they will not comment on the reports until the masterplan has been finalised.

2.10 Arup have also consulted with the Environment Agency and Dwr Cymru Welsh Water (DCWW) regarding the surface water and foul drainage on site between 2007 and 2008. The EA's requirements regarding surface water drainage has been taken into account. The consortium commissioned DCWW to undertake a hydraulic modelling exercise dealing with the foul drainage on the site, discussions with DCWW are still ongoing.

3.0 Assessment Methodology & Significance Criteria

Assessment Methodology

3.1 In assessment of the water environment, significance of the potential impact from the project takes account of sensitivity and magnitude. The sensitivity relates to the ability of the environment to absorb any change without alteration to the baseline. The magnitude is related to the scale, extent and persistence of the potential impact.

3.2 No standard criteria for the assessment of significance is available for the water environment. The criteria outlined in Tables H.1 – H.3 below have been compiled from a number of sources.

3.3 For the purpose of this assessment it is assumed that the significance classification will refer to the lowest risk as being a negligible significance and that neutral significance criteria is not used.

3.4 There are very minor differences between the red line boundary submitted as part of the planning application and those which are shown within the geotechnical reports which are appended to this chapter. It is not considered that the marginal differences in site boundary, which relate to existing highway infrastructure, has any impact upon the assessment made nor on the conclusions drawn within this ES.

Sensitivity to Change	Sensitivity Criteria Examples			
	Water Quality	**Groundwater**	**Water Interest Ecology**	**Flood Risk**
High	Surface water source used for public water supply; Surface water abstraction on/adjacent to site. Waterbody of very good chemical/biological quality (GQA definition) Designated bathing waters, salmonid and shellfish fisheries	Ground water used for public water supply Designated aquifer, groundwater Source Protection Zone (SPZ) 1 or 2 of a Public Water Supply (PWS); Ground water providing significant baseflow volume to local rivers. Nitrate Vulnerable Zones	Within or adjacent to a Site of Special Scientific Interest, Natura 2000 site, Ramsar site Ecosystem/habitats highly vulnerable to changes in water quality/quantity	Flood Zone C2 – Area of floodplain without significant flood defence infrastructure.
Medium	Waterbody of good or fairly good chemical/biological quality (GQA definition) Surface water abstraction within 2 km downstream of site	Minor aquifer with intermediate vulnerability; Within SPZ 3 (total catchment) of a Public Water Supply Moderate groundwater abstraction for private use; Contributes to baseflow to local rivers.	Sites important for water dependent Biodiversity Action Plan habitats/species Sites of recognised county or regional level importance for biodiversity e.g. Local Nature Reserves, County Wildlife Sites Ecosystem/habitats moderately vulnerable to changes in water quality/quantity	Flood zone C1 – Areas of floodplain which are developed and served by significant infrastructure, including flood defences.
Low	Waterbody of fair chemical/biological quality (GQA definition) No surface water abstractions.	Minor aquifer of low vulnerability; No SPZ but private water supplies present Minor groundwater abstractions for private use; River flows are predominately from runoff.	Sites with records of water dependent Biodiversity Action Plan habitats/species Ecosystem/habitats with low sensitivity to changes in water quality/quantity	Flood Zone B – Areas known to have flooded in the past evidences by sedimentary deposits.
Negligible	Waterbody of poor or bad chemical/biological quality (GQA definition) No surface water abstraction.	Non or Minor (or Unproductive) aquifer with unclassified vulnerability; No groundwater abstractions present; No groundwater baseflow contribution to rivers.	Sites with no records of water dependent Biodiversity Action Plan habitats/species Ecosystems/habitats independent of water quality/quantity	Flood Zone A – Considered to be at little or no risk of flood or tidal / costal flooding.

Table H1 Matrix for Determining the Sensitivity of the Receiving Environment

Magnitude of Change	Criteria	Description and example
High	Loss/Creation of attribute	Loss/Creation or fundamental change to physical features (e.g. water channels) hydrology or water quality
		Loss of designated site species/habitats features Major change in the water quality (GQA) of a watercourse Significant change in flood risk and consequences of that risk on and off site Significant pollution to aquifer
Medium	Effect on or partial loss of attribute	Material (but notfundamental), short to medium term changes to physical features, hydrology or water quality
		Material change in flood risk (+/- 1:200 year probability) /consequences on site Moderate changes to water chemical/biological quality that may contribute to changes in long term quality status Significant changes to species/habitats features on designated sites Reduction in the economic value of the feature.
Low	Minor changes/effects on the attribute	Measurable (but not material) and transitory changes to the physical features, hydrology or water quality
		Changes in extent/distribution of species/habitats features that do not affect their viability Predicted changes to water chemical/biological quality not likely to alter long term quality status Measurable changes in flood risk that are not greater than 1:200 year probability
Negligible	Impact on the identified attribute is of insufficient magnitude to affect the use / integrity	No perceptible changes to the hydrology, water quality or hydrogeology

Table H2 Criteria for Assessing Impact Magnitude

Magnitude of Change	**Sensitivity to Change**			
	High	**Medium**	**Low**	**Negligible**
High	Major	Moderate to Major	Minor to Moderate	Negligible
Medium	Moderate to Major	Moderate	Minor	Negligible
Low	Minor to Moderate	Minor	Negligible to Minor	Negligible
Negligible	Negligible	Negligible	Negligible	Negligible

Table H3 Matrix for Determining the Significance of Impacts on Water Resources

4.0 Baseline Conditions

4.1 The site setting, topographical, geological, hydrogeological conditions at the Application Site are presented below. This baseline gives further details regarding the history of the site presented in Chapter I and summarises the findings of the following site studies:

- Ove Arup and Partners (2008) Waterfront Barry – Arno Quay, Geotechnical and Risk Assessment Report, June 2008.
- Ove Arup and Partners (2008) Waterfront Barry – West Pond, Geo-Environmental Site Investigation: Report, September 2008.
- Ove Arup and Partners (2008) Waterfront Barry – South Quay, Geo-Environmental Site Investigation Report, November 2008.
- Ove Arup and Partners (2008) Waterfront Barry – East Quay, Geo-Environmental Site Investigation Report, November 2008.
- Ove Arup and Partners (2007) Waterfront Barry Strategic Level Flood Study, November 2007 (see Appendix H1).

4.2 The geotechnical reports can be viewed on the Arup CD attached to Chapter D.

Location and Description

4.3 The site is located to the south-west of Barry Town Centre in the Vale of Glamorgan at National Grid Reference ST 124 675. The Arno Quay, East Quay, West Pond and South Quay areas of Waterfront Barry are some 43Ha in size. The areas are located north, east, west and south of Barry Dock No 1.

4.4 The Arno Quay site is situated within the North Quay of Barry No 1 Dock. The site is currently vacant and features two quay projections into the harbour. The projections are at an elevation of between 7.8m and 8.2AOD and the site itself varies between 8.2m and 14.5m AOD. However, the majority of the site is between 7.0m and 8.5m AOD, the lower areas are located along the sides of an old Graving Dock whilst the higher levels are situated along Ffordd-y-Mileniwm in north.

4.5 East Quay is located on the east side of the former Barry Dock No 1. The area of the site is approximately 3.7Ha and is currently an unused area of land south of Ffordd-y-Mileniwm. An old Graving Dock runs through the centre of the site; another graving dock to the north was backfilled in the 1990's. Topographical information shows that the site varies in level between 6.4m and 11mAOD, with the majority of the site being between 7.0m and 8.5mAOD.

The lower areas are located along the sides of the Graving Dock whilst the higher levels are situated along Ffordd-y-Mileniwm in the north.

4.6 West Pond and South Quay are located to the west and south of the dock. Topographical information shows that site levels of South Quay typically vary between 8.0m and 8.5m AOD although specific areas along the quay walls in the southwest corner are lower, varying between 7.7m and 8.0m AOD. West Pond levels generally vary between 8.0m and 8.75m AOD, although site levels rise to between 9.5m and 11.0m AOD in the western corner, and in stockpiled mounds in the central area; levels vary between 7.7m and 8.0m in the southwest corner and along the dock revetment in the east.

Geology and Hydrogeology

4.7 The following sections summarise the geology, ground conditions and hydrogeology for individual development areas. The groundwater vulnerability map for the area shows that Arno Quay, East Quay, South Quay and the majority of West Pond are non-aquifer, with the south-west area of West Pond is shown as a Minor Aquifer. Two groundwater abstraction points are present within 1.5km of the site, one at Barry Island some 500m to the south-east of West Pond another to the south of Barry Dock No 2, some 600m to the south-east of East Quay.

4.8 There are Geological SSSI's located along the coastline over 400 metres from the site. It is considered that there are no likely significant effects of works on the application site, given the distance together with the presence of the existing Barry Island developments in between, and as such the SSSI's have not been assessed any further in this chapter.

Arno Quay

4.9 The published geological map shows that Arno Quay is underlain by made ground. The made ground overlies alluvium - although this is absent in the northern area of Arno Quay. The underlying bedrock is the Penarth Group, with Blue Anchor Formation shown in the east.

4.10 The ground investigation confirmed the presence of made ground overlying alluvium in the south, which –in turn - rests on Penarth Group bedrock. The thickness of made ground typically varies between 1.8m and 3.2m but thins to 0m on the bank in the north the fill is deeper beneath the projections. The made ground typically comprises firm sandy gravelly clay and medium dense clayey sand gravels, clayey gravelly cobbles and clayey gravelly sand. The underlying alluvium varies in thickness from 0m to the north to 3.5m in the south and consists of a soft to firm sandy gravelly clay. The underlying Penarth Group bedrock was found to consist of layers of stiff clay, very weak or weak mudstone and weak becoming strong siltstone with depth.

4.11 A typical cross-section of Arno Quay is presented in Figure ESH1. Groundwater was encountered in the made ground, alluvium and bedrock. The nearest licensed abstraction is some 900m to the south of the site, with the other located some 1500m to the south-east with Barry No 1 dock in between. Taking into account their position in relation to the site and the presence of the dock, the abstraction are not considered critical receptors to potential contamination from this site. The analysis of groundwater monitoring results and encountered ground conditions suggests the presence of two groundwater bodies:

- groundwater within made ground, alluvium, weathered mudstone in the northern part of the site encountered at between 1.5 and 8.9mbgl (5-8.2 mAOD) with monitored levels typically 2.5-5.2 mgbl (6.7 to 8.2 mAOD). Generally, groundwater flows in the southern direction, towards the dock. The groundwater near the southern edge of the site is expected to be in hydraulic continuity with tidal dock waters. This is indicated by changes in monitored groundwater levels within boreholes BH1B and BH2 between monitoring events from 2.2 and 4 mbgl (5.5 to 7 mAOD). This may be due to the aged joints within masonry lining of the dock wall. This shallow groundwater may also be migrated into the underlying siltstone through the hard fill of the dock walls.
- groundwater within siltstone was encountered at 7.6-10 mbgl (-0.5 to 2 mAOD) on only two occasions. This could indicate water accumulation within fractured areas of siltstone and a discontinuous character of this water body.

4.12 An assessment of the groundwater contamination results has indicated that the shallow groundwater is contaminated with inorganics and hydrocarbons at levels above the applicable EQSs. The site is currently vacant and covered in grass. The proposed development will introduce areas of hardstanding and buildings. This is expected to result in a significant decrease of the infiltration through the subsurface which has been taken into account in the assessment. The detailed groundwater risk assessment shows that the identified contaminants of concern in the groundwater underlying the site do not pose a significant risk to the dock water quality. Therefore no remediation of contaminated groundwater is proposed.

East Quay

4.13 The published geological map shows East Quay lies on made ground resting on alluvium. The bedrock below the majority of the site is Mercia Mudstone Group, although Blue Anchor Formation is shown in the north-west corner of the site.

4.14 Site investigations indicate that the depth of fill and alluvium varies across the East Quay Site. In the north, the fill and alluvium are relatively shallow, typically up to 5.6m thick. The thickness of fill between the two graving docks deepens to between 3m and 8.2m, the alluvium also thickens to between 1.6m and 6.1m. Further east and south the fill thickness extends to up to

12.7m and the Estuarine Alluvium thickens to between 6.3m and 18.1m, the alluvium also contains a band of peat up to 0.9m thick. These superficial deposits are underlain by Mercia Mudstone in the central and southern areas and Blue Anchor Formation in the north. The fill is typically loose to medium dense clayey gravelly sand and firm silty gravelly clay. The Estuarine Alluvium is a very soft and soft organic silty clay with bands of silty sand/sandy silt. The Mercia Mudstone Bedrock is typically a very weak to weak becoming strong siltstone and mudstone. The Blue Anchor Formation is moderately weak to moderately strong mudstone.

4.15 The conceptual hydrological model for East Quay is shown in Figure ESH2. The main groundwater re-charge is via rainfall infiltration directly into the site. Limited groundwater recharge is expected from the hills to the north and north-west due to low permeability of mudstones of the Penarth Group. The railway line -(which runs along the hillside in a cutting) and its drainage system is expected intercept some of the groundwater. The area between the railway line and the docks is relatively flat, with no major groundwater movement expected. The groundwater is likely to be locked between the two docks with a hydraulic gradient present just on the edges of the site. In addition, the dock wall was found to be in very poor condition, facilitating the dock water ingress. The nearest licensed abstraction is some 600m to the south-east of the site, with Barry No 2 Dock in between, the other abstraction is located some 1000m to the south with Barry No 1 dock in between. Taking into account their position in relation to the site and the presence of the dock, these abstractions are not considered critical receptors to potential contamination from this site.

4.16 During the site investigation, groundwater strikes were encountered in the made ground in the north or within alluvium in the area of plots in the south approximately between 2mbgl and 4mbgl (4mAOD and 5mAOD). Groundwater levels were monitored on six occasions; monitored levels across the site were typically between 3mbgl and 5mbgl (4.5mAOD and 5.5mAOD). The groundwater monitoring results indicate that the groundwater underlying the site is static, with occasional discharge in the dock.

4.17 The analysis of groundwater monitoring results and encountered ground conditions and contamination indicates the presence of a single groundwater body. The investigation at the East Quay site indicated that the site has a single groundwater body within made ground in the north and alluvium in the south. There is also groundwater within mudstone. The groundwater is contaminated (mainly with inorganics) at levels marginally above the applicable EQSs. The groundwater risk assessment has revealed that the majority of the identified contaminants of concern in the groundwater underlying the site do not pose a significant risk to the docks water quality. Copper, sulphates and ammoniacal nitrogen have been measured at concentrations with a potential for adverse impacts on the dock water quality. Simple remedial measures in relation to copper contamination are required e.g. the removal of a hot spot of highly leachable copper contamination in the area of EQTP57. Sulphate

concentrations have been found lower than within the dock water and therefore no further action is required. Ammoniacal nitrogen within groundwater is a result of peat / organic matter decomposition process and therefore no further action is required.

West Pond

4.18 The made ground across the majority of the site is underlain by Estuarine Alluvium, however the alluvium is absent in the south-eastern area. The superficial deposits are underlain by the St Mary's Well Bay Formation and the Penarth Group.

4.19 The investigations indicate that the southern area of West Pond consists of 0.4-1.1m of fill overlying bedrock. The thickness of fill in the central area increases to between 4.8m and 11.6m, overlain by between 10.4m and 21.4m of alluvium. Further north, the fill thickness reduces to between 6.2m and 7.7m, the alluvium thickness also reduces to between 0m and 7.6m. The fill material is typically a loose to medium silty, ashy, coaly sand and gravel including slag fragments. The alluvium is typically very soft to soft silty clay/sand clayey site with occasional sand layers and traces of peat. The bedrock consists of limestone and siltstone.

4.20 The West Pond site comprises the infilled former tidal estuary of the Cadoxton River. The ground rises to the north and north-west of the site, eventually reaching an elevation of about 75mAOD, some 66m higher than the site. To the south and south-east, tidal inlets of Barry Harbour and Whitmore Bay are present. Barry No.1 Dock has a coping level of about 8mAOD and adjoins the north-east part of the site. The ground elevations of Barry Island to the south-east are typically between 12mAOD to 17mAOD.

4.21 The conceptual hydrogeological model for West Pond is shown on Figure ESH3. Groundwater re-charge is via rainfall infiltration into the hillside to the north as well as into the site an adjoining areas. The Severn Estuary, with a mean level close to Ordnance Datum, provides an obvious base level for groundwater discharge. On this basis, a hydraulic gradient across the site approximately from north to south would be anticipated.

4.22 The hillside to the north and north-west is largely urban. It is estimated that this may limit rainfall infiltration to perhaps 30% to 40% of the corresponding "green field" value. Infiltrating water will penetrate the underlying strata According to the published geology plan, there is no cover of superficial material on the hillside, other that the "head" or weathered profile of the bedrock. The strata comprised Porthkerry and St Mary's Well Bay Formations of the Lower Lias. Both formations consist of alternating limestones and calcareous shaly mudstones. These formations are separated by a comparatively thin band of Lavernock Shales. The dip of the beds is towards the south at about 5°.

4.23 Rainwater is unlikely to infiltrate beyond the near-surface weathered zone. This is because the beds dip out of the hillside and the un-weathered strata are expected to be tight and impervious. Consequently, groundwater will gravitate downhill towards the south.

4.24 The Lower Lias strata pass downwards into low-permeability Triassic mudstones which underlie the West Pond site. They include dark grey mudstones of the Penarth Group, grey-green mudstones of the Blue Anchor Formation and red-brown mudstones of the Mercia Mudstone Group. Occasional thin sandstone, siltstones and limestones occur with the Penarth Group and Blue Anchor Formation.

4.25 Low permeability estuarine silts (alluvium) of the former Cadoxton River tidal estuary overlay the Triassic mudstone, with a top layer of made ground within the West Pond site. The made ground is mostly industrial wastes that are mainly granular and expected to be significantly more permeable that the alluvium or underlying mudstones.

4.26 From the overall hydrogeological regime, it is expected that a water table would exist in the made ground beneath the site, transmitting groundwater from the hillside to the north and discharging to the Severn Estuary via Barry Harbour.

4.27 The nearest licensed abstraction is some 500m to the south-east of the site, the other abstraction is located some 1800m to the east with Barry No 1 dock in between. The conceptual hydrogeological model demonstrates that the location of these abstractions are not in the direction of flow of groundwater. Consequently, they are not considered as critical receptors to potential contamination from the site.

4.28 During the site investigation, strikes were encountered in the made ground between approximately 3mbgl and 6mbgl (4mAOD and 5mAOD) and in alluvium typically between 10mbgl and 12 mbgl (-1mOD and 3mAOD). At the majority of locations the ground has been identified as being saturated all the way down to the rock. Groundwater levels were monitored on six occasions between May and July 2008. The monitored levels across the site were typically between 3mbgl and 5mbgl (4.5mAOD and 5.5mAOD).

4.29 The ground water monitoring results indicate that the groundwater within the made ground, particularly within the former pond area, is perched over the estuarine alluvium, without evidence of discharge in to the Severn Estuary. The groundwater levels in this part are constant at between 3mbgl and 4mbgl (4.6mAOD and 5mAOD). This may indicate that groundwater is trapped within made ground over less permeable alluvium, between the dock quay - originally built as a dam across the former Cadoxton River channel and the causeway.

4.30 Within the mudstone sequence, individual thin beds or bands of fractured limestone, sandstone or siltstone are confined by the overlying mudstones and estuarine clays and stilts. Such thin beds may be capable of transmitting

groundwater under pressure, but it is likely that these flow paths are interrupted by the Cold Knap Fault which brings up to Mercia Mudstone Group on its south side.

4.31 The analysis of groundwater monitoring results are encountered ground conditions and contamination suggests the presence of a single groundwater body.

4.32 The overall hydrogeological regime described above may be modified locally by the presence of Dock No. 1 and Barry Island. The dock water level is typically held between 3mAOD and 6mAOD.

4.33 Depending on the relative elevation of the water table in the made ground, a hydraulic gradient towards the dock may exist locally. In that case, groundwater and be expected to flow locally from the made ground into the dock.

4.34 The higher parts of Barry Island consist of Lower Lias strata comprising alternating limestones and mudstones. Locally, rainwater infiltrating these strata may generate groundwater flows towards the site.

4.35 The ground investigation has groundwater remedial targets derived with respect to the dock water and using available environmental standards. The groundwater risk assessment with respect to the encountered groundwater contamination on the site indicates that the majority of the hydrocarbon contamination encountered in the former tank farm area is in excess of these target values, and consequently remedial action is required.

4.36 Monitoring and sampling of the dock water indicates that the levels of hydrocarbon based contamination under the current site conditions (i.e. an undeveloped site with little or no hardstanding to prevent infiltration) are either:

- below analytical detection limits, or
- less than the applied environmental standards

Therefore, under present worst case conditions, there is no discernible adverse impact upon the dock waters from the contamination encountered. Therefore no widespread remediation of the hydrocarbon contamination encountered in the tank farm area is considered necessary. However, evidence of free product has been encountered in a number of locations; it is therefore recommended that this continuing source is removed to ensure the minimisation of future risks to:

- the adjacent dock water and;
- to site end users in areas where free product has been encountered.

At these locations, excavations down to the contaminated strata will be undertaken, and any free product encountered skimmed off. The recovered free product should be disposed at a landfill that accepts hazardous waste. Validation sampling and testing will be undertaken to confirm that the

remaining hydrocarbon contamination is below remedial targets in relation to human health.

South Quay

4.37 The published geological plan shows that the northern and eastern part of the site is underlain by the Penarth Group. The south-western part of the site overlies the St Mary's Well Bay Formation and the south-west corner by the Lavernock Shales formation. The solid strata is lies below made ground with Estuarine Alluvium in the northern part of the site.

4.38 The investigation indicates that the ground conditions beneath the southern area of the South Quay consist of 0.1-2.9m of made ground overlying limestone and siltstone bedrock. In the north, the fill thickness increased to up to 15.6m, above a layer of alluvium up to 9.4m thick. The alluvium is predominately cohesive although sand layers are present in places. The alluvium overlies a 0.3-2.0m layer of clayey gravel above limestone and siltstone bedrock.

4.39 The South Quay site is located on Barry Island. The area of South Quay was created by cutting the cliff southwards and backfilling the northern area to create the dock and to achieve current ground level.

4.40 To the south of the site, the cliff of Barry Island bounds the site with an elevation of between 17 and 26 mAOD, some 9 to 18m higher than the site. Barry No.1 Dock, with a quay level of about 8 mAOD, adjoins the northern part of the site. The higher parts of Barry Island consist of Lower Lias strata (St Mary's Formation and Lavernock Shales) comprising alternating limestones and mudstones. The dip of the beds is towards the south at about 5° to 8°. However, rainwater infiltrating these strata may generate local groundwater flows towards the site.

4.41 The conceptual hydrological model for South Quay is shown on Figure ESH4. The main groundwater re-charge is via direct rainfall infiltration into the site. The dock adjacent to the northern edge of the site provides an obvious base level for groundwater discharge. On this basis, an hydraulic gradient across the site approximately from south to north is expected. Groundwater from the western end of the site is expected to flow into the West Pond area and to eventually discharge to the dock or Barry Harbour.

4.42 The nearest licensed abstraction is some 500m to the south of the site, the other abstraction is located some 1100m to the east with Barry No 1 dock in between. The conceptual hydrogeological model demonstrates that the location of these abstractions are not in the direction of flow of groundwater. Consequently, they are not considered as critical receptors to potential contamination from the site.

4.43 The site investigation found possibly very shallow rockhead in the southern part of the site which is conjectured to dip towards the dock firstly very gently (in the former cliff area) and then, in the northern part, steeply reaching some -5 mAOD, as shown on Figure 5. Rainwater is unlikely to infiltrate beyond the near-surface weathered zone. This is because the unweathered strata are expected to be tight and impervious. Consequently, groundwater is generally expected to gravitate towards the dock. In the area of the former cliff line, groundwater is perched over shallow bedrock and will move slowly towards the dock, firstly feeding into the main groundwater body within the made ground underlying the northern part of the site.

4.44 Made ground (consisting mainly of clayey gravels), overlies a discontinuous layer of alluvium and a layer of weathered mudstone, (generally recovered from the cable percussive holes as gravel) over mudstone of the Penarth Group. The made ground consists largely of reworked natural material.

4.45 The site investigation identified groundwater in the made ground typically between 3 and 5m bgl (4 – 5 mAOD) in the area nearer the dock, between 2 and 4m bgl (5 – 6 mAOD) in the central part of the site and 0 and 2m bgl (7 – 8 mAOD) in the former cliff area. These levels are based on water strikes within boreholes and trial pits. Groundwater levels were monitored between May and July 2008 during six monitoring rounds of the standpipes installed in boreholes. The monitored levels were typically 2 – 4 mbgl (4.5 – 5.5 mAOD) along the quay side and at around 1.5m bg; (6.5 mAOD) in the central part of the site. As discussed in Section 2.5, the dock water level may vary between 3 and 6 mAOD, and during the monitoring rounds it was measured between 4 and 5.5 mAOD.

4.46 Free product of significant thickness (up to 3m) was found within SQBH2 during the groundwater monitoring. The presence of free product caused a localised depression in the groundwater table, resulting in groundwater levels being significantly lower than encountered across the central part of the site. Therefore the level of free product within SQBH2 below will be taken into account for further hydrogeological risk assessment.

4.47 The monitoring results indicated that the groundwater levels within the boreholes located along the dock wall are strongly controlled by the level of water within the dock.

4.48 Groundwater beneath the site was found to be saline with elevated concentrations of sodium and chloride.

4.49 The analysis of groundwater monitoring results and encountered ground conditions and contamination indicates the presence of a single groundwater body. No double water strikes were encountered during the investigation and no continuous strata of very low permeability was encountered which would act as an aquitard.

4.50 The groundwater quality assessment and the hydrogeological conceptual model indicated that there is potentially a significant risk to the quality of dock water from contamination found in the area of the former tank farm. However, no significant contamination was found in groundwater beneath the quay side, on the entry to the dock. Nonetheless, free product was found within SQBH5 located on the quay side.

4.51 Monitoring and sampling indicated that groundwater beneath the former tank farm area was affected by hydrocarbon contamination (including free product). This free product (up to 3.05m thick) has been encountered on the site, and this will require remediation as it will be acting as a source term for both soils and groundwater contamination; it also presents a direct risk to site end-users. Although no significant contamination was found within groundwater leaving the site, it is proposed to ensure that this situation remains by undertaking remediation that meets the remedial targets (both for soils and groundwater) protective of the dock water. The free product is expected to be acting as a source term for groundwater and soil contamination on the site. In these locations it is recommended that excavations down to the contaminated strata are undertaken, and any free product encountered is skimmed off. The recovered free product will be disposed at a landfill licensed to accept hazardous waste. Validation sampling and testing should be undertaken to confirm that the remaining hydrocarbon contamination is below remedial targets.

Drainage and Flooding

4.52 The Application site, consisting of Arno Quay, East Quay, West Pond and South Quay are all unused site with little or no active drainage. Remnant surface works drainage is still present in parts of West Pond and South Quay from the previous uses of the site.

4.53 A positive drainage system,(installed in the 1990s) exists around the capped landfill facility present on East Quay. Surface water drainage was also installed within Cory Way on East Quay and Y Rhodfa on Arno Quay with spurs leading into the proposed development areas with outfalls discharging into the adjacent dock. The majority of rainwater on Arno Quay, East Quay, West Pond and South Quay currently infiltrates into the made ground.

4.54 The Environment Agency has stated in draft planning conditions that no infiltration of surface water into the ground should be permitted, to prevent pollution of controlled waters. Positive drainage will therefore be required to convey flows from roofs, roads and hardstandings for discharge into Barry Docks No.1.

4.55 The Environment Agency have confirmed that since the drainage will be discharged into the dock, there would be no greenfield/brownfield run-off rate requirements. However, there will be a situation during an extreme flood where storm water flows will be tide locked and storage will be required to

accommodate such a scenario. The proposed drainage network is shown on Figure ESH8.

4.56 Existing foul gravity and rising main drainage pipes are present within West Pond, Arno Quay and East Quay, these transmit flows from existing development to the foul drainage network. Consultation with DCWW has been ongoing for some time, they have undertaken hydraulic modelling of the foul network and have indicated that capacity is available in the existing foul network providing that an existing storm overflow culvert from Broad Street is diverted away from the existing 450mm foul pipe. They have proposed that a new 1350mm diameter pipe is laid across West Pond that connects the Broad Street overflow to the Barry Island Trunk Sewer located south of the site. Consultation regarding this work is ongoing. Due to existing levels and the length of foul drainage required, gravity sewers will not be able to transmit flows from most of South Quay and all of East Quay, pumping stations will be required at these locations.

4.57 The site is on the coastline and has the potential for tidal inundation during an extreme event. The TAN15 Development Advice Map shows that the majority of the sites are within Zone B, see Figures ESH5. Some areas of Arno Quay, East Quay and South Quay are in Zone A, other areas of East Quay and land along the dock walls at Arno Quay, West Pond and South Quay are shown within Zone C2.

4.58 The principle of undertaking a strategic flood study prior to detailed development proposals being available was discussed at meetings with the Environment Agency. The appropriate flood and development levels, taking into account a 100 year design life and projected sea level rises during that period was discussed and agreed with the Environment Agency. The design level of the development to provide protection for a 0.5% tidal (1 in 200 year) event is 8.868mAOD. Figure ESH6 shows the potential flood pathways together with areas of the site currently below this threshold level. The strategic level flood study for the project is included in Appendix 1

4.59 The principle of raising the site to or above this extreme flood level has been discussed and agreed with the Environment Agency, this applies to the finished floor levels of building and new roads. A secondary flow-path from the west of the site could be influenced by a surge event from Barry Harbour. A quantity of water from this shorter term wave event could be transmitted across the car park and beneath the railway viaduct and reach the western area of West Pond. The potential for both an extreme high tide and surge event occurring at the same time is unrealistic. To assess a surge event, a combination of stillwater levels and wave heights was taken into account by using a joint probability analysis. To prevent a possible surge being transmitted into the western area of West Pond; it has been agreed that ground levels immediately to the east of the viaduct structure is raised to 9.34mAOD, the Environment Agency require this to be a general ground level raise rather than to a local bund, see correspondence within Appendix H1.

4.60 To allow movement within the site during a flood event, all new roads will also be raised above the 1 in 200 year extreme flood level of 8.868mAOD, this is in accordance with the requirements of TAN15. To allow access/egress to/from the site, the existing access points will need to be used. To ensure that the off-site access roads do not flood by more than 0.6 during an extreme event, local lengths of Y Rhodfa and Cory Way roads may need to be raised by up to 0.2m and 0.4m locally to ensure emergency access during an extreme flood event.

4.61 To provide such flood protection across East Quay, West Pond and South Quay, ground levels will need to be revised, typically by 0.5 – 1.0m. The ground conditions across West Pond and East Quay contain significant thicknesses of highly compressible Estuarine Alluvium which will consolidate when loaded. To preconsolidate the alluvium, surcharging is proposed across much of West Pond and East Quay which require the importation of additional volumes of material.

4.62 In total, it is estimated that some 40,000m^3 of suitable material will need to be brought onto site to fill and surcharge. The majority of this material will need to be imported during the first few months and placed in the Phase 1 area. It is also proposed to move some 30,000m^3 from the existing site for use as filling and surcharging onto Phase 1 area. Once the surcharging is complete, much of this volume will then be moved to subsequent phases of development in West Pond, South Quay and East Quay.

5.0 Potential Impacts

Introduction

5.1 Significant environmental effects could arise from site development without mitigation, these will include loss of groundwater quality and quantity, impacts to surface water quality and impacts from flooding.

5.2 The potential effects that may occur as a result of the development during the construction and operational phases are summarised in the following sections, are outlined in this section during, mitigation measures will be addressed in the subsequent section of this chapter.

Impacts During Construction and After Completion

Contamination of surface water and groundwater from construction activities

5.3 There will be a large amount of construction activity across the site with potential contamination risk to both groundwater and surface water.

5.4 Activities such as vehicle operations may lead to potential spillages/leakages of contaminants which may impact on the dock water and groundwater. Migration of contaminated groundwater during treatment could also have indirect impact surface water receptors.

5.5 The dock water volume is large, the yield of the aquifer is low and as stated in Section 4, the location of existing abstractions are not in the direction of flow of groundwater. Overall the sensitivity is therefore considered to be Low to Medium and the impact magnitude is considered to be Low to Medium.

5.6 The impact is considered to be of **Minor to Moderate Adverse Significance** prior to the implementation of mitigation measures.

Migration of contaminated groundwater in the made ground and impacts to the underlying aquifers and dock water

5.7 The made ground within South Quay and within a perched groundwater in both South Quay and parts of West Pond is contaminated with hydrocarbons. There is a potential for this contamination to migrate into the adjacent dock and existing aquifers within granular alluvial layers and the underlying bedrock. Flows from the perched water table may migrate into the dock through the dock walls and revetment. The perched water table is generally confined by low permeability alluvial bands, but these layers are sometimes absent in West Pond and much of South Quay.

5.8 The dock water is a large water body and recharged regularly by the opening and closure of the dock gates. The yield of the aquifer is low and as stated in Section 4, the location of the existing abstractions are not in the direction of

flow of groundwater. Contaminated groundwater is only present across parts of the site. Overall the sensitivity of the dock water and groundwater is therefore considered to be Low to Medium and the impact magnitude is considered to be Low to Medium due to varied contamination of the groundwater in the made ground.

5.9 The impact on the dock water and groundwater in the Alluvial aquifer beneath the site is considered to be of **Minor to Moderate Adverse Significance** prior to the implementation of mitigation measures.

Migration of contaminants due to ground improvements and/or piling on site

5.10 There is potential for creation of containment mitigation pathway from the made ground into the underlying aquifers by the use of piled foundations and possibly the use of ground improvement measures such as band drains.

5.11 The yield of the aquifer is low and as stated in Section 4, the location of the existing abstractions are not in the direction of flow of groundwater. The sensitivity of the groundwater is therefore considered to be Low to Medium. The impact magnitude is considered to be Low to Medium due to the variable contamination of the made ground.

5.12 The impact of potential contamination arising from the made ground on the groundwater beneath the site is considered to be of **Minor to Moderate Adverse Significance** prior to the implementation of mitigation measures.

Flood Risk

5.13 The Strategic Level Flood Study shows that the flood zones vary across the sites from Zone A, B, C1 and C2. The topographical information shows that much of West Pond, South Quay and East Quay are below the development level agreed with the Environment Agency of 8.868mAOD. Prior to undertaking mitigation measures, the sensitivity of the receiving environment resulting from flood risk for the majority of the site is **High**. The impact magnitude is considered to be **High**. The impact of flooding across the development is considered to be of **Major Adverse Significance** prior to the implementation of mitigation measures.

6.0 Mitigation Measures

Introduction

6.1 The development proposals for this site include mitigation measures to ensure the protection of the water environment both during construction and operational phases. Key mitigation measures include source removal of free product contamination within the groundwater and raising the site to above the agreed flood level.

6.2 Hydrocarbon contamination in the form of free product within the perched water table has been encountered within both West Pond and South Quay. Excavations down to the contaminated strata will be undertaken, and any free product encountered skimmed off. The recovered free product should be disposed at a landfill that accepts hazardous waste. Validation sampling and testing will be undertaken to confirm that the remaining hydrocarbon contamination is below remedial targets in relation to human health

6.3 Much of the site is currently below the extreme flood level, see Figure ESH6 and mitigation measures consisting of raising ground levels of the development up the 0.5% tidal (1 in 200 year) flood level of 8.868mAOD has been discussed and agreed with the Environment Agency, this relates to buildings and roads, landscaped areas may be at a lower level. To prevent a possible surge being transmitted into the western area of West Pond; it has been agreed that ground levels immediately to the east of the viaduct structure is raised to 9.34mAOD, the Environment Agency require this to be a general ground level raise rather than to a local bund. The proposed levels across the site are shown on Figure ESH7

6.4 To provide such flood protection across East Quay, West Pond and South Quay, ground levels will need to be revised, typically by 0.5 – 1.0m. The ground conditions across West Pond and East Quay contain significant thicknesses of highly compressible Estuarine Alluvium which will consolidate when loaded. To preconsolidate the alluvium, surcharging is proposed across much of West Pond and East Quay which require the importation of additional volumes of material. In total, it is estimated that some 40,000m^3 of suitable material will need to be brought onto site to fill and surcharge. The majority of this material will need to be imported during the first few months and placed in the Phase 1 area. It is also proposed to move some 30,000m^3 from the existing site for use as filling and surcharging onto Phase 1 area. Once the surcharging is complete, much of this volume will then be moved to subsequent phases of development in West Pond, South Quay and East Quay.

Impacts During Construction

Contamination of surface water and groundwater from construction activities

6.5 There are likely to be a number of contractors operating on different parts of the site during construction, detailed mitigation measures will be developed as part of the construction plan in accordance with appropriate best practice.

6.6 A site Construction and Environmental Management Plan (CEMP) will be developed including a site environmental and health and safety management policy to mitigate construction risks. General rules apply to site works to ensure that no significant impact to identified receptors will occur during construction. Best practice recommendations for the prevention of contamination will be outlined in the detailed Construction Environment Management Plan (CEMP) and Site Waste Management Plan (SWMP) both of which will be developed and discussed with the Local Authority and Environment Agency, prior to commencing construction.

6.7 The position and extent of working areas shall reflect surrounding areas and works being carried out. The contractor shall appraise the suitability of such working areas in this respect as part of working method statements.

6.8 The measures applied should conform to the pollution prevention guidance note, good practice guide for handling soils, control of groundwater, sustainable water management and environmental good practice as listed in to the guidance documents outlined in Section 2 of this chapter.

Migration of contaminated groundwater in the made ground and impacts to the underlying aquifers and dock water

6.9 Development of the site will ultimately result in significant areas of roads, hardstandings and roofs will result in a significant reduction in rainwater permeating into the ground and recharging the perched water table.

6.10 Site remediation includes source removal of the free product encountered in areas of West Pond and South Quay, together with excavation and bio-remediation or source removal of contaminated soils. This will result in a significant reduction in contamination across the site that could impact on the dock water and ground water within the underlying aquifers.

6.11 Site specific issues which will need to be considered include temporary surface water and pollution management measures, which will be required to avoid migration of the free product contamination during the remediation works.

6.12 The remediation measures will consist of ex-situ bioremediation and removal of grossly contaminated material and free product groundwater. Details of the remediation measures are not covered within this ES chapter since the details will depend on the method of construction to be employed by the chosen contractor. However, the remediation contractor will need to obtain the

appropriate Environmental Permits from the Environment Agency and will need to submit his working method for approval. Broad principles will apply in all cases, not least the pollution prevention guidance notes (PPG series) referred to in Section 2 together with the implementation of Construction Environmental Management Plans (CEMP).

Migration of contaminants due to ground improvement and/or piling on site

6.13 Due to the presence of made ground and thick layers of soft, highly compressible alluvium beneath the majority of West Pond and parts of South Quay, Arno Quay and East Quay, piled foundations will need to be utilised. In addition, parts of West Pond and East Quay will need to be pre-consolidated by surcharging. Pre-consolidation periods could be accelerated by the use of band drains taking into the underlying Estuarine Alluvium.

6.14 The formation of piled foundations and band drains could result in preferential pathways for contamination migration into the underlying aquifers. The use of specific piling techniques such as Continuous Flight Auger (CFA) or bored piles will also result in volumes of soil which may need to be treated or removed from site.

6.15 To reduce the risk of such pathways developing and to avoid having to deal with significant volumes of material, the use of driven piles is being considered across the site. Such piles, when driven into soft, highly compressible alluvium tend to seal the pile sides and prevents migration from occurring. The final method of piling is however to be agreed with the regulators in due course.

6.16 The use of band drains must be avoided as these will inevitably produce a pathway between the made ground and underlying aquifers.

Flood Risk

6.17 Areas of the site are below the extreme flood level and are at risk of flooding during the construction period. Mitigation of flood risk during construction will be achieved by early development of temporary flood bunds adjacent to the dock and the specific area identified in the west which is at risk of flooding from a surge event. The work will involve raising the site level along the eastern site of West Pond, the northern side of South Quay and western areas of East Quay at or above 8.868mAOD as development of those phases proceed. The site levels around the western areas on West pond will also be raised at or above 9.34mAOD to protect the development areas from a possible surge event. Such bunding may be used in conjunction with measures to prevent site run-off from discharging into the dock.

Impacts After Completion

Migration of surface runoff from the developed site into the dock

6.18 The new surface water drainage system will pick-up rain water from roads, roofs and hardstandings and transmit flows through the drainage network and discharge into the dock. Trapped gullies and interceptors will be incorporated into the design which will prevent contamination migration from the new drainage network into the dock. The proposed drainage network is shown on Figure ESH8.

Migration of contaminated groundwater in the made ground and impacts to the underlying aquifers and dock water

6.19 The remediation measures include source removal of free product contamination within the groundwater in the made ground together with bio-remediation of contaminated soils. This will result in a significant reduction in the contamination across the site that could impact on dock water and ground water. Furthermore, the provision of roads, hardstandings and roofs across much of the site will reduce the amount of rainwater permeating into the ground that could recharge the perched water table.

Flood Risk

6.20 In accordance with the Strategic Level Flood Study, development levels will be raised above the extreme flood level to prevent the site from flooding, see Figure ESH7. The raised areas will include development plots and access roads, however, landscaped areas may be formed beneath the extreme flood levels.

6.21 The drainage design incorporates measures to attenuate storm water drainage during an extreme tidal flood when outfalls will be tide locked for a specific period. The drainage system will be oversized so that storm water will be stored within the system during the period of high tide when discharge into the dock from the drainage network is not possible. This will prevent flooding occurring from surcharged drainage. The proposed drainage network is shown on Figure ESH8.

7.0 Residual Impact Assessment

Introduction

7.1 Following the identification of the mitigation measures, re-assessment has been undertaken to identify residual impacts on the water environment. A summary of the residual impacts is outlined in the tables below.

Impacts During Construction

7.2 The impacts, mitigation and residual risk during the construction phase are summarised in Table H.4.

Environmental Topic	Description of Impact		Description of Mitigation Measures	Description of Residual Impact	
	Description	Significance		Description	Significance
Hydrology, Hydrogeology and Drainage: Construction Impacts	Contamination of surface water and groundwater from construction activities	Minor to moderate Adverse, Direct, Temporary, Medium-Term	Use of a CEMP and best practice to control run off and infiltration of contaminants	Contamination of surface water and groundwater from construction activities	Negligible, Adverse, Direct, Temporary, Medium-Term
Hydrology, Hydrogeology and Drainage: Construction Impacts	Migration of contaminated water from the made ground and impacts to groundwater and dock water	Minor to moderate Adverse, Direct, Temporary, Medium-Term	Control and source removal during construction	Migration of contaminated water from the made ground and impacts to groundwater and dock water	Minor, Beneficial, Direct, Permanent, Medium-Term
Hydrology, Hydrogeology and Drainage: Construction Impacts	Migration of contaminants due to piling and ground improvement	Minor to moderate, Adverse, Direct, Temporary, Medium-Term	Potential use of driven piles and avoidance of band drains	Migration of contaminants due to piling and ground improvement	Negligible, Adverse, Direct, Permanent, Medium-Term
Hydrology, Hydrogeology and Drainage: Construction Impacts	Flood Risk	Major, Adverse, Direct, Temporary, Short-Term	Land raising and temporary bunding	Flood Risk	Negligible, Adverse, Direct, Temporary, Short-Term

Table H4 Summary of impacts, mitigation and residual risk during construction phase

Impacts After Completion

7.3 The impacts, mitigation and residual risk during the operational phase are summarised in Table H.5.

Environmental Topic	Description of Impact		Description of Mitigation Measures	Description of Residual Impact	
	Description	Significance		Description	Significance
Hydrology, Hydrogeology and Drainage: Operational Impacts	Migration of surface runoff from the developed site	Minor to moderate Adverse, Direct, Permanent, Long-Term	Drainage network with storage to deal with tide locked scenario	Migration of surface runoff from the developed site	Negligible, Adverse, Direct, Permanent, Long-Term
Hydrology, Hydrogeology and Drainage: Operational Impacts	Migration of contamination from the made ground and impacts to groundwater and dock water	Minor, to Moderate, Adverse, Direct, Temporary, Medium Term Long Term	Remediation and source removal during construction, development of hard standing and reduction in infiltration	Migration of contamination from the made ground and impacts to groundwater and dock water.	Minor, Adverse, Direct, Permanent, Long-Term
Hydrology, Hydrogeology and Drainage: Operational Impacts	Migration of contaminants due to piling and ground improvement	Minor to moderate, Adverse, Direct, Temporary, Long Term	Potential use of driven piles and avoidance of band drains	Migration of contaminants due to piling and ground improvement	Negligible, Adverse, Direct, Permanent, Long-Term
Hydrology, Hydrogeology and Drainage: Operations Impacts	Flood Risk	Major to Negligible, Adverse, Direct, Permanent, Long-Term	Land rising and drainage attenuation measures to be implemented across the site	Flood Risk	Minor, Beneficial, Direct, Permanent, Long-Term

Table H5 Summary of impacts, mitigation and residual risk during operational phase

8.0 Summary and Conclusions

8.1 The site lies along the dockside of Barry Docks and there is a long history of industrial use which has resulted in ground and groundwater contamination. Large areas of the site are below the extreme flood levels.

8.2 The geology varies across the site, but generally consists of made ground overlying cohesive and granular alluvium (sometimes absent) overlying bedrock. Most of the sites are classified as non-aquifers although part of West Pond is considered a minor aquifer. There are no water courses on the site, but there are a number of old discharges transmitting flows into the adjacent dock.

8.3 The main risk to water resources posed by the development is the presence of contamination within the made ground together with a contaminated perched water table. There is a potential for flows to migrate into the dock water and into underlying aquifers. The other significant risk of flooding due to low lying nature of much of the site.

8.4 A number of mitigation measures are proposed as part of the works to control the risk of pollution during construction and operation of the development. These include remediation of the made ground and source removal of grossly contaminated material and free product, together with the potential use of driven piles to mitigate the potential for pathways to be developed.

8.5 A positive drainage network will also be installed to transmit storm water flows into the dock and reduce infiltration into the ground.

8.6 The development levels of new roads and residential/commercial units will be raised to prevent the risk of flooding.

8.7 Following mitigation, residual impacts will be significantly reduced and are considered to have a minor or negligible effect on the water environment.

9.0 Abbreviations

- DCWW – Dwr Cymru Wesh Water
- EA- Environment Agency
- EQS – Environmental Quality Standards
- Ha - Hectares
- m - metres
- mAOD – metres Above Ordnance Datum
- mbgl – metres below ground level
- VoG – Vale of Glamorgan

10.0 References

Relevant Legislation:

- Environment Protection Act 1990
- The Water Resources Act (1991)
- The Environment Act (1995)
- Groundwater Regulations 1998
- The Land drainage Act (1999)
- The Water Environment (Water Framework Directive) (England and Wales) Regulations (2003)
- The Water Act (2003)
- The Private Water Supplies Regulations (1991)
- UK Water Supply (Water Quality) Regulations 2000 and 2001
- Water Resources (Environmental Impact Assessment) Regulations 2003
- Water Resources (Abstraction and Impounding) Regulations 2006
- Pollution Prevention and Control Act 1999
- Environmental Impact Assessment (Land Drainage Improvement Works) Regulations 1999
- Land Drainage Act 1991
- Public Health Act 1848
- Control of Pollution Act 1974
- Control of Pollution Regulations 1996
- Pollution Prevention and Control (England and Wales) Regulations 2000
- Anti Pollution Works Regulations 1999
- EC Dangerous Substances Directive (76/464/EEC)

Relevant codes of practice:

- BS5930: 1990 Code of Practice for site investigations
- BS EN 1997 Eurocode 7 Geotechnical Design
- BS EN 1997-1:2004: General rules
- BS EN 1997-2:2007: Ground investigation and testing
- BS1377-9 (1990) Standard methods of laboratory testing for civil engineering purposes
- ISRM (1985) Rock characterisation methods
- BS6031: 1981 Code of Practice for earthworks
- BS8004: 1986 Code of Practice for foundations
- Policy and Practice for the Protection of Groundwater, 1992, Environment Agency.

Relevant guidance documents:

- Environment Agency Pollution Prevention Guidance Notes (PPG series)
- Good Practice Guide for Handling Soils (MAFF 2000)
- CIRIA 113 Control of Groundwater for Temporary Works,1988
- CIRIA 630 Sustainable water management in land use planning, 2006
- Environmental Good Practice on Site, CIRIA

Planning Policy

- Planning Policy Wales (PPW) (2002)
- Technical Advice Note (TAN):15 Development and Flood Risk. (2004)
- Adopted Vale of Glamorgan Unitary Development Plan (UDP) 1996-2011

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- Ove Arup and Partners (2008) Waterfront Barry – Arno Quay, Geotechnical and Risk Assessment Report, June 2008.
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- Ove Arup and Partners (2008) Waterfront Barry – East Quay, Geo-Environmental Site Investigation Report, November 2008.
- Ove Arup and Partners (2007) Waterfront Barry Strategic Level Flood Study, November 2007.