

Barratt, Persimmon,
Taylor Wimpey

Waterfront Barry

Strategic Level
Flood Study

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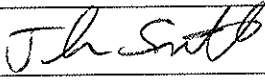
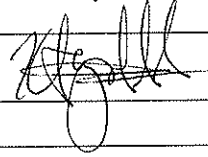
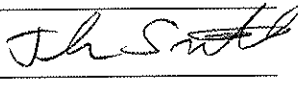
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1 Introduction

A Consortium consisting of Barratt, Persimmon and Taylor Wimpey propose to redevelop the Waterfront Barry for mixed uses. The proposed development will include areas known as Arno Quay, East Quay, South Quay and West Pond area around the former Barry No 1 Dock. Ove Arup and Partners have been appointed to undertake a Strategic Level Flood Study for this area. The aim of the study is to provide a high level document that can be referred to in addressing the requirements of Technical Advice Note 15: Development and Flood Risk (TAN 15) for the outline planning application prior to development details being made available.

The Waterside Barry area is relatively low lying and is located along the northern, eastern, western and southern edges of the former Barry No 1 Dock. The TAN 15 Development Advice Map shows that the majority of the sites are within Zone B with some areas in Zone A and others within Zone C2.

TAN 15 provides technical guidance which supplements the policy set out in Planning Policy Wales (PPW) in relation to development and flooding. The purpose of the document is to provide a framework within which risks arising from both river and coastal flooding, and from additional run-off from development in any location, can be addressed. Accompanying Development Advice Maps (DAM's) produced by the Welsh Assembly Government (WAG) provide initial guidance on flood risk and classify sites into zones, which rate flood risk based on historical events. TAN 15 aims to ensure that all proposed development in Wales is directed away from areas at high risk of flooding in order to all new development to be sustainable. All new development sites within the flood plain must be tested in line with TAN 15 to assess flood risk, which is the purpose of this Strategic Level Flood Study.

The Environment Agency (EA) have been consulted and are supportive of providing a strategic level flood study for the site. It is usual practice to consider proposed development plot individually based on building footprints and end use and test against TAN 15. However, due to the large number of development plots on this site and the uncertainty at initial stages regarding development footprints, it was agreed with the EA that a strategic level flood study was more appropriate.

2 Existing Site and Surrounds

The site is located to the south-west of Barry Town Centre in the Vale of Glamorgan at National Grid Reference ST124 675, see Figure FS 01. The Arno Quay, East Quay, West Pond and South Quay areas of Waterfront Barry are some 40Ha in size. The areas are located north, east, west and south of Barry Dock No. 1, see Figure FS 02.

The Arno Quay site is situated within the North Quay of Barry No. 1 Dock, see Figure FS 02 and FS 03 and is currently accessed via Y Rhodfa, a cul-de-sac that serves 40 public car parking spaces. Y Rhodfa is connected to Ffordd Y Mileniwm, the principal distributor road running through the North Quay Waterfront area that runs parallel to the adjacent rail corridor. Barry town centre lies a distance of around 800 metres to the north of the site and is accessed via Gladstone Bridge and Broad Street. The site is currently vacant and features two quay projections into the harbour.

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, see Figure FS 02 and FS 03. Cory Way runs through the eastern area of the site linking to David Davies Road in the south-east. The old Dock No. 1 forms the western boundary, the channel connecting Dock No. 1 and the operational Dock No. 2 is present in the south. An old Graving Dock runs through the central area of the site. Topographical information shows that the site varies in level between 6.4m and 11m AOD. However, the majority of the site is between 7.0m and 8.5m AOD, 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.

West Pond and South Quay are located to the west and south of the dock and are bounded to the south-west by the A4055 Harbour Road and Barry Island Railway; to the north by land adjoining the Vale of Glamorgan Railway Line; to the south by Clive Road and to the east by Barry No. 1 Dock, see Figure FS 02 and FS 03. The site is largely unused, Powell Duffryn Way runs through the eastern side of West Pond, Charles Darwin Way runs along the northern edge of South Quay. 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 and in the south-west 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 south-west corner and along the dock revetment in the east.

The sites can be sub-divided into twenty five separate areas where land constraints are broadly similar, these are shown on Figure FS 03, existing ground levels in these areas are outlined in Table 1. The range of existing ground levels are shown on Figure FS 04.

Barry No. 1 Dock was built in the 1880's, the level of the dock water typically varies between 4.9m and 5.3m AOD. However, dock water levels are influenced by the dock gates located to the south-east. During extreme tide events, the dock gates are opened to prevent gate damage, the high tides are also used to re-charge the dock water levels as there are no significant feeders flowing into the dock.

3 Proposed Development and Study Methodology

The most recent development proposals across West Pond and South Quay is shown on Figure FS 05. The masterplan incorporates some 2000 residential units consisting mainly of two or three stores of housing with some higher-rise apartments together with a food store, hotel, retail units, offices, educational facilities and parkland. New access roads are to be formed across the site. A primary road is to be constructed across West Pond, linking Ffordd-y-Mileniwm in the north-east to Paget Street in Barry Island in the south-west. A new primary road, re-aligning Cory Way/David Davies Way will also be formed along the eastern boundary of East Quay. Secondary roads will also be constructed across West Pond and South Quay, further localised access roads will be formed within the development areas.

The site is on the coastline and has the potential for tidal inundation during an extreme event. The TAN 15 Development Advice Map shows that the majority of the sites are within Zone B, see Figure FS 06. 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.

The principal of undertaking a strategic flood study prior to detailed development proposals being available was discussed at meetings with the EA, see correspondence in Appendix C.

The Environment Agency (EA) have advised that the current still water tide levels (YEAR 2005) for Barry are as follows:

- 7.85m AOD (0.5% tidal event)
- 8.10m AOD (0.1% tidal event)

They have advised that the development should take into account a 100 year design life.

Current planning guidance in Wales predicts mean sea level to rise 5mm/year up to the year 2030 and 7mm/year thereafter. In accordance with TAN 15, the Threshold Frequency for residential, commercial and general infrastructure is 0.5% tidal (1 in 200 year). For a build year of 2010, a 100 year design life and the above sea level rises, the design level of the development should be at or above 8.545m AOD; the 0.1% tidal (1 in 1000 year) level for a 100 year design life would be 8.795m AOD, see Appendix A for full details.

It is noted that the Welsh Assembly Government is currently reviewing the document 'Flood and Coastal Defence Appraisal Guidance (FCDPAG3) Economic Appraisal Supplementary Note to Operating Authorities – Climate Change Impacts', DEFRA October 2006. It is understood that WAG has not signed up to the DEFRA guidance on climate change, however the EA have advised that the application of the DEFRA guidance on climate change is imminent and DEFRA Guidance on sea level rise should be used, i.e. 3.5mm/year up to 2025, 8mm/year between 2025 and 2055, 11.5mm/year between 2055 and 2085, 14.5mm/year between 2085 and 2115. Taking into account the Threshold Frequency for residential and general infrastructure of 0.5% tidal (1 in 200 year), and the Stillwater tide levels (Year 2005) for Barry of 7.85m AOD (0.5% tidal event), the typical build year of the development of 2010, and a 100 year design life, the design level of the development would increase to at or above 8.868m AOD; the 0.1% tidal (1 in 1000 year) level for a 100 year design life would be 9.118m AOD, see Appendix A for full details.

4 Flood Pathways and Assessment

The Barry Docks area is relatively low lying and situated adjacent to the Bristol Channel. There are currently two potential pathways for flooding into the area. The main pathway is through the dock entrance, via a relatively narrow entrance channel and dock gates and into the main body of the dock, see Figure 7. Considering this pathway is relatively narrow, together with a large body of dock water present in front of the development area, there is no need to include any further allowance for surge affects. There is currently a secondary pathway along a specific area in the west, where flows could be transmitted from Barry Harbour and across an existing car park and beneath a road/railway viaduct. The current car park levels are around 8.0m AOD, the area beneath the viaduct is slightly lower. Therefore, there is a potential that extreme flood flows being transmitted over the existing ground, and under the existing viaduct structure and into the site.

Taking into account the methodology set out in the previous sections together with the existing topography of the site, the 0.5% outline in accordance with DEFRA (2006) is shown on Figure FS 08.

The principle of raising the site above the extreme flood levels have been discussed and agreed with the Environment Agency. The site may be raised so that FFL of buildings and new roads are at or above 8.87m AOD.

The 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 short 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 will need to be taken into account by using a joint probability analysis, see Appendix B for full details. The following table summarises the findings of the analysis.

Extreme Sea Level		Wind Generated Wave Height		Q1000 Joint Probability Combined Level (mAOD)
Annual Probability Event	Sea Level (mAOD)	Annual Probability Event	Wave Height (m)	
Q0.1	7.598	Q786.082	0.531	8.129
Q0.16	7.634	Q491.302	0.514	8.148
Q0.5	7.850	Q157.216	0.475	8.325
Q1	7.958	Q78.608	0.443	8.401
Q2	8.061	Q39.304	0.403	8.464
Q5	8.219	Q15.722	0.375	8.594
Q10	8.318	Q7.861	0.350	8.668
Q25	8.488	Q3.144	0.320	8.808
Q50	8.588	Q1.572	0.303	8.891
Q100	8.758	Q0.786	0.282	9.041
Q250	8.908	Q0.314	0.257	9.165
Q1000	9.118	Q0.079	0.217	9.335

To prevent a possible surge being transmitted into the western area of West Pond; it is recommended that ground levels immediately to the east of the viaduct structure is raised to 9.34mAOD, this could be in the form of a local bund or a general ground level raise. The Environment Agency have required that such land raising takes the form of a general ground raise rather than local bund, see correspondence in Appendix C.

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 TAN 15. To allow access/egress to/from the site, the existing access points will need to be used, the existing roads and associated levels are outlined in the below table. To ensure that the off-site access roads do not flood by more than 0.6m during an extreme event, local lengths of Y Rhodfa and Cory Way roads will need to be raised by up to 0.2m and 0.4m locally to ensure emergency access during an extreme flood event.

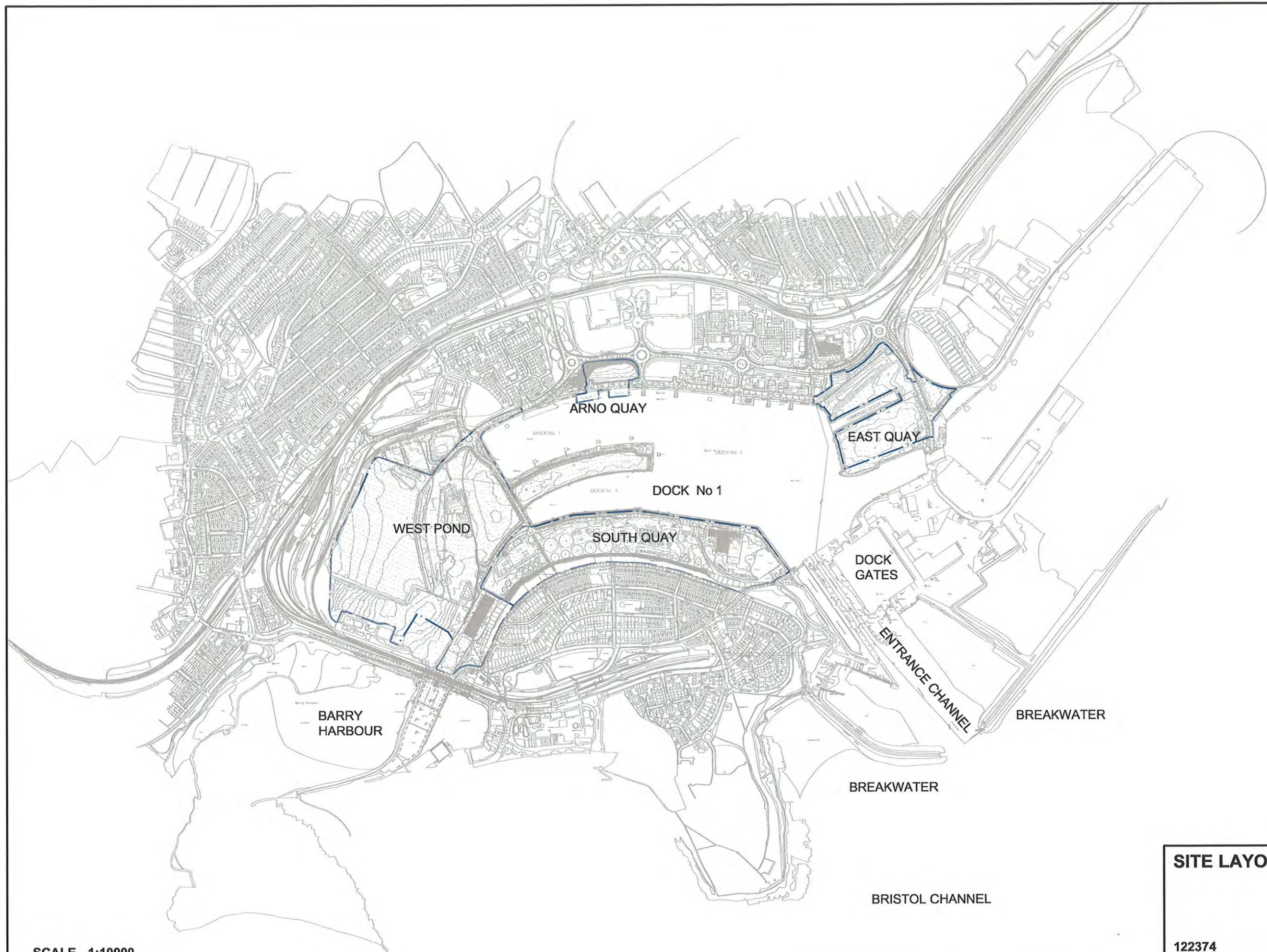
Site Area	Access/Egress Road	Off-site Road Level (mAOD)	Comments
Arno Quay	Y Rhodfa – West/East	8.3 - 8.5	Adjust levels to >8.52mAOD locally
	Y Rhodfa – North-South Ffordd y Mileniwm	8.5 - >9.0 >9.0	
East Quay	Cory Way Ffordd y Mileniwm	8.1 - >9.0 >9.0	Adjust levels to >8.52mAOD locally
West Pond/South Quay	Ffordd y Mileniwm	8.4 - >9.0	Adjust levels to >8.52mAOD locally
	Hood Road	8.4 - >9.0	Adjust levels to >8.52mAOD locally
	Paget Road	>9.0	
	Harbour Road	8.5 - >9.0	

The above assessment has identified that areas of the development site will need to be raised to allow development to proceed. The scale of uplifting varies across the different parts of the site are summarised in Table 1.

5 Summary and Conclusion

This strategic level flood study provides a high level document that can be referred to in addressing the requirements of TAN15 for the outline planning application prior to development details being made available. It considers the topography of the existing site and flood pathways during an extreme event. It proposes that site levels be raised to protect the site from extreme flooding during a 100 year design life, taking into account predicted sea level rises using both TAN15 guidance and the more onerous DEFRA guidance. The site levels typically vary between 7.7mAOD and 8.5mAOD, development levels will need to be raised above 8.868mAOD, new access roads will also need to be raised above this level. The proposed mitigation measures also include providing additional protection along the south-west area of West Pond to protect that area against a potential surge event from a specific pathway from Barry Harbour, beneath an open viaduct. The EA have agreed to this approach, providing this protection takes the form of a general land raise rather than a bund, they have also suggest a relevant planning condition to deal with planning applications, see correspondence in Appendix C. Such measures will protect the development from the risk of flooding for a 100 year design life, taking into account the relevant TAN15 and DEFRA guidance for sea level rises during this period.

FIGURES

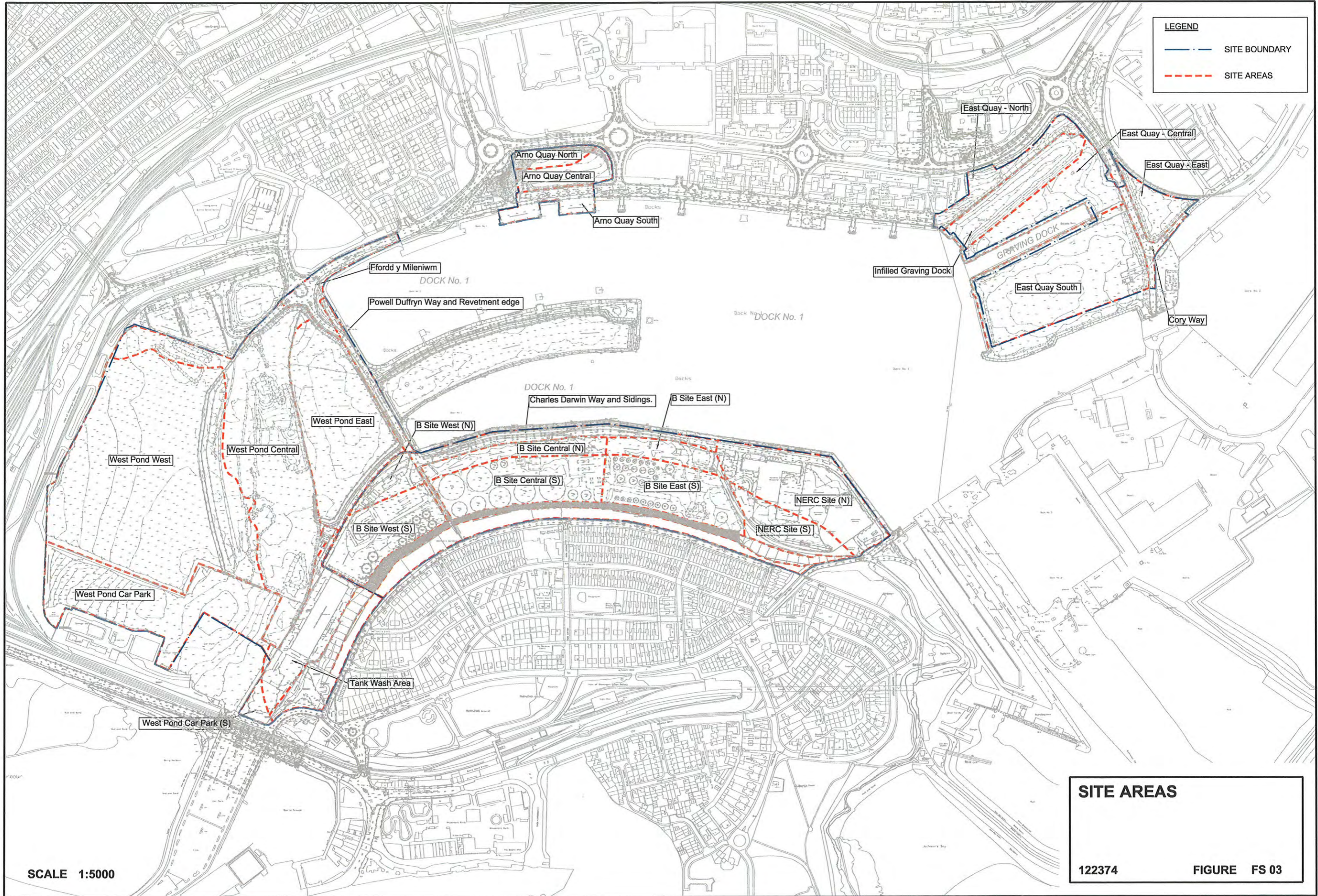


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SITE LAYOUT

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FIGURE FS 02

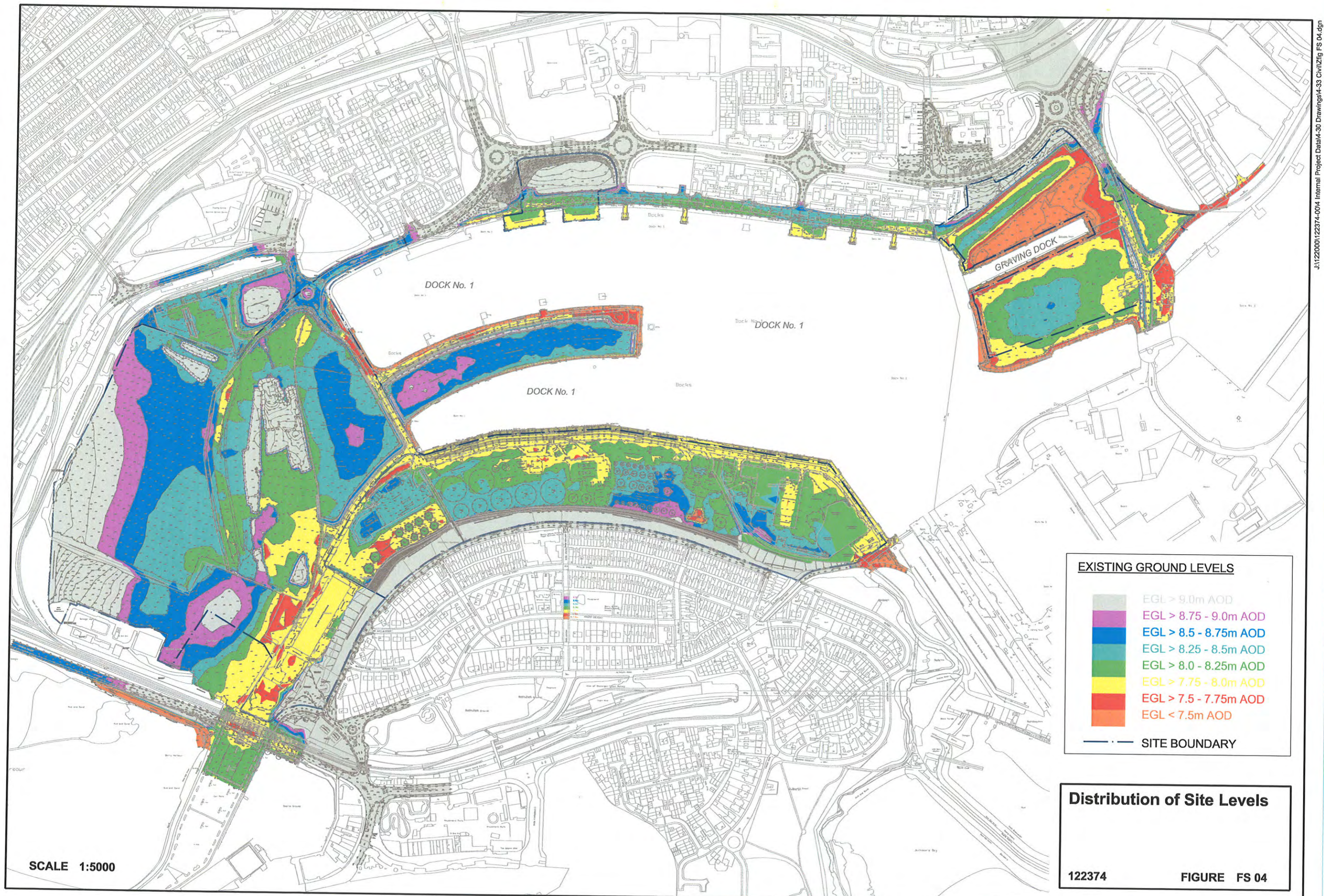


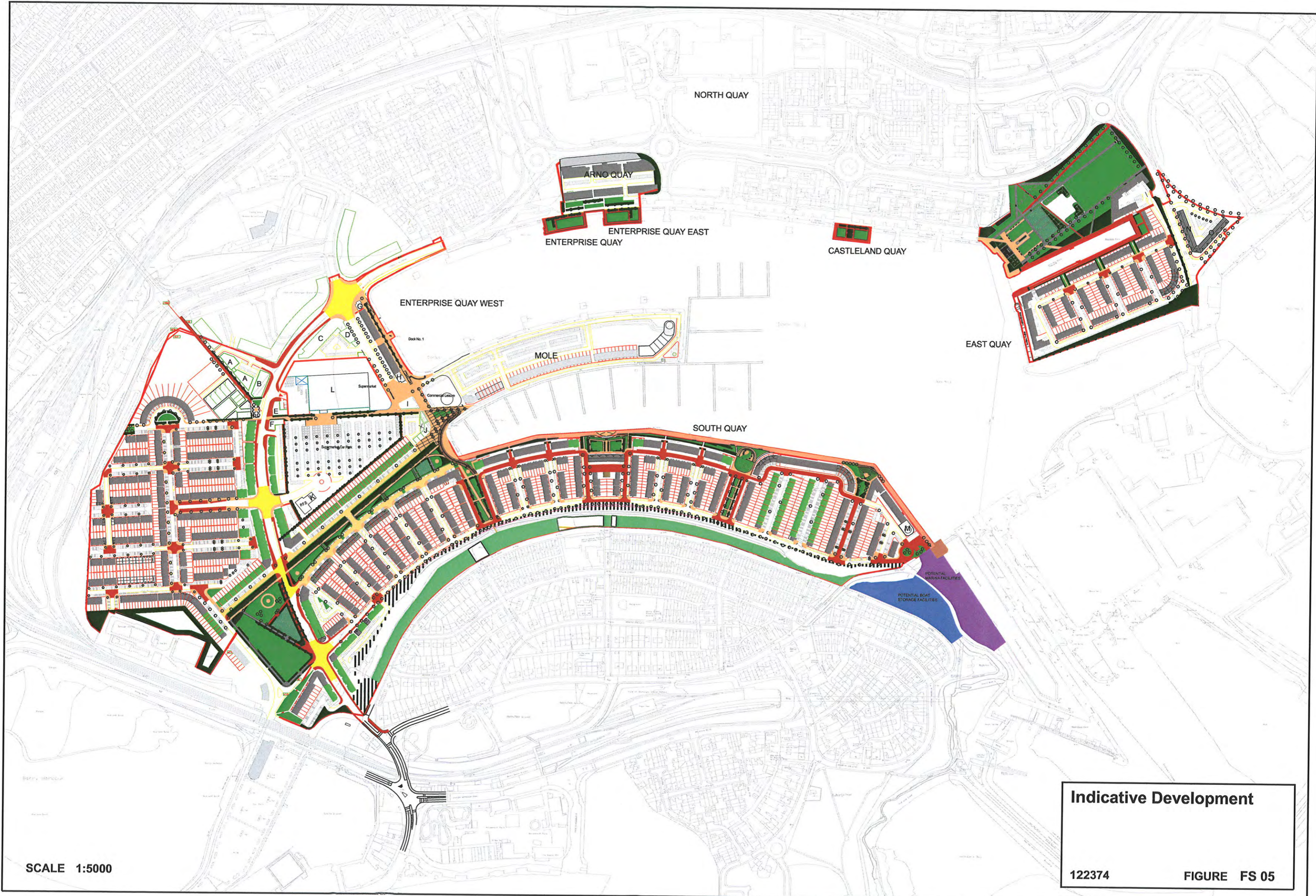
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SITE AREAS

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FIGURE FS 03





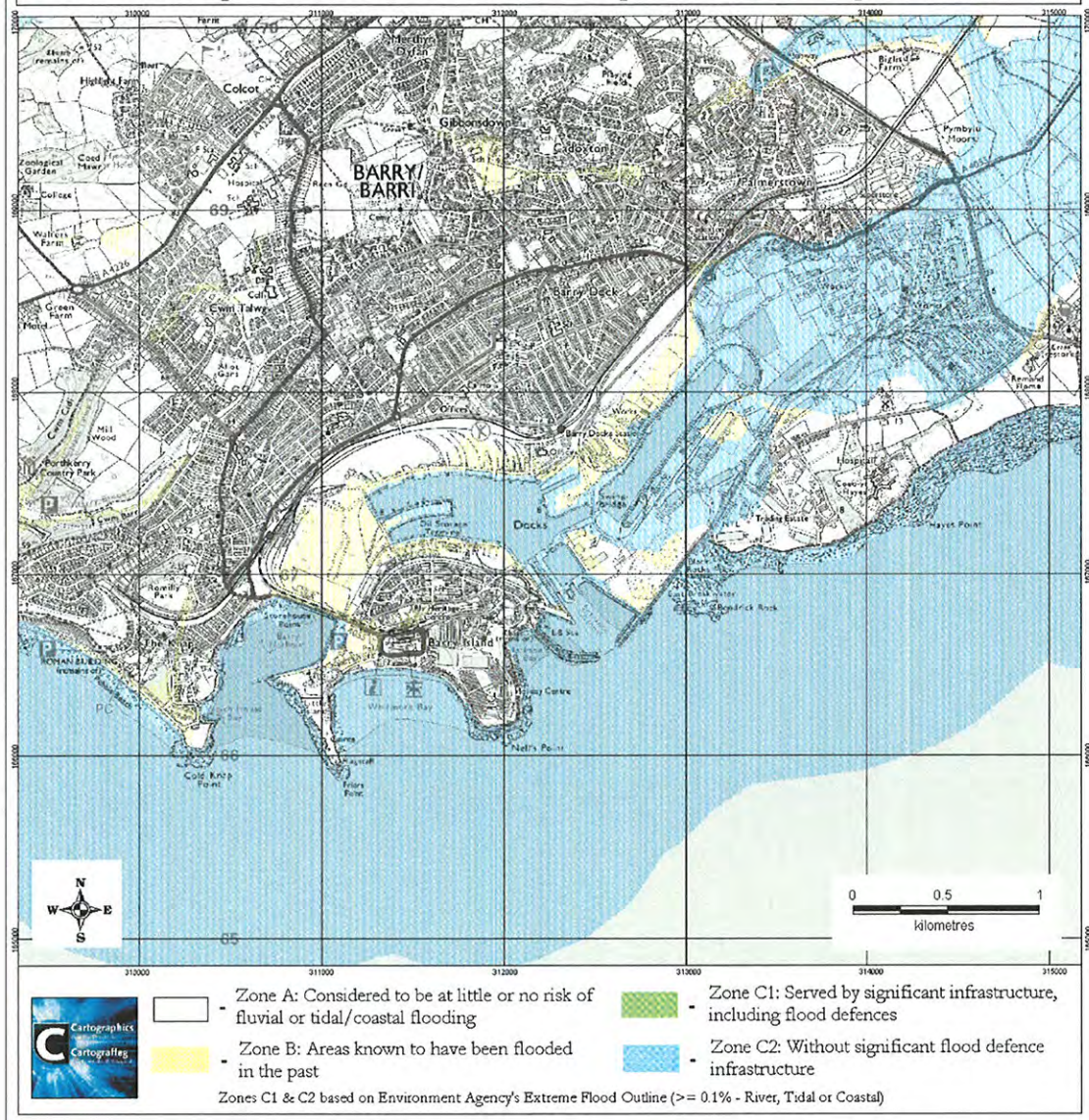
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Indicative Development

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FIGURE FS 05

TAN15 Development and Flood Risk: Development Advice Map ST16NW



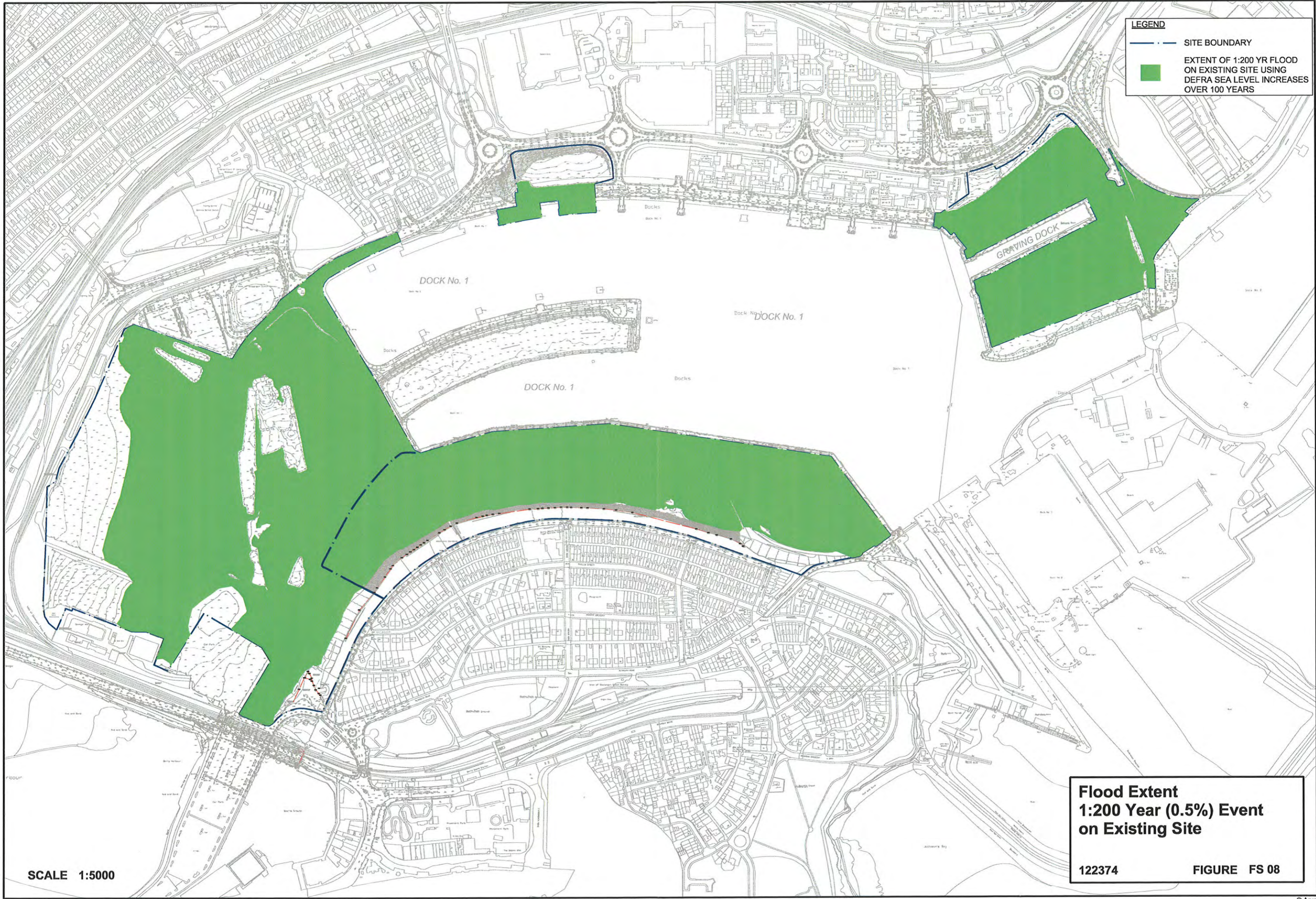
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TAN 15 DAM

SCALE :Use Scale Bar

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FIGURE FS 06



Appendix A

Flood Levels

WATERFRONT, BARRY

Flood Levels

The Waterfront Barry Site is at risk of flooding during an extreme tidal event. The EA have advised that the following stillwater (2005) levels are applicable.

1 in 200 year (0.5%) – 7.85m AOD

1 in 1000 year (0.1%) – 8.1m AOD

Allowances for sea level rises will need to be included during the design life of the development, the EA have advised that a 100 design life should be used.

Current planning guidance in Wales (TAN 15) predicts the mean sea level to rise 5mm/yr up to 2030 and 7mm/yr thereafter.

Assuming development starts around 2010, and a 100 year design life, the following stillwater levels are applicable.

$$1 \text{ in } 200 \text{ year (0.5\%)} = 7.85 + \frac{(5+15) \times 5}{1000} + \frac{85 \times 7}{1000} = 8.545 \text{m AOD}$$

$$1 \text{ in } 1000 \text{ year (0.1\%)} = 8.1 + \frac{(5+15) \times 5}{1000} + \frac{85 \times 7}{1000} = 8.795 \text{m AOD}$$

In future, the EA have advised that DEFRA guidance on sea level rises is likely to be applied, this states the following mean sea level rises:

3.5mm/yr	up to 2025
8mm/yr	2025 – 2055
11.5mm/yr	2055 – 2085
14.5mm/yr	2085 – 2115

Using these estimates, the following stillwater levels are applicable:

$$1 \text{ in } 200 \text{ year (0.5\%)} = 7.85 + \frac{(5+15) \times 3.5}{1000} + \frac{30 \times 8}{1000} + \frac{30 \times 11.5}{1000} + \frac{25 \times 14.5}{1000} \\ = 8.868 \text{m AOD}$$

$$1 \text{ in } 1000 \text{ year (0.1\%)} = 8.1 + \frac{(5+15) \times 3.5}{1000} + \frac{30 \times 8}{1000} + \frac{30 \times 11.5}{1000} + \frac{25 \times 14.5}{1000} \\ = 9.118 \text{m AOD}$$

In accordance with TAN 15, development level for housing should be at or above the 1 in 200 year (0.5%) level. Currently this is 8.545m AOD, but could rise to 8.868m AOD if DEFRA guidance is applied.

The majority of the site is influenced from a tidal event through the dock entrance. The dock entrance includes a narrow breakwater, lock gates and channel, together with the large water body of Dock No 1 and 2. Taking into account these factors, the potential and consequences of a surge event affecting the waterside sites under considerations is considered negligible. However, there is a secondary pathway to the western area of West Pond via Barry Harbour and beneath the Harbour Road viaduct, see pathway on Figure FS07. It is proposed to raise levels to the east of the viaduct to prevent the pathway from effecting the development. The height of such ground raising will need to be at least the 1 in 200 year (0.5%) stillwater level (8.545m AOD or 8.868m AOD). To assess a surge event, a combination of extreme stillwater levels and extreme wave heights will need to be taken into account by using a joint probability analysis.

EA have advised Arup to contact Proudman Oceanographic Laboratory (POL) to obtain a range of stillwater levels for different events. Consultation with POL has resulted in the advice to use the document Dixon and Tawn (1997) Spatial Analyses for the UK Coast, Chapter 9.0 to obtain 1 in 1 year, 1 in 10 year, 1 in 20 year, 1 in 50 year, 1 in 100 year, 1 in 500 year stillwater tide levels.

Using Dixon and Tawn (1997):

The Barry site needs to be located in terms of Figure 9.1 and Table 9.2. O/S Plans and Figure 9.1 shows that the Longitude/Latitude of the site is -3.25, 51.40. Table 9.1 shows the appropriate distance to be 286km and Reference No. 112.

Using Table 9.4, the 1 year level (to MSL) against the distance metric = 6.61m.

The actual stillwater tide level for the various events need to be adjusted in accordance with Table 9.7, 9.10 and 9.12.

	EVENT							
	1	10	25	50	100	250	500	1000
DM Level (Table 9.4)	6.61							
DM Level (Table 9.7)		6.61+0.36 6.97	7.14	7.24	7.41	7.56	7.66	7.78
Trend Adjustment (Table 9.10)	$7 \times 2.04/10^3$ = 0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
Adjustment ODN – MSL	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Stillwater Level (mAOD)	6.774	7.134	7.304	7.404	7.574	7.724	7.824	7.944
Sea Level Rise (DEFRA) – 100 yr	1.018	1.018	1.018	1.018	1.018	1.018	1.018	1.018
Resulting Stillwater Level (mAOD) – 100 year	7.792	8.152	8.322	8.422	8.592	8.742	8.842	8.962

Comparing the 1 in 200 year and 1 in 1000 year level provided by the EA and from Dixon & Tawn (1 in 200 year is interpolated from 1 in 100 and 1 in 250 year levels)

EA 1 in 200 year level = 8.868m AOD
D&T 1 in 200 year level = $8.592 + \frac{2}{3} (8.742 - 8.592) = 8.692\text{m AOD}$

EA 1 in 1000 year level = 9.118m AOD
D&T 1 in 1000 year level = 8.962m AOD

There is a difference of 0.176m and 0.156m respectively, assume average of 0.166m. Adjust levels appropriately.

1 in 1 year extreme level = $7.792 + 0.166 = 7.958\text{m AOD}$
1 in 10 year extreme level = $8.152 + 0.166 = 8.318\text{m AOD}$
1 in 25 year extreme level = $8.322 + 0.166 = 8.488\text{m AOD}$
1 in 50 year extreme level = $8.422 + 0.166 = 8.588\text{m AOD}$
1 in 100 year extreme level = $8.592 + 0.166 = 8.758\text{m AOD}$
1 in 200 year extreme level = 8.868m AOD
1 in 250 year extreme level = $8.742 + 0.166 = 8.908\text{m AOD}$
1 in 500 year extreme level = $8.842 + 0.166 = 9.008\text{m AOD}$
1 in 1000 year extreme level = 9.118m AOD

Appendix B

**Joint Probability
Assessment**

WATERFRONT BARRY - FLOOD STUDY

Assessment of Joint Probability of Flood Risk from Overtopping

1.1 Background

Joint Probability is the probability of two or more conditions occurring at the same time. In terms of coastal engineering, high sea levels coupled with severe wave height conditions can cause the overtopping of coastal structures. Therefore it is necessary to carry out a joint probability analysis in order to determine the probability of these events occurring simultaneously.

This joint probability analysis for a 0.1% Annual Probability Event (Q1000) at Waterfront Barry site has been carried out in accordance with DEFRA/Environment Agency Technical Report 'Use of Joint Probability Methods in Flood Management: A Guide to Best Practice' (March 2005).

1.2 Analysis of Extreme Sea Levels

The analysis of extreme sea levels has been carried out in order to determine the sea level for the Q1000 event at Waterfront Barry site (Please refer to Appendix A of FCA Report). The Environment Agency has advised Arup that the following Stillwater (2005) levels are applicable:

0.5% Annual Probability (Q200) – 7.850m AOD

0.1% Annual Probability (Q1000) – 8.100m AOD

The Environment Agency has recommended that a 100 year design life should be considered for the development and therefore it is necessary to provide an allowance for global warming and sea level rise. In accordance with current planning guidance Technical Advice Note 15: Development and Flood Risk (TAN 15), an allowance for mean sea level rise of 5mm/year up to 2030 and 7mm/year thereafter should be provided per annum over the life of a scheme. The Stillwater Levels in accordance with TAN 15 are as follows:

0.5% Annual Probability (Q200) – 8.545m AOD

0.1% Annual Probability (Q1000) – 8.795m AOD

Environment Agency has also advised that it is likely that the DEFRA guidance on climate change impacts (October 2006) is likely to be applied in Wales in the future. In accordance with DEFRA guidance the increased stillwater levels up to 2110 are as follows:

0.5% Annual Probability (Q200) – 8.868m AOD

0.1% Annual Probability (Q1000) – 9.118m AOD

In order to carry out a joint probability analysis it was necessary to obtain Extreme Sea Levels for an array of Annual Probability events in order to correlate with Wave Height information. This information was estimated using the above and guidance from Dixon and Tawn (1997) (Refer to Appendix A) and shown below in Table 1.1:

Annual Probability Event	Sea Level (mAOD)
1 Year (Q1)	7.958
2 Year (Q2)	8.061
5 Year (Q5)	8.219
10 Year (Q10)	8.318
25 Year (Q25)	8.488
50 Year (Q50)	8.588
100 Year (Q100)	8.758
250 Year (Q250)	8.908
1000 Year (Q1000)	9.118

Table 1.1. Summary of Extreme Sea Levels at Waterfront Barry Site

1.3 Analysis of Wind Generated Wave Growth

Wave generation in coastal regions can often be attributed to wind action on the sea surface. Wind generated waves are often small in comparison with extreme sea levels however when combined with an extreme tidal event they can contribute to overtopping of coastal defences. The Environment Agency has therefore advised Arup to assess the wave height due to wind action simultaneously with Extreme sea level for a Q1000 Joint Probability Event.

Arup obtained Wind speed data for the South Wales coast from the Met Office. The dataset provides a wind frequency analysis based on 10 years of wind speed data between 1998 and 2007. This data is taken from a wind station near St Athan recorded at 49m above sea level. Wind speed data was corrected to 10m above sea level (ASL) within the wave prediction model. This is necessary in order to allow certain assumptions to be made regarding wind conditions. At 10m ASL the wind lies within the constant stress region of the idealised atmospheric boundary layer. Within this region the following assumptions apply:

- The wind flows parallel to the water surface.
- The stress remains constant within the layer.
- The wind velocity is adjusted so that the horizontal frictional stress is nearly independent of height.

The wind speed data clearly indicates that the most frequent winds for all wind speeds above 1.5 m/s are from the West wind direction (250° – 285°). Wind data outside this directional range was disregarded in the extreme wind analysis. Maximum values for wind were extracted from the wind frequency tables considering only wind speed data within the highest 5% limit. This provided a range of wind speeds between 11.5m/s – 24.2m/s (at 49m ASL).

An extreme wind analysis was carried out using the Coastal Design and Analysis System (CEDAS) ACES software. The ACES software is a Coastal engineering numerical analysis software developed to assist the U.S. Army Engineer Waterways Experiment Station. The Extreme wind analysis used the maximum wind data in order to compute wind speed estimates for a range of return periods as shown in Table 1.2. Candidate distribution functions are Fisher-Tippet Type I and Weibull with exponents ranging from 0.75 to 0.2. Please note that the Q1, Q250 and Q1000 Probability Events have been interpolated by the author from a logarithmic best fit of the data set.

Annual Probability Event	Wind Speed at 49m ASL (m/s)
1 Year (Q1)	21.49
2 Year (Q2)	22.89
5 Year (Q5)	24.75
10 Year (Q10)	26.15
25 Year (Q25)	28.01
50 Year (Q50)	29.41
100 Year (Q100)	30.82
250 Year (Q250)	32.67
1000 Year (Q1000)	35.48

Table 1.2. Annual Probability Events for Extreme Wind Speeds

An analysis of wave height was carried out for the array of wind speed Annual Probability Events using the ACES Wind Adjustment and Wave Growth software. Three main parameters for Wave generation are:

- Wind speed – Data for an array of Return Periods derived from Extreme Wind Analysis
- Fetch Length – The length and shape of the body of water over which the waves are generated
- Wind Duration – the duration of constant wind speed and direction for analysis.

Due to the shape of Barry Harbour the fetch length was determined using the restricted fetch method within the ACES software. The restricted fetch method applies the concept of wave propagation in off-wind directions using radial fetch lengths representing the geometry of the basin. The radial fetches were taken at 10° intervals through 360° from True North to provide a suitable representation of the fetch. The effective fetch length determined by the ACES software

was then checked using Saville's Effective Fetch Method. The ACES method provided a marginally longer effective fetch length therefore this was used for the analysis to provide a more conservative wave prediction. The estimated effective fetch length for the restricted shallow water area at Barry Harbour was 720m. See Figure 1.1 for a graphical representation of Barry Harbour fetch geometry.

The wind data obtained from the Met Office is based on hourly averaged wind data and this was therefore used within the ACES model.

Sensitivity testing has been carried out on the wind duration input within the model and it has been found that adjustment of wind duration has no significant difference for this fetch. This suggests that the wave generation is fetch limited due to the short length of the fetch.

The ACES software was used to compute the wind generated wave growth for an array of extreme wind conditions in the Barry Harbour restricted shallow water area as shown in table 1.3. Please note that the Q1, Q250 and Q1000 Probability Events have been interpolated by the author from a logarithmic best fit of the data set.

Annual Probability Event	Adjusted Wind Speed (m/s)	Wave Height (m)
1 Year (Q1)	21.48	0.320
2 Year (Q2)	27.62	0.340
5 Year (Q5)	30.17	0.380
10 Year (Q10)	32.13	0.400
25 Year (Q25)	34.76	0.410
50 Year (Q50)	36.78	0.430
100 Year (Q100)	38.81	0.460
250 Year (Q250)	41.54	0.520
1000 Year (Q1000)	45.75	0.570

Table 1.3. Wind Generated Wave Heights

1.4 Q1000 Joint Probability Study

As stated previously, high sea levels coupled with severe wave height conditions can cause the overtopping of coastal structures therefore Arup have been advised to carry out a joint probability analysis for the Q1000 joint probability event at Waterfront Barry, site.

The probability of the Q1000 Sea Levels occurring at the same time as the Q1000 wave height is extremely low/negligible as neither event are dependent on the other. Arup have carried out a joint probability analysis in accordance with DEFRA/Environment Agency Technical Report 'Use of Joint Probability Methods in Flood Management: A Guide to Best Practice' (March 2005)

in order to determine the extreme sea level probability and wave height probability that combine to provide a Q1000 joint probability event. The technical report indicates that the correlation between wave height and sea level in the Barry Harbour area is modest.

The DEFRA/Environment Agency Technical Report is accompanied by a software tool used for evaluation of joint exceedence extremes in the form of a Microsoft Excel Spreadsheet. This software tool is based on the simplified method set out in DEFRA/Environment Agency Report 'Joint Probability: Dependence Mapping and Best Practice' (2003). This tool was used to determine the combined Extreme Sea Levels and Wave heights for a Q1000 Joint Probability Event for the Waterfront Barry site as shown in Table 1.4.

Extreme Sea Level		Wind Generated Wave Height		Q1000 Joint Probability Combined Level (mAOD)
Annual Probability Event	Sea Level (mAOD)	Annual Probability Event	Wave Height (m)	
Q0.1	7.598	Q786.082	0.531	8.129
Q0.16	7.634	Q491.302	0.514	8.148
Q0.5	7.850	Q157.216	0.475	8.325
Q1	7.958	Q78.608	0.443	8.401
Q2	8.061	Q39.304	0.403	8.464
Q5	8.219	Q15.722	0.375	8.594
Q10	8.318	Q7.861	0.350	8.668
Q25	8.488	Q3.144	0.320	8.808
Q50	8.588	Q1.572	0.303	8.891
Q100	8.758	Q0.786	0.282	9.041
Q250	8.908	Q0.314	0.257	9.165
Q1000	9.118	Q0.079	0.217	9.335

Table 1.4. Q1000 Joint Probability Analysis for Extreme Sea Level and Wave Height

As shown in Table 1.4 the worst case Q1000 Joint Probability Event combines the Q1000 Extreme Sea Level event with a Q0.079 extreme wave height generating an extreme level of 9.335m AOD.

Appendix C

**Environment Agency
Correspondence**



Mr John Smith - Associate
Ove Arup & Partners
4 Pierhead Street
Cardiff
South Glamorgan
CF10 4QP

Ein cyf/Our ref: SE/2007/100881/04-L01
Eich cyf/Your ref: 122374/JS

Dyddiad/Date: 13 May 2008



Annwyl Mr Smith / Dear Mr Smith

DRAFT STRATEGIC LEVEL FLOOD STUDY, WATERFRONT BARRY

Thank you for your enquiry and following enclosure, which was received on 28 March 2008.

- Waterfront Barry - Strategic Level Flood Study produced by Ove Arup & Partners Ltd, Report Reference 07/7285 (Draft 1) dated November 2007

We wish to respond as follows;

It is evident that the "East and South Quay" sites are partially within zone C2 as defined by the development advice map (dam), referred to under Technical Advice Note 15 (TAN15) (July 2004). In accordance with TAN15, the development category is regarded as highly vulnerable and the TAN states that such developments should not be permitted within zone C2. It also appears that other sites lie entirely within zones A and B, as defined by the development advice map development advice note (dam) referred to under TAN 15.

We would recommend that the proposed mitigation measures indicated in the aforementioned report along the south-west area of West Pond/Barry Harbour that is east of the viaduct structure, is constructed as a landform and not as an earth bund. If it is proposed to construct a "local bund", a breach scenario of this will need to be undertaken to be included in the report, and submitted for further review and agreement.

Notwithstanding the above comments, should a planning application be submitted and if the Local Planning Authority (LPA) were minded to approve then we would recommend inclusion of the following condition in any planning permission granted. This condition would also apply to those sites within zones A and B where existing



ground levels have been established as being below that stated in the condition.

CONDITION: The development levels within the proposed sites must be set to a minimum level of 8.868 mAOD.

REASON: To reduce the risk of flooding

Please be aware that we may wish to make further comments as more details are received in relation to proposals and as related to our other interests e.g. pollution prevention measures.

If you have any further queries, then please do not hesitate to contact me.

Yn ddifffuant / Yours sincerely



Mrs SARA WILKES
Planning Liaison Officer

Deialu uniongyrchol/Direct dial 029 20245091

Ffacs uniongyrchol/Direct fax 029 20362920

E-bost uniongyrchol/Direct e-mail wilkes.Cardiff2.WLS@environment-agency.wales.gov.uk

Job title	Waterfront Barry	Job number
		122374

Meeting name & number	Consultation with EA on Flooding	File reference
		6.30

Location	EA Offices, Cardiff	Time & date
		2.30pm 14 December 2007

Purpose of meeting		
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Present	Johnathan Austin - EA	John Smith - Arup
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Apologies

Circulation	Those present	
	David Peake - WPM	Richard Keough - Persimmon
	Phill Stokes - Persimmon	John Penuluna - Barratt
	Will Phillips - Taylor Wimpey	Craig Jones - HMA
	Ron Das - HMA	
	Gareth Williams - NPL	

Prepared by	John Smith
Date of circulation	17 December 2007
Date of next meeting	TBA

Job title	Job number	Date of Meeting
Waterfront, Barry	122374	14 December 2007

Action

1. JSS provided an update on the progress since the last correspondence in the Summer. The masterplan is currently being developed with a view of submitting an outline planning application for the site next year. JSS presented a current version of the masterplan, it is indicative and likely that further iterations of the masterplan will occur before a version is agreed, this could take some time. Currently, the proposed development predominantly contains residential houses with apartments in places, and a commercial hub consisting of hotel, retail, offices, educational and possible leisure at the north-eastern area of West Pond. There have been discussions regarding submitting detailed planning applications for specific areas, but these plans are currently being reviewed.
2. The previous discussions were based on available topographical information together with a supplementary spot level survey. Since this time, a detailed topographical survey has been undertaken across the site and it's surroundings. In addition, detailed consultation has taken place with ABP to confirm the dock gate operational requirements during a flood. The topographical survey showed that site levels typically varied between 7.7m and 8.8m AOD although specific areas were higher whilst isolated areas are lower, particularly the area of land around East Quay where levels drop to 6.4m AOD.
3. EA had previously advised on the current extreme flood levels, as outlined on correspondence received from Kayna Tregay on the 26th February 2007. Arup had used this information to calculate the extreme design levels to be utilised for the development, taking into account future estimated sea level rises and a 100 year development design life, as advised by the EA. The levels are discussed in Arup's correspondence dated 25th June 2007, showing the following:-
 - Design level of development (0.5% tidal event) using TAN 15 sea level rises over 100 years \geq 8.535m AOD
 - Design level of development (0.5% tidal event) using DEFRA sea level rises over 100 years \geq 8.753m AOD

Arup asked what was the current view regarding which sea level rises estimation that should be applied. JA indicated that whilst TAN 15 rises were currently being used, it is likely that the application of DEFRA rises is imminent, JA advised that these levels should be used for any assessments submitted.

Arup

The assessment to date confirms that the pathway through the dock gates in the south-east is the primary route of flooding to the sites being considered. Whilst protection could theoretically be formed on land in the south east, the dock gates are lower and ABP open the gates during a flood event to prevent damage. Consequently, there is no protection during an extreme event. Considering the dock entrance area is relatively narrow and the Dock No 1 and 2 areas are large and contain a significant surface area, the effect of a surge event along this pathway is considered negligible.

Job title	Job number	Date of Meeting
Waterfront, Barry	122374	14 December 2007

Action

The topographical survey has identified a secondary pathway for a flood event from the west of West Pond from the tidal Barry Harbour located to the west. A road and railway embankment is present along the western boundary of West Pond, the latter is well above the extreme flood level. However, in the extreme south-west, the road and railway are on a viaduct for a width of some 90m, the road and car park beneath and to the west of the viaduct is at a typical level of 8.0m AOD. Consequently during an extreme flood event higher than 8.0m AOD, there is a pathway for flooding areas of West Pond. It is also possible that a higher surge event could be transmitted into Barry Harbour, and could extend beneath the viaduct. Arup suggested that an allowance of a further 0.6m above the extreme tide level could be used to deal with a surge event, JA indicated that surges could be higher, but are notoriously difficult to estimate, advise that we research published information and discuss further.

Arup

4. Whilst the secondary pathway in the west could be protected by forming a bund at the western boundary of the site or raising general levels to prevent ingress, preventing the primary pathway is not feasible since dock gates are opened during an extreme flood event. It is likely that site levels will be raised so the building finished floor levels will be above the 0.5% tidal extreme level. JA advised that for tidal events, new roads should also be above the 0.5% tidal extreme level, JA to confirm. Consequently, if DEFRA guidance is to be applied, buildings and roads will need to be formed at a minimum level of 8.753m AOD. This should apply to all residential and commercial buildings together with roads and car parks. Cycleways, footpaths, public open spaces and landscaped areas would be acceptable below this level.

JA

5. The production of a strategic flood study and flood consequences assessment was discussed. The EA will require some indication of development proposals for a formal strategic flood document, this could be in the form of block plans indicated development proposals in specific areas rather than a final masterplan. This could then be submitted and agreed up-front to iron-out any issues, changes could then be dealt with as a revision. Such a study would also set development levels, and discuss access/egress, negating the need for individual FCA's for individual developments. When detailed planning applications were then made for development plot, the strategic flood study and agreed development levels quoted could then be referred to rather than producing a separate FCA for each. Arup have already prepared a draft strategic flood study, but have yet to submit or circulate. JA advised that the document should include plans identifying areas/types of development, coloured plans showing ranges of site levels together with drawings showing extent of inundation should extreme event occur now. Arup will include these and submit a first draft in January, providing the proposed development plan is available. This should give sufficient time-scales to deal with comments and amend as necessary.

Arup/EA

Job title	The Waterfront, Barry	Job number 122374
Meeting name & number	Consultation with the EA regarding Drainage and Flooding	File reference 9.10
Location	EA Offices, St. Mellons	Time & date 2.00 pm 22 May 2007
Purpose of meeting		
Present	Kayna Tregay (KT) - Environment Agency John Austin (JA) - Environment Agency Kambiz Ayoubkhani (KA) - Arup John Smith (JS) - Arup	
Apologies		
Circulation	Those present John Whithead - WPM Phil Stokes – Persimmon Lisa Woodwood - Persimmon Ken Thomas - Wimpey Terry Egan - Wimpey John Penaluna - Barratt Gareth Hawke - Barratt George Gardiner - Gardiner Stewart Gareth Williams – Nathaniel Litchfield Jim Leighton – Davis Langdon	
Prepared by	John Smith	
Date of circulation	23 May 2007	
Date of next meeting	TBA	

Job title	Job number	Date of Meeting	Action
The Waterfront, Barry	122374	22 May 2007	

- Arup explained that Arup are working for a consortium headed by Barratt, Persimmon and Wimpey who are the preferred bidder for the redevelopment of The Waterfront, Barry, formerly Barry Dock No 1. The current master plan includes some 2000 residential units together with commercial development, located at the East Quay, Arno Quay, West Pond and South Quay areas of the old docks. The Tan 15 Development Advice map shows that the majority of the site is within Zone B, although some areas are shown within Zone C. Arup explained that during extreme tide event, the dock gates are opened to prevent damage and allow tide water into the dock. A spot level survey undertaken during tender stage showed that the West Pond and South Quay areas typically varied between 8m AOD and 9m AOD. The Environment Agency were consulted regarding extreme flood levels during the tender period, they advised that the Stillwater (2005) Extreme Tide Levels for Barry are as follows:
 - 1 in 200 year (0.5% tidal) – 7.85m AOD
 - 1 in 1000 year (0.1% tidal) – 8.1m AOD.

They also advised that the current predicted mean sea level rise is 5mm/year up to 2030 and 7mm year thereafter. Taking the above into account the above, for a 50 year design life, the finished floor level of the development has been taken to be 8.4m AOD.

- JA confirmed that in principle the low areas of the site could be raised to allow development to proceed since the mechanism involved is tidal. It is likely that site levels would need to be raised by around 0.5m in any case as part of the remediation scheme to provide cover in gardens and to provide hardstanding construction thicknesses. There was a discussion regarding the most appropriate sea level rise values and design life to be taken into account taking into account the potential more onerous requirements of the DEFRA (2006) document that WAG are currently reviewing. If this document is implemented in Wales in the future, it could result in a higher development level required. JA to discuss internally and advise what estimates of sea level rises and design life would be acceptable to the EA for phased development during the next few years. JA
- JA indicated that the East Quay area could possibly be affected by a fluvial event of the Cadoxton River. The river channel runs though an area to the south of Dock No. 2, it is considered likely that any extreme flows from this river overtopping and flowing overland will be transmitted through Dock No. 2 and is unlikely to affect East Quay. This will need to be checked and confirmed in due course. Arup/EA
- Discussed whether formal flood consequences assessments would be required on the development sites, as detailed information is not yet available. The strategic approach could be taken, i.e. to produce an overall strategic flood consequences assessment to cover the whole area.
- Arup outlined the storm drainage proposals, consisting of conventional drainages together with attenuation storage prior to discharge into the dock. Open channels will be formed within the proposed green corridors across West Pond, which will have a dual role of providing relatively flat drainage paths and also attenuate storm water flows. Arup explained that during a tidal event, flows from the drainage may not be able to discharge into the dock containing a higher water level. The tide locking scenario would be relatively short, attenuation storage volumes may be designed to take into account a concurrent drainage storm flow (1 in 1 year) happening at the same time as an extreme tidal event. JA reminded Arup that the drainage network as a whole

Job title	Job number	Date of Meeting	Action
The Waterfront, Barry	122374	22 May 2007	
<hr/>			
would still need to be designed for a 1 in 30 year storm flow, although it was recognised that there would not be a concurrent extreme tidal event during such extreme storm flow event.			
6.	In summary, it was agreed that the lower areas of the site could be raised above the extreme flood level to allow development to proceed. EA will advise on appropriate sea level increase to be used for the development.		JA

John Smith

122374

File 6.30

From: Kayna Tregay [kayna.tregay@environment-agency.wales.gov.uk]
Sent: 26 February 2007 08:49
To: John Smith
Subject: RE: FW: Barry Waterfront - Flood Levels

John,

In response to your email of 7 February 2007, the stillwater tide levels (YEAR 2005) for Barry are as follows:

7.85 mAOD (0.5% tidal event)
8.10 mAOD (0.1% tidal event)

These levels are based on the best available information we have and may be subject to change.

Current planning guidance in Wales predicts mean sea level to rise 5mm/year up to the year 2030 and 7mm/year thereafter.

The Welsh Assembly Government is currently reviewing the document 'Flood and Coastal Defence Appraisal Guidance (FCDPAG3) Economic Appraisal Supplementary Note to Operating Authorities - Climate Change Impacts', DEFRA October 2006. As a result, it is anticipated that the estimate of sea level rise used for planning purposes will increase.

If you have any queries regarding the above, please do not hesitate to contact me.

Kind regards,

Kayna

Kayna Tregay
Planning Liaison Officer
Environment Agency Wales
Rivers House, St Mellons Business Park,
Cardiff, CF3 0EY
External phone: 02920 245046
Internal extension: 2046
kayna.tregay@environment-agency.wales.gov.uk

>>> "John Smith" <john.smith@arup.com> 02/15/07 01:54pm >>>
Kayna,

Thanks for this, we have a very tight tender period to meet, are you able to get us this information sooner?

Regards,

John

-----Original Message-----

From: Kayna Tregay [mailto:kayna.tregay@environment-agency.wales.gov.uk]
Sent: 15 February 2007 13:39
To: John Smith
Subject: Re: FW: Barry Waterfront - Flood Levels

John,

This is with a colleague in our Development Control team at the moment.

I know they're very busy at the moment, but hopefully we should be able to get a response to you by the end of next week or the beginning of the week after.

/ds,

/ia

/yna Tregay
Planning Liaison Officer
Environment Agency Wales
Rivers House, St Mellons Business Park,
Cardiff, CF3 0EY
External phone: 02920 245046
Internal extension: 2046
kayna.tregay@environment-agency.wales.gov.uk

>>> "John Smith" <john.smith@arup.com> 02/15/07 11:55am >>>
Kayna,

Any news on the below?

John

>
> _____
> From: John Smith
> Sent: 07 February 2007 16:23
> To: 'kayna.tregay@environment-agency.gov.uk'
> Subject: Barry Waterfront - Flood Levels
>
> Kanya,
>
> Further to our telephone conversation today, I confirm that we are
> working for developers bidding for the re-development of areas of
> land
> at Barry, I attach a plan showing the areas involved. Can you let me
> know the 1 in 1000 year flood level for this area.
>
> Thanks,
>
> John
> _____
>
> John Smith
> Associate
>
> Arup
> 4 Pierhead Street, Capital Waterside, Cardiff CF10 4QP
> Tel: +44 (0)29 2026 6599
> Fax: +44 (0)29 2047 2277
> john.smith@arup.com
> www.arup.com
>
> <<barry site areas_20070207114255.pdf>>

Gall yr wybodaeth yn y neges hon fod yn gyfrinachol, ac yn gyfreithiol freiniol. Os ydych wedi derbyn y neges hon trwy gamgymeriad, rhoddwch wybod ar unwaith i'r sawl a'i gyrrodd, os gwelwch yn dda. Yna dilêwch hi, a pheidiwch â gyrru copi at neb arall.

Bu inni fwrw golwg ar yr e-bost hwn a'i atodiadau, rhag bod feirysau ynddo. Serch hynny, dylech chwilio unrhyw atodiad cyn ei agor.

Efallai bydd rhaid inni ryddhau'r neges hon, ac unrhyw ateb iddi, i sylw'r cyhoedd pe gofynnid inni tan y Ddeddf Rhyddid Gwybodaeth, y Ddeddf Gwarchod Data neu at ddibenion ymglyfreithio. Y mae'n bosib hefyd y darllenir negesau ac atodiadau e-bost a yrrir at unrhyw gyfeiriad Asiantaeth yr Amgylchedd, neu a dderbynnir oddi yno, gan rywun arall na'r gyrrwr a'r derbynnydd. Hynny at ddibenion busnes.

Os ydym wedi gyrru gwybodaeth atoch, a chithau'n dymuno'i defnyddio, yna ddarllenwch ein telerau a'n hamodau, os gwelwch yn dda. Gellir eu cael trwy ein galw ar 08708 506 506. Am ragor o wybodaeth ynghylch Asiantaeth yr Amgylchedd Cymru, ewch at www.asiantaeth-amgylchedd.cymru.gov.uk.

Our ref 122374/JS
File ref 6.30
Date 25 June 2007

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Kayna Tregay
Environment Agency Wales
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ARUP

Dear Kayna

**Waterfront Barry
Development Levels**

I refer to our meeting dated 22nd May 2007 and your e-mail dated 20th June 2007 together with my telephone discussion with Gary Purnell. We are close to signing agreements with the current landowner and we would like to take this opportunity to confirm and record the principles that we are taking forward for the development.

It is recognised that parts of the development site are currently below the 1 in 1000 year extreme tide level, taking into account future estimated sea level rises. The principle of raising the site has been established and there has been some discussion as to what levels are appropriate on such a long term development. You have advised that the development should take into account a 100 year design life, the current guidance (TAN15) indicates sea level rises of 5mm/year up to 2030 and 7mm year thereafter. In accordance with TAN15, the Threshold Frequency for residential and general infrastructure is 0.5% tidal (1 in 200 year), you have previously advised that the stillwater tide levels (Year 2005) for Barry is 7.85 mAOD (0.5% tidal event). Taking into account the fact that the average build year of the development is 2010, a 100 year design life and the above sea level rises, the design level of the development should be at or above 8.535mAOD. Considering the presence of relatively narrow pathways for flooding mechanism to enter the dock area together with the large body of dock water present in front of the development areas, there is no need to include any further allowances for surge effects.

You have stated that the Welsh Assembly Government is currently reviewing the document 'Flood and Coastal Defence Appraisal Guidance (FCDPAG3) Economic Appraisal Supplementary Note to Operating Authorities - Climate Change Impacts', DEFRA October 2006. It is understood that WAG has not signed up to the DEFRA guidance on climate change as they are currently in the process of producing their own guidance. You have advised that for any long term New Development (larger scale sites assumed) it would be prudent to apply DEFRA Guidance on sea level rise, i.e. 3.5mm/year up to 2025, 8mm/year between 2025 and 2055, 11.5mm/year between 2055 and 2085, 14.5mm/year between 2085 and 2115. Taking into account the Threshold Frequency for residential and general infrastructure of 0.5% tidal (1 in 200 year), and the stillwater tide levels (Year 2005) for Barry of 7.85 mAOD (0.5% tidal event), the average build year of the development is 2010, and a 100 year design life, the design level of the development would increase to at or above 8.753mAOD.

../2

It is recognised that access roads into the site from the external off-site infrastructure are typically at a level of around 8.5mAOD which are below the design levels. You have confirmed that there is no requirement to raise these levels, as potential flooding is manageable since the potential depth of flooding is less than 600mm.

I trust the above accurately records our discussions, let me know if you have any comments otherwise we will proceed with the agreements on this basis.

Yours sincerely



John Smith
Associate

Enc

cc John Austin, EA
 Gary Purnell, EA
 Kambiz Ayoubkhani, Arup

Our ref 122374/JSS
File ref 6.30
Date 27 March 2008

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ARUP

Dear Johnathan

**Waterfront Barry
Strategic Level Flood Study**

Referring to our previous meetings regarding the flood study at the above site, I have finally had consortium and stakeholder agreement to submit the draft document which includes the latest indicative development layout. It is likely that the development layout will be reviewed and revised as the masterplanning process develops, although the principles of the development and access roads will remain. I attach a copy of the document for comment, which incorporates the items you suggested we include at the meeting dated 14th December 2007.

Can you review the document and comment as appropriate.

Yours sincerely



John Smith
Associate

Enc

Cc – Keyna Tregay – Environment Agency

creu lle gwell
creating a better place

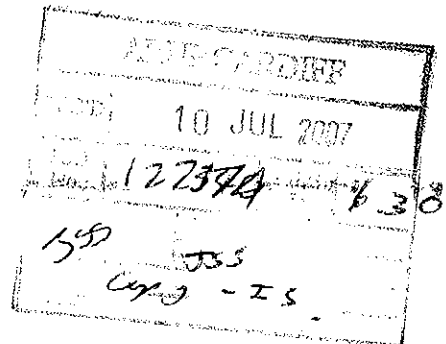


Asiantaeth yr
Amgylchedd Cymru
Environment
Agency Wales

Mr John Smith - Associate
Ove Arup & Partners
4 Pierhead Street
Cardiff
South Glamorgan
CF10 4QP

Ein cyf/Our ref: SE/2007/100881/02-L01
Eich cyf/Your ref: 122374/JS

Dyddiad/Date: 09 July 2007



Annwyl Mr Smith / Dear Mr Smith

FLOOD LEVELS AT BARRY WATERFRONT

Thank you for your letter dated 25 June 2007 regarding the above site.

As discussed, we are happy with the proposed development levels that you have put forward based upon the most recent guidance provided by Defra. While we are still awaiting confirmation from Welsh Assembly Government on predicted sea level rise, the proposals have considered the best information to date.

With regards to the protection of controlled waters, please find following comments we recommend you consider:

The site is currently situated on a non-aquifer. However, the classification of aquifers is currently being reviewed for the Water Framework Directive. The new categories will be principle aquifer, secondary aquifer and non-productive strata. Following the review, the site area is due to be classified as a secondary aquifer. Groundwater should therefore be regarded as a receptor in its own right as well as providing a pathway to surface water receptors.

Given the brownfield status of the site, the Environment Agency Wales recommends that developers should:

- Follow the risk management framework provided in CLR11, Model Procedures for the Management of Land Contamination when dealing with land affected by contamination.
- Refer to the Environment Agency Guidance on Requirements for Land Contamination Reports* for the type of information that we require in order to assess risks to controlled waters from the site. The Local Authority can advise on risk to other receptors, e.g. human health.

Asiantaeth yr Amgylchedd Cymru/Environment Agency Wales
St Mellons Business Park, Fortran Road,, St Mellons,, Cardiff, CF03 0EY.
Llinell gwasanaethau cwsmeriaid/Customer services line: 08708 506 506
E-bost/Email: enquiries@environment-agency.gov.uk
www.environment-agency.gov.uk

Cont/d..



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* http://www.environment-agency.gov.uk/subjects/landquality/113813/887579/887905/?version=1&lang=_e

Should an application for planning permission be submitted, we would be likely to recommend to the local planning authority that a number of conditions be incorporated into any planning permission granted. The wording of these conditions is given below for your information:

CONDITION: Prior to the commencement of development approved by this planning permission (or such other date or stage in development as may be agreed in writing with the Local Planning Authority), a scheme to deal with the risks associated with contamination of the site shall be submitted to and approved, in writing, by the local planning authority. That scheme shall include all of the following elements unless specifically excluded, in writing, by the Local Planning Authority.

1. A desk study identifying:

- all previous uses
- potential contaminants associated with those uses
- a conceptual model of the site indicating sources, pathways and receptors
- potentially unacceptable risks arising from contamination at the site

2. A site investigation scheme, based on (1) to provide information for an assessment of the risk to all receptors that may be affected, including those off site.

3. The results of the site investigation and risk assessment (2) and a method statement based on those results giving full details of the remediation measures required and how they are to be undertaken.

4. A verification report on completion of the works set out in (3) confirming the remediation measures that have been undertaken in accordance with the method statement and setting out measures for maintenance, further monitoring and reporting.

Any changes to these agreed elements require the express consent of the local planning authority.

REASON: To ensure that the proposed site investigations and remediation will not cause pollution of Controlled Waters.

CONDITION: If, during development, contamination not previously identified is found to be present at the site then no further development (unless otherwise agreed in writing with the Local Planning Authority) shall be carried out until the developer has submitted, and obtained written approval from the Local Planning Authority for, an amendment to the Method Statement detailing how this unsuspected contamination shall be dealt with.

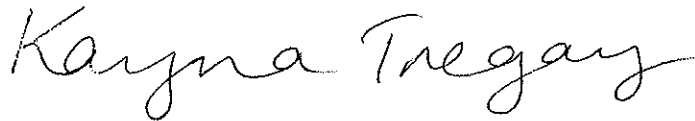
REASON: To ensure that the development complies with approved details in the interests of protection of Controlled Waters.

CONDITION: No infiltration of surface water drainage into the ground is permitted other than with the express written consent of the Local Planning Authority, which may be given for those parts of the site where it has been demonstrated that there is no resultant unacceptable risk to controlled waters.

REASON: To prevent pollution of controlled waters.

If you have any further queries, please do not hesitate to contact me.

Yn ddifffuant / Yours sincerely

A handwritten signature in black ink, reading 'Kayna Tregay'. The script is cursive and fluid, with the first name 'Kayna' and the surname 'Tregay' clearly distinguishable.

Miss Kayna Tregay
Planning Liaison Officer

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