Phil Worthing

LECKWITH QUAY

Flood Consequences Assessment

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1. INTRODUCTION & BACKGROUND

1.1. INTRODUCTION

WSP UK Ltd (WSP) were commissioned by Phil Worthing (the client) to undertake flood studies at Leckwith Quay, Vale of Glamorgan.

This Flood Consequences Assessment (FCA) has been undertaken in accordance with Technical Advice Note 15 (TAN15) and is based on data sets provided by the client and licensed from Natural Resources Wales (NRW). TAN15 advises on development and flood risk by providing a framework within which risks arising from river flooding, coastal flooding and runoff from development can be assessed.

The Construction Industry Research and Information Association (CIRIA) has defined a tiered three-level approach to flood risk assessment (C624)[1] which will be used to identify the level of detail required for this FCA proportionate to the degree of flood risk. The three levels defined are as follows:

- Level 1 Screening study to identify whether there are any flooding issues related to a development site which may warrant further consideration;
- Level 2 Scoping study to be undertaken for each potential flood risk issue that is identified as being associated with a site during a Level 1 FCA. A Level 2 FCA involves a qualitative assessment of the flood risk to the site, and the impact of the site on flood risk elsewhere; and
- Level 3 Detailed study to be undertaken if the Level 2 study concludes that quantitative analysis is required to assess flood risk issues related to the development site.

Given the magnitude of the Scheme and the changes that are proposed within and adjacent to the floodplain it was deemed appropriate to undertake a Level 3 FCA to provide a robust evidence base to support the planning application.

1.2. PREVIOUS RELEVANT STUDIES

1.2.1. LECKWITH QUAY

Whilst the site and its surrounding area (on both sides of the river) has a long and varied history of planning applications, none of these contain pertinent and up to date information regarding to the flood risk at this location. There are a number of reports developed to support this application which are of relevance to this FCA and should be read in conjunction with this report. These specifically include:

- The Drainage Strategy. Ref: 3561-WSP-C-RP-001
- The Environmental Statement. Ref: RPS October 2020
- The Geology and Hydrogeology Reports. Ref: 70053561_PRA_001
- The Hydraulic Modelling Report Ref:3561-WSP-C-RP-004

[1] Lancaster J.W. , Preene, M. & Marshall, C.T. (2004) *Development and flood risk - guidance for the construction industry* CIRIA C624 ISBN 0-86017-624-X

1.2.2. OTHER STUDIES OF INTEREST

There are several other reports that are of interest to this document, which although not specific to Leckwith Quay, are of relevance concerning the more general hydrological environment. These include:

- The Shoreline Management Plan (SMP)[2];
- Sea Level Rise Data and User Guide (SC060064/TR7)[3];
- The Vale of Glamorgan Local Flood Risk Management Strategy (LFRMS)[4];
- Cardiff Phase 1 Strategic Flood Consequence Assessment[5], and;
- The Cardiff Strategic Flood Consequences Assessment (SFCA)[6].

1.3. LOCATION

Leckwith Quay is a 7.7 ha site located between the A4232, Leckwith Road and the Afon Elái (River Ely) on the outskirts of Cardiff in the Vale of Glamorgan CF11 8AU. The site extends approximately 890 m along the Afon Elái riverbank in the Vale of Glamorgan (with the opposite bank within Cardiff City) it extends some 100 m into Vale of Glamorgan from the river bank. There are currently two river crossings at this location:

- Leckwith Road (B4267) roadbridge has a single span concrete arch conveying the channel itself with a springing level of 4.8 m AOD and soffit of 9.26 m AOD and includes a series of nine additional spans over the western bank as the road climbs to the higher ground.
- Historic Roadbridge (Grade II*) is a single track, triple arch, rough masonry viaduct with pedestrian refuges between each arch. The bridge sits lower than its more modern companion with each soffit approximately 7 m AOD and the parapet generally below 9.0 m AOD.

The site is some 3 km upstream of the Afon Elái's outfall into Cardiff Bay, behind the Cardiff Bay Barrage and some 700 m upstream of the Nant Cydfin's confluence with the Afon Elái which itself is just upstream of the A432 Roadbridge. Upstream of the site there is at least one minor outfall from the features which once drained Leckwith Moors on the east bank and an unnamed watercourse draining the Leckwith & Plymouth Woods as well as the remnants of what was the Caerau Brook on the western bank. The site is also some 490 m downstream of another A432 Roadbridge as well as an Ely Trail Footbridge approximately 690 m upstream.

There are also water features on site, specifically noted in the Ordnance Survey mapping, towards the southern end of the site where a water feature issuing from Hillside Farm / Factory Wood flows via a waterfall before trifurcating into drains; the northern two of which sink on the edge of the redline

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[2] Atkins (December 2010) *Severn Estuary Shoreline Management Plan Review SMP2* Severn Estuary Coastal Group

[3] Environment Agency (May 2019) *Coastal flood boundary conditions for the UK: 2018 update.* Environment Agency, Bristol, U.K. Available at: https://assets.publishing.service.gov.uk/media/603652cce90e0740b7caac9d/Coastal_flood_boundary_conditions_for_the_UK_2018_update_-_technical_report.pdf [Accessed: March 2022].

[4] Capita (December 2013) *Local Flood Risk Management Strategy V.1.1* Vale of Glamorgan Council

[5] Atkins (June 2009) *Cardiff Strategic Flood Consequences Assessment: Report on Phase 1 (Scoping Study) and Proposed Methodology for Offer of Services for Phase 2 – the Assessment* Cardiff Council Doc Ref: 5076243.56.DG.045.4 – Ph.1 Final Report.doc

[6] Atkins (November 2011) *Cardiff Strategic Flood Consequences Assessment Phase 2 Part 1 Update Extend Development Lifetime to 2110 Areas A, G, H and I* Cardiff Council Ref: 5097656-DG-017

boundary with the southern drain flowing into a pond at the southern part of the site prior to outfalling into the Afon Elái. The available data does not identify whether these features are natural or culverted or if they pass below the site.

Site levels are understood to be around 7.0 m AOD along the Afon Elái's top of bank and rising to the west. Figure 1-1 below shows the redline boundary and masterplan (Appendix A) provided by Loyn + Co Architects.

According to the British Geological Society maps, the known superficial deposits within the redline boundary are tidal flat deposits of clay, silt and sand overlying the Mercia Mudstone Group with soil textures tending towards sandy in the identified floodplain and moving to a clayey loam on higher ground.

1.4. PROPOSED DEVELOPMENT SUMMARY

The development proposals are for a residential development (target of up to 250 residences) along with associated public open space, amenities and includes a new highway link via a bridge across the Afon Elái, with the existing B4267 bridge being demolished along with the existing business units. The development is split into two parcels on either side of the proposed new bridge crossing referred to as the northern (1.3 ha) and the southern plateaus (6.4 ha). It is proposed to raise the development parcels above the flood level to reduce the risk of onsite flooding and flood relief culverts bypassing the historic bridge are also proposed. The proposed layout of the development (1844/S.102H) and bridge are included in Appendix A. It is noted that the hydraulic modelling undertaken to support this FCA and described in the associated report (7005-3561-C-RP-0004-01-HMR) considered an earlier version of this layout (1844/S.102C) we have been assured that this will not affect the flood model with changes confined to areas of plateau not at risk of flooding. The changes have been summarised as:

- The layout of Block A has been altered slightly to bring the edge inside the redline.
- Strengthening/widening of the 'green wedges' for ecological benefit. Some blocks on the southern plateau have been shifted to accommodate this.
- Reconfiguration of blocks along the riverside of the southern plateau to create sufficient acoustic shadows where outdoor amenity space can be situated.
- Area 03 (Block Es) has revised road, building and parking layout to accommodate the above acoustic and ecological requirements, as well as improve efficiency.
- Drainage basins, swales and rain gardens have been amended in association to the changes made to the site layout and landscaping scheme.
- Movement Hierarchy – the key routes have been revised to reflect the new internal layout.
- Building Heights – the middle block of Area 03 has been increased in height by 1m (from 27m to 28m) to accommodate under croft parking within the revised design.

Figure 1-1: Proposed Development

1.5. FLOOD EVENT DEFINITION

There are a number of ways in which the likelihood or probability of a flood can be described. It is standard practice within the UK to refer to a flood in terms of its Return Period (RP), which is the average interval in years between consecutive events exceeding a specified magnitude. It is also possible to express an event in terms of its Annual Exceedance Probability (AEP). The AEP is the percentage chance that a flood of a specified magnitude or greater may occur in any given year. The equivalence between the two methods of describing the rarity of events is shown in Table 1-1 below.

Table 1-1: Annual Exceedance Probability - Return Period Equivalence

AEP (%)	50	20	10	4	3.3	2	1	0.1
RP (1 in *X* years)	2	5	10	25	30	50	100	1000

The equivalence[7] reported in the above table holds for return periods substantially greater than one year.

For fluvial simulations there are two key events of interest, the 1%CE AEP event is the design event, the CE denotes the central estimate uplift for climate change over the anticipated lifespan of the development, it is equivalent to the 1 in 100 year return period with the aforementioned climate change allowance. The second event of interest is the 0.1% AEP event or extreme event which is equivalent to the 1 in 1000 year return period.

[7] The equivalence $AEP \approx \left(\frac{1}{RP}\right) * 100$ as reported in table can be more accurately derived as $AEP = \left(1 - e^{(-1/RP)}\right) * 100$

2. EXISTING UNDERSTANDING OF FLOOD RISK

Developments which include residences are classified as Highly Vulnerable Developments in accordance with Technical Advice Note 15 (TAN15). The Natural Resources Wales (NRW) flood maps show that the majority of the site is located within Development Advice Map (DAM) Zone C1. DAM Zone C1 is the area defined by NRW as served by significant infrastructure, including flood defences. According to TAN15, Highly Vulnerable Developments may be permissible in Zone C1, subject to: the Justification Test, acceptability of consequences and surface water requirements which are discussed within this FCA. Figure 2-1 below shows an extract from the DAM.

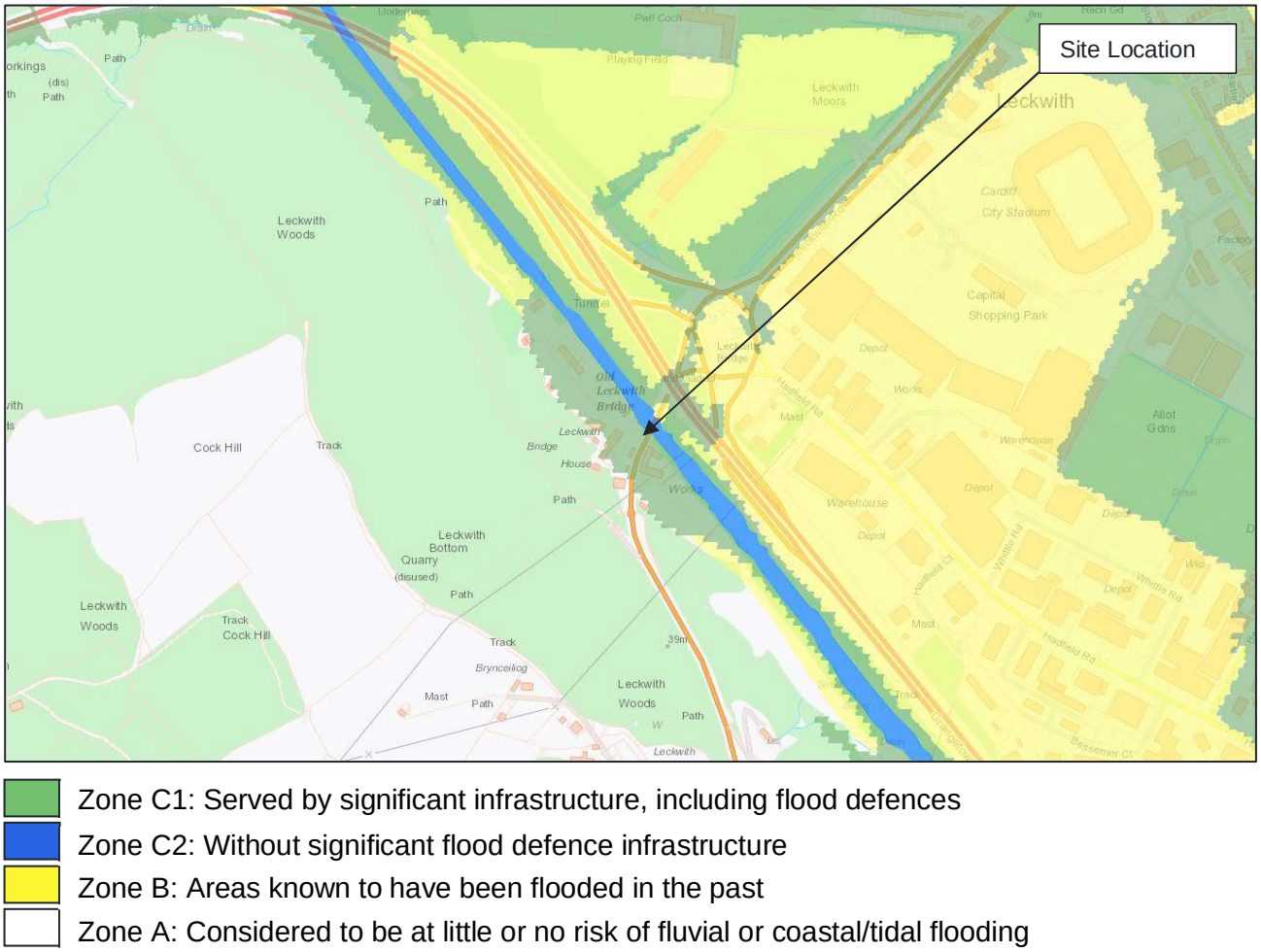


Figure 2-1: Development Advice Map

Figure 2-2 below shows an extract from the NRW Flood Map for Planning, which shows flood risk that includes an allowance for climate change, with the full set of flood risk maps included in Appendix B. The recently published mapping is intended to support the new TAN15 guidance and whilst the implementation of this guidance has been suspended until June 2023, the mapping will be treated as a material consideration in planning applications prior to this date. The map shows that the site is within Flood Zone 3 but falls within an area benefitting from flood defences (sea). Flood Zone 3 is the area NRW predict would flood either with a probability of greater than 1% Annual Exceedance Probability (AEP) from fluvial sources or 0.5% AEP from tidal or with those probabilities from both sources. Areas considered to be benefiting from defences indicates those areas that benefit from the presence of defences in a 1 in 100 (1%) chance of flooding each year from rivers; or 1 in 200 (0.5 %) chance of flooding each year from the sea.

Figure 2-2: NRW Flood Map for Planning

The set of NRW flood maps in Appendix B also illustrate that:

- The site is predicted to have a low risk of flooding from rivers and/or the sea. Which NRW define as an area assessed as having a chance of flooding between a 0.1% AEP and 1% AEP,
- The site is located within a flood warning area.
- Isolated spots within the site have a low risk of surface water flooding, however these areas appear to be associated with surface water runoff locally arising within the site.
- Flood defences are present along the right (west) bank of the Elái upstream of the Leckwith Road roadbridge. A review of the NRW data set indicates that this is assessed as protecting adjacent land up to the 4% AEP fluvial flood event and is in good to fair condition.
- The site is at risk of flooding from the Pontsticill (Taf Fechan) Reservoir were it to fail catastrophically with flood waters predicted to be up to 2 m deep at a velocity of up to 0.5 m/s. The risk of reservoir failure is however deemed to be low, due to the regulatory regime.

2.1. NRW FLUVIAL FLOOD DATA

The NRW data indicates that the proposed development is at risk of flooding, it is currently understood that this is principally from the overtopping of the riverbank alongside the Afon Elái, complicated by the afflux (backwater) resulting from the Historic Roadbridge.

NRW have previously completed hydraulic modelling for the Afon Elái in 2013, this was undertaken at a strategic scale to provide an understanding of flood risk along the Afon Elái, Table 2-1 provides these flood levels (as extracted from provided 'h_max.asc' files). With each event combined with a Mean High Water Springs (MHWS) downstream level.

Table 2-1: NRW Predicted Fluvial Stage Levels

Event AEP	Predicted Stage Level (m AOD)			
	Upstream at Redline Extent	Upstream of Bridges	Downstream of Bridges	Downstream at Redline Extent
1% (defended)	7.40	7.33	7.08	6.90
1% (undefended)	7.19	7.14	6.95	6.83
1% (defended with climate change)	8.14	8.11	7.94	7.88
0.1% (defended)	8.00	7.92	7.40	7.16
0.1% (undefended)	8.07	7.99	7.36	7.08

It should be noted that as the results in Table 2-1 were created in October 2013 a now obsolete value for climate change (20% uplift to flow) would have been applied. The current uplift for climate change for these rivers is 25% and hence design flood levels are also anticipated to be higher than those in the table.

2.2. TIDAL DATA

The site is understood to be at limited risk of flooding from tidal sources in the present day which are reduced by the presence of the tidal barrage. The barrage is understood to protect against the 0.1% AEP event (1000 year return period); however, it should be recognised that the risk of tidal flooding may increase over the lifetime of the development depending on the rate of sea level rise. The SMP policy (S2.3) is to maintain the standard of protection which should limit this risk. There are two sources of tidal data of interest, those from NRW's VDM model and those from the Extreme Sea Level data set.

2.2.1. NRW VDM TIDAL DATA

NRW's VDM model suggests that the simulated tidal event (0.5% AEP) combined with a (3.3% AEP) fluvial event floods the site, although the joint probability of these two events is considered to be more extreme than the TAN15 requirements.

Table 2-2: Predicted Tidal Stage Level

Event AEP		Predicted Stage Level (m AOD)			
Fluvial	**Tidal**	**Upstream at Redline Extent**	**Upstream of Bridges**	**Downstream of Bridges**	**Downstream at Redline Extent**
3.3 %	0.5 %	8.06	8.05	7.97	7.95

2.2.2. EXTREME SEA LEVEL DATA

It should be noted that the climate change values applied for sea level rise are as per the allowances as recommended in the guidance issued in Welsh Government guidance note from September 2021[8],.

The key data provided in Table 2-3 below shows the projected still water levels for tides to the 70th percentile and Table 2-4 beneath the 95th percentile for climate change uplift, both are shown alongside the confidence interval for the predicted sea level return period for chainage 412 (seaward of Cardiff Bay) from the extreme sea level data (Aug 2019). The effective height of the Cardiff Bay Barrage (and embankment) is 9.7 m AOD. The 95% confidence interval is reported for the base year and so do not include any uncertainty regarding climate change. Additionally, it should be noted as stated in the user guide (SC060064/TR7) that:

> *'extreme sea level values include the effects of storm surge and astronomical tides but do not specifically account for any localised increase in sea level that may be induced by onshore wave action, orientation or topography. Two additional effects are of note and can be significant in certain circumstances. Wave set-up is an increase in water level due to on shore wave action (wave set-down is the opposite). Wind set-up is where the local wind shear stress*

[8] https://gov.wales/climate-change-allowances-and-flood-consequence-assessments

pushes the water level up at the shore (and again set-down is the opposite). Depending on the circumstances these may or may not be well accounted for in the extreme sea level estimates.'

For tidal flooding the design event is the 0.5% (T200) event over the lifetime of the development which should not flood in this event. The extreme event is the 0.1% event (T1000) under which limited flooding may be acceptable.

Table 2-3: Extreme Sea Levels m AOD (Chainage 412) 70th Percentile Sea Level Rise

Year	Annual Exceedance Probability					
	5 %		0.5 %		0.1 %	
	Prediction	95 % Confidence	Prediction	95 % Confidence	Prediction	95 % Confidence
Base (2017)	7.39	7.35	7.79	7.63	8.16	7.86
		7.5		8.19		8.96
2120	8.40	8.36	**8.80**	8.64	9.17	8.87
		8.51		9.2		9.97

Table 2-4: Extreme Sea Levels m AOD (Chainage 412) 95th Percentile Sea Level Rise

Year	Annual Exceedance Probability					
	5 %		0.5 %		0.1 %	
	Prediction	95 % Confidence	Prediction	95 % Confidence	Prediction	95 % Confidence
Base (2017)	7.39	7.35	7.79	7.63	8.16	7.86
		7.5		8.19		8.96
2120	8.72	8.68	9.12	8.96	9.49	9.19
		8.83		9.52		10.29

The key event of interest when considering tidal flooding is the design event which has been highlighted in blue and bold in the table above for the anticipated lifespan of the proposal.

Although the above data are of interest three key points should be remembered:

1. The projections are for an offshore point[9], given the location of the site were the tide to directly route towards the site, some alteration to peak sea levels might occur via estuary funnelling or damping due to distance for the Taf and Elái watercourses, but does account for the Bristol Channel.
2. These are still water levels only and have no allowance for waves or other local environmental variables.
3. Although the base year data are reported to two decimal places, they can only be considered accurate to one decimal place.

Although the presence of the Cardiff Bay Barrage and its associated embankment will provide some protection to the site the available data suggest that:

- The defence in its current configuration could be overtopped in the extreme event (albeit for a limited duration) within the lifetime of the proposed development.
- Overtopping increases the risk of breach / failure of the defence, and in such event the site itself could be affected by flooding.
- There are anecdotal suggestions that the seaward gates of the Queen Alexandra Docks do not provide the same standard of protection as the Cardiff Bay Barrage. Given the interconnectivity of the docks, this could raise water levels within Cardiff Bay.

Notwithstanding this, the Shoreline Management Plan (as described in S 2.3) identifies the coastline as defended.

2.3. SHORELINE MANAGEMENT PLAN

The relevant Shoreline Management Plan (SMP) for this stretch of coastline is SMP19 (Anchor Head to Lavernock Point Policy Unit CAR1). The policy identified in the plan is to 'hold the line' across all epochs and the erosion is expected to be negligible, therefore, the policy suggests that this area will remain protected in the foreseeable future. Given the understanding that the barrage will be maintained, there is no requirement to consider overtopping of the barrage as part of the design scenario for this scheme.

2.4. HISTORIC FLOOD DATA

A search of the Chronology of British Hydrological Events[10] for the term 'Leckwith' returned no results, the term 'Cardiff' returned 10 relevant results between 1696 and 1968, which are included in Appendix C, though these do not specifically describe flooding at the quay. A particular item of interest is a flood mark in St Luke's Church, Canton recording a water height of 2 feet and 4 inches for an event in 1927.

Discussions with the Client have identified that he has no knowledge of the existing site flooding. Records held by NRW do not cover the site and no specific events have been found online. The Cardiff

[9] reported at OS NGR 321276.8, 171819.9

[10] http://www.cbhe.hydrology.org.uk/ [Accessed March 2020]

Phase 1 Strategic Flood Consequence Assessment does identify a number of historic flood events in the wider area:

> *There have only been three notable events in the River Ely catchment within the last few decades, March 1998, October 2000 and September 2008. The March 1998 & October 2000 events – flooding from the River Ely affected a small number of properties in the Ely Bride area of Cardiff, Sandbags were issued in the Ely Bridge area of Cardiff. The September 2008 event flooding affected areas including the Ely Bridge area; 6 properties along Wroughton Place and 21 properties on Mill Road and Cowbridge Road West. Environment Agency Wales report states that initial flooding occurred from highway drains followed by overtopping of the river banks. Anecdotal evidence from residents following the event suggests that the roads in the area have flooded on previous occasions, although no properties were known to have flooded in the last 20 to 25 years leading up to 2008.*
>
> *Section 2.3.1 (pg8)*

Although no flood events have been found specifically related to the site itself, given its proximity to the river and its geology it is likely to have flooded in the past, which could have been prior to the current topographical and defence arrangements.

3. SURFACE WATER DRAINAGE

This document should be read in conjunction with the Surface Water Drainage Strategy which sets out the method of management and disposal of surface water runoff from the site (Ref: 3561-WSP-C-RP-001). The strategy ensures that the hydrological impact of the development is minimised and complies with local and national policy requirements for the management of surface water. As part of the design process sustainable drainage methods should be considered from the start of the project and included where practicable.

The drainage strategy when implemented should facilitate approval by the SuDS Approval Body (SAB). SuDS measures should be implemented where possible to ensure that surface water runoff from the site is minimised and/or attenuated in order to ensure that rates of runoff from the site do not increase.

4. HYDRAULIC MODEL - KEY RESULTS

The hydraulic model developed for this study is described in the Hydraulic Modelling Report (Ref:3561-WSP-C-RP-004) which should be read alongside this document. For ease of reference and assessment the key results for this FCA are described in this section. Additional results and maps are presented within the hydraulic modelling report. It should be noted that the hydraulic modelling was completed based on an earlier proposed layout (1844/S.102C) rather than the one included in Appendix A (1844/S.102H) we have been assured that the changes will not affect the flood model.

In the design event (1%CE AEP) the proposed site development is predicted to remain dry and lower floodwater levels are observed across the developed floodplain in comparison to the baseline or pre-development scenario. The reduction in afflux still extends to the Cowbridge Road West bridge and the reduction in level in Sanatorium Park and Paper Mills Development is only circa 3 cm. There are however, significant reductions further into Leckwith (11 to 14 cm), around Riverside (9 to 11 cm) and Grangetown (6 to 7 cm) as well as the A4161 and Victoria Park (4 cm). This is illustrated in Figure 4-1 below.

In the extreme event (0.1% AEP) the proposed site development is also predicted to remain dry; however, whilst the reduction in upstream floodwater levels is less than in the design event (when compared to the baseline or pre-development scenario) they cover a wider area of developed floodplain. The impact of the reduction in afflux still extends to the Cowbridge Road West bridge and the reduction in flood level in Sanatorium Park and Paper Mills Development remains circa 3 cm. There are also reductions further into Leckwith (5 cm), around Riverside (4 cm) and Grangetown (8 cm) as well as the A4161 and Victoria Park (3 cm). Downstream from the historic bridge an increase in floodwater levels is noted through to Cardiff Bay, this reduces from 3 cm to 2 cm at the southern end of the site to 8 mm within Cardiff Bay. This increase is principally constrained to the river channel, except immediately downstream of the site within the wooded area where an increase of 2 cm is observed on the southern bank . This is illustrated in Figure 4-2 beneath.

	>30cm reduction		Less than 0.5 cm change		≥ 0.5 cm increase
	≥ 25 cm reduction		Was Dry Now Wet		≥ 5 cm increase
	≥ 20 cm reduction		Was Wet Now Dry		≥ 10 cm increase
	≥ 15 cm reduction				≥ 15 cm increase
	≥ 10 cm reduction				≥ 20 cm increase
	≥ 5 cm reduction				≥ 25 cm increase
	≥ 0.5 cm reduction				≥ 30 cm increase

Figure 4-1: VarD-Existing 1%CE MHWSCC Maximum Flood Stage Comparison Map

	>30cm reduction		Less than 0.5 cm change		≥ 0.5 cm increase
	≥ 25 cm reduction		Was Dry Now Wet		≥ 5 cm increase
	≥ 20 cm reduction		Was Wet Now Dry		≥ 10 cm increase
	≥ 15 cm reduction				≥ 15 cm increase
	≥ 10 cm reduction				≥ 20 cm increase
	≥ 5 cm reduction				≥ 25 cm increase
	≥ 0.5 cm reduction				≥ 30 cm increase

Figure 4-2: VarD-Existing 0.1% MHWS Maximum Flood Stage Comparison Map

Blockage variations were also simulated for these events, at the request of NRW they consist of a blockage of 80% to the central arch of the historic bridge and, if relevant, a 30% blockage to the upper section of both bypass culverts.

Were the 1%CE event to coincide with a blockage of the type described: shallow flooding is predicted post-development to the northern plateau of circa 5 cm deep in external and ancillary areas only and at a hazard classification rating of low, with the remainder of the development site dry.

Comparing the Variation D Blockage Scenario against the Baseline (pre-development) Blockage Scenario, lower floodwater levels are predicted in the developed floodplain the reduction in level in Sanatorium Park and Paper Mills Development is only circa 8 mm. There are also reductions further into Leckwith (4 cm), around Riverside (5 cm) and Grangetown (4 to 9 cm) as well as the A4161 and Victoria Park (5 cm). Downstream from the historic bridge an increase in water levels is noted along essentially the remaining reach to Cardiff Bay. A similar effect is noted in the Afon Taf suggesting higher levels in Cardiff Bay propagating upstream, this higher water level results in increased levels around Cardiff Bridge of between 8 to 16 cm as well as additional overflow around Stuart Street adjacent to Cardiff Bay suggesting increases of circa 1.5 cm.

Were the 0.1% event to coincide with a blockage of the type described: shallow flooding is predicted to the northern plateau of under 20 cm deep in external and ancillary areas only and at a hazard classification rating of low, with the remainder of the development dry. The effects on the floodplain are more ambiguous, reductions noted around Riverside (1 cm) and Grangetown (2.5 cm). Downstream from the historic bridge an increase in water levels is largely absent, though the effect observed in the 1%CE blocked event is still identifiable. Higher water levels in the Afon Taf propagating upstream from Cardiff Bay remains essentially in-channel dissipating 400 m downstream of the Penarth Road bridge though an isolated increase in water levels at the measurable limit (i.e. 5 mm is noted around Cardiff Central station.

5. ASSESSMENT OF FLOOD RISK

The aim of this section of the report is to provide an assessment of the suitability of the proposed development against the requirements of TAN15, by outlining the flood risks that have been identified in this report and provides mitigative measures to enable the site to improve compliance with the current legislation.

Section 2 of this report references the different flood maps for the site provided by NRW, from Figure 2-1 the site lies predominantly within the DAM Zone C1 region with some Zone B in the south. As the site is intended to be developed for residential purposes it is classified as Highly Vulnerable by TAN15 which in Section 9 states that Highly Vulnerable developments may be permissible Zone C1, subject to: the Justification Test, acceptability of consequences and surface water requirements. Given the existing level of risk identified it is considered that mitigative measures to reduce the level of risk and the consequences of flooding will need to be incorporated into the design.

5.1. FLUVIAL FLOOD RISK

5.1.1. EXISTING ONSITE WATER FEATURES

The Afon Elái is a main river, works effecting its main channel and its floodplain will, other than for specific exemptions, require an environmental permit[11] from NRW, this typically requires a standard easement from the top of the riverbank for maintenance (approximately 8 m).

The other water features are ordinary watercourses and are the responsibility of the Lead Local Flood Authority (LLFA), however as there is a general presumption against culverting, these should be kept open except in the case of access. Works effecting ordinary watercourses typically require an ordinary watercourse consent from the LLFA. The design should also include, where possible, a suitable buffer to reduce the impact of localised flooding from these features, allow adequate maintenance, and also to provide opportunity for ecological and water quality improvements. NRW's surface water flood maps suggest that these features do not pose a significant risk to the site. Given however, that these features are identified on maps as sinking prior to the development, additional survey data to understand the capacity and risks associated with this land drainage feature and the detailed consideration of the hydrogeological report (70053561_PRA_001) will be given due consideration during detailed design stage and suitable mitigation can be submitted/approved during the reserved matters stage.

5.1.2. AFON ELÁI

The existing site is at risk of flooding from fluvial sources. It is currently understood that this is principally from the overtopping of the riverbank alongside the Afon Elái, and complicated by the afflux (backwater) resulting from the Historic Roadbridge. Hydraulic modelling has identified (Variation D) that, by introducing bypass culverts at the choke point and raising site levels as part of the proposed development, the level of flood risk is reduced both on site and in the wider area. The results from the proposed model (Variation D) identify a configuration whereby the site remains dry in both the design

[11] https://www.gov.uk/guidance/flood-risk-activities-environmental-permits

event (1%CE) and the extreme event (0.1%), alongside widespread and significant reductions in flood levels predicted upstream.

5.1.3. BLOCKAGE RISK

Should a blockage establish at the Historic Bridge the implications in the proposed scenario are likely to be minor. The results suggest the modelled blockage would be insufficient to result in flooding of the site in a 3.3% AEP event, however, could flood the external areas of the proposed development in a 1%CE event with depths circa 5 cm and in the 0.1% event up to 20 cm and with a low hazard classification. This report recommends that flood resilience and resistance measures are considered for incorporation into the design up to this level plus freeboard. It is noted however, that the benefits predicted as a result of the bypass channels are reduced and more ambiguous than in the free flowing (unblocked) scenarios.

5.1.4. FLOOD LEVELS, UNCERTAINTY & FREEBOARD

There is an unavoidable level of uncertainty associated with the results of any model. For this particular model this uncertainty stems from two main sources:

- the uncertainty surrounding the Paper Mills Scheme, and;
- general uncertainty arising from simulating a complex system.

The Environment Agency report[12] provides guidance on translating uncertainty into a suitable freeboard allowance. The scoring methodology is to take the two highest scoring topics to derive a 'star score' via the matrix. This FCA assesses the two worst scoring topics which can be any two of: Flood Risk Analysis, Defence Failure or Evidence Strength each with a score of 3. This results in an overall score of three stars '*Likely to be locally reliable*'. As per the residual uncertainty table this suggests an uncertainty allowance of 20% as a proportion of design flood depth or 600 mm. Improving two or more of the highest scoring topics would improve the star rating and reduce the uncertainty; however, as proposed the incorporation of a freeboard allowance of 600 mm within the habitable FFL is currently considered appropriate for this site, based on the current modelling. This is based upon the in-channel change in stage recorded at the site of interest in the Sensitivity Scenarios (max +520 mm) and Blockage Scenarios (max +289 mm).

5.2. TIDAL & OVERTOPPING RISK

The site is understood to have a reduced risk of flooding from tidal sources in the present day due to the presence of the tidal barrage. The barrage is understood to protect against the 0.1% AEP. The risk of tidal flooding may increase over the lifetime of the development depending on the rate of sea level rise, although this is likely to be countered by any works undertaken to improve the wider off-site defences as part of the hold the line policy. The results from the VDM event identified in Section 2.2 suggest a lower floodwater level than that identified by the latest fluvial model results for this study set out in Section 4. In this case, it would be anticipated that the prevention of flooding in the design fluvial event will also mitigate against tidal flooding, this assumes that Cardiff Bay Tidal Barrage is maintained

[12] Tarrant, Owen et al (February 2017) *Accounting for residual uncertainty: updating the freeboard guide*. Environment Agency, Bristol, U.K. Ref: SC120014 . ISBN: 978-1-84911-388-5

to remain at an effective standard of protection, which given the large areas of Cardiff which it protects is deemed to be a reasonable assumption.

5.3. PLUVIAL & SURFACE WATER RISK

The site is identified as having isolated areas of low risk from surface water flooding; however, floodwaters appear to accumulate on site and the models used to inform the NRW map do not typically account for local drainage systems. A surface water drainage strategy has been developed and is detailed in an accompanying report (Ref: 3561-WSP-C-RP-001), this outlines how runoff is to be managed across the site to ensure that there is no increased risk to users of the site or third parties and to support this demonstrates the post development surface water exceedance pathways. In this case, assuming the acceptability of the drainage strategy report and noting the pluvial and surface water risk is separate from surface water features (S 5.1.1), the risk from this source may be considered low.

5.4. ACCESS & EGRESS

Safe access and egress is a planning requirement for developments of this nature, with Section A1.15 of TAN15 giving descriptive guidance on what is considered acceptable for standard development types. In order to consider access/egress, this development is classed under A1.15 as 'residential'. The recommendations of A1.15 for residential development are: a maximum depth of 600 mm, a maximum rise of floodwater of 0.1 m/hr, a maximum speed of inundation of area of 4 hours and a maximum velocity of floodwater of 0.3 m/s.

Both the northern and southern development plateau areas are accessed from the B4267. This road is anticipated to be flooded to impassable depths on the opposite (eastern) side of the bridge toward Ninian Park in the Proposed (Variation D) Scenarios extreme event; however, the route westward remains flood free. It is therefore anticipated that, whilst access and egress to the east would be affected during the peak of a design flood event; the route westward remains viable and provides a connection to the wider strategic highway network via Leckwith Road, B4267 and A4055.

5.5. FLOOD COMPENSATION & THIRD-PARTY EFFECTS

The current design includes ground raising within the floodplain of the Afon Elái. Raising the site, in combination with the proposed bridge, could result in flood water and flow routes being displaced and thus third party effects may be anticipated, however the modelling indicates that the bypass culverts have the intended effect in mitigating third party effects.

5.6. GROUNDWATER FLOOD RISK

The site is not within a groundwater source protection zone. The Vale of Glamorgan Local Flood Risk Management Strategy (LFRMS) identifies that the risk of groundwater flooding is poorly understood, and there is little evidence of this having occurred:

> *Groundwater flood risk in the Vale is currently poorly understood. Very little historic evidence of this type of flooding is available and the predicted future impacts are primarily based on generic national geological mapping.*
>
> *Section 2.3.2 (pg. 21)*

Figure 2-4 of the LFRMS shows that the site is located within a grid square identified as having between 25% and 50% susceptibility to groundwater flooding.

Furthermore, the Cardiff SFCA, which specifically considers the Elái Catchment states that groundwater flooding is not generally considered a concern in Cardiff:

> *The Taff and Ely CFMP states that groundwater flooding is not considered to be a significant issue within the catchment. It is noted that a large groundwater control scheme was introduced as part of the Cardiff Barrage scheme. There is a groundwater control system built into the Millennium Stadium. There are other similar schemes dotted throughout the low lying areas, designed to keep the groundwater levels low. It is not perceived that groundwater flooding would be a significant issue for the study sites. However, risks associated with groundwater should be investigated as part of site-specific FCAs. It is recommended that assessments should be made of additional control measures which may be required for specific sites.*
>
> *Section 5.4.3 (pg. 54)*

The site is anticipated to be situated on tidal and alluvial deposits which may, depending on their exact composition, be susceptible to groundwater movements. Although the groundwater table would be anticipated to be dominated locally by the Afon Elái, water features are noted as 'issuing' and 'sinking' around the southern part of the site, which may either be natural or manmade. The Scheme does not include any basement dwellings, therefore the risk of groundwater flooding is considered minimal, particularly given the elevated FFLs which will be set to protect against both fluvial flooding and the surface water exceedance flow routes through the site. An assessment of groundwater risk associated with the issuing and sinking features in the southern part of the site will be undertaken during detailed design, this will be supported by way of appropriate investigations.

5.7. RESERVOIR & INFRASTRUCTURE FLOOD RISK

The site is understood to be at risk of flooding from reservoirs as described previously (S 2). This is associated with failure of the Pontsticill Reservoir, however, in the UK, considering the legally required inspection and maintenance regime for reservoirs, the risk is considered residual and, unless there are any known issues with this reservoir, is usually considered to be acceptable.

Based on a review of mapped data the site is not expected to be at any significant risk of flooding from ponds, lakes or other such bodies of water. There is a pond identified in the OS mapping on the southern edge of the site, however, LiDAR analysis demonstrates that this is at a significantly lower level than the site, detailed design will ensure that there is no risk of flooding to the Scheme associated with this feature.

No canals have been identified from the OS mapping that would put the site at risk of flooding from a canal.

Residual risks of flooding from artificial flooding remain as subject to detailed design there may be a risk of flooding from a burst water main / foul sewer, although no DCWW mains are evident on the

current site, this would be mitigated by the fluvial mitigation requirements and the drainage strategy. Additionally, there is a risk of flooding associated with a blockage on either the Historic Roadbridge or the Proposed Bridge, which would be expected to increase the risk of flooding at the site. However, this risk for the Historic Bridge is understood (described in Section 5.1.3) and, concerning the proposed bridge, given the size of the openings the risk of a significant blockage is considered to be reasonably low.

6. MITIGATION SUMMARY

The previous sections of this FCA describes the mitigation that needs to be embedded within the Scheme to ensure that it is compliant with TAN15 and can secure planning consent, these mitigation measures are:

- The highly vulnerable aspects of this development are not proposed in any areas predicted to flood in either the design (1%CE AEP) event the extreme (0.1% AEP) event.
- The design flood level is predicted to be 8.36 m AOD at the upstream end of the site and 7.90 m AOD at its downstream end. This report recommends 600 mm freeboard above this for habitable FFLs. Therefore, the indicative minimum habitable floor levels are 8.96 m AOD at the upstream end of the site and 8.50 m AOD at the downstream end.
- The external areas of the proposed development are predicted to remain dry in both the design and extreme events but has a residual risk of flooding flood up to 20 cm if the extreme event coincides with a blockage event, though to a low hazard classification. Any external amenity and ancillary areas in the northern plateau that are adjacent / in close vicinity to the riverbank that will be at risk of flooding will be designed to passively accommodate flood waters, with readily accessible egress to safety, prevent floating debris being carried by floodwater (e.g. vehicles) as well as be sufficiently drainable post flood event.
- The surface water drainage strategy will be refined during detailed design to the satisfaction of the SAB and will ensure that surface water attenuation is accommodated without increasing the risk of flooding.
- The foul water strategy will be developed to the satisfaction of DCWW and will ensure that there is no undue risk of flooding from this source.
- The Scheme does not include any basement dwellings, but does include undercroft car parking, these areas are to be readily evacuable and protected by self-raising barriers to ensure that an appropriate level of protection is provided.
- Any services or other infrastructure provision within the undercroft parking areas will be evaluated as part of the detailed design to ensure that appropriate flood constraints are considered (i.e. raised threshold / platform levels or flood proof doors).
- Service ingress /egress points should be located above the 1%CE event plus 600 mm freeboard level, where this is not feasible appropriate seals will be provided.
- The undercroft carpark will be at or above external levels outside the building footprint.
- Detailed design will include obtaining the appropriate consents and permits that will be required from NRW, the SAB and the Lead Local Flood Authority.
- Detailed design will refine the mitigation measures associated with groundwater flood risk. This risk is identified to be low, with the groundwater table anticipated to be dominated by the Afon Elái, the mitigation is that the development platform and threshold levels are raised, with any groundwater emergence predicted to follow surface water exceedance routes. The detailed design should include the completion of appropriate investigatory and mitigatory (if required) works in the south of the site, associated with the ‘issues’ and ‘sinks’ for the unnamed surface water features, as shown on the OS maps.

In addition to these measures the detailed design stage of the Scheme should consider the following points to refine the proposed mitigation measures:

- Review of the level of the undercroft car parks, to remove the need for self raising barriers or other active mitgative measures.

Additionally, the detailed design stage could assess:

- The risk of blockages: The Historic Bridge is currently considered to be more susceptible to blockages than a bridge designed in the present day and the result of a blockage is to locally increase flood levels. The mitigation measures (i.e. freeboard allowance which is in addition to the fluvial 1%CE flood level) could be refined potentially by reducing the potential for a blockage at the Historic Bridge. Notwithstanding that, it is unlikely that the statutory consultees would find the following points acceptable, but are worth due consideration:
    - A commitment to significant and regular vegetation/debris clearance from the riparian corridor;
    - An offset debris screen, boom or other interception method which could potentially be installed upstream of the proposed bridge to reduce the debris loading at the Historic Bridge;
    - An increased maintenance and inspection regime could be considered at the historic bridge; with the development including proposals to facilitate said maintenance
    - Affixing debris screens directly to the listed bridge; or
    - Removing the bridge.

7. COMPLIANCE WITH TAN15

Section 9 of TAN15 summarises: the planning requirements, acceptability criteria and development advice for a Highly Vulnerable development in DAM Zone C1. This summary is replicated in this section and discussed for completeness.

7.1.1. JUSTIFICATION

For developments in DAM Zone C1 the planning requirements are: that the Justification Test is applied, the consequences are acceptable and that surface water requirements are met.

Section 6 of TAN15 outlines the Justification Test, it states:

> *'Development, including transport infrastructure will only be justified if it can be demonstrated that:*
>
> *i. Its location in zone C is necessary to assist, or be part of, a local authority regeneration initiative or a local authority strategy required to sustain an existing settlement; or,*
>
> *ii. Its location in zone C is necessary to contribute to key employment objectives supported by the local authority, and other key partners, to sustain an existing settlement or region.*
>
> *And:*
>
> *iii. It concurs with the aims of PPW and meets the definition of previously developed land (PPW fig 4.1); and,*
>
> *iv. The potential consequences of a flooding event for the particular type of development have been considered, and in terms of the criteria contained in sections 5 and 7 and appendix 1 found to be acceptable.'*

Each point is addressed in turn:

i. As the site is a 'windfall' site it is not included within the Local Development Plan. Notwithstanding this, the development is supporting and facilitating the replacement of the Leckwith Road (B4267) roadbridge, which having been built in the 1930's is considered to be nearing the end of its design life and is required to sustain existing settlements.

ii. As outlined above, without the replacement B4267 roadbridge, employment objectives and sustainability of the region could be negatively impacted through the removal of the highway connection between the Vale of Glamorgan to Cardiff.

iii. The presence of the existing buildings demonstrates that the majority of the site comprises previously developed land and is considered to meet the aims of PPW.

iv. The earlier sections of this report demonstrate that flood related impacts may be considered acceptable. The hydraulic model demonstrates that by bypassing (or removing) the constriction on the Afon Elái, the impacts of the proposed scheme are mitigated in both the design event and extreme event with a reduction in flood consequence predicted in all (unblocked) events.

7.1.2. ACCEPTABILITY

Under Section 7.2 of TAN15 two key criteria of acceptability are safe access and the availability of timely flood warnings. As previously noted in this report, flood warnings are available in this location and ground levels are understood to be set higher than the predicted flood levels enabling safe access.

Section 7.3 of TAN15 notes that if a development is justified, mitigation measures should be incorporated into the design to make it as safe as possible (Section 6) and that there is:

- Minimal risk to life;
  This FCA demonstrates that the risk to life is to be minimised through the incorporation of raised FFL (a minimum of 600 mm above the 1%CE flood level) and by raising the development platform above the 0.1% flood level to minimise the extents and depths of flooding across the areas in which residential development is proposed.
- Minimal disruption to people living and working in the area;
  The disruption to people living and working in the area will be minimised through the replacement of the roadbridge, whilst the on-site impacts are minimised by appropriate FFL's (the 1%CE event plus 600 mm freeboard) and setting external ground levels above the 0.1% event.
- Minimal potential damage to property;
  The FFL's will be appropriately set at 600mm above the 1%CE flood level to minimise the potential damage to property the hydraulic model demonstrates that the impacts of the proposed scheme are beneficial in all of the modelled (unblocked) events.
- Minimal impact of the proposed development on flood risk generally, and;
  The hydraulic model demonstrates that the impacts of the proposed scheme are almost entirely beneficial to the developed Afon Elái floodplain.
- Minimal disruption to natural heritage.
  The impact of the scheme and mitigation thereof is considered in the appropriate accompanying reports.

8. CONCLUSIONS

This FCA, and the hydraulic model developed in support of this scheme, has determined the potential impacts of the development in the key design events and scenarios; as well as how these risks can be reduced to acceptable levels by the implementation of mitigative measures. This FCA also provides an assessment of the acceptability against TAN15.

The proposed development featured in this report is considered to have a low risk of flooding from all sources. This FCA demonstrates that the scheme can be considered compliant with TAN15 and beneficial to the developed Afon Elái floodplain, subject to the interpretation of blockage scenarios. In this case, both NRW and the LPA are in a position to complete their assessment as to whether the level of risk and consequences are acceptable.

This report details how the risks and consequences can be mitigated, as detailed in Section 6. TAN15 considers Highly Vulnerable (residential) sites to be potentially permissible within DAM Zone C1, subject to additional criteria. The results as presented within this document enable an assessment to be made as to whether the proposal is in accordance with the requirements associated with this DAM Zone.

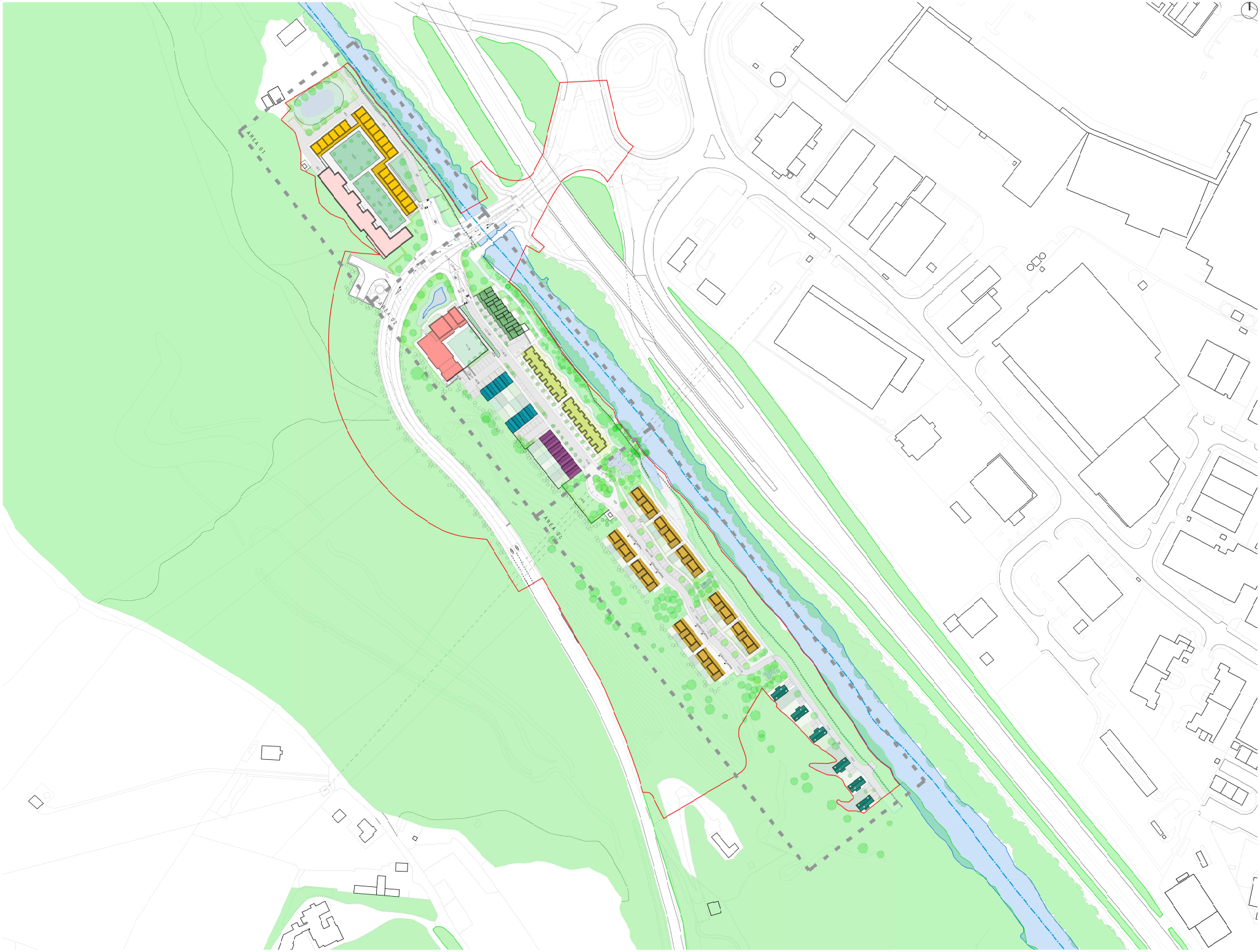
This document provides sufficient evidence to determine that the level of risk associated with this site can be considered commensurate with the aims and intent of the proposed development. The responsibility for making said determination lies with the Vale of Glamorgan as the LPA and as advised by NRW.

Appendix A

PROPOSALS

Appendix A.1

PROPOSED DEVELOPMENT LAYOUT



DWELLING MIX + 3IFA

BLOCK A
50no. 2B 4P apartments
Dwelling size average: 70m2

BLOCK B
19no. 3B 5P houses (HOUSE TYPE B)
Dwelling size average: 116m2
18no. 2B 4P duplex (Duplex Dwelling Type 7)
Dwelling size average: 73m2

BLOCK C
31no. 2B 4P apartments
Dwelling size average: 70m2

BLOCK D
28no. 2B 4P duplex
(Duplex Dwellings Types 1 + 2)
Dwelling size average: 94m2

BLOCK E
54no. 3B 5P duplex (Duplex Dwelling Types 3 + 4)
Dwelling size average: 113m2

HOUSE TYPE A
7no. 3B 5P houses
Dwelling size average: 125m2

HOUSE TYPE C
8no. 3B 5P houses
Dwelling size average: 96m2

HOUSE TYPE C
6no. 4B 7P houses
Dwelling size average: 165m2

HOUSE TYPE E
7no. 3B 5P houses
Dwelling size average: 178m2

DWELLING MIX:

Apartments	81
Duplex Dwelling	100
Houses	47
TOTAL	228

REVISIONS
A 13.09.2020 GE
LEVELS UPDATED TO NORTHERN PLATEAU
B 30.10.2020
C 05.10.2021
AREA 3 LAYOUT UPDATED
D 24.02.2022
BLOCKS C AND E UPDATED
E 05.04.2022
LEVELS UPDATED
F 11.04.2022
LEVELS UPDATED
G 16.06.2022
REVISED BLOCK A
H 05.10.2022
UPDATED TO DRAINAGE + LANDSCAPE

PLANNING

1844/S.102H

LECKWITH QUAY

PROPOSED MASTERPLAN

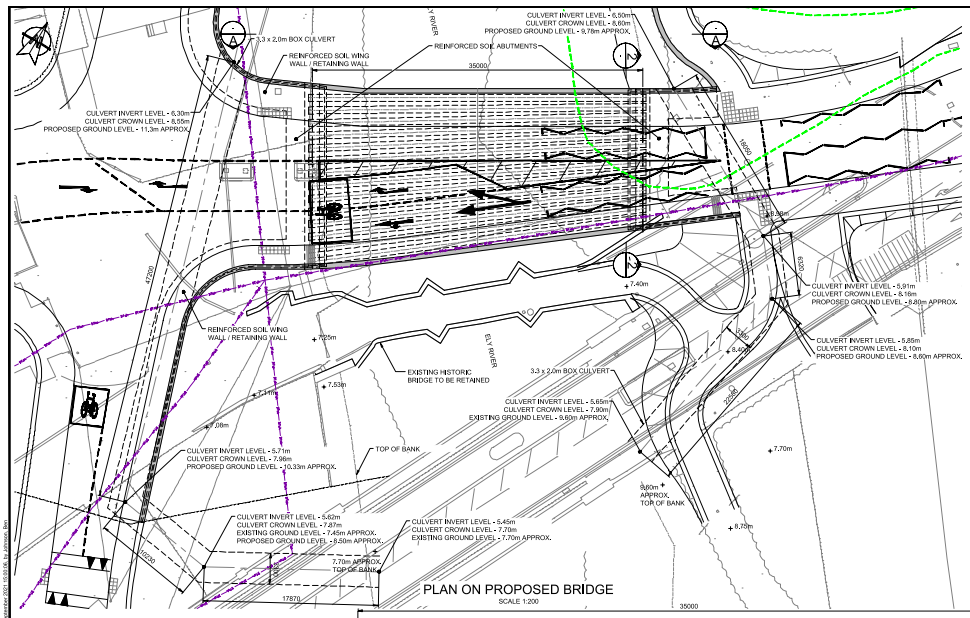
1:1250@A1 OCT 22

LOYN+CO ARCHITECTS

07920 711432 | architecture@loyn.co.uk
88 Glebe Street Penarth CF64 8F | loyn.co.uk

Appendix A.2

PROPOSED VIADUCT LAYOUT



LOCATION PLAN
SCALE 1:10,000

DO NOT SCALE

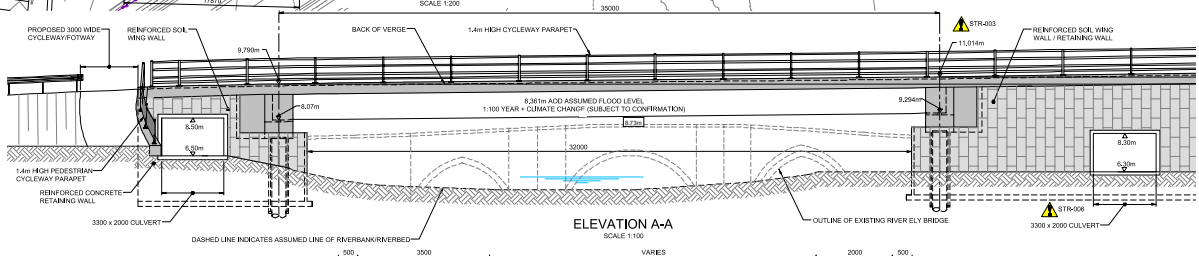
NOTES:

1. DO NOT SCALE FROM THIS DRAWING - USE ONLY VALUES OF STATED DIMENSIONS.
2. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SHOWN.
3. ALL EXISTING STATUTORY INFORMATION SHOWN HAS BEEN PROVIDED BY THE RELEVANT STATUTORY AUTHORITIES. THE CONTRACTOR SHALL CONFIRM THE LOCATIONS AND OWNERSHIP OF THE SERVICES PRIOR TO ANY WORKS BEING CARRIED OUT. ANY DIVERSIONS REQUIRED ARE TO BE CARRIED OUT IN ACCORDANCE WITH THE REQUIREMENTS OF THE RELEVANT STATUTORY AUTHORITY PRIOR TO CONSTRUCTION.

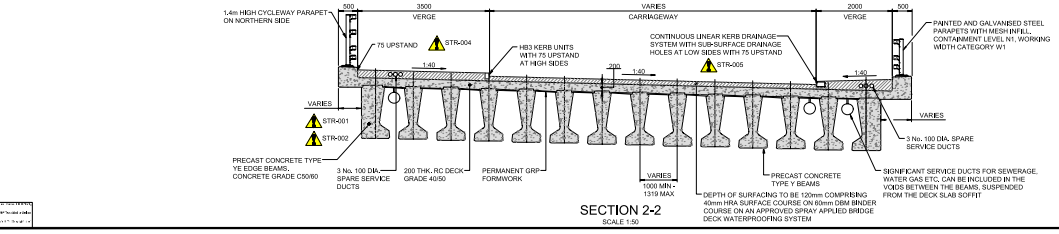
KEY

BT OPENREACH

WESTERN POWER HV (33kV)



ELEVATION A-A
SCALE 1:100



SECTION 2-2
SCALE 1:50

Health and Safety Symbols Legend

All Risks are Recorded in the Significant Residual Design / BS Risks Schedule
Document Number: 70053561-***

⚠ UNIDENTIFIED RESIDUAL RISKS WARNING.

IN ADDITION TO THE HAZARDS/RISKS NORMALLY ASSOCIATED WITH THE TYPES OF WORK DETAILED ON THIS DRAWING, NOTED RISKS, UNUSUAL OR SIGNIFICANT RISKS ARE:

Construction Risks	S1 R001 - Lifting of precast beams.
	S1 R002 - Landing of precast beams onto capping beam.
	S1 R003 - Segmental construction.
	S1 R004 - Potentially Existing Statutory Undertakers Apparatus.
	S1 R005 - Deep Excavation.
	S1 R006 - Stitched construction.
	S1 R007 - Fixing reinforcement.
	S1 R008 - Fixing reinforcement (pile).
Maintenance Risks	No significant maintenance risks identified.
Demolition/Adaptation Risks	No significant demolition risks identified.

REV	DATE	BY	DESCRIPTION	CHK	APP
P03	01/12/22	GW	Additional width level added	GW	GW
P02	24/09/2021	GJ	CULVERT DIMENSIONS/LEVELS ADJUSTED	SH	SS
P02	27/08/2020	GJ	DPM INCREASED	SH	SS
P01	21/10/2019	GJ	FIRST ISSUE	SH	SS

S0 - WORK IN PROGRESS

1 Capital Quarter, Tyndall St, Cardiff, CF10 4BZ, UK
T+ 44 (0) 292 076 9200

CLIENT:

PROJECT:

LECKWITH QUAY DEVELOPMENT

TITLE:

LECKWITH QUAY BRIDGE
PROPOSED GENERAL ARRANGEMENT

Drawing at: A1 SHOWN	Designed: SH	Checked: SS	
Project No: 70053561	Drawn: SS	Approved: SJ	Date: September 21

Drawing No: 70053561-002 | Rev: P04

DO NOT SCALE

NOTES

1. DO NOT SCALE FROM THIS DRAWING, USE FIGURED DIMENSIONS ONLY.
2. ALL LEVELS ARE IN METRES ABOVE ORDNANCE DATUM (AOD)
3. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE STATED.
4. THIS DRAWING IS FOR PLANNING PURPOSES ONLY AND IS SUBJECT TO DETAILED DESIGN
5. HIGHWAY GEOMETRY & DESIGN IS SUBJECT TO TECHNICAL APPROVAL OF THE ADOPTING HIGHWAY AUTHORITIES

KEY:

- 1:2 FILL SLOPE*
- 1:1 CUTTING SLOPE (ROCK CUTTING/ STRENGTHENED CUT)*
- 1:2 CUTTING SLOPE*

*SUBJECT TO CONFIRMATION OF GROUND CONDITIONS

DRAWING STATUS: FOR PLANNING

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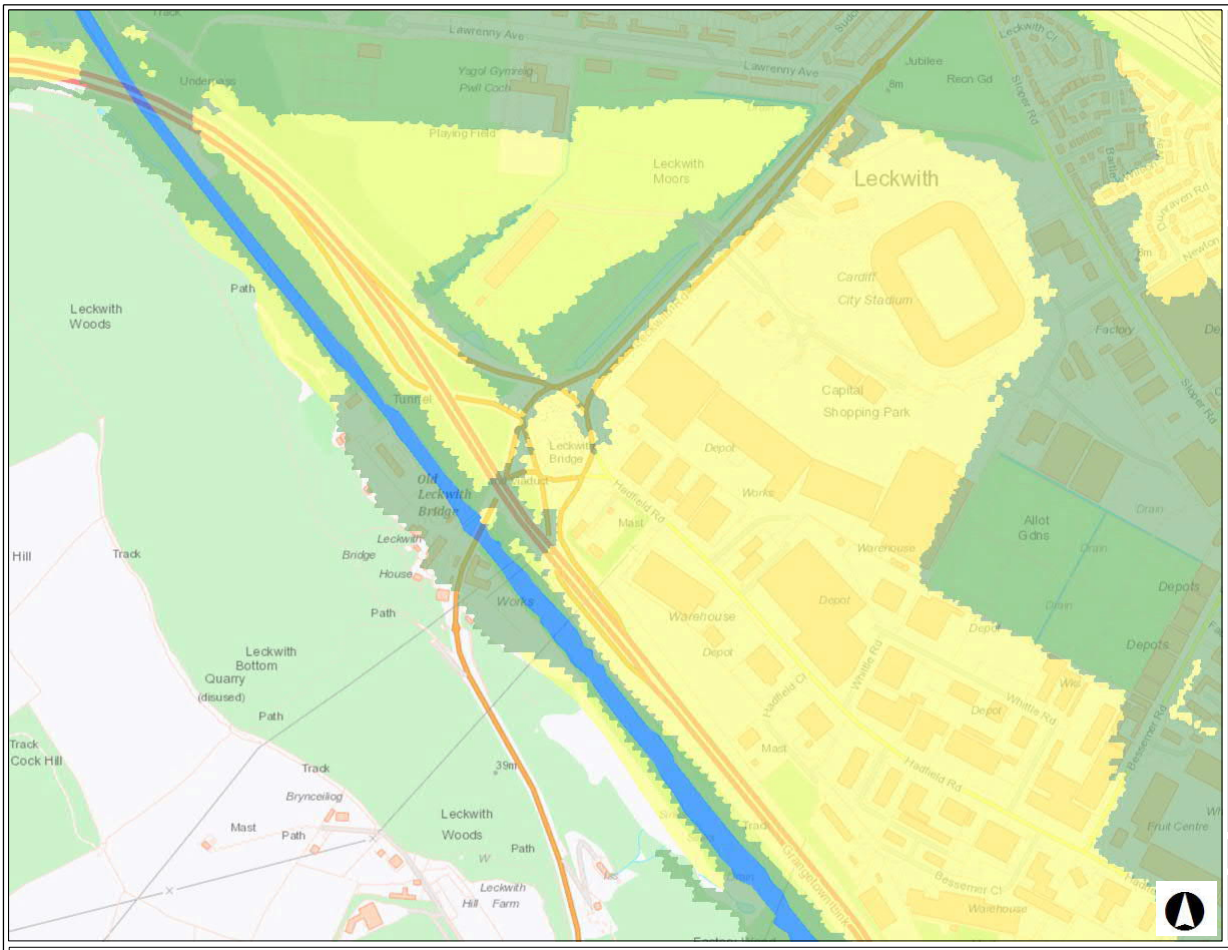
CLIENT:	PHILIP WORTHING
ARCHITECT:	LOYN ARCHITECTS
PROJECT:	LECKWITH QUAY
TITLE:	B4267 LECKWITH ROAD HIGHWAY IMPROVEMENTS LEVELS AND CONTOURS
SCALE @ A1:	1:500
CHECKED:	SID
APPROVED:	GW
PROJECT No:	70053561
DESIGNED:	SID
DRAWN:	GS
DATE:	September 19
DRAWING No:	70053561-WSP-XX-XX-CR-DE-600
REV:	-

Appendix B

NRW ONLINE MAPS



Cyfoeth Naturiol Cymru
Natural Resources Wales

Map Title

Map Perygl Llifogydd / Flood Risk Map

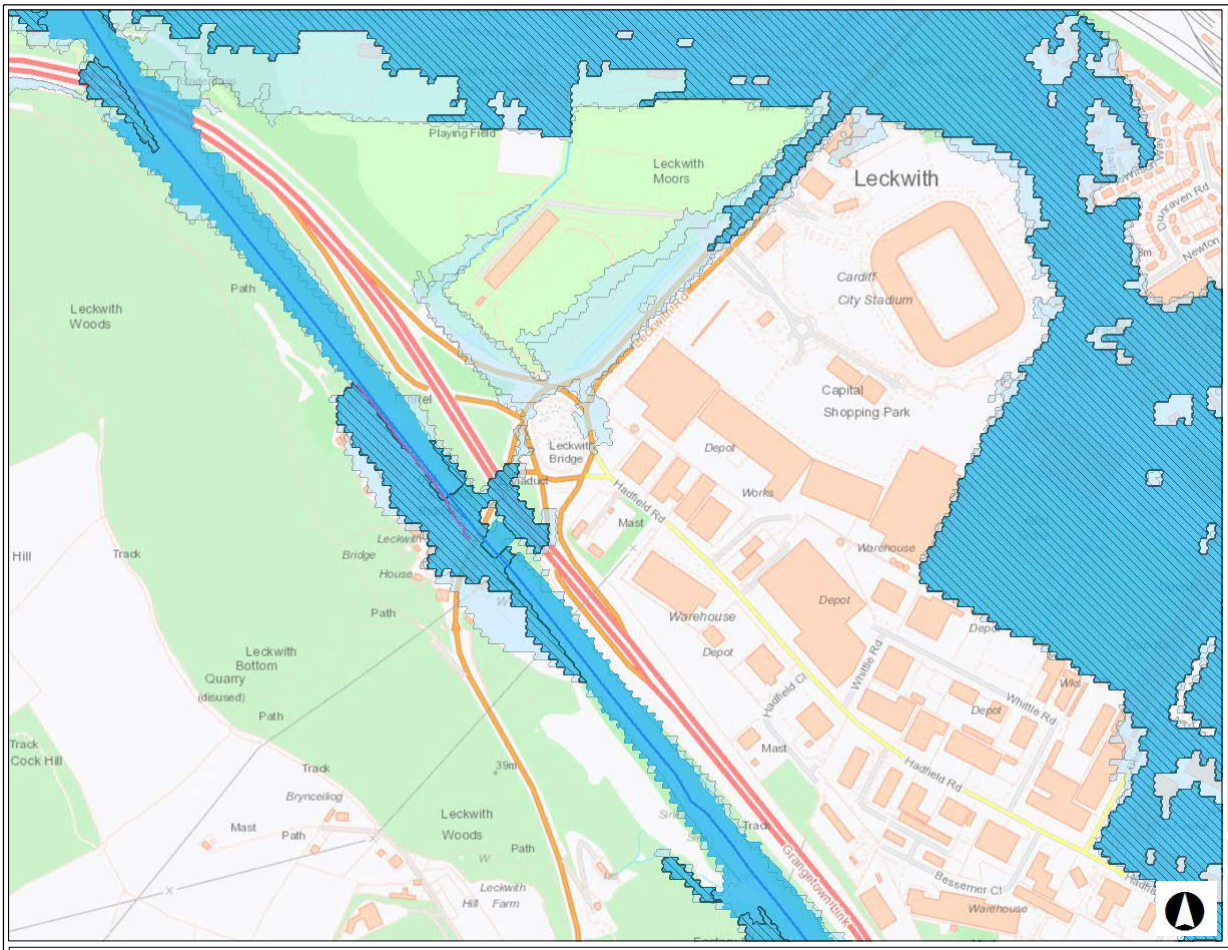
Allwedd / Map Key

- Zone C1
- Zone C2
- Zone B
- Zone A

Graddfa / Scale 1: 5,001

Dyddiad / Date
14/05/2020

0.3 0 0.13 0.3
British_National_Grid Kilometers



Cyfoeth Naturiol Cymru
Natural Resources Wales

Map Title

Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

- Main Rivers
- Flood Defences
- Areas Benefiting from Flood Defences
- Flood Storage Areas
- Floodmap Flood Zone 3
- Floodmap Flood Zone 2

Graddfa / Scale 1: 5,001

Dyddiad / Date
14/05/2020

0.3 0 0.13 0.3
British_National_Grid Kilometers

Cyfoeth Naturiol Cymru
Natural Resources Wales

Map Title

Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

- Main Rivers
- Risk of Flooding from Rivers & Sea
  - High
  - Medium
  - Low
  - Very Low

Graddfa / Scale 1: 5,001

Dyddiad / Date
14/05/2020

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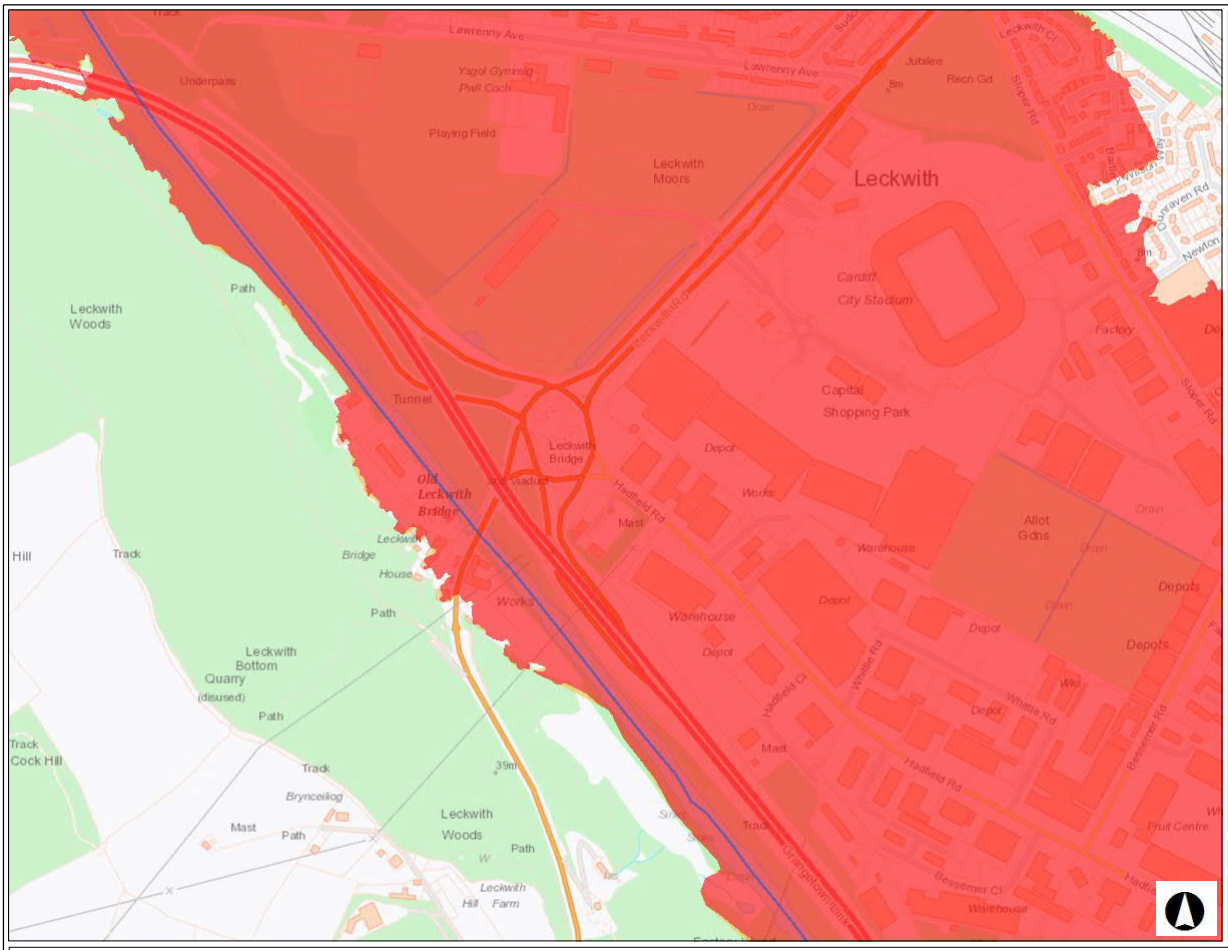
British_National_Grid Kilometers



Cyfoeth Naturiol Cymru
Natural Resources Wales

Map Title

Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

- Main Rivers
- Flood Warning Area
- Flood Alert Area

Graddfa / Scale 1: 5,001

Dyddiad / Date
14/05/2020

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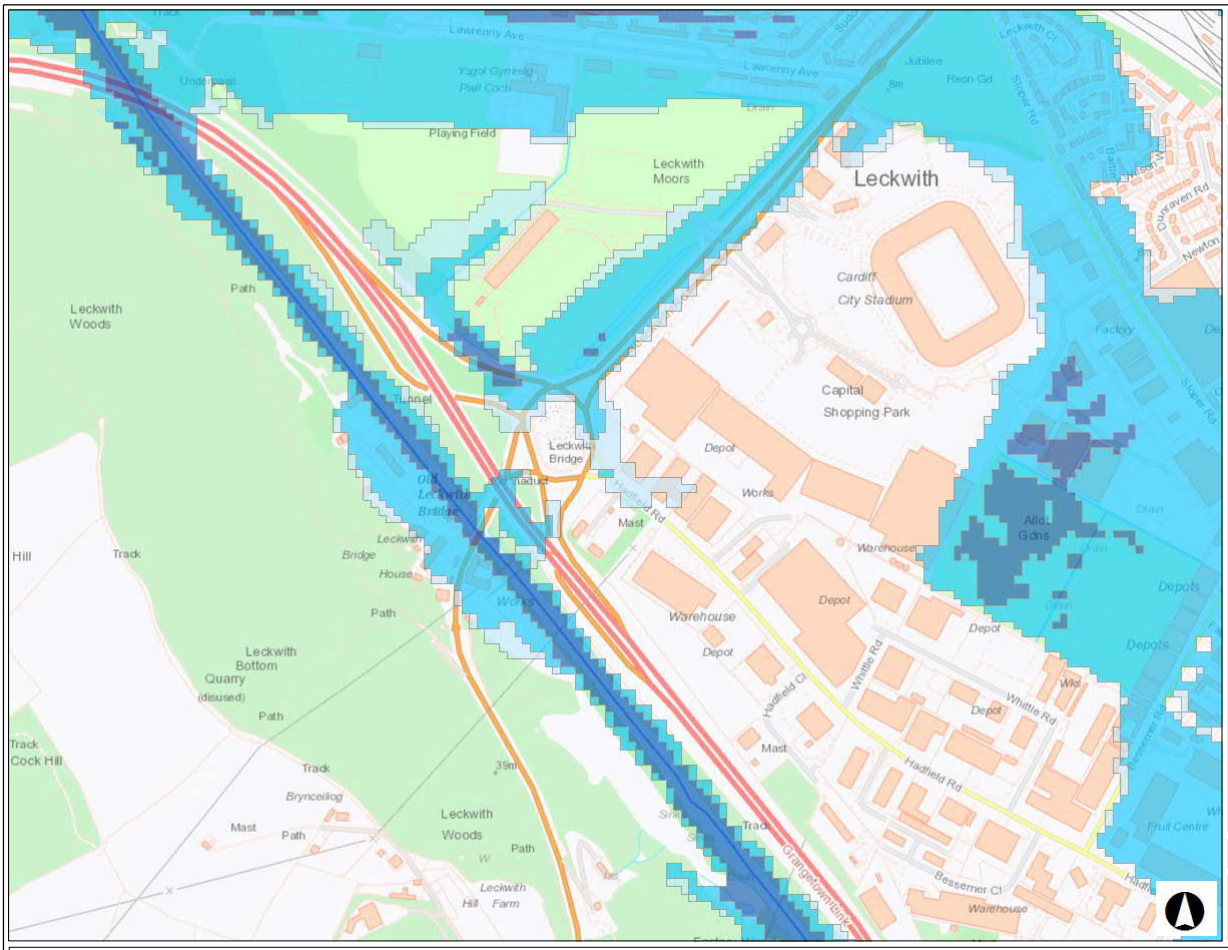
British_National_Grid Kilometers



Cyfoeth Naturiol Cymru
Natural Resources Wales

Map Title

Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

- Main Rivers
- Reservoir Depths
  - 0 - 0.3m
  - 0.3 - 2.0m
  - Greater than 2.0m

Graddfa / Scale 1: 5,001

Dyddiad / Date
14/05/2020

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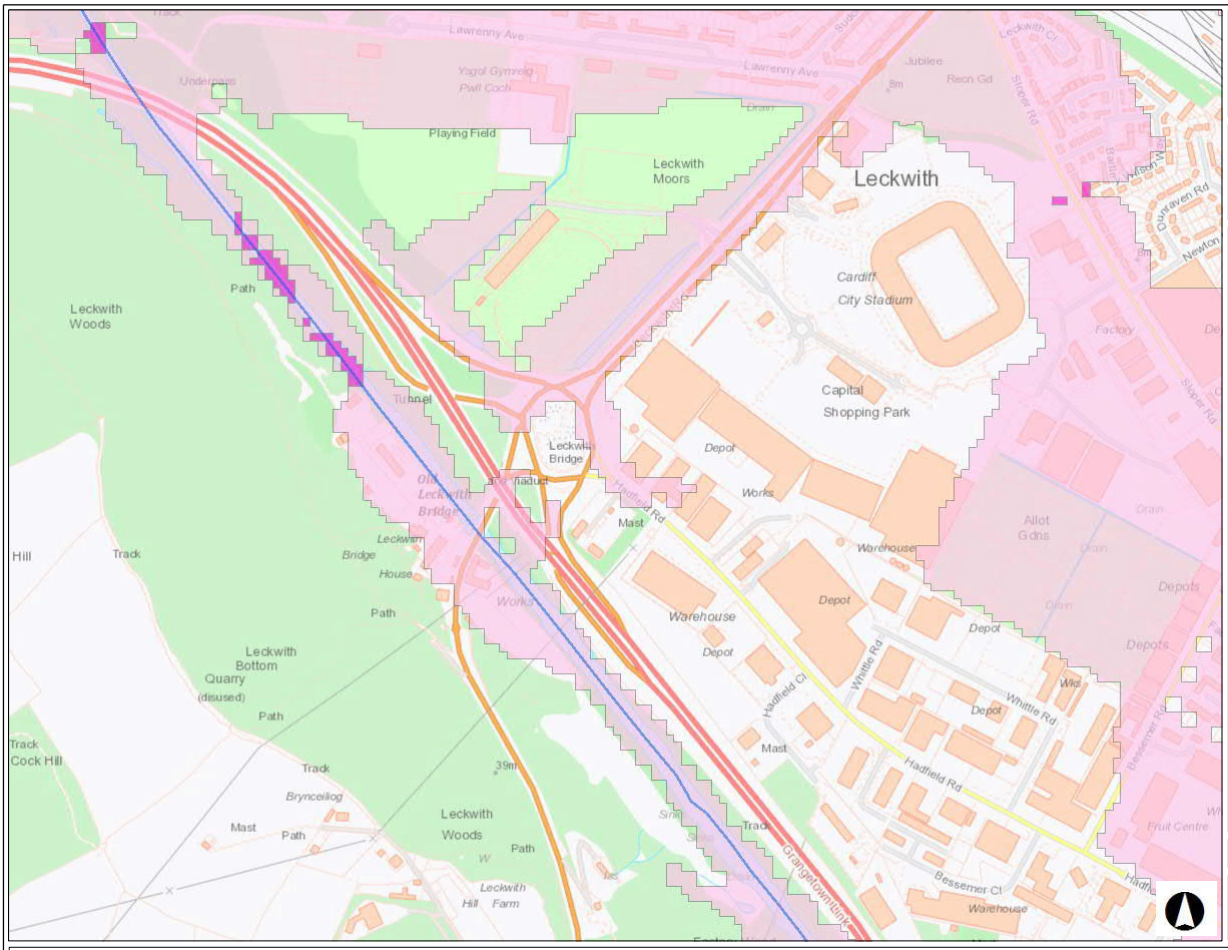
British_National_Grid Kilometers



Cyfoeth Naturiol Cymru
Natural Resources Wales

Map Title

Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

- Main Rivers
- Reservoir Velocities
  - 0 - 0.5m/s
  - 0.5 - 2.0m/s
  - Greater than 2.0m/s

Graddfa / Scale 1: 5,001

Dyddiad / Date
14/05/2020

Cyfoeth Naturiol Cymru
Natural Resources Wales

Map Title

Map Perygl Llifogydd / Flood Risk Map

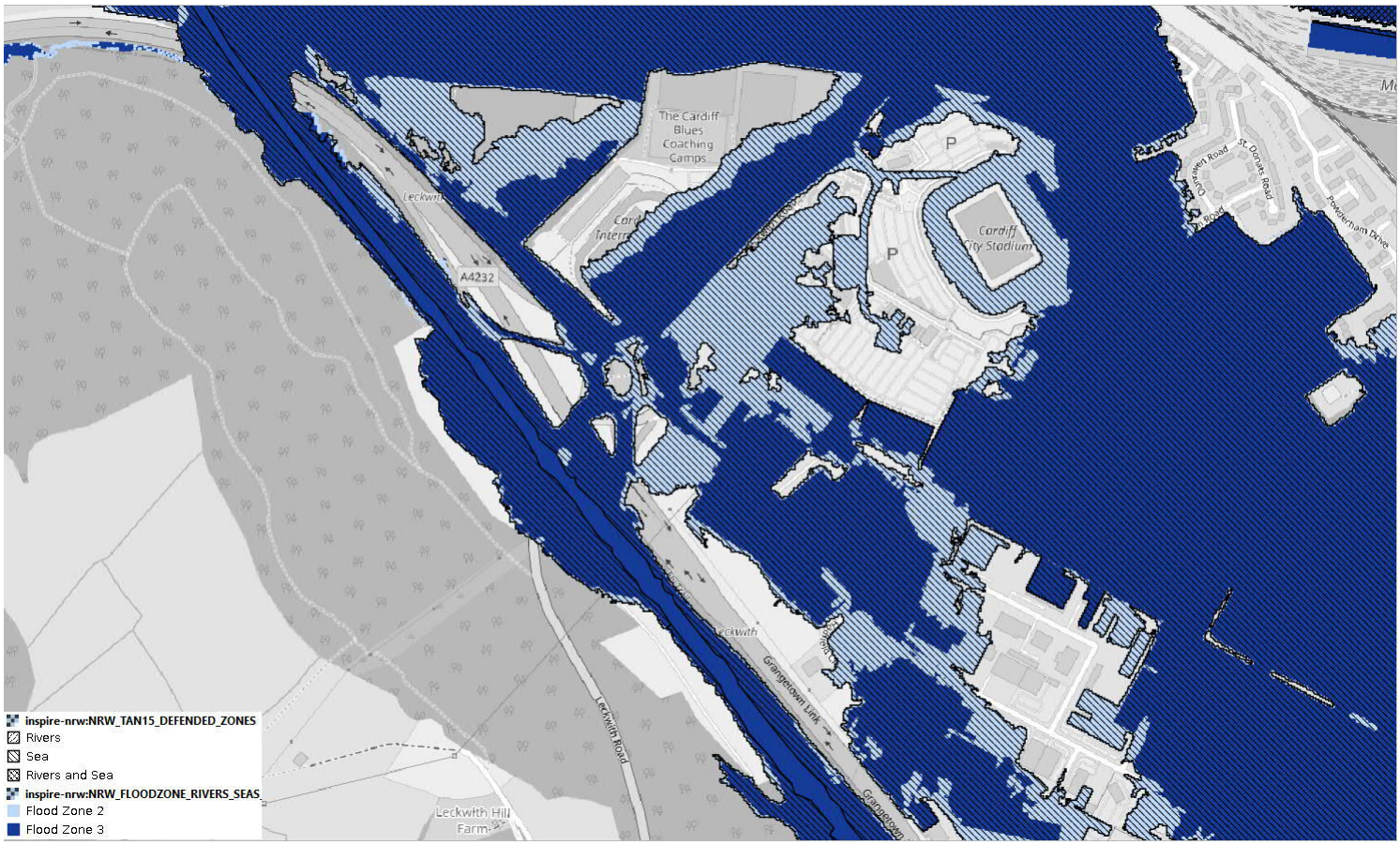
Allwedd / Map Key

- Main Rivers
- High Surface Water Flood Risk - Extent
- Medium Surface Water Flood Risk - Extent
- Low Surface Water Flood Risk - Extent

Graddfa / Scale 1: 5,001

Dyddiad / Date
14/05/2020

0.3 0 0.13 0.3
British_National_Grid Kilometers


The Cardiff Blues Coaching Camps
Cardiff City Stadium
P
P
A4232
Leckwith
Leckwith Road
Grangetown Link
Grangetown
Leckwith Hill Farm
St. Donats Road
Pontcanna Drive
inspire-nrw:NRW_TAN15_DEFENDED_ZONES
Rivers
Sea
Rivers and Sea
inspire-nrw:NRW_FLOODZONE_RIVERS_SEAS
Flood Zone 2
Flood Zone 3

Appendix C

CBHE: HISTORIC EVENTS EXTRACT

University of Dundee

British Hydrological Society CHRONOLOGY OF BRITISH HYDROLOGICAL EVENTS

Search Results

Matching Search Item: Quotation LIKE 'Cardiff',

Results Per Page: 10 | 25 | 50 | 100

ID	Date	Quotation	Area	Contributor
10334	1696	1696 p15: Central Cardiff: "... The name 'Kings Castle' was also taken by one of Canton's oldest and largest private houses [on the site later taken by the Memorial Hall] ... The house and its occupants featured in a court case of 1696 in which Nicholas Greene blocked a water-course and flooded Cowbridge Road ... 'to vex and oppose Henry Fox ...'". [ha 057, Taff]	057 - Taff (Glamorgan) Group	Frank Law
12534	27-01-1795	Such a rare and sudden thaw that ice floes swept away the temporary works for a new bridge over the River Taff in Cardiff.	057 - Taff (Glamorgan) Group	Frank Law
10333	1827	1827 p37: "This photograph of Cardiff [Canton] Bridge in 1891 shows the remains of the 1796 bridge. The first stone bridge - to replace the earlier wooden structures often destroyed by debris brought down by floods - was probably raised in 1582 and rebuilt after the damage caused in the Civil War. A new bridge built in 1796 was destroyed by floods about 1827 ..." [ha 057, River Taff]	057 - Taff (Glamorgan) Group	Frank Law
11836	14-07-1875	P 56: "The amounts recorded in Cardiff for May 27th [1931] were the largest recorded there since July 14th, 1875, when 4.84 inches, 4.80 inches and 4.75 inches fell at Lisvane, Pentyrch and Ely respectively. On that occasion the rivers Taff and Ely overflowed ther banks in many places and there was considerable damage to hay, etc."	057 - Taff (Glamorgan) Group	Frank Law
10444	15-07-1875	1875 July 15 "Cardiff: The rivers Taff and Ely overflowed their banks in many places; the damage to hay was immense ... Flocks of sheep have been washed down both rivers, and also horses and a large number of pigs. At St Fagans the railway was more than 2 ft. under water, near Canton Common, at Grangetown, and in the village of Ely many houses had the water 4 or 5 ft. deep, so that the inhabitants could only be visited or removed in boats. The turnpike road between Cardiff and St Nicholas was impassable for one whole day ... Tongwynglais: The Taff rose to a great height; the Pentyrch works were flooded, and at Nangarw there was 6 ft. of water over the turnpike road." [ha 057, Taff]	057 - Taff (Glamorgan) Group	Frank Law
11251	14-07-1875	1875 July 14 Daily rain at Cardiff of 4.75 in. [ha 057]	057 - Taff (Glamorgan) Group	Frank Law
8079	1893	1893 April For these reasons I select, for special notice, only droughts, of sixty days or upwards, which have begun in February or March and finished in April, May or June. That the spring is the usual period for such droughts is strikingly proved by the fact that this limitation excludes only two out of the eight long partial droughts of the present century..." 1893 rain records show Greenwich - partial drought from Feb 28 to May 16 or 78 days, including an absolute drought of 30 days from Mar 18 to April 15.Camden Square - Partial drought from Feb 28 to May 16, or 78 days, including an absolute drought of 29 days from March 18 to April 15...The area over which the drought has been severe is that S.E. of a line joining Cardiff to Hull, and it has been worst along the south coast from Dover to Exeter.""	039 - Thames	Frank Law

ID	Date	Quotation	Area	Contributor
10332	03-11-1927	1927 November 3 p97: Central Cardiff: "A Swansea-Cardiff train passing the paper mill on 3 November, 1927. After those floods, which began two days earlier, the [Cardiff] Council straightened the course of the River Ely and undertook other work which prevented their recurrence [but note flood of 5/12/1960 on photos, p10 and p123, of Cowbridge Road]. In St Luke's Church a tide-mark can still be seen which records the height of the water there: 2 feet, 4 inches." [ha057, River Ely]	057 - Taff (Glamorgan) Group	Frank Law
11835	27-05-1931	P 54-56, inc isohyetal map:More than 4 inches fell over 104 square miles, and between 3 and 4 inches over 218 square miles, lying roughly north-south from Breconshire to Glamorgan.Largest fall was 4.50 inches at Penarth (Council Offices). The fall recorded in Cardiff (4.18 inches at Penylan) was the largest since July 14th, 1875.	057 - Taff (Glamorgan) Group	Frank Law
13852	05-12-1939	"At 1-40 pm on 5th December 1939 after a period of heavy rainfall a large slide of a [coal waste] tip belonging to the Albion Colliery (owned by the Powell Duffryn Company) occurred at Cilfynydd Common near Abercynon some five miles from Aberfan [south of Merthyr Tydfil]. The tip situated on the hillside adjoining the main Cardiff-Merthyr road slid some 710 feet to the road crossed it and then progressed a further 720 feet to beyond the river bed. The width of the slide below the tip was 400 feet the main road was blocked for 585 feet to a depth of 20 ◆ 25 feet the Glamorgan Canal was filled for 540 feet and the railway for 500 feet. The River Taff was blocked to a depth of 15 feet for some 500 feet and substantially diverted. It was estimated that the total weight of tip material in the slide was some 18000 tons." [page 41] "Mr Brynmor Davies a consultant civil and mining engineer ... concluded that unusually heavy rainfall had caused a rotational slide." [page 42]	057 - Taff (Glamorgan) Group	Henry Gunston
13399	01-07-1968	Llancarfan, near Cardiff Airport: Photos of "Great Flood of 1/7/1968"	058 - Mid-Glamorgan Rivers Group	Frank Law

Total Number of Records: **11** **Displaying Records: 1 - 11**

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