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Merthyr Bus Station
Flood Consequence Assessment

May 2016

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Quality Management

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1. Introduction

1.1 Purpose of the Flood Consequence Assessment

1.1.1 Capita has been commissioned by Merthyr Tydfil County Borough Council (MTCBC) to undertake a Flood Consequence Assessment (FCA) for a proposed Bus Station in Merthyr Tydfil. Figure 1-1 shows the location of the proposed Bus Station.

1.1.2 The proposed scheme includes, demolishing of the old Police station on Swan Street and the Health Care centre on Swan Street. Drawings showing the main components of the development are provided in Appendix B.

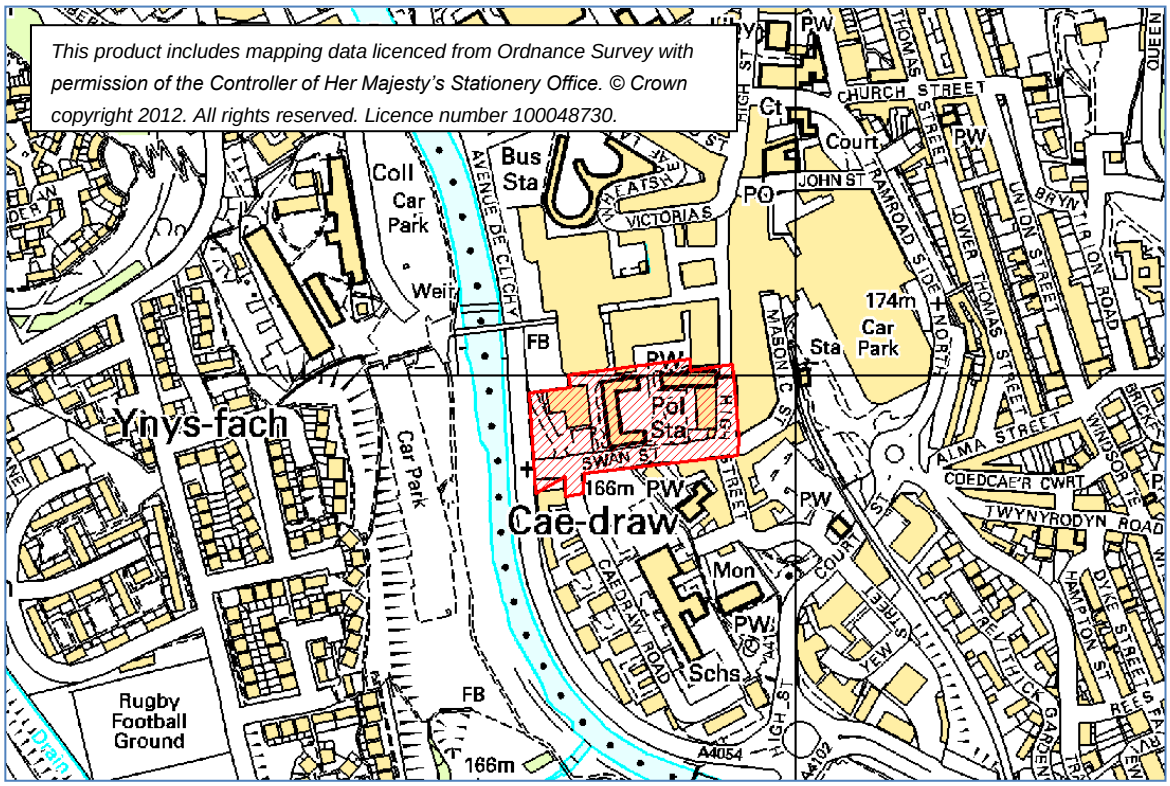


Figure 1-1: Location of the Proposed Development

1.1.3 The contents of this FCA describe the assessment of the proposed site and the implications of the proposed uses on flood risk. The FCA has been prepared in accordance with guidance provided by Technical Advice Note 15: Development and Flood Risk (TAN15) (July 2004). Details of the hydrological and hydraulic assessments which informed the FCA are included in the appendices.

1.1.4 A planning application is being submitted and this assessment provides the level of detail necessary to demonstrate that the potential effects of the proposal with respect to flood risk have been addressed by:

- Identifying the source and probability of flooding to the site, including effects of climate change;
- Determining the consequences of flooding to and from the proposed development site and advising on the how this will be managed, if necessary; and
- Demonstrating the flood risks described in this assessment are compliant with the relevant guidance and that the flood consequences are acceptable.

1.1.5 The data available to inform the assessment is summarised in this report and in the associated plans (attached within the appendices). An assessment of areas potentially at risk from flooding has been undertaken and the development proposals have been examined in relation to their potential to increase flood risk both on and off site.

1.1.6 This FCA accompanies has been updated following comments from NRW to demonstrate that flood risk has been given material consideration throughout the development planning process and redevelopment should not be restricted at this site due to flood risk.

2. Policy and Guidance

2.1 Flood and Water Management Act, 2010

2.1.1 Combined with the Flood Risk Regulations 2009, (which enact the EU Floods Directive in the England and Wales) the Act places significantly greater responsibility on Local Authorities to manage and lead on local flooding issues. The Act and The Regulations together raise the requirements and targets Local Authorities need to meet, including:

- Playing an active role leading Flood Risk Management;
- Development of Surface Water Management Plans (SWMP);
- Implementing requirements of Flood and Water Management legislation;
- Preparation of preliminary flood risk assessments and flood risk management plans;
- Development and implementation of drainage and flooding management strategies; and
- Responsibility for first approval, then adopting, management and maintenance of Sustainable Drainage Systems (SuDs).

2.1.2 **The Flood and Water Management Act also clarifies three key areas that influence development:**

1. ***Sustainable drainage (SuDs) -*** the Act makes provision for a national standard to be prepared on SuDs, and developers will be required to obtain local authority approval for SuDs in accordance with the standards, likely with conditions. Supporting this, the Act requires local authorities to adopt and maintain SuDs, removing any ongoing responsibility for developers to maintain SuDs if they are designed and constructed robustly.
2. ***Flood risk management structures -*** the Act enables the EA and local authorities to designate structures such as flood defences or embankments owned by third parties for protection if they affect flooding or coastal erosion. A developer or landowner will not be able to alter, remove or replace a designated structure or feature without first obtaining consent.
3. ***Permitted flooding of third party land*** - **The** EA and local authorities have the power to carry out work which may cause flooding to third party land where the works are deemed to be in the interest of nature conservation, the preservation of cultural heritage or people's enjoyment of the environment or of cultural heritage.

2.1.3 On 1st October 2012 the Welsh Government implemented Section 42 of the Flood and Water Management Act 2010 in the operating area of Dŵr Cymru Welsh Water. This requires any developer who wishes to make a connection to the public sewer system, that creates any sewers or lateral drains first to enter into a Section 104 agreement with the Water and Sewerage Company that will ensure the any sewers or lateral drains created by the connection will be adopted by the Sewerage Undertaker.

2.2 Technical Advice Note 15 (TAN15) July 2004

2.2.1 In determining an approach for the assessment of flood risk & consequences for the proposed development there is a need to review the policy context. Welsh Assembly Government Guidance advises that managing flooding makes an important contribution to achieving sustainable development.

2.2.2 Planning Policy Wales, supported by TAN 15, advises caution in respect of new development in areas at high risk of flooding and sets out a precautionary framework to guide planning decisions. The aim of the framework is to:

- Direct new development away from those areas which are at high risk of flooding; and
- Only allow development in high risk areas (zone C) where they can be justified on the basis of the tests (justification of development and acceptability of flood consequences) outlined in TAN15.

2.2.3 Flood risk should be considered at all stages throughout the planning and development process to ensure that new development proposals in flood risk areas are justified and not exposed to unacceptable flood consequences. TAN15 advises that:

- The susceptibility of land to flooding is a material planning consideration;
- Natural Resources Wales (NRW) has the lead role in providing advice to the planning authority on flood risk issues;
- Development Plans should include site specific policies and proposals for development and flood risk. Planning authorities should apply the Precautionary Framework when allocating sites for development, seeking to direct new development away from those areas at high risk of flooding, unless justified on sustainability grounds;
- The vulnerability of a proposed land use should be considered when assessing flood consequences; and
- Developers are responsible for providing information to demonstrate that their proposal satisfies the tests contained in the TAN. Furthermore developers should bear the costs of mitigation, construction and long term maintenance of flood defence required for the proposed development.

2.2.4 Within TAN15 the operation of the precautionary framework is governed by:

- A development advice map which designates land into flood risk zones and which is used to trigger the appropriate planning tests; and
- Definitions of vulnerable development and advice on permissible uses in relation to the location of development and the consequences of flooding.

2.3 Taff and Ely Catchment Flood Management Plan (CFMP)

2.3.1 CFMPs are documents prepared by NRW which set out the long term strategic aims for flood risk management on a catchment scale.

2.3.2 The Taff and Ely CFMP covers the River Taff, River Cynon and other watercourses within the drainage catchment of the River Taff. The CFMP area is sub-divided into 'management units'. Each management unit is formed of areas featuring similar sources, pathways and receptors of flooding.

2.3.3 Each management unit has been assigned a long term flood risk management policy appropriate to their physical characteristics, sources of flooding and level of risk. The proposed development site is located within the Merthyr Tydfil, Aberfan and Mountain Ash management unit. The CFMP policy for this management unit is Policy 4 - areas of low, moderate or high flood risk where NRW are already managing flood risk effectively but where further actions may be needed to keep pace with climate change.

2.3.4 Actions identified within the CFMP to implement the policy include:

- Encouraging and supporting the production of long term plans to manage all sources of flooding, including an assessment of the consequences of flooding and actions to manage these;
- Continuing to maintain defences and provide flood warnings;
- Encouraging and supporting studies to identify surface water and sewer flooding issues and management options, particularly at Aberdare and Mountain Ash;
- Engaging with and advising the local community to encourage people at risk to take action to help themselves;
- Encourage and support owners and operators of important infrastructure to plan for and manage their current and future flood risks.

2.4 Merthyr Tydfil Local Development Plan (May 2011)

2.4.1 The Merthyr Tydfil development plan forms the development plan for Merthyr Tydfil County Borough and is the basis for decisions on land use planning. It sets out the Council's priorities for development and use of land over the 15 year period covered by the plan and the policies it will adopt to implement them. The Local Development Plan incorporates a Core Strategy, supported by a number of borough-wide, area based and topic based policies. The proposed development site is located in the Primary Growth Area centred around Merthyr Tydfil.

2.4.2 The following policy is relevant to the FCA:

Policy BW8: Development and the water environment

2.4.3 "Proposals for built development will only be permitted where:-

2.4.4 they avoid identified river flood plains in order that these areas continue to fulfil their flood flow and water storage functions; they do not have an adverse effect on the quality and/or quantity of surface waters or groundwater resources, and where opportunities exist, they incorporate measures to improve existing water quality; and adequate water and sewerage systems exist, or are reasonably accessible, or are capable of being provided prior to the development becoming operational without placing unacceptable pressure on existing capacity or causing unacceptable environmental harm. In addition, development proposals will be required to avoid exacerbating flood risk locally and elsewhere within the river catchment by incorporating sustainable drainage systems (SuDs) for the disposal of surface water. Alternative methods of surface water disposal

will only be considered where a developer demonstrates that the incorporation of SuDs is inappropriate for practical or environmental reasons."

2.4.5 The accompanying explanatory text notes that the LDP has sought to avoid development in Flood Zone C, however in some cases allocations have been made in areas where consent has already been granted following submission of a flood consequence assessment and / or where the type of development is not considered sensitive to flooding and where its location elsewhere is not appropriate or desirable.

2.4.6 The proposed development is within Flood Zone C2 on the LDP proposals map and therefore it is assumed that the flood consequences at the site were considered during preparation of the LDP.

2.4.7 The 2013 - 2014 Local Development Plan Annual Monitoring Report[1] included an analysis of the application of Policy BW8. The report noted that in all cases where developments were granted planning permission in zone C the developments were justified in their location and the consequences associated with flooding were acceptable. As no developments were permitted in zone C that did not meet TAN 15 tests, it is considered that Policy BW8 is functioning effectively in respect of this matter and continues to be relevant and applicable.

2.5 Strategic Flood Consequence Assessment

2.5.1 MTCBC did not undertake a formal Strategic Flood Consequence Assessment (SFCA) to inform the preparation of the LDP and instead completed a SFCA screening exercise (similar in scope to a Stage 1 SFCA). This used existing information to assess the significance of flooding in the plan area, how new development could avoid adding to that risk and which of the potential allocations lie outside Flood Zone C. According to the screening report the LDP avoided committing new development to Zone C, with only 3 previously committed allocation sites located in the flood zone. It was therefore considered that a more detailed SFCA was not required.

2.6 The SuDS Manual, CIRIA (2015)

2.6.1 This guidance provides best practice on planning, design, construction, operation and maintenance of Sustainable Drainage Systems (SuDS) to facilitate their effective implementation within developments.

2.6.2 The guidance supersedes previous general guidance on SuDS and addresses landscaping, biodiversity issues, public perception and community integration as well as water quality treatment and sustainable flood risk management.

2.6.3 The SuDS Manual aims to provide comprehensive advice on the implementation of sustainable drainage techniques in the UK. It provides guidance on:

- Initial planning;
- Design through to construction;
- The management of SuDS in the context of the current regulatory framework; and
- Advice on landscaping, waste management, cost, and community engagement.

[1] Merthyr Tydfil Local Development Plan 2006 – 2012 Annual Monitoring Report for the period 1st April 2013 – 31st March 2014, Published October 2014.

2.7 UK Climate Impact Programme 2009 (UKCIP09)

2.7.1 In June 2009 the UK Climate Impact Programme released new guidance with respect to climate change predictions. The predictions have moved from a deterministic approach (i.e. one range of outcomes) to a probabilistic approach (i.e. a range of possible outcomes based on a range of climate change scenarios).

2.7.2 The results indicate that based on a central estimate of likely outcomes (i.e. 50 percentile), increases in rainfall are expected to remain similar to those predicted by UKCP02 (i.e. those used in this FCA). A high estimate of likely outcomes (i.e. 95 percentile) could result in significantly more intense rainfall than at present.

2.7.3 At present Government advice is to continue using the existing climate change guidance. The precautionary approach taken in this FCA, and in development of the drainage strategy, means that some capacity exists to manage any change in climate change guidance.

3. Development Planning Considerations

3.1 Development Description and Location

3.1.1 The proposed scheme includes a new bus station for Merthyr Tydfil on Swan Street. Drawings showing the main components of the development are provided in Appendix B. Figure 1.1 shows the proposed development site location.

3.1.2 This FCA has been prepared to accompany the planning application for the Bus Station scheme. Redevelopment of the site includes demolition of Police Station and Health Centre buildings, which have already been demolished and total re-development. The redevelopment includes a Bus Station building at the northern end of the site, a bus circular for the incoming and exiting bus traffic and bus parking/loading zones. A taxi rank is also included in the site design at the southern end.

3.1.3 Three scenarios were simulated through the hydraulic model for this assessment. These represented:

- A baseline scenario; before the demolition of the old health centre and police station.
- An existing scenario; the current layout of the proposed site,
- A proposed scenario; post construction of the bus station.

3.1.4 In the baseline scenario the old health centre and police station were present. The northern wall of the old health centre and the raised walkway between St Tydfil's Shopping Centre and the od police presented a barrier to flooding lowing towards the proposed site from the North. The health centre itself was located in a topographic low spot, below the level of Service Yard C of the St Tydfil Shopping Centre to the North. This scenario is presented in Figure 3-2 and Figure 3-2.

3.1.5 The existing scenario is shown in Figure 3-3 and Figure 3-4. The old health centre and police station have been almost entirely demolished and only one wall remains. It is unlikely that this would prevent a barrier to flow during a flood event as it would most likely be washed away. The area has also been flattened and the topographic low where the old health centre was situated no longer exists. The proposed scenario represents the fully constructed bus station. The proposed site layout for this development is shown on drawing reference 2015 08 19 - General Arrangement (Appendix B). It includes:

- A proposed bus station building running along the northern edge of the site.
- A central bus access road through the middle of the site with proposed carriageways into bus parking spaces.
- Landscaped areas and pedestrian footways.
- Upgrades Swan Road along the southern edge of the bus station to allow for bus traffic and proposed bus lanes.

3.1.6 As part of the proposed development the existing road network will be updated to allow for access to the new bus station on Avenue de Clichy and exit on Swan Road, also allowing for the continuous access to adjacent buildings from Swan Road. The access and egress for Service Yard C of the Saint Tydfil Shopping Centre to the North of the site will be moved as part of the

development. A new access to the service yard, off Avenue de Clichy north of the existing footbridge and a new exit back onto Avenue de Clichy to the west of the Wilkinsons store will be provided. The proposed access and egress for the development is laid out on drawing number CS/74720/PA/103, and described in more detail as part of Appendix B. The ground levels and outlines for the site have been designed by Capita.

Figure 3-1: The old health centre located within a topographic low and its northern wall. © Google images

Figure 3-2: The location of the old health centre, raised walkway, old police station and Service Yard C of the St Tydfil Shopping Centre. © Google images

Figure 3-3: The eastern area of the proposed development in the existing scenario

Figure 3-4: The western area of the proposed development in the existing scenario

3.2 Justification Test

3.2.1 The development site is located within TAN15 Flood Zone C2, according to the Development Advice Map (Figure 4-1). Development in Flood Zone C would normally be subject to the application of the Justification Test[2]. To pass the test it should be demonstrated that:

i) The development location is necessary to assist or be part of a local authority regeneration initiative and / or strategy to sustain an existing settlement; or

ii) The development location is necessary to contribute to key employment objectives to sustain an existing settlement or region; and

iii) The development concurs with the aims of Planning Policy Wales (PPW) and meets the definition of previously developed land; and

iv) The potential consequences of flooding for the particular type of development has been considered and found to be acceptable (referring to criteria contained in TAN15).

3.2.2 The proposed scheme is commissioned by MTCBC and is part of the supporting infrastructure for future developments in the Town Centre Boundary (Policy AS19), adjacent to the Town Centre Primary Shopping Area in the LDP. The site has previously been developed and the scheme is therefore considered to pass as part i and iii of the test.

3.2.3 The proposed scheme is transport infrastructure and therefore considered Less Vulnerable development according to the land use vulnerability classifications defined in TAN15. According to TAN15 guidance less vulnerable development is acceptable in Flood Zone C2 provided it passes the Justification Test, including the acceptability of flood consequences.

3.3 Consultation with Natural Resources Wales

3.3.1 Natural Resources Wales (NRW) has been consulted to discuss the approach to the FCA and acceptability of flood consequences. Copies of relevant correspondence are included in Appendix C. The important points taken from the consultation are listed below:

3.3.2 An assessment of the fluvial flood risk from the River Taff and Nant Morlais should be carried out. This includes assessment of potential flood sources, and possible risk from surface water flooding. Flood risk on access/egress routes must be considered.

3.3.3 The best available data that the NRW have for this area is the 2013 1D/2D model for the Gyratory Scheme held by Capita/Merthyr Tydfil CBC. It is recommended that this model is used to inform the FCA.

3.3.4 Existing information on flood extent and depth should be included alongside flood predictions.

3.3.5 An assessment of the volume of water displaced and runoff from the site following development is required if there are significant changes to building footprint and hard standing.

3.3.6 A plan and description of the bridges on the Taff adjacent to the site must be included in the FCA, including an assessment of blockage at these structures and the potential impact on the site.

[2] TAN15 Section 6 (page 8)

3.3.7 On the Nant Morlais culvert, upstream of the confluence with the River Taff there is a high chance of debris accumulation on the face of the structure. It is recommended by the NRW that a 67% blockage (according to the CIRIA C689 guidance) and a 100% blockage is applied to the culvert for the 100 year plus climate change event.

3.3.8 It was noted that the original FCA provided a conservative approach to flood risk as the model uses coincident flood events on the River Taff and Nant Morlais (i.e. combined 1 in 1000 year events), which are unlikely to occur in reality given the differences in catchment area and watercourse size. It is unclear from the model whether the upstream flood storage area on the Nant Morlais at Pant (north of the Heads of Valleys Road) has been taken into account when deriving the hydrology. If not, this could potentially reduce flood risk and extents from this source, although given the reduced risk to the site from the Nant Morlais compared to the River Taff the effect on the site may be minimal.

4. Flood Probability and Hazard

4.1 Description of the site

4.1.1 In order to assess the risk and consequences of flooding to the proposed development site and vicinity, it is important to understand the existing catchment characteristics and flow patterns.

4.1.2 Figure 1.1 shows the location of the site. The site is located on Swan Street in central Merthyr Tydfil, adjacent to the River Taff. The proposed Bus Station will occupy the site of a demolished Health Centre and old Police Station. Some changes to the existing road alignment on Swan Street is proposed, however the general road network will be largely unaffected.

4.1.3 The site lies in the upper Taff catchment, which at this location has an area of approximately 126 km^2 and is steep and predominantly rural. Two tributaries (Cwm Taff and Cwm Taff Fechan) merge to form the River Taff just upstream of Merthyr Tydfil. Large public water supply reservoirs (Taff Fawr and Taff Fechan) are located in the upper catchment. The reservoir catchments are largely Old Red Sandstone. However, the two tributaries cross a Carboniferous Limestone outcrop and merge on Millstone Grit with Boulder Clay. The steep valleys would typically cause the rivers to respond rapidly to rainfall although the reservoirs may slightly mute this response. The River Taff flows southwards through Merthyr Tydfil and continues for a further 38km before draining into the Severn Estuary. Merthyr Tydfil has a notable effect on the urbanisation of the catchment, principally affecting flow estimates at the site and on the Nant Morlais tributary.

4.1.4 The Nant Morlais is located east of the River Taff and discharges to the river via a culvert upstream of Penry Street Bridge. The NRW Flood Map indicates flooding from the Nant Morlais may affect the town centre and floodwaters may join with flooding from the main river (River Taff) flowing south along Avenue De Clichy and adjacent areas. It is understood that the current NRW EA Flood Map (shown in Figure 4-1) is derived from national generalised modelling in this area and therefore may be overestimated as this modelling is unlikely to have accounted for the capacity of the culvert.

4.1.5 There is a flood storage area found near Pant that provides attenuation to flows coming in from the upper parts of the Nant Morlais catchment. This was accounted for within the hydrology using a 1D only model of the basin, outflow structure and downstream culvert. For more details on this see Section D.4 (Appendix D).

4.1.6 The proposed Merthyr Tydfil Bus Station is located 350m downstream of the Nant Morlais confluence with the River Taff. The Nant Morlais discharges to the River Taff via an outfall structure. Due to the location of the proposed Bus Station, the influence of this structure and the Nant Morlais has been included when predicting the baseline, existing and proposed flood extents.

Local Geology

4.1.7 The digital maps provided on the British Geological Survey website[3] show that the site is underlain by the South Wales Coal Measures Formation (mudstone, siltstone and sandstone), overlain by Till and Alluvium along the river corridor.

[3] http://www.bgs.ac.uk/GeoIndex/. Viewed 25th August 2015.

Soil Classification

4.1.8 The Soil Survey of England and Wales mapping, Soils of England and Wales, sheet 5 – South West England (1:250,000) (1980) shows the soils on site as unclassified. The soils in nearby areas (close to the river corridor) are described as Waltham (well drained fine loamy soils over limestone); Lugwardine (silty soils variably affected by groundwater); and Wilcocks 1 (slowly permeable seasonally waterlogged loamy soils).

4.1.9 This available information suggests that the soils and geology on site are reasonably impermeable. This is verified by the standard percentage runoff (SPRHOST) and baseflow index (BFIHOST) values obtained for the catchments (refer Appendix D) which suggest reasonably impermeable soils and geology. Infiltration of runoff to the underlying soils and geology may therefore be limited. This could be exacerbated by high groundwater levels on site, particularly when river levels are higher than normal.

Site Topography

4.1.10 A topographic survey was completed in 2011 as part of the River Taff Central Link (Gyratory) FCA which included the River Taff and the Nant Morlais.

4.1.11 Survey of the proposed development area was carried out in 2011. The site of the proposed bus station is reasonably flat, sloping downwards towards the River Taff in the western half of the site. The maximum elevation difference from the east to the west of the site is 2m.

4.1.12 LiDAR, flown in 2011, was provided for the study with a resolution of 2 m. The ground levels fall from approximately 170 mAOD at the Nant Morlais to 165.5 mAOD at the northern end of the site. The ground level falls further downstream; there is a 4m elevation difference from the Bus Station site to the A4102 Bridge 250 m downstream.

4.1.13 Topographic survey was collected in September 2014 following the demolition of the Health Centre and in May 2015 following the demolition of the Police Station. This survey, as well as the 3D ground model of the proposed Bus Station was used to amend levels in the hydraulic model. The new bus station is proposed to be set at 168.48m AOD. Figure A1 in Appendix A presents the ground levels proposed for the new development.

4.1.14 Figure A2 in Appendix A shows the changes in elevation between the baseline case and the proposed development. The elevations of the proposed development are generally higher than those found in both the baseline case and the existing case. Some areas on the western side of the site show a greater than 2.5m increase in elevation between the proposed and baseline case. The increases in elevation are less pronounced on the eastern side of the site, the maximum increase is in the region of 1m. Along the northern edge of the proposed development and in the South-West corner the proposed development has lower ground elevations than the baseline case. The greatest decrease in ground levels as a result of the proposed development is found in North-West corner of the development.

4.1.15 Figure A3 in Appendix A shows the changes in elevation between the existing case and the proposed development. The proposed development is significantly higher than the existing case for the majority of the development. The western areas of the development are generally between 1.0m and 2.5m higher in the proposed development. Changes are less pronounced in the eastern part of the development and the proposed development is between 0.5m and 1.0m

higher than the existing case. Some areas around the perimeter of the proposed development show changes in ground elevation of between -0.05m and -0.50m from the existing case.

4.2 Flood Zone

4.2.1 The site is located almost entirely within TAN15 Flood Zone C2, according to the Development Advice Map, which is described as 'Areas of the floodplain without significant flood defence infrastructure' and is based on the NRW extreme flood outline (equal to or greater than 0.1% annual probability of flooding).

Historic flood records

4.2.2 The Flood Map has been downloaded from the Welsh Government flood mapping website and is shown in Figure 4-1. The maps includes the approximate extent of historic flooding. It shows flooding to land immediately adjacent to the River Taff on the east bank, including half of the proposed site. The FCA recently completed for the college (MLQ) development refers to flooding reported during the 1979 event in central Merthyr Tydfil. Other than this event there are no historic flood records available for this study.

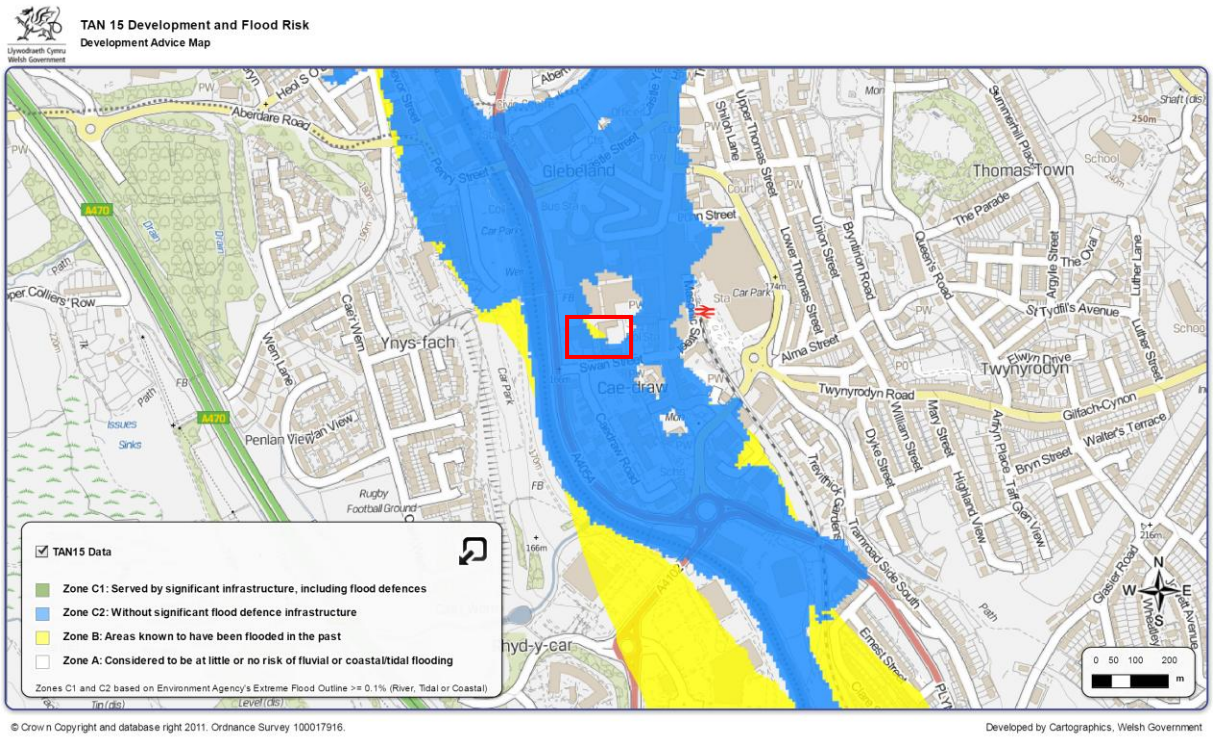


Figure 4-1: NRW Flood Map (Downloaded on 25th August 2015). Site highlighted by red box.

Existing flood management

4.2.3 No specific flood defences or flood management infrastructure have been identified for the site. A site visit was carried out as part of this FCA and no formal flood defences were identified during the visit or during consultation with the NRW.

4.3 Assessment of Sources of Flooding

4.3.1 It is necessary to consider the risk of flooding from all sources within a FCA. This section provides a review of flooding from land, sewers, groundwater and artificial sources, in addition to rivers and the sea.

Fluvial Flood Risk

4.3.2 Fluvial flooding occurs when the amount of water exceeds the flow capacity of the river channel. Most rivers have a natural floodplain into which the water spills in times of flood. The site is situated adjacent to the River Taff and to the south of the Nant Morlais.

4.3.3 The proposed development is shown to lie within NRW Flood Zone C2 and is described as having a significant risk of flooding.

4.3.4 Fluvial flood risk and the resulting consequences at the development site have therefore been assessed in greater detail as described in Section 5.

Tidal Flood Risk

4.3.5 Tidal flooding occurs when a high astronomical tide and storm (tidal surge) exceeds the level of coastal land or coastal flood defences. Tidal flooding can also be caused by 'tide locking' of rivers or estuaries. Tide locking prevents a river from discharging into the sea, causing 'backing up' and resulting in tidal/fluvial flooding.

4.3.6 The site is inland and therefore not at tidal flood risk.

Flood Risk from Land, Surface Water and Sewers

4.3.7 Flooding from land can be caused by rainfall being unable to infiltrate into the natural ground or entering the drainage systems due to blockage, or flows being above design capacity. This can then result in (temporary) localised ponding and flooding. The natural topography and location of buildings/structures can influence the direction and depth of water flowing off impermeable and permeable surfaces.

4.3.8 High intensity storms (often with a short duration) are sometimes unable to percolate into the ground or be drained by formal drainage systems since the capacity of the collection systems is not sufficient to convey runoff to underground pipe systems (that might themselves be surcharged). The pathway for surface water flooding can include blockage and overflows of the drainage system, and failure of sluice outfalls and pump systems.

4.3.9 Flooding can also result when sewers, typically combined foul and surface water, are overwhelmed and surcharge water into the nearby environment. A combined surface water/foul pipe is located along Swan Street, south of the proposed Bus Station which will capture runoff from the surrounding hard standing areas. There is risk that sewers can become overwhelmed or a blockage occurs, which would cause localised flooding but the consequences of this flooding are unlikely to be significant compared to the fluvial risk at the site and have therefore not been considered further. The surface water management for the proposed scheme is described in section 6.

4.3.10 Welsh Water sewer plans show foul sewers are discharge at the sewage treatment works via a combined sewer system east of the river. If a blockage occurred or the pumps failed flooding of the site is possible, however this would likely flow overland towards the river and therefore is unlikely to pose a significant risk to the development.

4.3.11 NRW Flood Mapping shows areas of risk from surface water flooding. There is a high risk of flooding from surface water at the north western boundary of the proposed development. Along the eastern part of Swan Street there is a high risk of surface water flooding and to the western part of the road there is a low risk of surface water flooding. (See Figure 4-2).

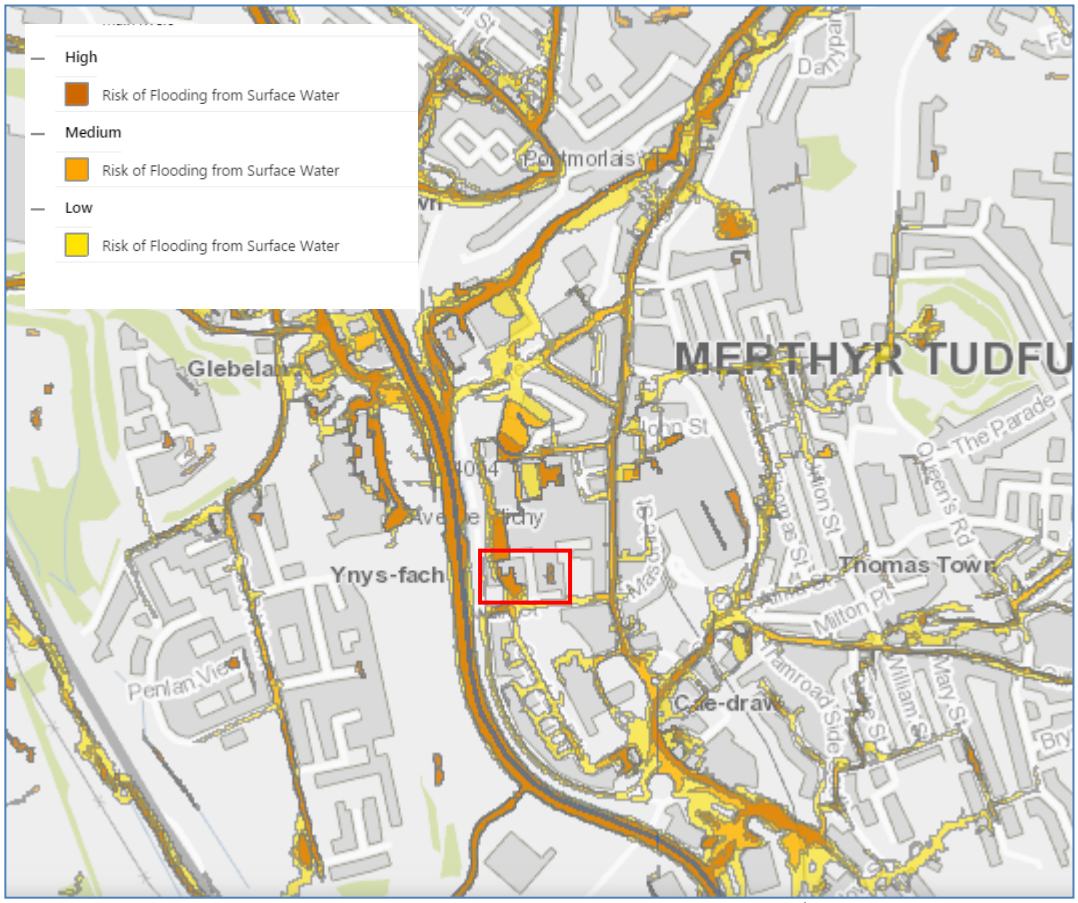


Figure 4-2: Risk of flooding from Surface Water (Downloaded 25th August 2015). Site highlighted by red box.

Groundwater Flood Risk

4.3.12 Groundwater flooding occurs when water levels in the ground rise above surface elevations. It is most likely to occur in low-lying areas underlain by permeable rocks. The underlying geology at the site is reasonably impermeable. The site is adjacent to the river and there may therefore be some sub-surface flows when river levels are high however the impact of groundwater flooding in terms of likelihood and flood depths is considered to be significantly less that that posed by fluvial flooding.

Flood Risk from Artificial Sources

4.3.13 Artificial sources of flooding include reservoirs, canals, lakes and mining abstraction. No artificial sources of flooding were identified in the immediate vicinity of the site from the site visit or OS Mapping. The water service reservoirs in the upper catchment are potential sources of flooding, should a breach occur in their embankments. NRW has completed inundation mapping for potential breach of high risk category reservoirs, including those in the Taff catchment[4]. This site is located within the predicted inundation extent. As the likelihood of a breach occurring is low this does not necessarily present a constraint to development however should be considered for emergency planning purposes.

[4] http://maps.environment-agency.gov.uk/wiyby. Viewed 6th November 2012.

5. Assessment of Fluvial Flooding

5.1.1 As described in Section 4 fluvial flood risk from the River Taff is considered to be the most significant source of flooding for the proposed development site.

5.1.2 A detailed 1D / 2D ESTRY TUFLOW model has been used to assess the impact of fluvial flooding at the proposed development site and test the potential impact of the development proposals on flooding in the vicinity. The hydraulic model includes both the River Taff and Nant Morlais. The model extends along the River Taff from the Cyfarthfa Road Bridge (NGR 304333 206789) to the dismantled railway line (NGR 605160 250370), and along the Nant Morlais from Penyard Road (NGR 305210, 206730) to the outfall structure where the Nant Morlais discharges into the River Taff (upstream of Penry Street Bridge).

5.1.3 The River Taff TUFLOW model, developed as part of the River Taff Central Link (Gyratory) FCA, was updated for as part of the FCA. The main update to the model was the representation of the Nant Morlais in the 1D domain. Details of the updates are provided in Appendix E.

5.1.4 A hydrological assessment was also carried out as part of the River Taff Central Link (Gyratory) FCA, this assessment has been updated as part of this FCA. Details of the updates are provided in Appendix D. The peak flows used in the FCA are shown in Table 5.1. The peak flows for the Nant Morlais have been attenuated by the FSA at Pant. For more details please see Section D.4 (Appendix D).

Table 5-1: Peak Flow Estimates (m^3/s)

	Final Flow Estimates for each flood return period (m3/s)							
Model Node	**2**	**10**	**20**	**50**	**75**	**100**	**100+CC**	**1000**
River Taff	118.3	182.2	209.5	253.6	276.9	295.3	354.3	522.8
Nant Morlais (Total)	12.0	18.5	21.8	27.1	29.8	32.0	38.4	57.1
Nant Morlais (Attenuated)	10.1	13.8	15.6	18.4	19.9	21.0	24.4	34.0

5.1.5 The hydraulic model was used to assess the impact of fluvial flooding at the site and inform the design of the scheme. The model was used to test the impact of the development on flood risk at the site and elsewhere and where necessary inform the design of appropriate mitigation measures. The ground levels at the proposed Bus Station site were changed in the hydraulic model to represent for the proposed (post-development) scenario in accordance with a 3D ground models.

5.1.6 A range of events have been modelled to assess the impact of flooding at the site and the vicinity for the baseline and proposed scenarios. The assessment of flooding has focussed on the results for the 50 year, 100 year with climate change (100+CC; climate change allowance was a 20% increase in flows) and 1,000 year events as the latter two are important events to consider with respect to the guidance provided in TAN15. The 50 year return period event is also important as it sees the onset of flooding at the proposed development. Scenarios assuming 100% and 67% blockages of the Nant Morlais culvert, located upstream of the confluence with the River Taff have been simulated. A range of sensitivity tests have been completed to test the robustness of

the model and the sensitivity of the results to changes in model assumptions and parameters as described in Appendix E.

5.2 Baseline flooding at the site

5.2.1 Figure A4 (Appendix A) shows the modelled flood extents for the 50, 100, 100+CC and 1,000 year events.

5.2.2 Flooding first occurs at the site during a 1 in 50 year event as water overtops the left and right banks of the River Taff upstream of River Walk footbridge. On the left bank flow is directed south down Avenue de Clichy and east towards the shopping centre. The northern wall of the old Health Centre and steps present a barrier to flow and ponding to a depth of 0.3m takes place within Service Yard C. The Health Centre that previously existed on the site is flooded to depths of 0.85m by flow bypassing its northern wall via the access route to the storage yard. The flood waters flow south and east through the site and down Avenue de Clichy towards Swan Street before being directed down Caedraw Road causing flooding the properties closest to the River Taff and to a lesser extent the grounds of the Caedraw Primary School opposite the site. Flood waters continue south towards the A4102 roundabout before re-joining the river south of this point. Velocities within the site and in the service yard are generally between 0 and 0.3m/s, where flow is throttled through the access to the service year velocities are greater and reach 0.5m/s. Velocities along the Avenue de Clichy are higher and reach 1.5m/s in some places.

5.2.3 During a 1 in 100 year event plus climate change the mechanisms by which flooding occurs at the proposed bus station site are unchanged. However, it is worth noting that the volume of water that overtops the banks of the River Taff in this event is increased significantly which causes more widespread flooding as well as greater depths of flooding at the site and elsewhere. Flooding of the Health Centre is more significant in the 1 in 100 year event with depths of greater than 1.0m in places. The ponding of flood waters in Service Yard C is also more prevalent and flood depths reach 0.9m over large areas. Flood velocities within the site are generally still slow at around 0.3 m/s. Velocities within the service yard and show slight increases and reach 0.7m/s along its western edge. Velocities along the Avenue de Clichy are high and reach a maximum of 2.8m/s.

5.2.4 The 1 in 1000 year flooding throughout Merthyr is far more significant, particularly around the location where the Nant Morlais discharges into the River Taff. Figure A9 (Appendix A) shows that flood depths within the 1 in 1000 year are much greater. The entire service yard is flooded to a depth of 0.6m and depths reach 1.6m in places. Flooding patterns within the site itself remain almost unchanged, although depths now reach 1.1m in places. Flooding downstream of the site is also far more significant although the mechanism for flood water returning to the River Taff is unchanged from the previous return periods. Flood velocities through the site are predicted at around 3 m/s in some locations suggesting a greater risk to people than in the previous events. Velocities within the service yard have increased dramatically and now reach 2.5m/s in many areas. Velocities are also high at the access point to the service yard and reach 3m/s in its vicinity within the site.

5.2.5 Flooding from the Nant Morlais itself is minimal in all events. It can be assumed that the storage basin at Pant provides sufficient attenuation to flows that they remain in bank even as far downstream as Merthyr.

5.3 Existing flooding at the site

5.3.1 The mechanisms for flooding in the existing scenario are very similar to the baseline scenario for all events. The only difference is the flow route by which flooding enters the site is through the location where the northern wall has been demolished, rather than through the access route to Service Yard C. The other key difference between the results in the baseline and existing scenario are related to changes in ground levels following the demolition of the Health Care Centre and Police Station.

5.3.2 In the 1 in 50 year flood event, flood extents are noticeably reduced with Service Yard C compared to the baseline case. Flood depths in this location are generally less than 0.1m, a significant reduction from the 0.3m found in the baseline case. This can be attributed to the removal of the old health centre wall and associated removal of a barrier to flow. Flood extents within the site are slightly decreased and there is also a slight decrease in flood depths from the baseline scenario. Maximum flood depths in this scenario are 0.5m, compared to 0.85m in the baseline case. This is due to the filling of the topographic depression where the health centre was sited meaning less water could be stored in this location. Flood velocities are in the region of 0.3m/s in the existing case, and are similar to those found in the baseline case.

5.3.3 For the 1 in 100 year event plus climate change the same patterns are evident. Maximum flood depths within the site reduce from around 1.0m in the baseline scenario to around 0.8m in the existing scenario. In the service yard flood depths are predicted to show a similar reduction, from around 0.9m to around 0.5m. Flood outlines between baseline and existing scenarios shows very little change. Velocities within the site are predicted to increase between the baseline and existing cases. Large areas of proposed site have modelled velocities over 0.5m/s in the existing scenario and velocities within the service yard reach 1.2m/s.

5.3.4 In the 1 in 1000 year events a similar lack of change in maximum flood extent is predicted between the baseline and existing cases. There is with a small predicted decrease in flood depths relative to the baseline scenario. The same increases in velocity in the site and the service yard are also predicted.

5.4 Proposed flooding at the site

5.4.1 The mechanisms for flooding are very similar to the baseline scenario. The major difference is the raised ground levels as a result of the proposed development deflect flows that previously passed through the site onto the Avenue de Clichy and back into the River Taff.

5.4.2 Figure A6 (Appendix A) shows the predicted flood extents if the proposed development were to go ahead. A small portion of the site at its western edge is predicted to be flooded within the 1 in 100 year flood event. However, this area is occupied by paving and landscaping in the proposed site plan shown in Appendix B. The area occupied by the bus station is not predicted to flood up in the 1 in 1000 year flood event. The development is classified as General Infrastructure and therefore complies with the requirements set out in Table A1.14 and Table A1.15 in TAN 15.

5.4.3 The mechanism of flooding for the site in the 1 in 1000 year event is from water ponding in Service Yard C reaching the elevation of the proposed development and flowing across the North West corner of the development towards the Avenue de Clichy and down towards Swan Street. Maximum flood depths in the site during the 1 in 1000 year event, shown in Figure A15 (Appendix A) are predicted to be 0.4m. The maximum predicted velocities found within the site during the 1 in 1000 year event shown in Figure A24 (Appendix A), is 3.3m/s. The consequences

of this flood event on the proposed development are likely to be small. Damage to the proposed development is likely to be limited to the paving and landscaping shown in the proposed site plan and people should be directed towards dry areas of the site in the event of a flood.

5.4.4 Flood depths on the Avenue de Clichy are predicted to be high in the proposed case. In the 1 in 50 year event flood depths will reach 0.3m at the junction of Avenue de Clichy and Swan Street. The majority of Avenue de Clichy will have flood depths greater than 0.1m in the 1 in 100 year event plus climate change, and maximum depths reach 0.6m. In the 1 in 1000 year event is predicted to flood the road to a depth of 0.3m and maximum depths are predicted to reach 0.8m. Velocities are also predicted to be high, over 1.0m/s in the 1 in 50 year, and over 2.0m/s in the 1 in 100 year plus climate and 1 in 1000 year. As a result of this safe access and egress cannot be guaranteed from the proposed development onto the Avenue de Clichy. The point shown on the proposed site plan connecting the proposed development to Swan Street is not predicted to flood in the 1 in 1000 year flood event. Therefore in the event of a flood the site safe access and egress should be sought using this route.

5.5 Impact of the development on flooding to third parties

5.5.1 To comply with TAN15 the proposed Bus Station Development must not have any impact on the flood risk to surrounding third parties. This section has compared the baseline scenario against the proposed scenario.

5.5.2 Figures A25 and A26 (Appendix A) show the change in maximum flood depth for the 100CC and 1000 year flood events. NRW guidance states that any detriment to third parties should be less than 5mm. For this reason a difference in flood depth of +/- 5mm is considered negligible for the purposes of the FCA.

Changes to flood risk within the site

5.5.3 The proposed development is predicted to cause widespread decreases in flood depths in the 1 in 100 year flood event. Most of the area previously covered by the old Health Centre is predicted to have >0.1m reductions in flood depths. This can be attributed to the increase in the ground levels at the site. A small area on western edge of the site is predicted to have increased flood depths. This is due to the flow using the flow route along the Avenue de Clichy preferentially to flowing through the site.

5.5.4 The 1 in 1000 year event shows very similar patterns within the site. Most of the area previously covered by the old Health Centre is predicted to have >0.1m reductions in flood depths. However, an area in the North West corner of the site shows increased flood depths of >0.1m. This is caused by flow reaching the elevation of the proposed development and passing across it towards the Avenue de Clichy. This does not happen in the baseline case as the old health centre walls are higher than the level of the proposed development.

Changes to floodplain flood risk outside the site

5.5.5 Downstream of the proposed development site, within the area along Caedraw Road the model results indicate that there is a decrease in the flood extent and maximum flood depths for both the 1 in 100 year with climate change and 1 in 1000 year flood event. For the 1 in 100 year and 1 in 1000 year flood event this decrease ranges between 0.025 to 0.1 m. The decrease in flood depth has occurred in the area as the increase in the ground levels at the bus station has

restricted the flow path that used to run through the site, and has deflected flow back into the River Taff.

5.5.6 Upstream of the proposed development in Service Yard C of the St Tydfil Shopping Centre there is predicted to be no change in flood depth as a result of the proposed development in the 1 in 100 year plus climate change event. In the 1 in 1000 year flood event flood depths in this location are predicted to decrease by >1m. This is because the levels of the proposed development are not as high as the northern wall of the old health centre.

5.5.7 There is a predicted increase in the flood depths along the Avenue De Clichy, as it runs adjacent to the proposed development. It is between 0.025 and 0.1m for the 1 in 100 year event plus climate change and >0.1m for the 1 in 1000 year event. The maximum increase in flood depth is 0.17m. The modelled velocities also show increases as a result of the proposed development in this area. These are shown in Figure A27 and A28 (Appendix A). In the 1 in 100 year plus climate change event velocities are predicted to increase by 0.1 to 0.5m/s, and by > 0.5m/s in some areas of the 1 in 1000 year flood event.

Changes to in-channel flood risk

5.5.8 In channel water levels downstream of the proposed development are also affected by the proposed development. Increases in water depth between 0.005m and 0.025m are predicted in the in the as far downstream as the A4102 road bridge, further downstream than this any changes are within the +/- 5mm is considered negligible by NRW guidelines. The 1 in 1000 year event shows predicted increases in water of up to 0.1m in close proximity to the site, and these propagate further downstream. At the termination of the model increases in flood depth are predicted to be very close to the 0.005m considered negligible by NRW guidelines. In channel velocities show very little change as a result of the proposed development.

5.5.9 NRW have expressed concerns over the effect these increases in channel water level may have on the flood risk posed by the new Gyratory Bridge, found approximately 50m downstream of the proposed site. Concerns were expressed over how the increase in water level would affect the risk of debris accumulation on the bridge, as the soffit of the bridge was set at the 1 in 100 year plus climate change level.

5.5.10 The model used to set the freeboard for the Gyratory Bridge was the River Taff Central Link model. This did not explicitly model the Nant Morlais and did not have a dedicated inflow for this tributary. It also did not account for the attenuation provided by the FSA at Pant. As a result of the different timing of the peak flow for the Nant Morlais and the attenuation of the flows from this catchment water levels are lower in the model simulation used for this FCA than in the River Taff Central link model. Although predicted water levels within the channel increase as a result of the proposed development, water levels are still lower than those predicted by the River Taff Central Link model. Therefore the risk of debris accumulation at the bridge is considered lower than predicted by the River Taff Central Link model.

Table 5-2: Predicted water levels at the new Gyratory Bridge in the River Taff Central Link model (2012) and the Merthyr Bus Station model.

Model	Location	Soffit (mAOD)	Modelled predicted Peak Level for flood return periods			
			100+CC		1000	
			Water Level (mAOD)	Freeboard (m)	Water Level (mAOD)	Freeboard (m)
River Taff Central Link, 2012	East	164.90	164.90	0.00	166.36	-1.46
	West	166.30	164.90	+1.40	166.36	-0.06
	Average	165.6	164.90	**+0.70**	166.36	**-0.76**
Merthyr Bus Station, 2015	East	164.90	164.72	+0.18	166.09	-1.19
	West	166.30	164.72	+1.58	166.09	+0.21
	Average	165.6	164.72	**+0.88**	166.09	**-0.49**

5.5.11 The proposed development will cause increases to flood depths and velocities on the Avenue de Clichy as it runs adjacent to the site. However, this is an area already characterised by high flood depths and velocities in the baseline case, and as such any change to the overall flood risk in the surrounding area is minimal. There are also substantial benefits to flood risk for other areas in the vicinity of the site. In channel water levels are also predicted to increase as a result of the development, however the effects are considered negligible further downstream than the termination of the model. The risk of debris accumulation at the Gyratory Bridge is considered lower than in the River Taff Central Link model.

5.5.12 Based on the findings of the FCA described above it is considered that the proposals will not have a significant impact on flooding to third parties.

Residual flood risks (blockage of Nant Morlais culvert)

5.5.13 The model results for the blockage scenario have been used to assess the residual risk due to blockage. The blockage scenario was modelled for the 100CC event and assumed a 67% and 100% blockage of the Nant Morlais culvert. Figure A29 (Appendix A) shows a comparison of the flood extents (post-development) for the 100+CC, 100+CC with 67% blockage and 100% blockage.

5.5.14 The model results show that blockage of the culvert increases the extent of flooding directly downstream of the culvert opening and through Merthyr Town Centre. Blockage of the Nant Morlais culvert causes the eastern area of the proposed development to be inundated from the North. Flows along the High Street further to the south also increase in the event of a blockage of the Nant Morlais outfall culvert.

5.5.15 The residual flood risk at the proposed development site is minimal; the maximum flood depth experienced on the site is 0.01m and the maximum flood velocity is 0.05m/s.

6. Surface Water Management

6.1.1 TAN15 requires that development should not increase the risk of flooding elsewhere through an increase in surface runoff. Runoff from developments can, if not properly controlled, result in flooding at other locations and significantly alter the frequency and extent of floods further down the catchment.

6.1.2 TAN15 advises that the aim for new development should be to not create additional runoff when compared with the undeveloped situation and for redevelopment to reduce runoff where possible. The use of sustainable drainage systems (SuDs) is recommended to help achieve this aim.

6.1.3 The area within the proposed Bus Station planning boundary is 9801 m^2. The soft landscaping of the existing layout is 1010 m^2. The soft landscaping of the proposed layout of the proposed Bus Station is 1107 m^2.

6.1.4 The surface water drainage proposals are illustrated on the drawings provided in Appendix B.

6.1.5 Four methods of surface water collection have been proposed on the development site.

- Slot drains are to be installed within the pedestrian areas having minimum visual impact on the hard landscaped areas. Where possible, these slot drains have been laid to tie in with the proposed paving layout.
- Grid drains with cast iron slotted covers are to be installed within the main bus station area.
- Linear kerb drainage is to be installed across the lower edge of the bus layover area.
- Trapped road gullies are to be used to replace existing road gullies where necessary.

6.1.6 It is proposed to collect the surface water runoff from the site at 4 no. soakaways. These have been designed to the 1 in 100 year rainfall event. However, in the event of this rainfall being exceeded the surface water runoff from the bus station site is to pass through a Class 1 By-pass type oil separator before connecting into the existing manhole chamber and discharging to the river.

6.1.7 Modelling of the proposed surface water network, by Capita, indicates that there is no flooding for the worst case storm event. The surface water management proposals are therefore considered to meet the requirements of TAN15.

7. Conclusion & Recommendations

7.1.1 Capita has been commissioned by Merthyr Tydfil County Borough Council to undertake a Flood Consequence Assessment for the proposed development of a Bus Station in the centre of Merthyr Tydfil on Swan Street. The site is located within TAN15 Flood Zone C2.

7.1.2 The proposed development is considered to be less vulnerable according to the TAN15 classifications. The development is identified by MTCBC as being acceptable in this Flood Zone.

7.1.3 An assessment of the flood risk to the site has concluded that fluvial flooding from the River Taff represents the most significant source of flood risk to the development. There is also some potential for surface water / sewer flooding and flooding from upstream reservoirs should a breach occur in their embankments. However fluvial flooding is expected to lead to the greatest flood consequences at the site.

7.1.4 A hydraulic model and its associated hydrological assessment (from the River Taff Central Link FCA developed by Capita in 2012) was updated as part of this study. The main update involved including the flow from the Nant Morlais and the representation of the Nant Morlais in 1D in the TUFLOW model. The hydrological assessment was also updated to include the attenuation provided by the FSA at Pant. The updated model has been used to assess the local flood mechanisms and flood consequences arising from fluvial flooding. Details of the model and hydrology are provided in the appendices (Appendix D and E, respectively). The results of the model have been used to test the proposals and inform the development design.

7.1.5 The results of the assessment indicate that for the baseline scenario the site is at risk of flooding from the River Taff for the 1 in 50 year and greater magnitude flood events. During the 1 in 1000 year event flooding occurs throughout the site and the depths at the Health Centre are over 1.1m.

7.1.6 The development proposals of the site involve amendments to ground levels and a change in land use type. Previously the site was comprised of two buildings, a Health Centre and a Police Station. The proposed development for the site is a Bus Station, which will consist mainly of open tarmac area.

7.1.7 Flood risk within the proposed development as well as its impact off-site has been assessed using the updated hydraulic model. The model results show that the proposed Bus Station building is not predicted to flood up to the 1 in 1000 year event. In this event there is flooding across the north west corner of the site (occupied by landscaping and paving within the proposed site plan). Safe access and egress from the site is possible onto Swan Street to the South up to the 1 in 1000 year flood event.

7.1.8 The proposed development is predicted to increase flood depths and velocities on Avenue de Clichy adjacent to the site in the River Taff. For the reasons discussed in Section 5.5 this is not considered to have a significant impact on flood risk to third parties.

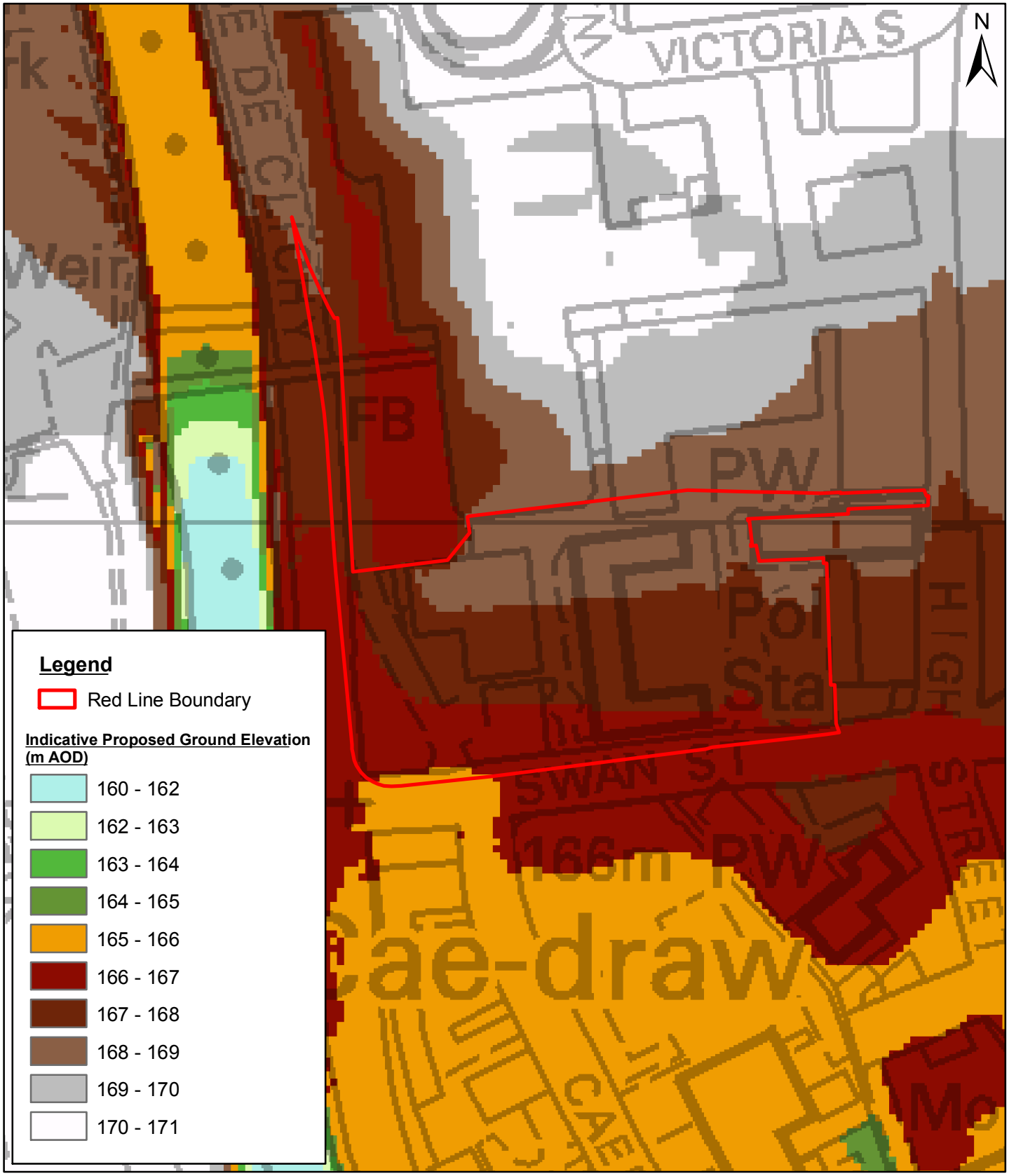
7.1.9 The residual flood risk to the site is associated with blockage of the Nant Morlais culvert, which flows into the River Taff. Following discussion with NRW it was agreed that a 67% (according to CIRIA guidance) and a 100% blockage would be applied to the culvert. The residual flood risk at the proposed development site is considered minimal.

7.1.10 It is proposed to collect the surface water runoff from the site at 4 no. soakaways, which are designed to the 1 in 100 year rainfall event.

7.1.11 Modelling of the proposed surface water network, by Capita, indicates that there is no flooding for the worst case storm event. The surface water management proposals are therefore considered to meet the requirements of TAN15.

7.1.12 Although the consequences of flooding at the site do not meet the indicative guidance in TAN15 it is considered that the consequences of flooding for the development are acceptable. The proposal will not increase the overall flood risk to the surrounding area; development at this site should not be restricted as a result of flood risk.

Appendix A Figures



Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A1 - Indicative Proposed Ground Elevation

CAPITA

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES @ A4	ISSUING OFFICE	DRAWING NUMBER	REV
MS	MM	MM	10/05/16	1:1500	London	CS0074270/Figure A1	001

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A2 - Indicative Changes in Ground Elevation
Baseline to Proposed

CAPITA

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES @ A4	ISSUING OFFICE	DRAWING NUMBER	REV
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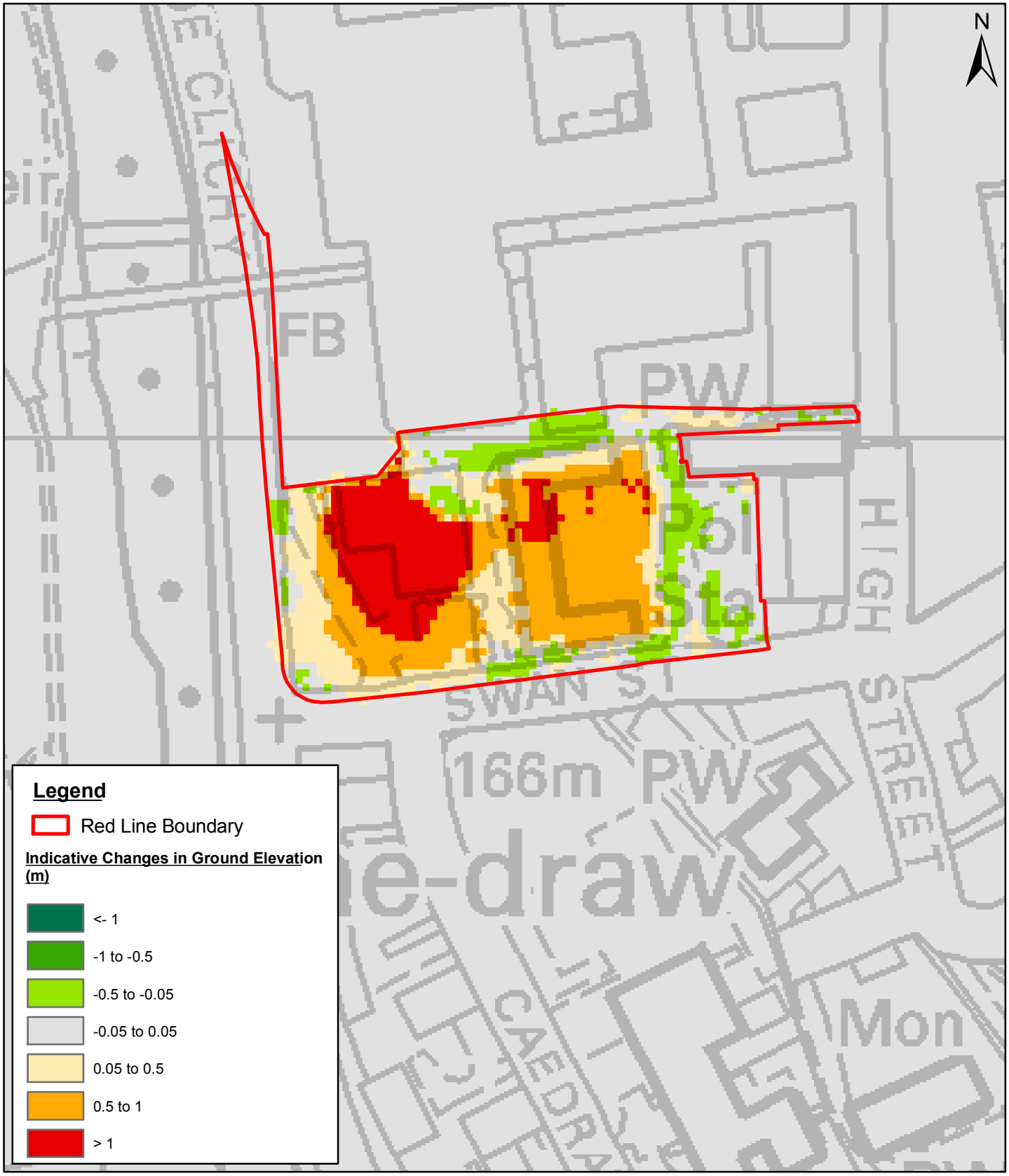

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A3 - Indicative Changes in Ground Elevation
Existing to Proposed

CAPITA

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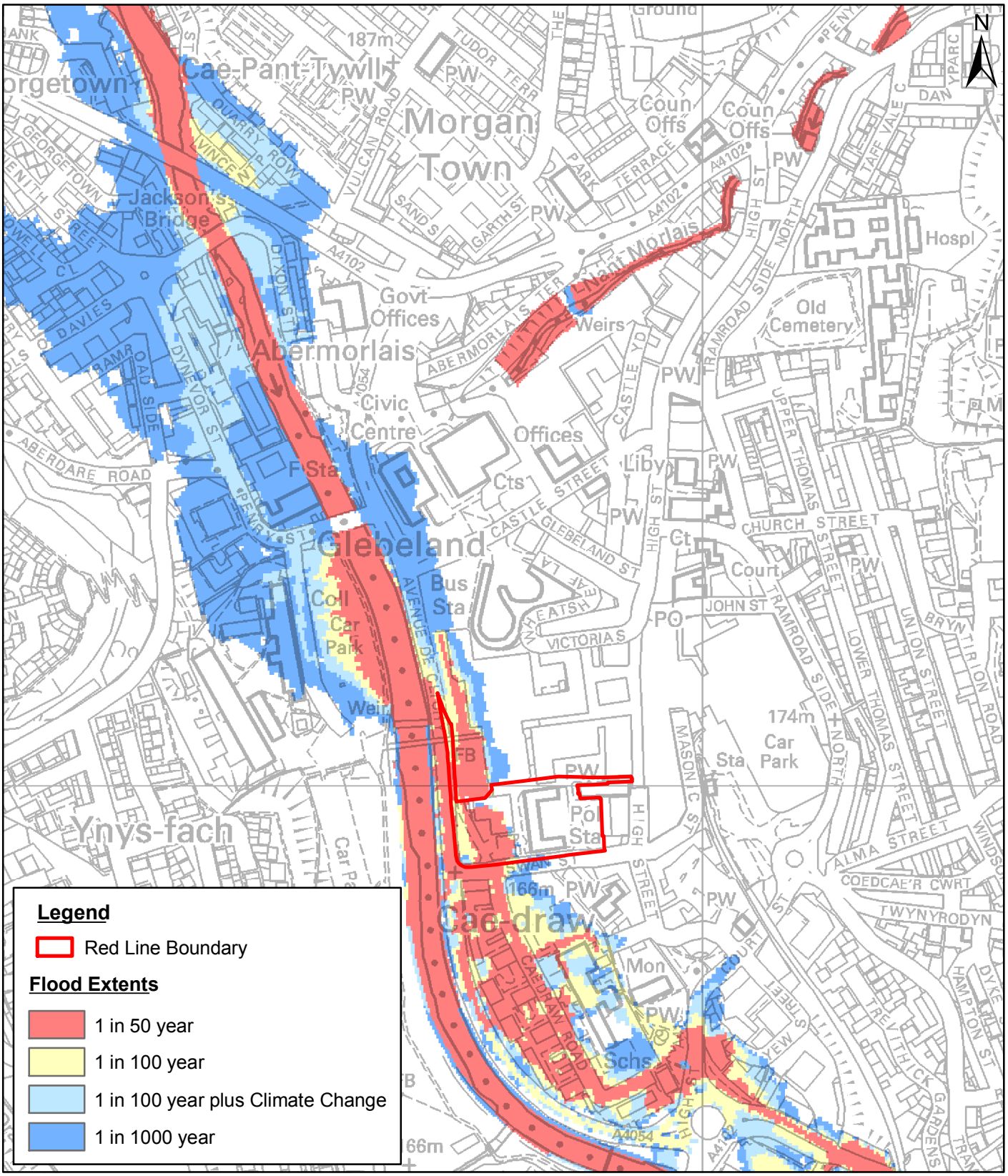

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A4 - Flood Extents
Baseline Scenario

CAPITA

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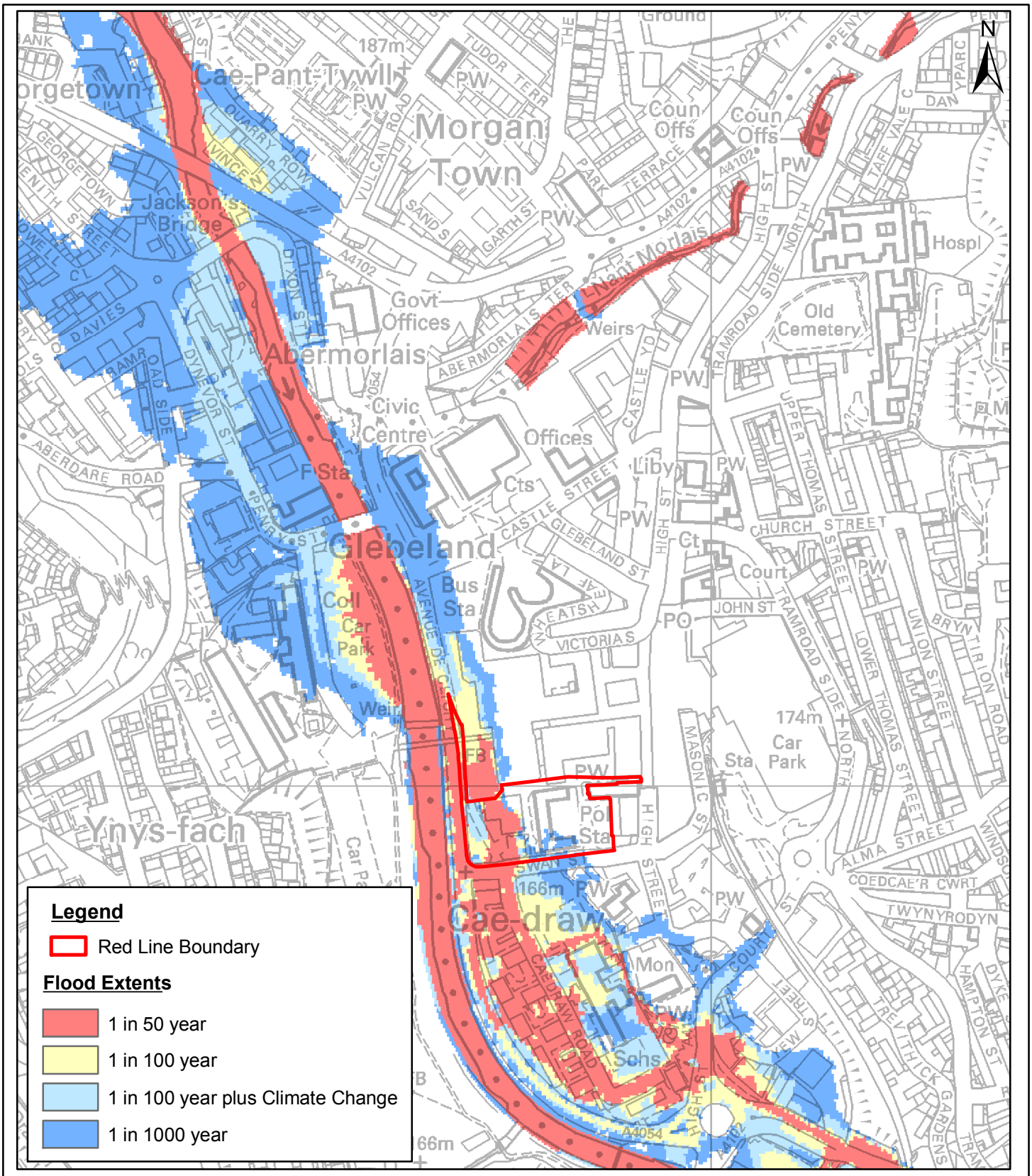

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A5 - Flood Extents
Existing Scenario

CAPITA

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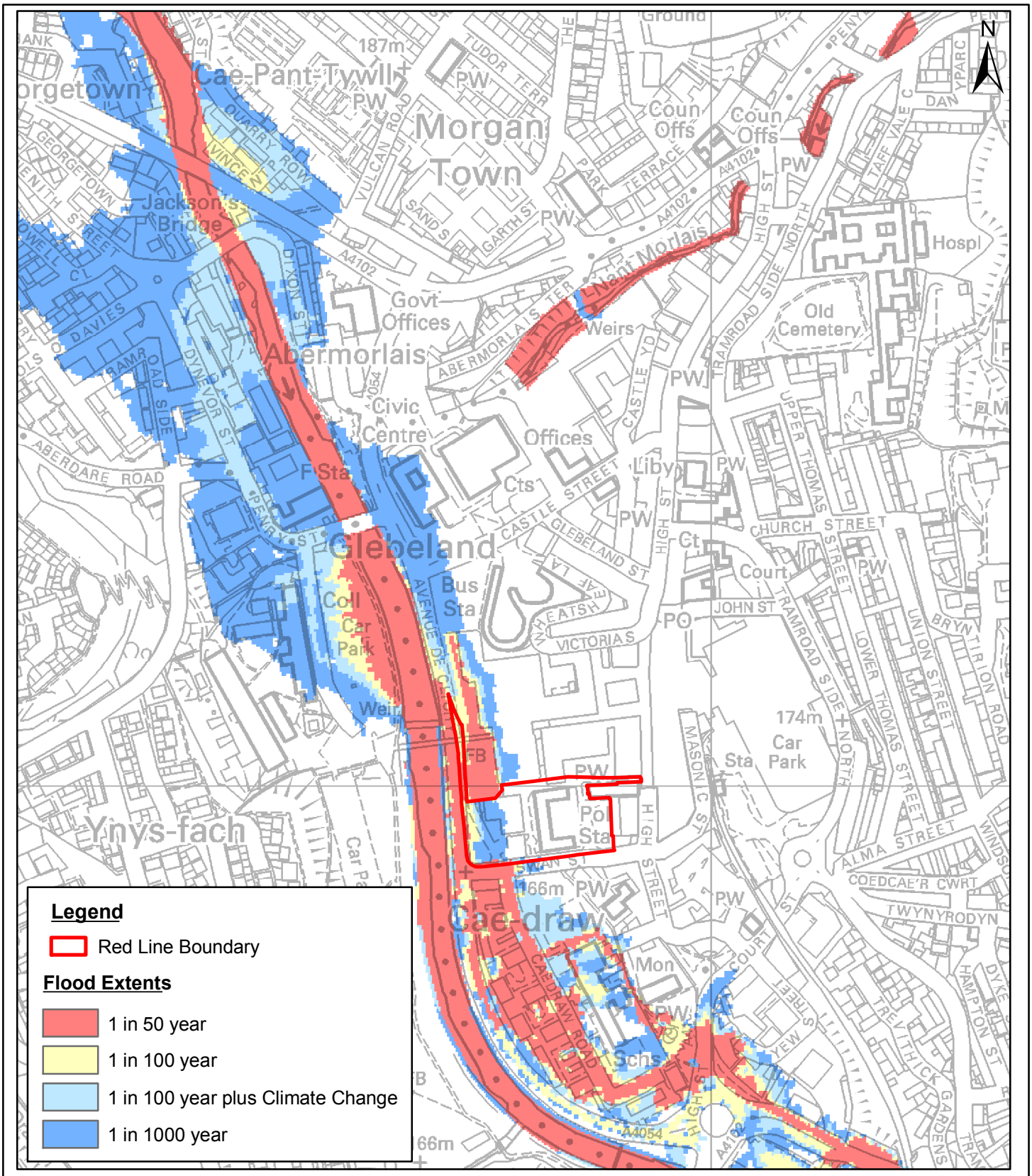

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A6 - Flood Extents
Proposed Scenario

CAPITA

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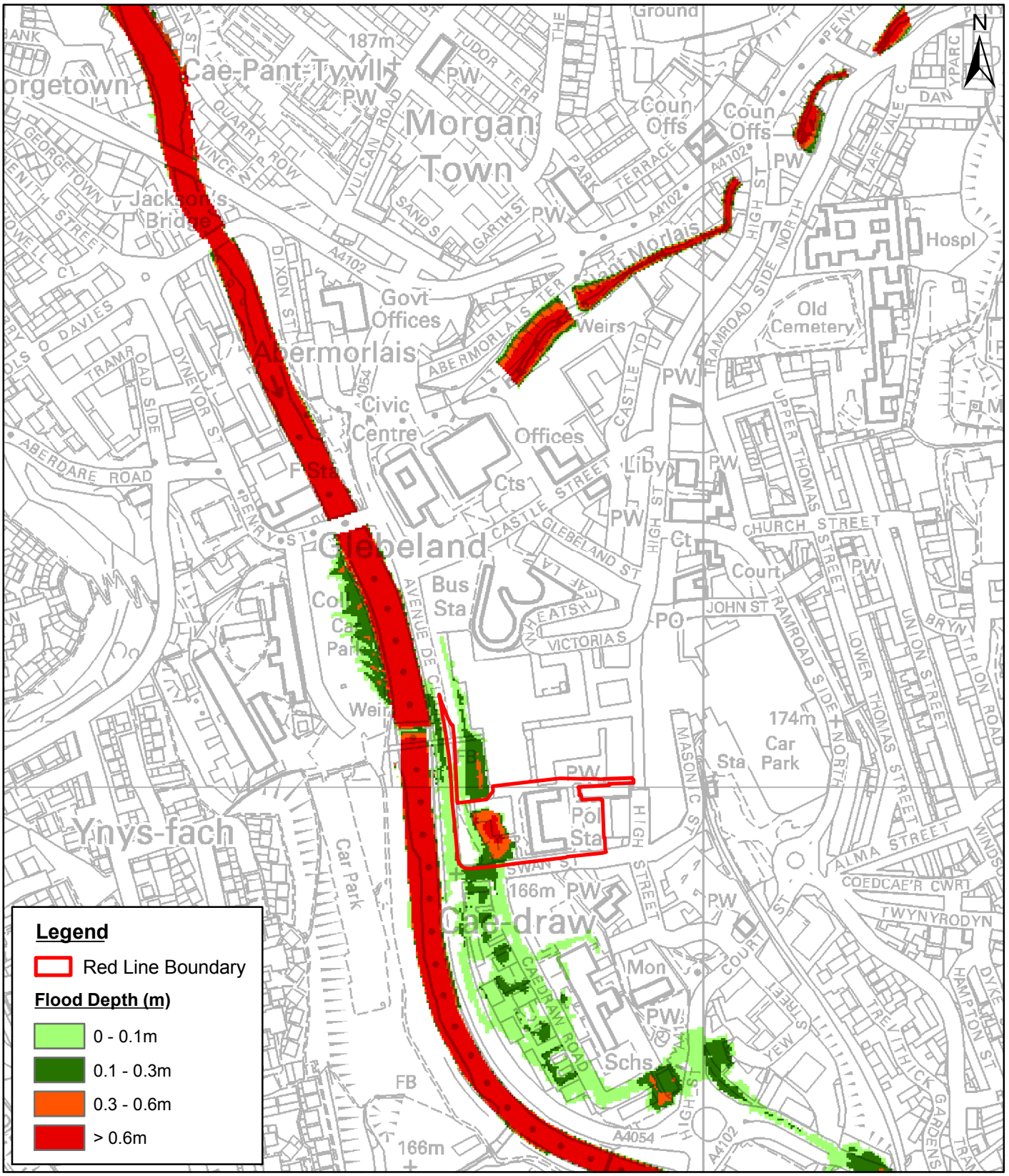

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A7 - Flood Depth
Baseline Scenario
1 in 50 year

CAPITA

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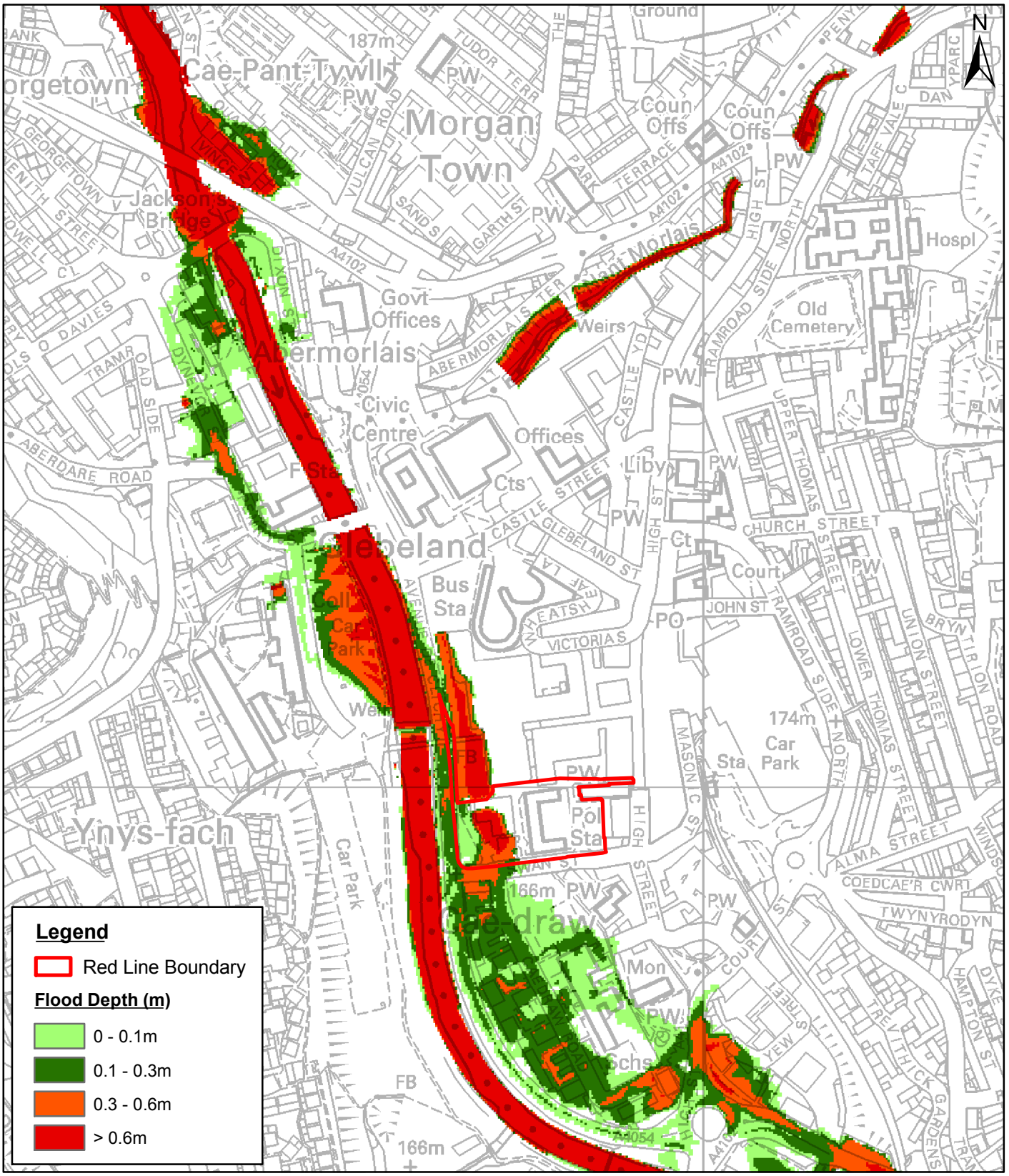

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A8 - Flood Depth
Baseline Scenario
1 in 100 year plus Climate Change

CAPITA

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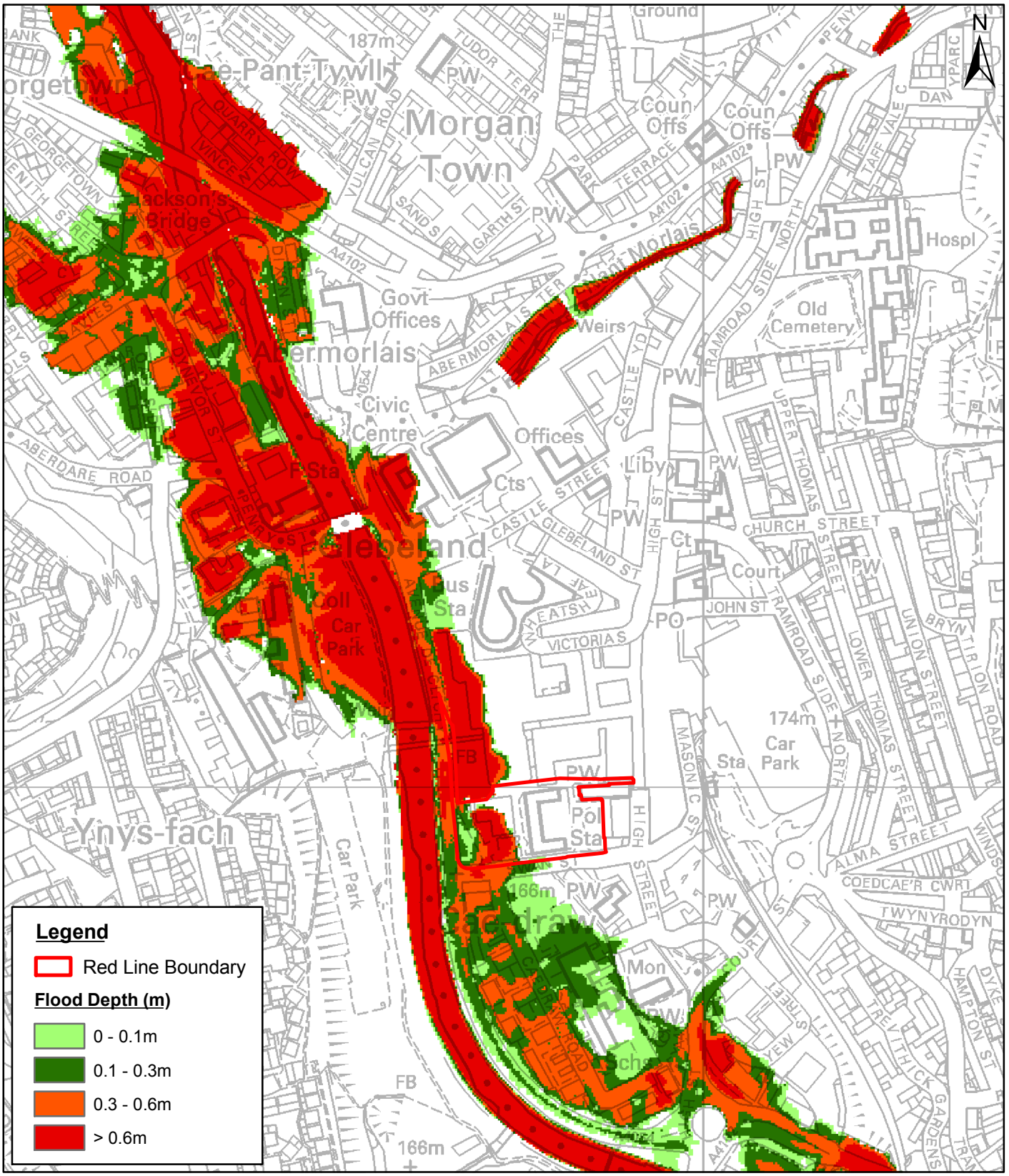

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A9 - Flood Depth
Baseline Scenario
1 in 1000 year

CAPITA

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES @ A4	ISSUING OFFICE	DRAWING NUMBER	REV
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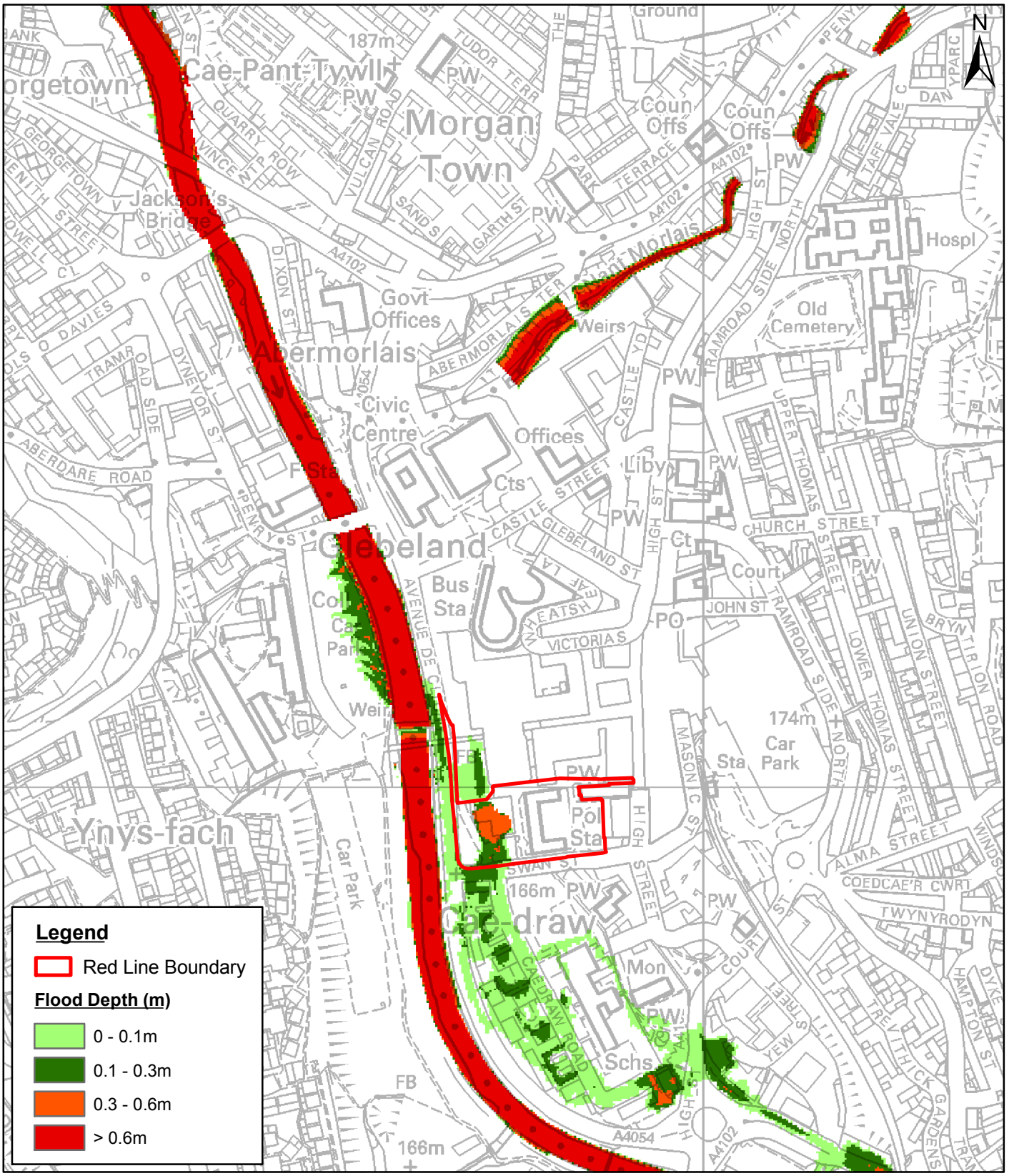

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A10 - Flood Depth
Existing Scenario
1 in 50 year

CAPITA

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES @ A4	ISSUING OFFICE	DRAWING NUMBER	REV
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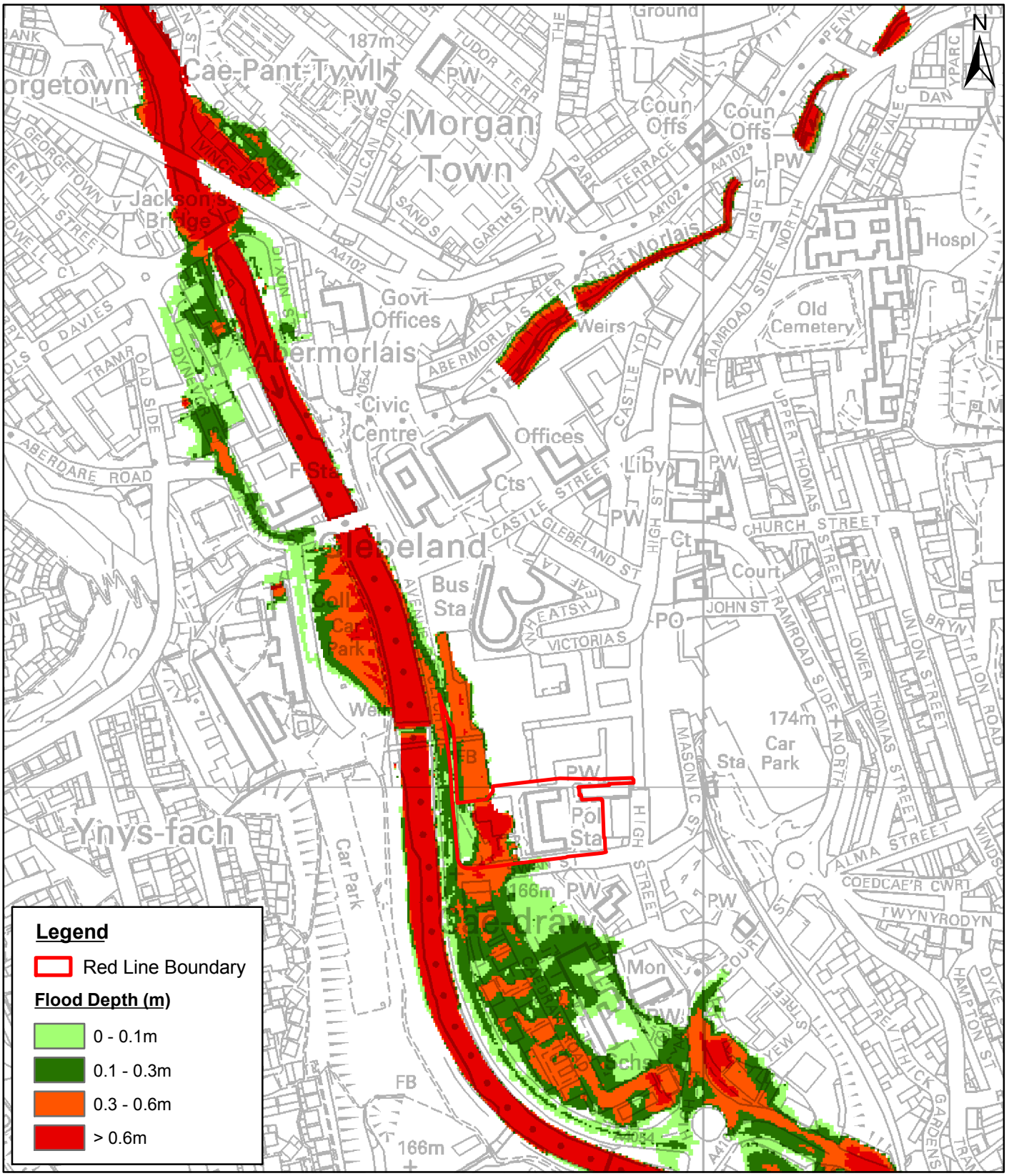
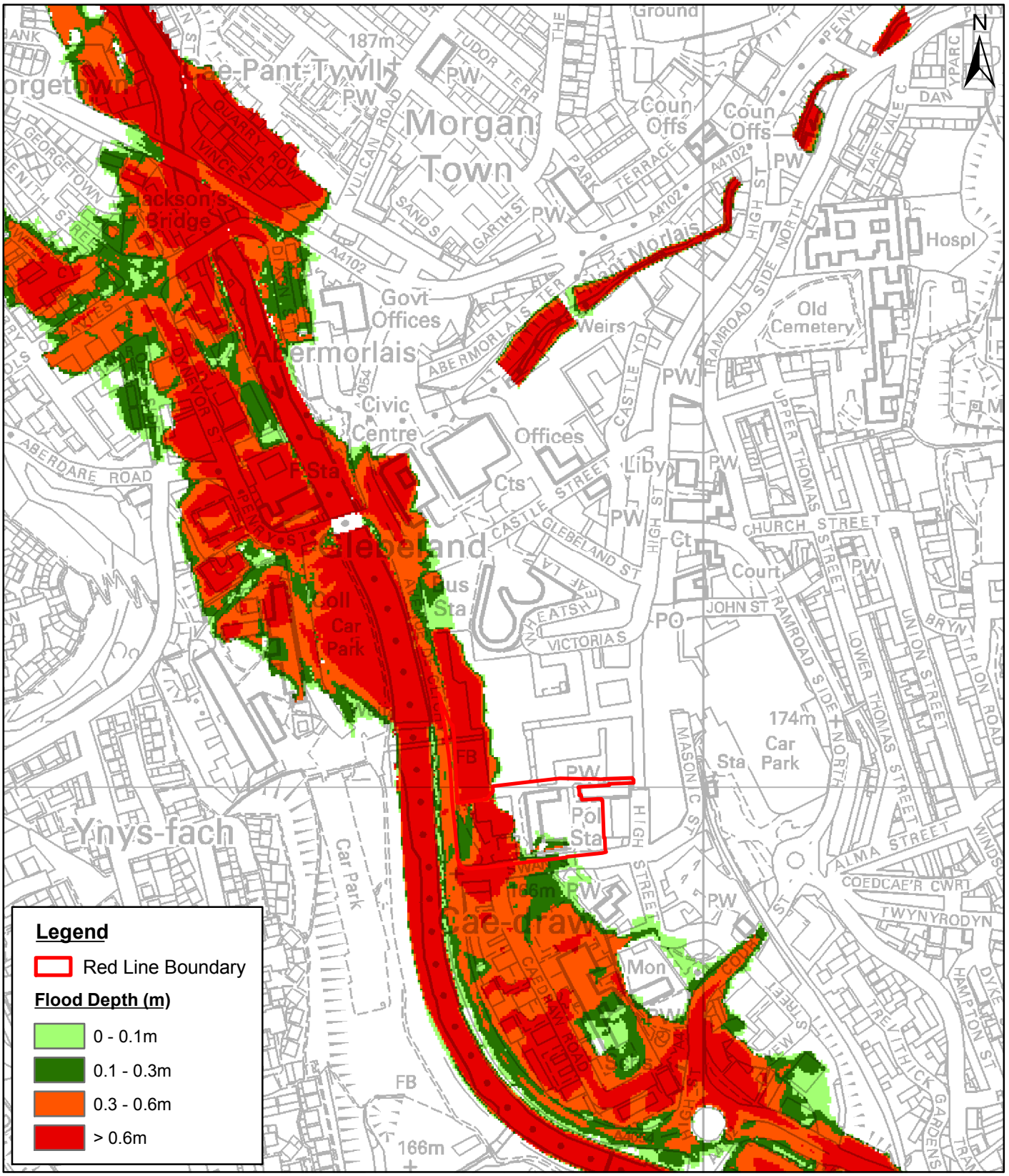


Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A11 - Flood Depth
Existing Scenario
1 in 100 year plus Climate Change

CAPITA

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES @ A4	ISSUING OFFICE	DRAWING NUMBER	REV
MS	MM	MM	10/05/16	1:5000	London	CS0074270/Figure A11	002



Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A12 - Flood Depth
Existing Scenario
1 in 1000 year

CAPITA

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES @ A4	ISSUING OFFICE	DRAWING NUMBER	REV
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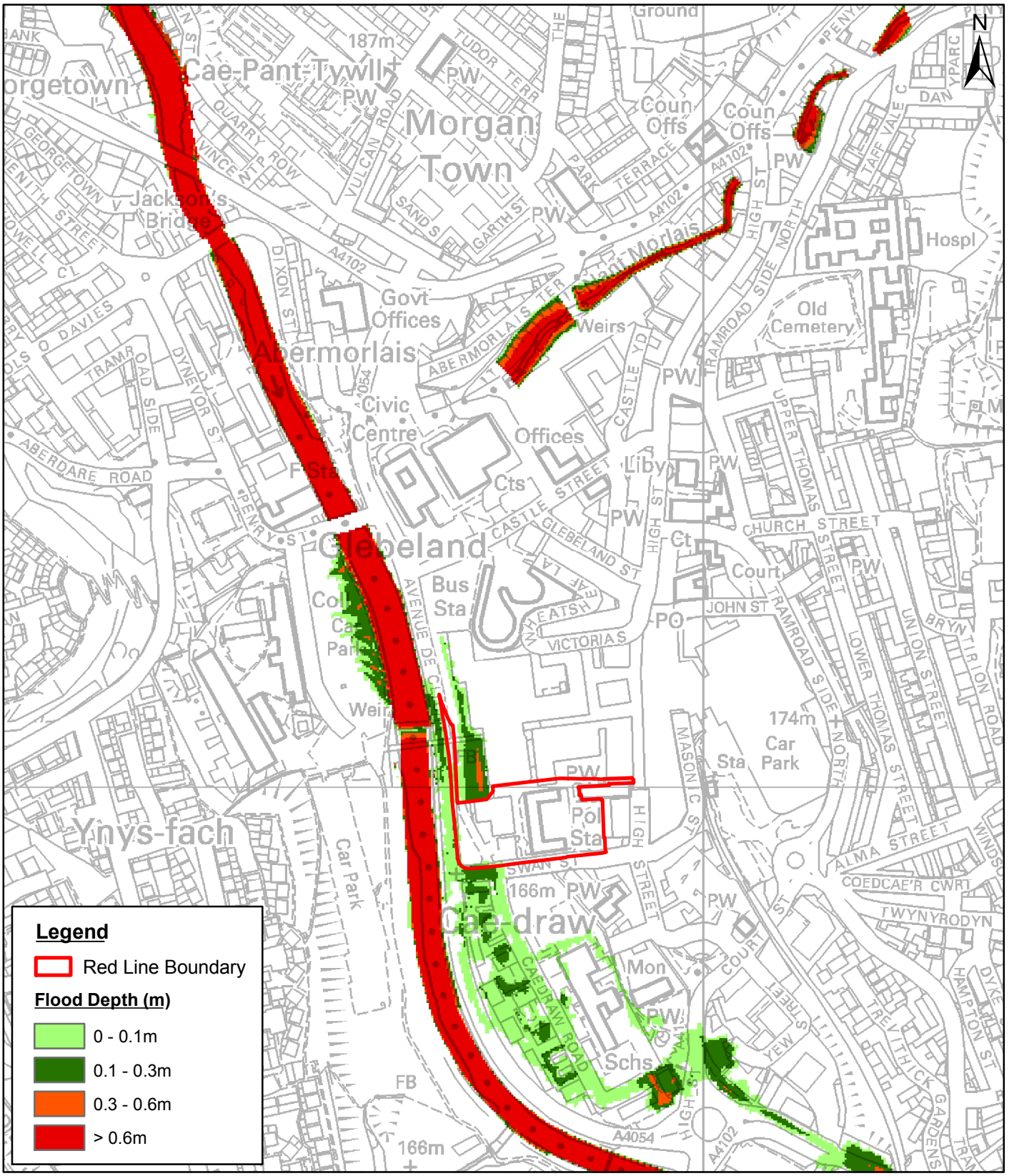

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A13 - Flood Depth
Proposed Scenario
1 in 50 year

CAPITA

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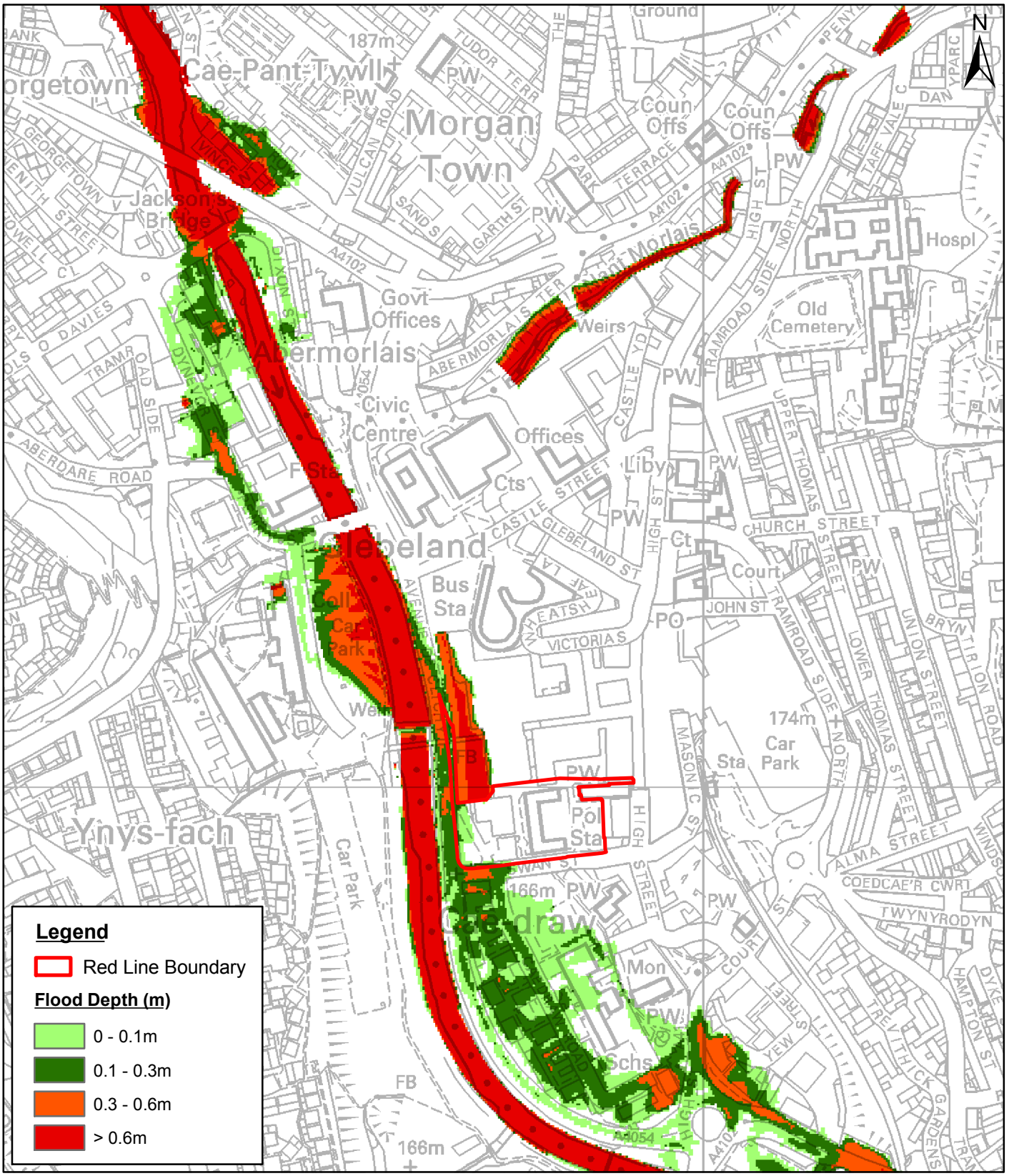

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A14 - Flood Depth
Proposed Scenario
1 in 100 year plus Climate Change

CAPITA

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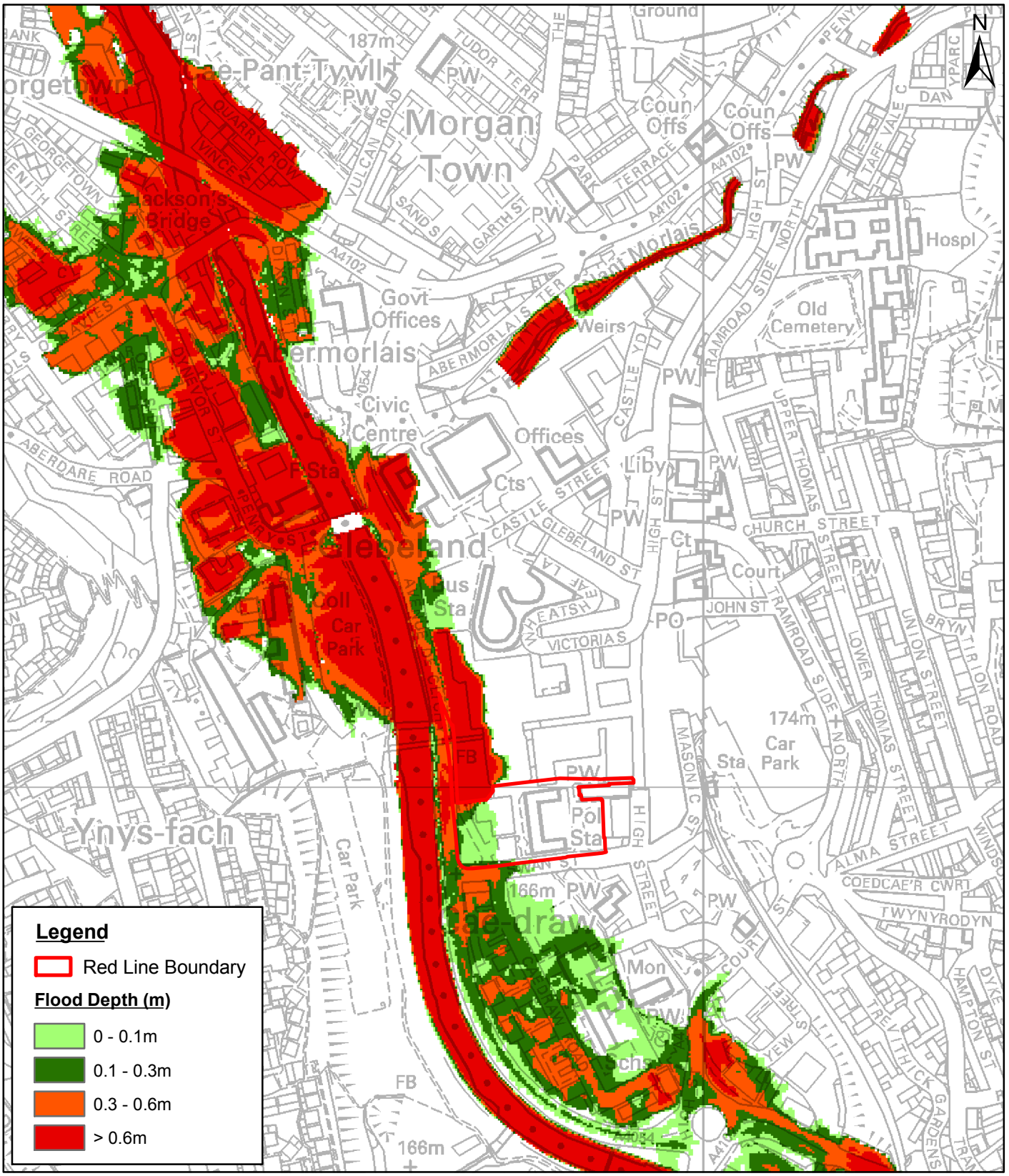

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A15 - Flood Depth
Proposed Scenario
1 in 1000 year

CAPITA

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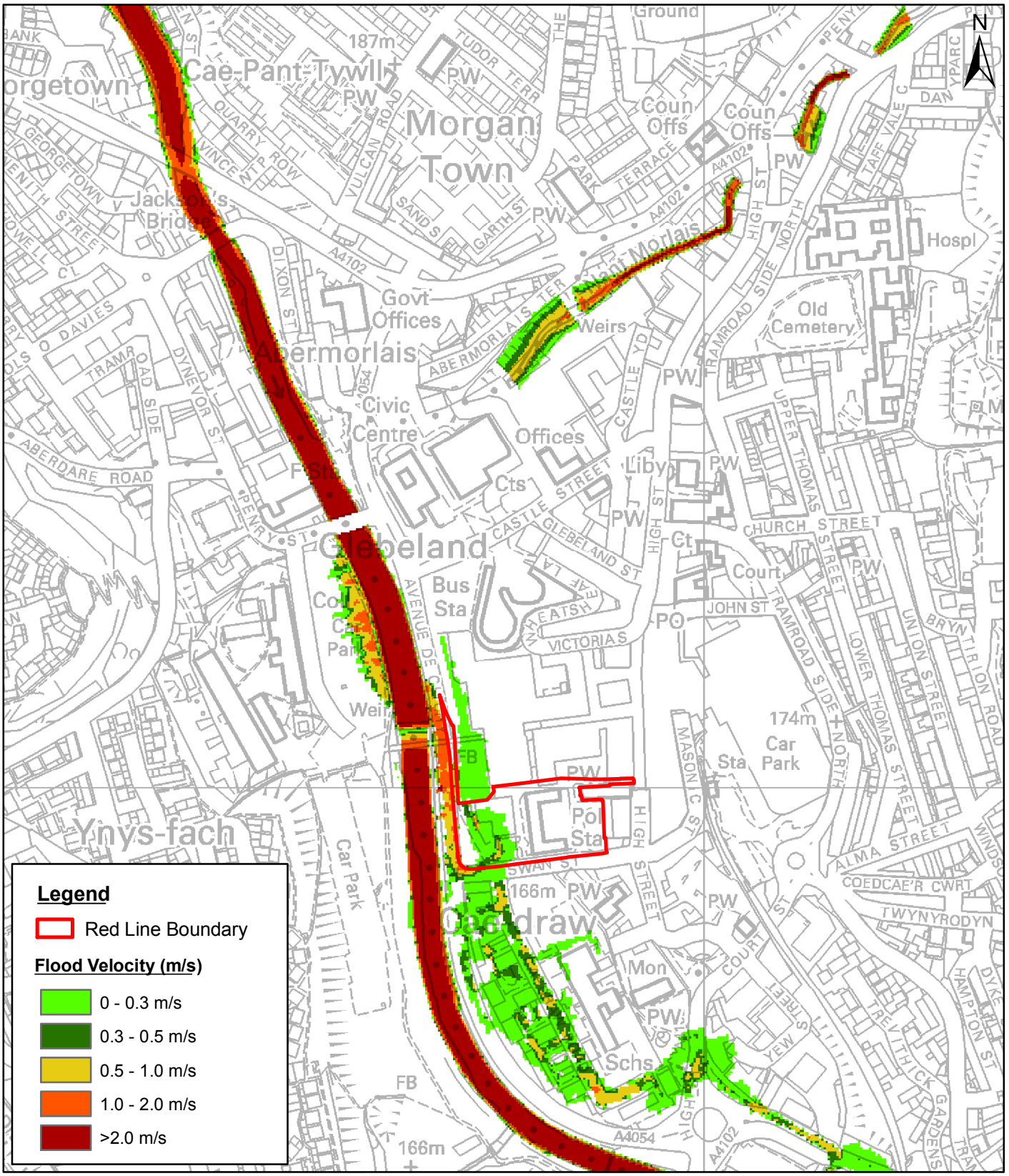

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A16 - Flood Velocity
Baseline Scenario
1 in 50 year

CAPITA

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES @ A4	ISSUING OFFICE	DRAWING NUMBER	REV
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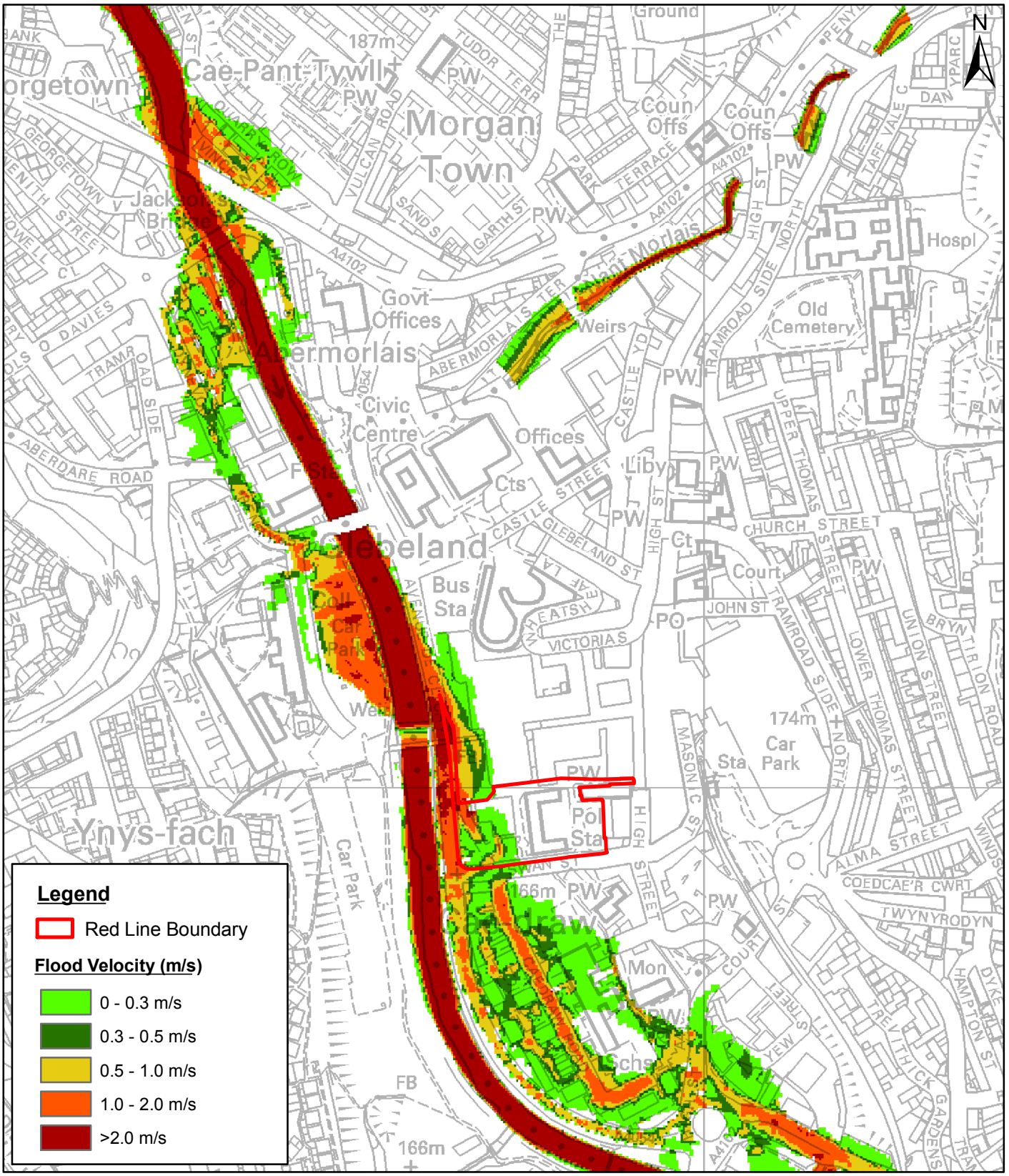

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A17 - Flood Velocity
Baseline Scenario
1 in 100 year plus Climate Change

CAPITA

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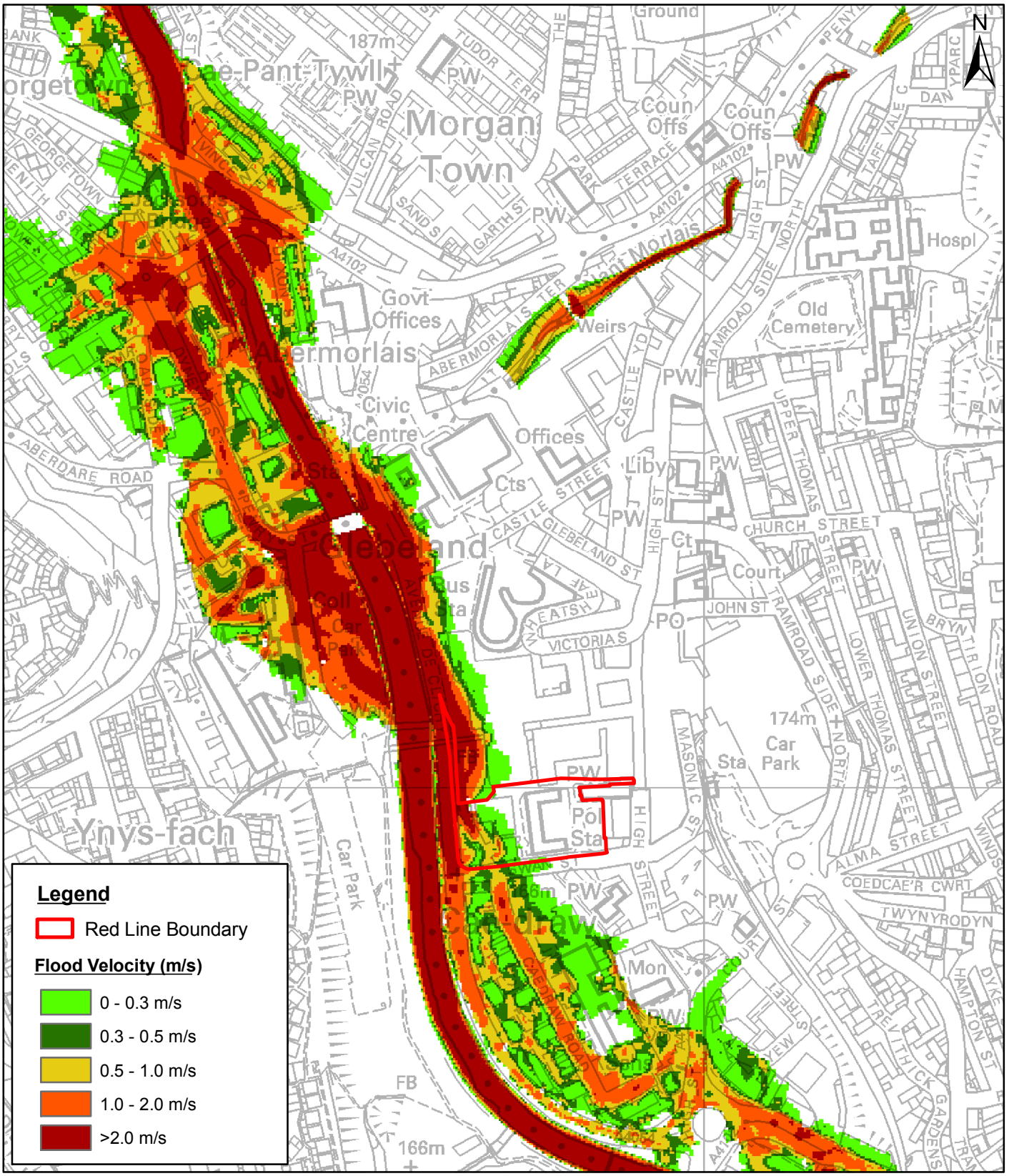

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A18 - Flood Velocity
Baseline Scenario
1 in 1000 year

CAPITA

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES @ A4	ISSUING OFFICE	DRAWING NUMBER	REV
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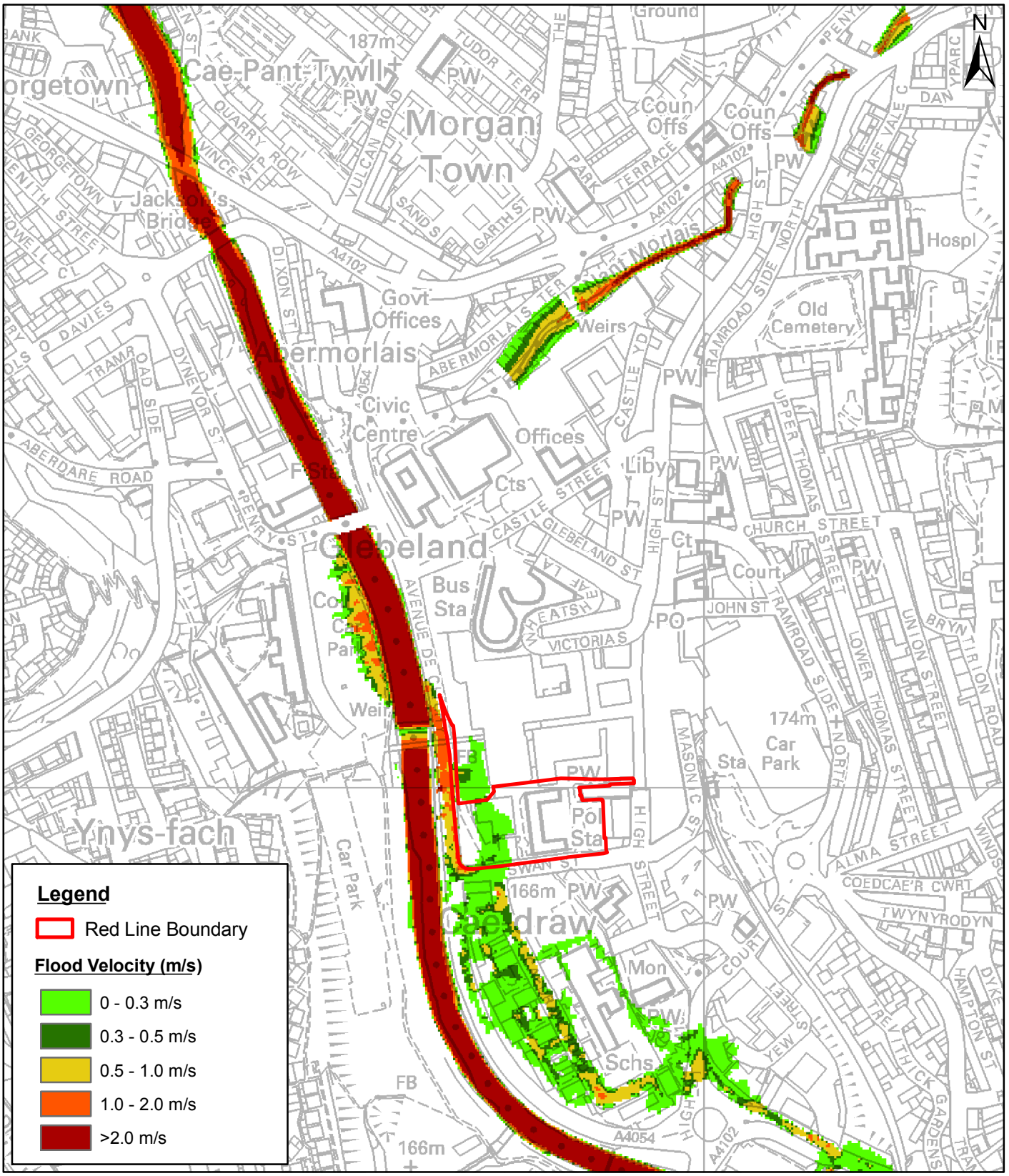

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A19 - Flood Velocity
Existing Scenario
1 in 50 year

CAPITA

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES @ A4	ISSUING OFFICE	DRAWING NUMBER	REV
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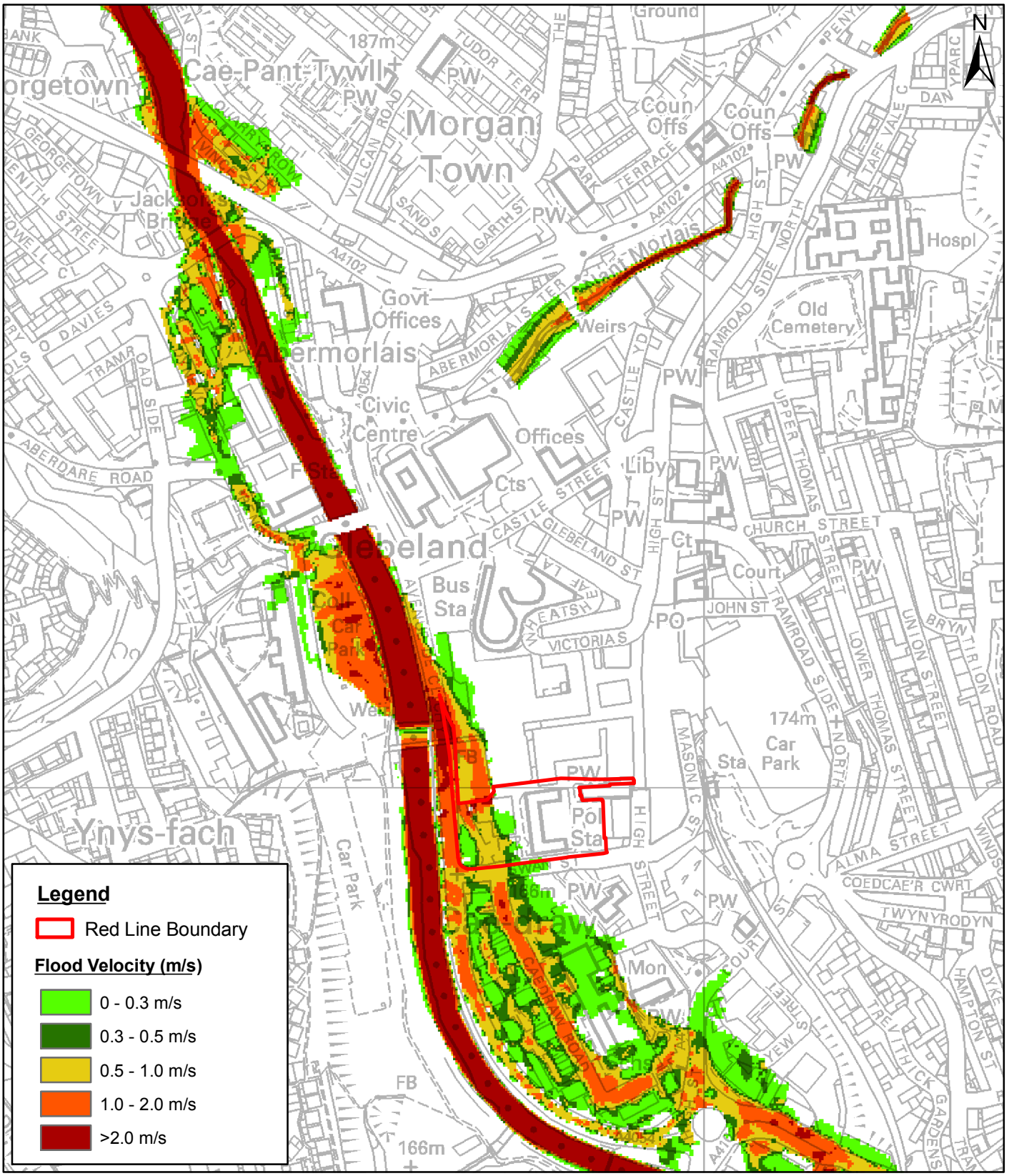

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A20 - Flood Velocity
Existing Scenario
1 in 100 year plus Climate Change

CAPITA

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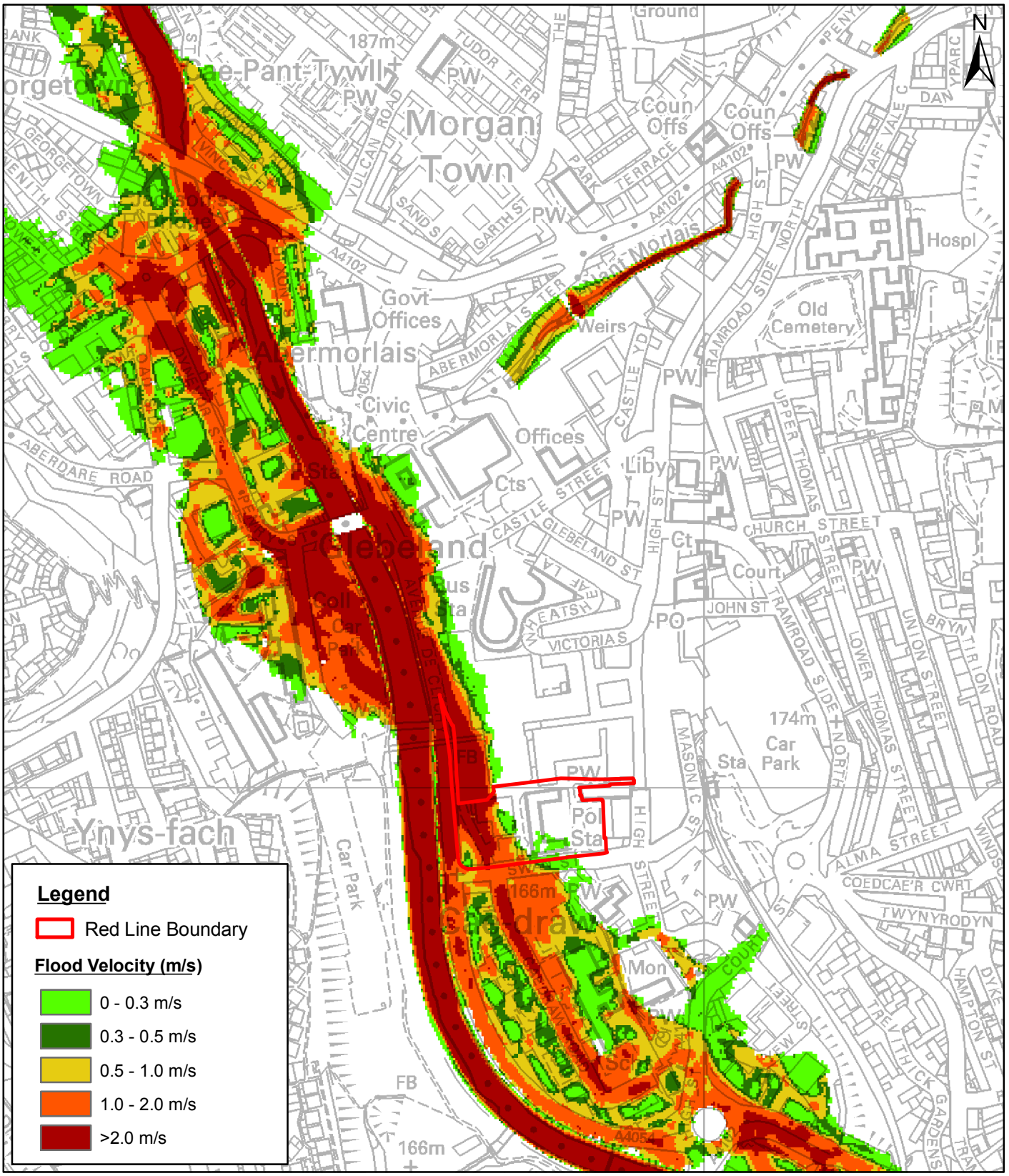

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A21 - Flood Velocity
Existing Scenario
1 in 1000 year

CAPITA

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES @ A4	ISSUING OFFICE	DRAWING NUMBER	REV
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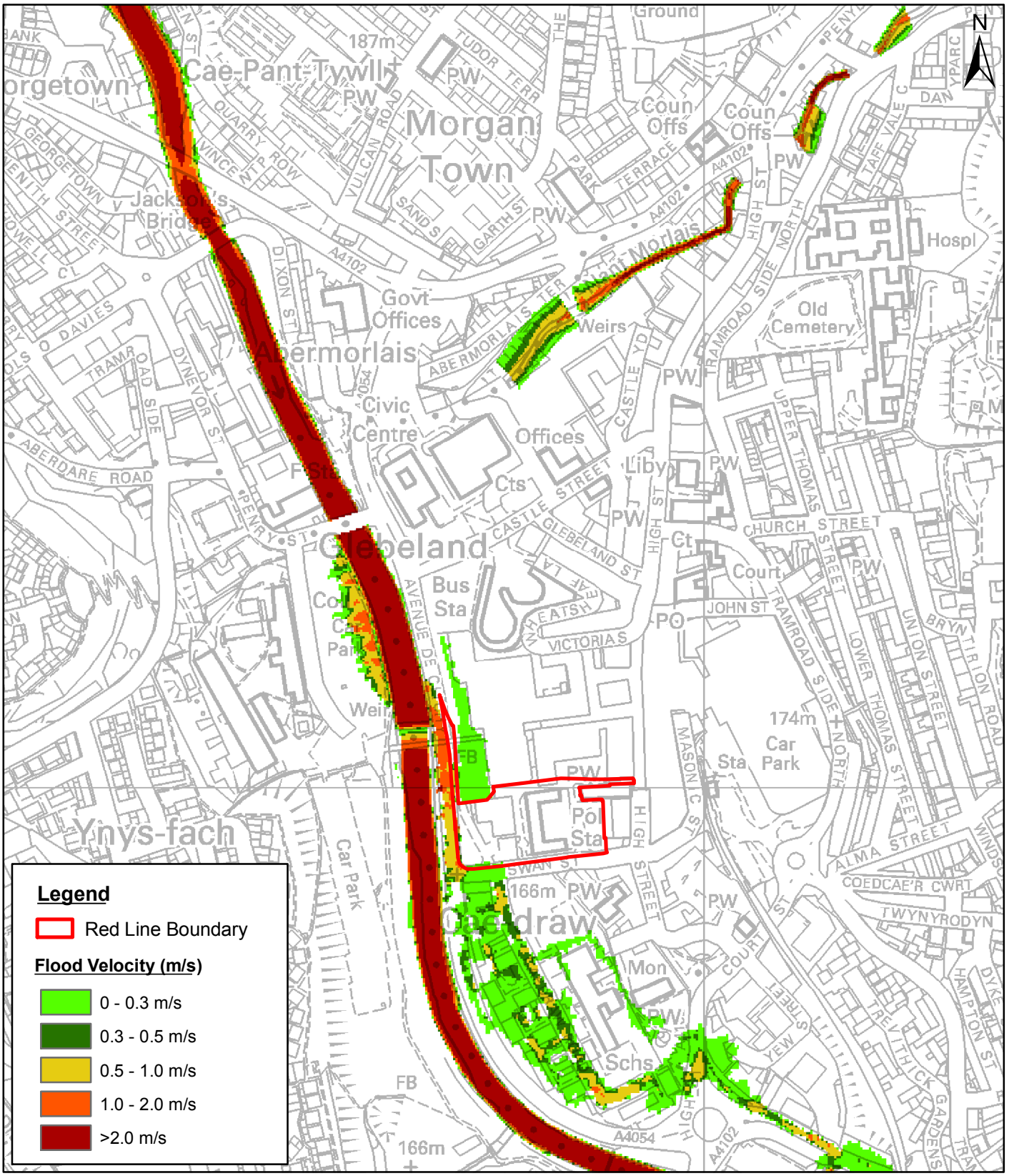

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A22 - Flood Velocity
Proposed Scenario
1 in 50 year

CAPITA

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES @ A4	ISSUING OFFICE	DRAWING NUMBER	REV
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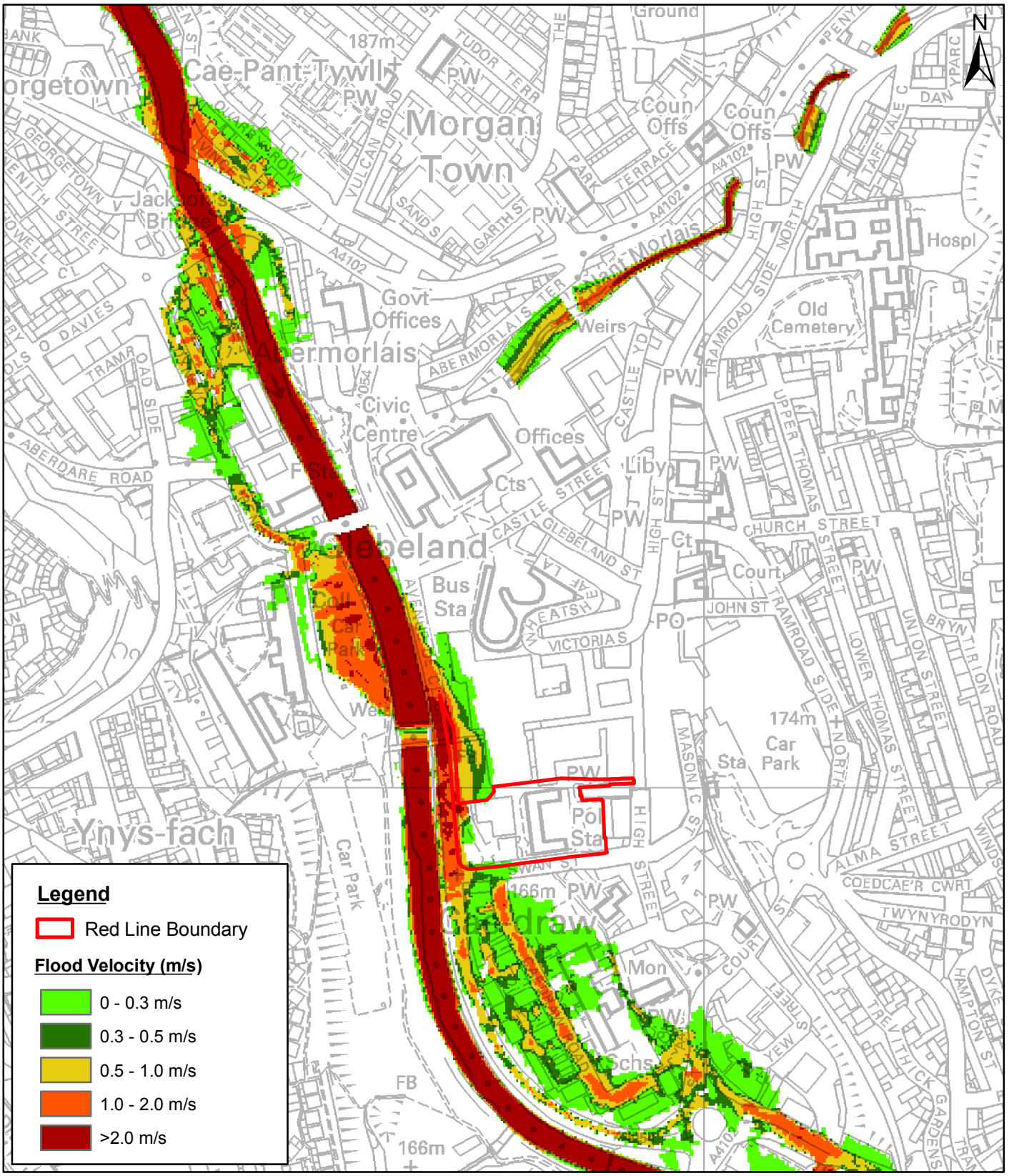

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A23 - Flood Velocity
Proposed Scenario
1 in 100 year plus Climate Change

CAPITA

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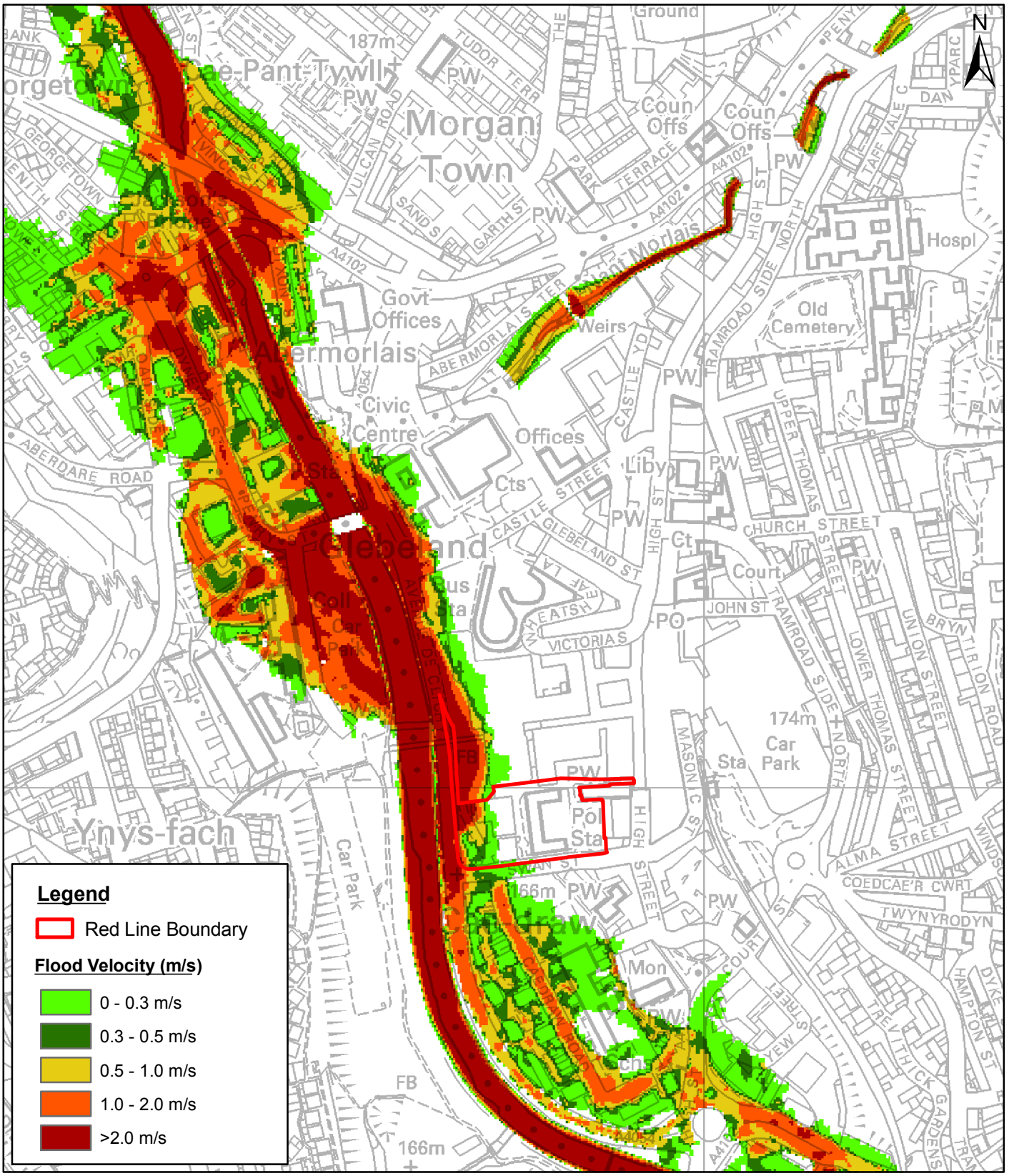

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A24 - Flood Velocity
Proposed Scenario
1 in 1000 year

CAPITA

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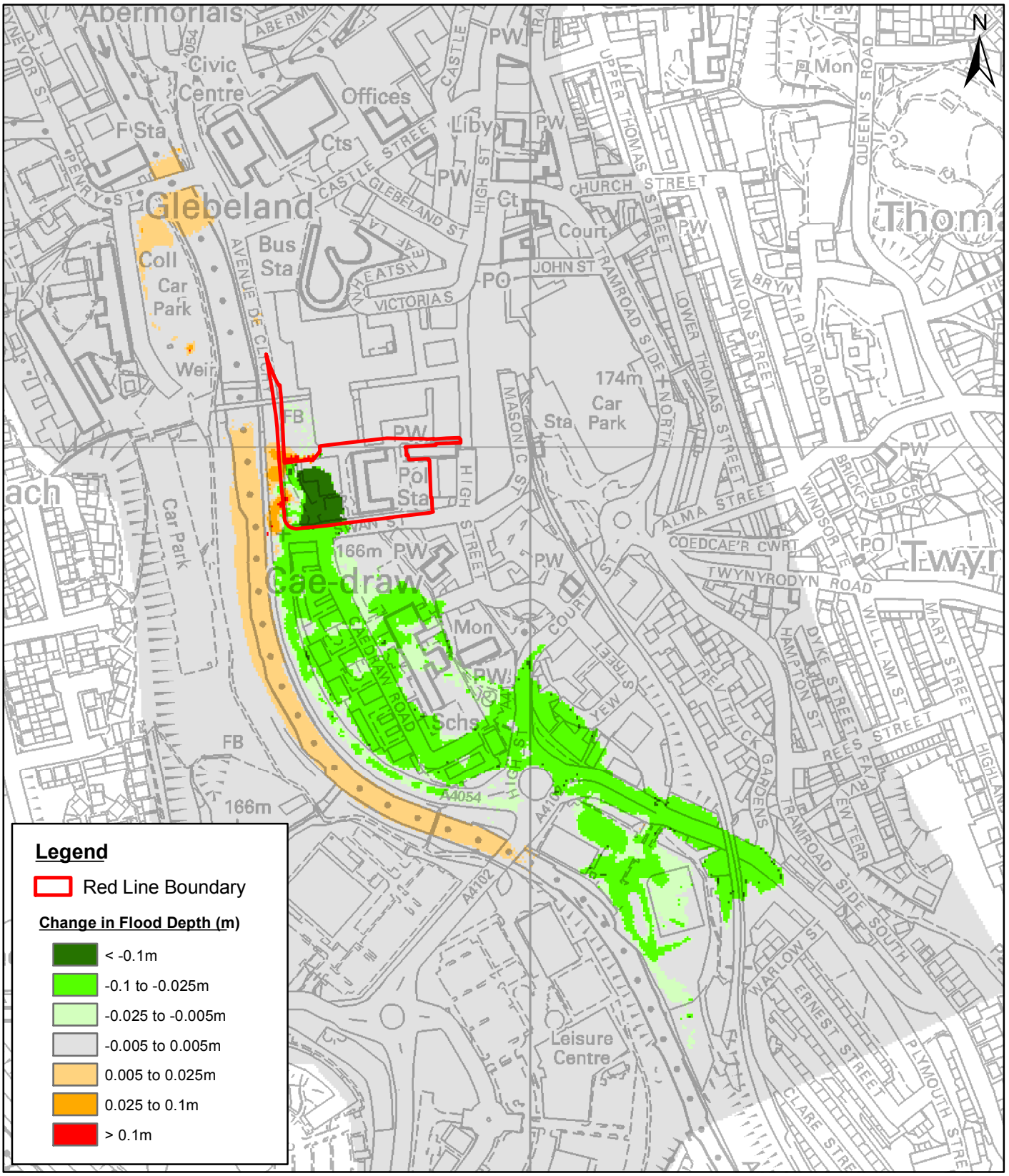

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A26 - Change in Flood Depth
1 in 100 year with Climate Change

CAPITA

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES @ A4	ISSUING OFFICE	DRAWING NUMBER	REV
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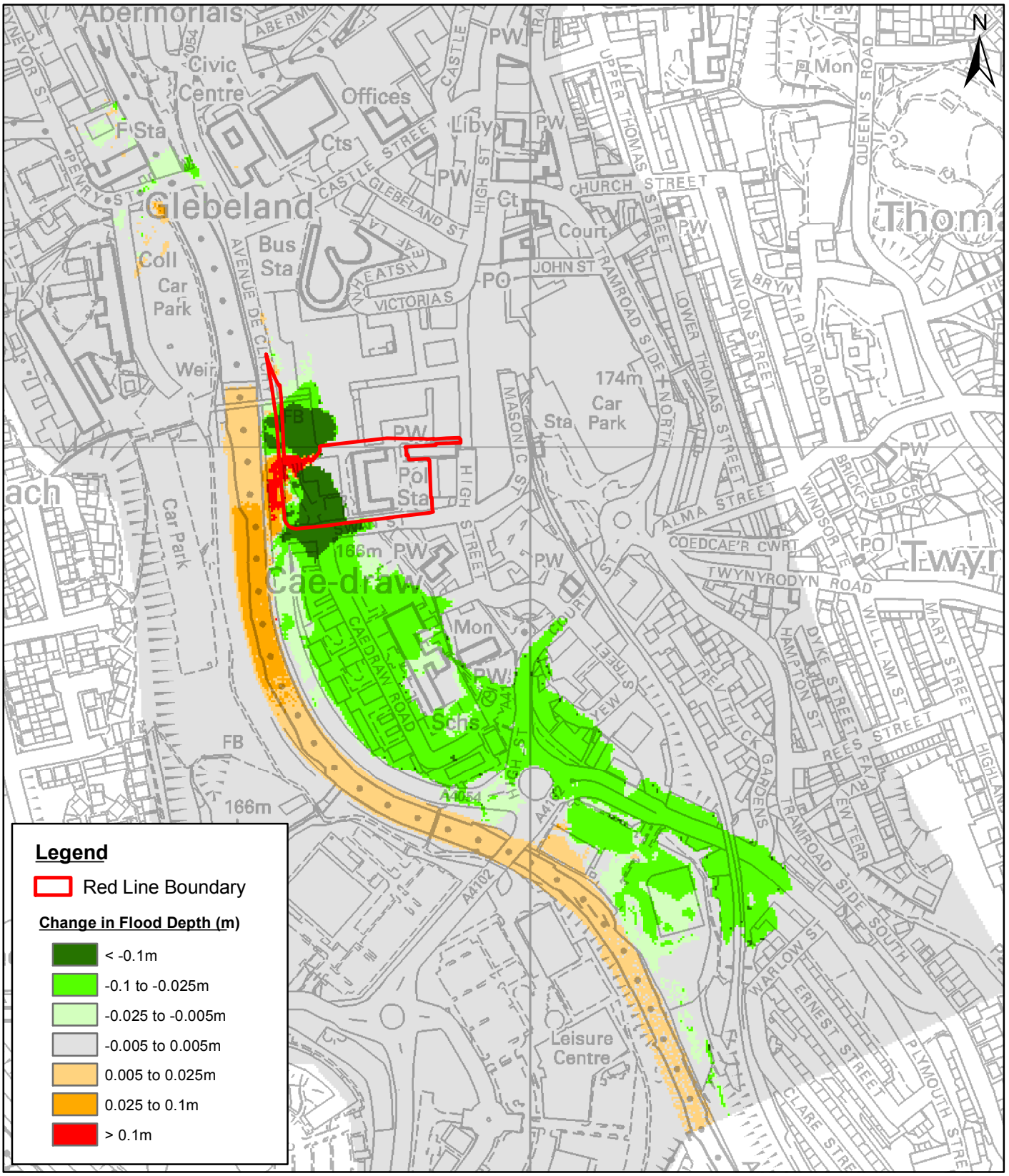

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A27 - Change in Flood Depth
1 in 1000 year

CAPITA

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES @ A4	ISSUING OFFICE	DRAWING NUMBER	REV
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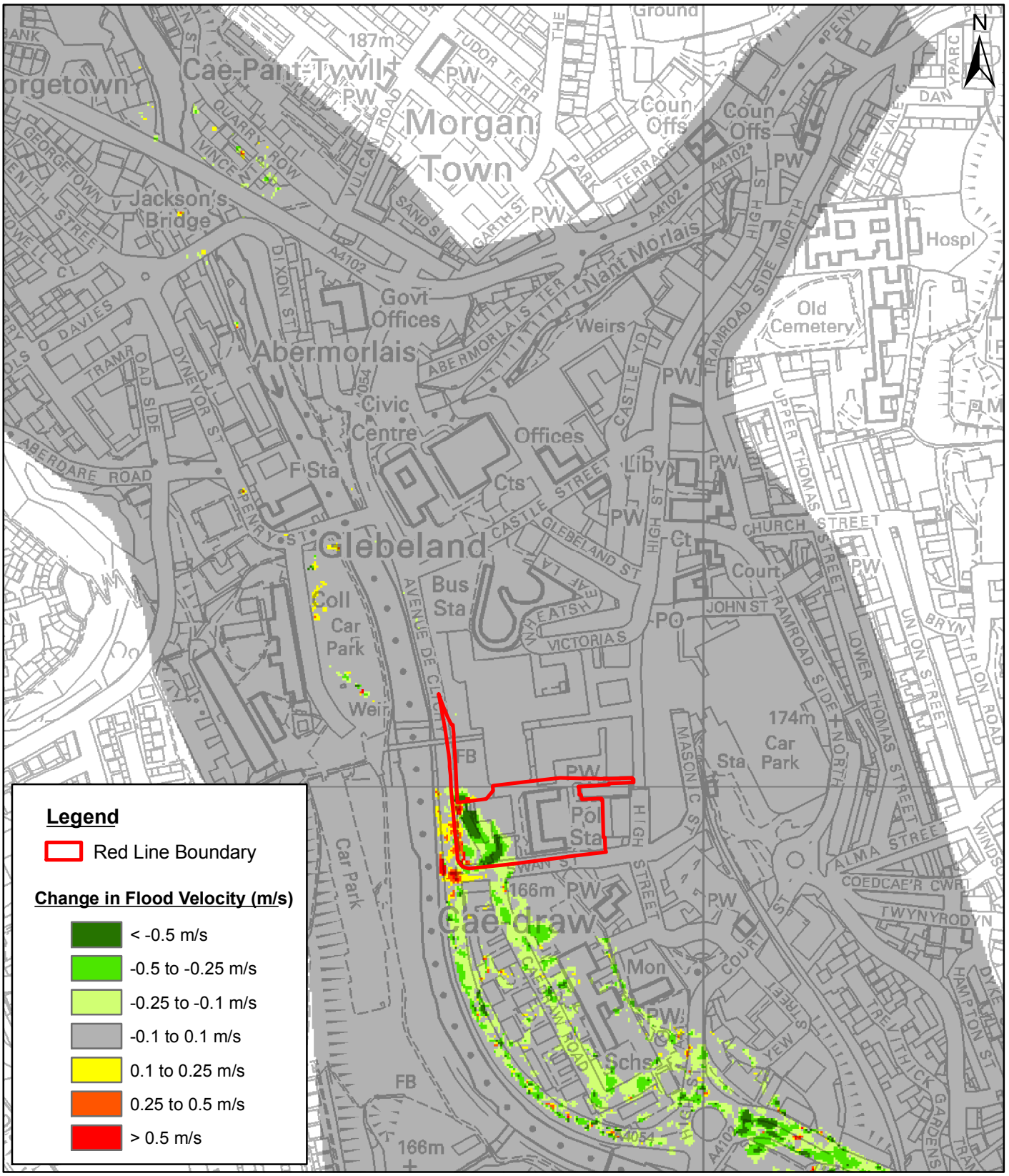

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A29 - Change in Flood Velocity
1 in 100 year with Climate Change

CAPITA

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES @ A4	ISSUING OFFICE	DRAWING NUMBER	REV
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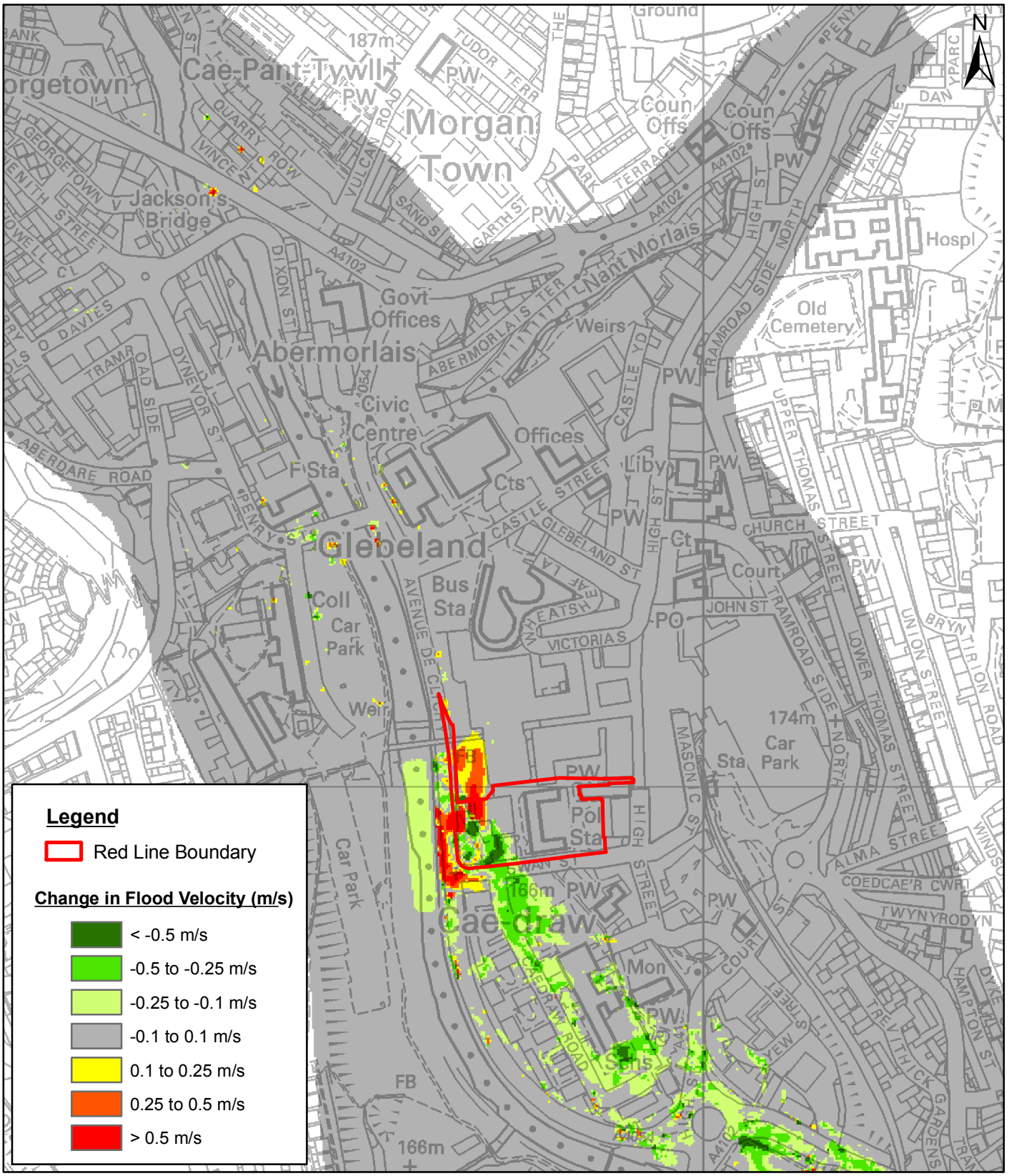

Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A30 - Change in Flood Velocity
1 in 1000 year

CAPITA

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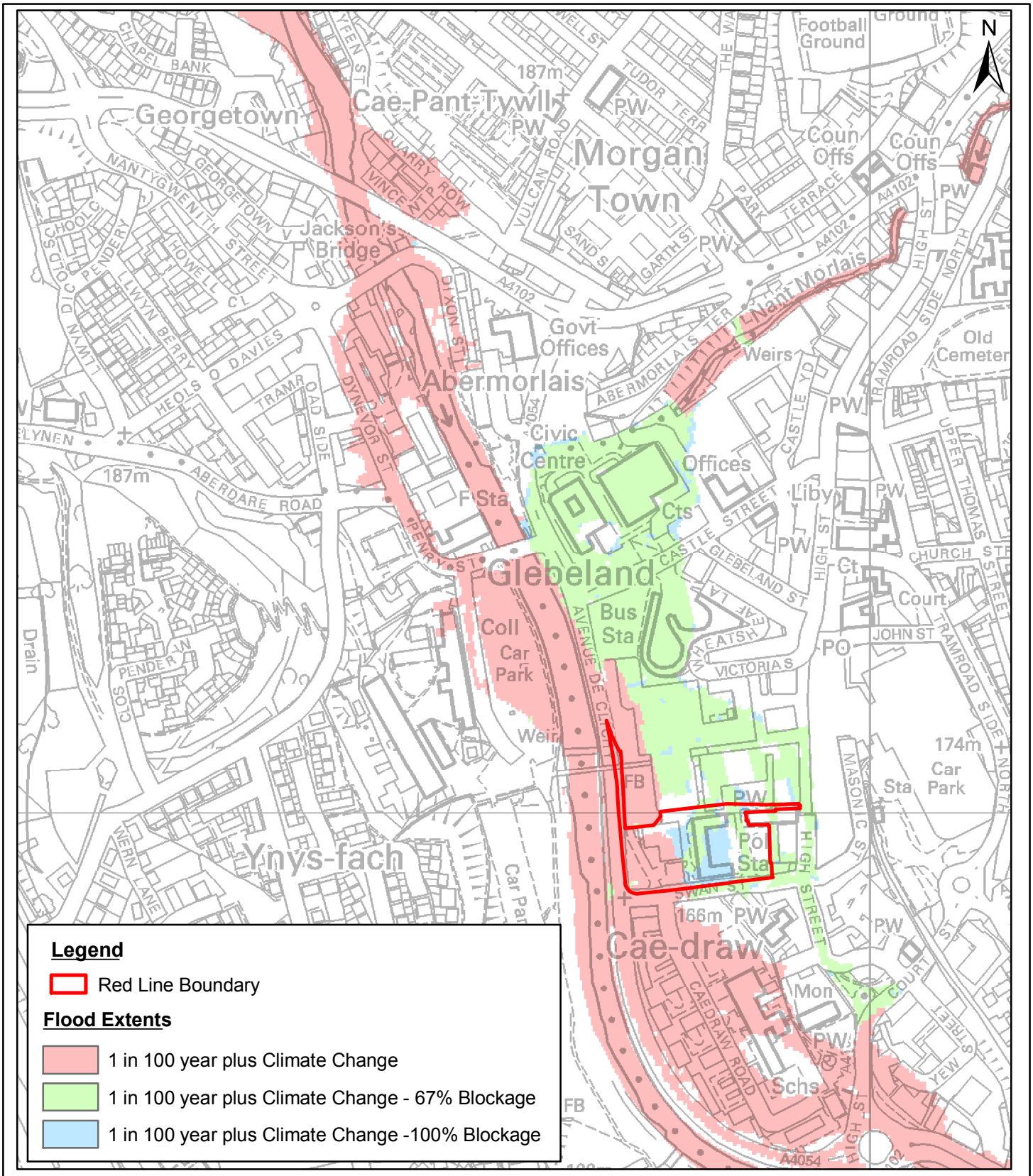


Merthyr Tydfil Bus Station

Flood Consequence Assessment
Figure A29 - Flood Extents
Blockage Scenario

CAPITA

DRAWN BY	CHECKED BY	PASSED BY	DATE	SCALES @ A4	ISSUING OFFICE	DRAWING NUMBER	REV
MS	MM	MM	10/05/16	1:5000	London	CS0074270/Figure A29	001

Appendix B Development Proposals

ST. TYDFIL'S SHOPPING CENTRE

AVENUE DE CLICHY

SERVICE YARD C

SERVICE YARD D

BUS STATION BUILDING

SWAN STREET

CAE-DRAW ROAD

BUS ONLY

DISABLED

Tarmac Road

Tarmac Carpark

Tarmac Service Yard

Tarmac Path

Tarmac Footpath

Decorative Paving

Construction Site

Fence

Wooden Fence

Concrete

Brick Wall

Crash Barrier

Steps

Stairs

Back of Shops

Church Building

Drain

Drainage Channel

Brick Paving Layby

Concrete Wall

Stone Wall

Bushes

Grass

Grass Playing Field

Flats

Locked Compound

Gas

Bins

Tactile Paving

Slab Paving

Sign

180MM UPSTAND KASSEL KERBS

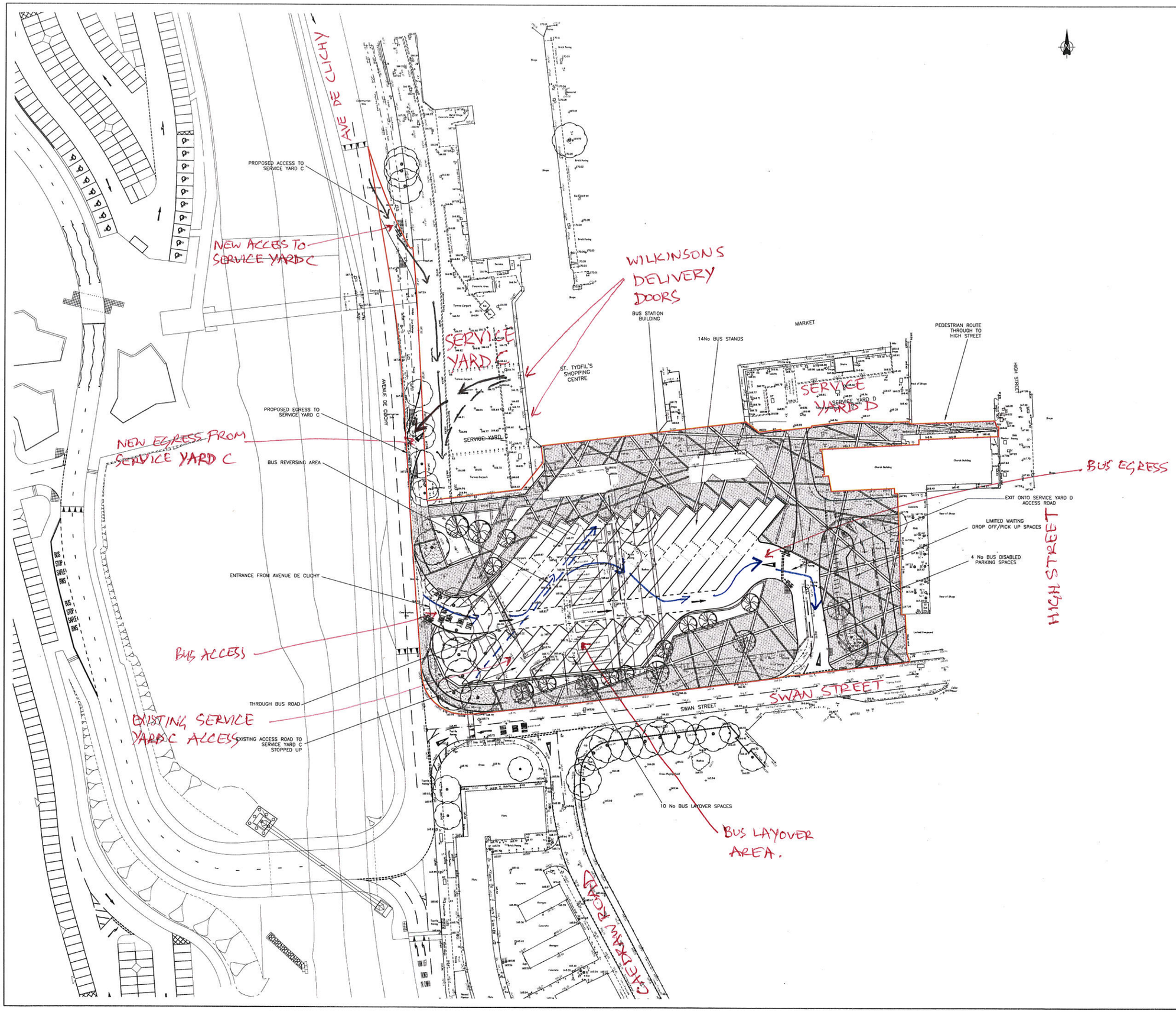
25MM CHAMFER KERB

0MM FLUSH

125MM UPSTAND

GENERAL ARRANGEMENT

DRG. No.	CS/74270/PA/103	REVISION REF.	A



ISSUE	AMENDMENTS	DRAWN	CHECKED	DATE
A	BOUNDARY AT SERVICE YARD D REVISED.	MJ	IP	NOV 15

CLIENT

MERTHYR TYDFIL
County Borough Council
Cyngor Bwrdeistref Sirol
MERTHYR TUDFUL

PROJECT

MERTHYR BUS STATION

TITLE

PROPOSED BUS STATION
GENERAL ARRANGEMENT

PURPOSE

PLANNING APPLICATION

CAPITA
Property and Infrastructure
St Davids House, Pascal Close, St Mellons, Cardiff, CF3 0LW
T: 02920 803500 w: www.capita.co.uk/infrastructure
Capita Property and Infrastructure Ltd.

DRAWN	DATE	SCALE
M JONES	JUNE 2015	1:500@A1
CHECKED	DATE	PROJECT No.
I. PRITCHARD	JUNE 2015	CS/74270
DRG. No. CS/74270/PA/103		REVISION REF. A

FILE: P:\Schemes_CS\cs0742xx\cs074270\CAD\Planning\103A Proposed Merthyr Bus Station_General Arrangement.dwg

MERTHYR BUS STATION DRAINAGE STRATEGY

Surface Water Sewer

The area within the Merthyr bus station planning boundary is 9801 sq.m. A Topographical survey carried out on the existing layout shows an area of 1010 sq.m as soft landscaping. The proposed layout of the new bus station includes 1107 sq.m of soft landscaping.

It is proposed to collect the surface water runoff from the site at 4 no. soakaways. These have been designed to the 1 in 100 year rainfall event. However, in the event of this rainfall being exceeded the surface water runoff from the bus station site is to pass through a Class 1 By-pass type oil separator before connecting into the existing drainage system and discharging to the river.

A CCTV survey carried out on the existing drainage network shows the main surface water outfall from the existing site discharging to the nearby river. It is proposed to connect the new site drainage to an existing manhole chamber located 50m upstream of this outfall on the northern side of Swan Street.

Four methods of surface water collection have been used on the development site.

- Slot drains are to be installed within the pedestrian areas having minimum visual impact on the hard landscaped areas. Where possible, these slot drains have been laid to tie in with the proposed paving layout.
- Grid drains with cast iron slotted covers are to be installed within the main bus station area.
- Linear kerb drainage is to be installed across the lower edge of the bus layover area.
- Trapped road gullies are to be used to replace existing road gullies where necessary.

The surface water sewer network has been designed using Micro Drainage design software. The network has been tested with a 15 minute winter 30 year return period rainfall event plus 30% increase for climate change. No surface flooding occurs with this worst case storm event.

The pipelines have generally been designed to have a minimum cover depth of 1.2m in the highway loading areas and 1.0m minimum cover depth in the pedestrian areas.

Manhole chambers are to be as the Highway Construction Detail drawings when located in highway loading areas and are to be non-entry polypropylene units when installed within the pedestrian areas.

The surface water runoff from the bus station site is to pass through a Class 1 By-pass type oil separator before connecting into the existing manhole chamber and discharging to the river.

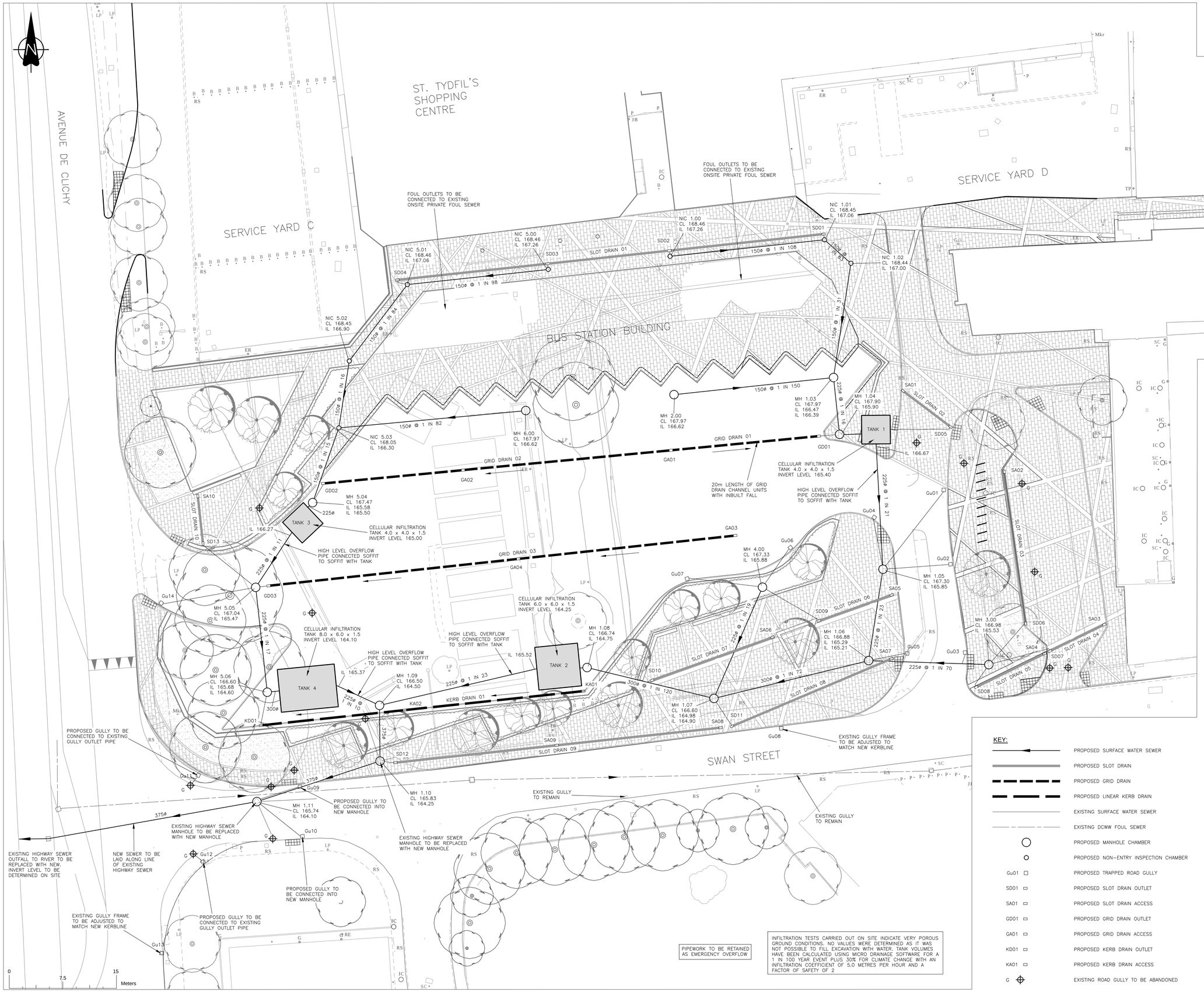
Drawing CS/74270/PD/106 shows the proposed drainage layout.

Drawing CS/74270/PD/107 shows the existing and proposed drainage areas.

Foul Sewer

The foul sewage discharge from the proposed bus station building is to connect to the private onsite foul sewerage network.

DRG. No.	CS/74270/PA/106	REVISION REF.	C



PIPEWORK TO BE RETAINED AS EMERGENCY OVERFLOW

INFILTRATION TESTS CARRIED OUT ON SITE INDICATE VERY POROUS GROUND CONDITIONS. NO VALUES WERE DETERMINED AS IT WAS NOT POSSIBLE TO FILL EXCAVATION WITH WATER. TANK VOLUMES HAVE BEEN CALCULATED USING MICRO DRAINAGE SOFTWARE FOR A 1 IN 100 YEAR EVENT PLUS 30% FOR CLIMATE CHANGE WITH AN INFILTRATION COEFFICIENT OF 5.0 METRES PER HOUR AND A FACTOR OF SAFETY OF 2

KEY:

- PROPOSED SURFACE WATER SEWER
- PROPOSED SLOT DRAIN
- PROPOSED GRID DRAIN
- PROPOSED LINEAR KERB DRAIN
- EXISTING SURFACE WATER SEWER
- EXISTING DCWW FOUL SEWER
- PROPOSED MANHOLE CHAMBER
- PROPOSED NON-ENTRY INSPECTION CHAMBER
- Gu01 PROPOSED TRAPPED ROAD GULLY
- SD01 PROPOSED SLOT DRAIN OUTLET
- SA01 PROPOSED SLOT DRAIN ACCESS
- GD01 PROPOSED GRID DRAIN OUTLET
- GA01 PROPOSED GRID DRAIN ACCESS
- KD01 PROPOSED KERB DRAIN OUTLET
- KA01 PROPOSED KERB DRAIN ACCESS
- G EXISTING ROAD GULLY TO BE ABANDONED

NOTES:

1. PROPOSED MANHOLE CHAMBERS TO BE TYPE 1 AND TYPE 3 AS HCD DRAWINGS No F3 AND F5
2. PROPOSED NON ENTRY INSPECTION CHAMBERS TO BE POLYPROPYLENE UNITS AS OSMA TEGRA 600 OR EQUIVALENT
3. PROPOSED GULLIES TO BE TRAPPED AS HCD DRAWING No F13
4. GULLY OUTLET PIPES AND KERB DRAIN/SLOT DRAIN OUTLET PIPES TO BE 150ø WITH TYPE Z BEDDING
5. ABANDONED GULLY TO HAVE FRAME REMOVED AND POT BACKFILLED WITH TYPE ST2 CONCRETE
6. LINEAR KERB DRAINS TO HAVE 210 BASE UNITS AND TOP COMPONENTS AS SHOWN ON KERBING DRAWING. OUTFALL UNITS TO BE TRAPPED WITH CAST IRON ACCESS COVERS, AS MARSHALLS MINI BEANY OR EQUIVALENT. ALL TO D400 LOADING
7. GRID DRAINS TO HAVE 150 WIDE BASE CHANNEL UNITS AND CAST IRON SLOTTED GRID TOP UNITS BOLTED IN PLACE WITH STAINLESS STEEL BOLTS. OUTFALL UNITS TO BE TRAPPED WITH CAST IRON ACCESS COVERS, AS MARSHALLS BIRCO 150, OR EQUIVALENT. ALL TO E600 LOADING
8. SLOT DRAINS TO BE AS GATIC FACADE SLOT CHANNELS WITH TRAPPED SILT BOX OUTLETS, OR EQUIVALENT. ALL TO C250 LOADING
9. TYPE Z BEDDING TO BE USED WHERE COVER TO PIPE IS LESS THAN 1.20m
10. CHAMBER ACCESS COVERS TO BE RECESSED IN HARD LANDSCAPE AREAS

ISSUE	AMENDMENTS	DRAWN	CHECKED	DATE
C	DIMENSIONS OF INFILTRATION TANKS AMENDED	RJA	IP	JAN 16
B	INFILTRATIONS TANKS ADDED. LAYOUT AMENDED. OIL SEPARATOR OMITTED	RJA	IP	JAN 16
A	BOUNDARY AT SERVICE YARD D REVISED.	MJ	IP	NOV 15

CLIENT

MERTHYR TYDFIL County Borough Council
Cyngor Bwrdeistref Sirol MERTHYR TUDFUL

PROJECT

MERTHYR BUS STATION

TITLE

PROPOSED BUS STATION DRAINAGE LAYOUT

PURPOSE

PLANNING APPLICATION

CAPITA
Property and Infrastructure
St Davids House, Pascal Close, St Mellons, Cardiff, CF3 0LW
T: 02920 803500 w: www.capita.co.uk/infrastructure
Capita Property and Infrastructure Ltd.

DRAWN	DATE	SCALE
R J ARTHUR	JULY 2015	1:250@A1
CHECKED	DATE	PROJECT No.
I. PRITCHARD	JULY 2015	CS/74270

DRG. No.	CS/74270/PA/106	REVISION REF.	C

FILE: P:\Schemes_CS\cs0742xx\cs074270\CAD\Planning\106C Proposed Merthyr Bus Station_Drainage Layout.dwg

PLAN SHOWING AREAS OF EXISTING SOFT LANDSCAPING

PLAN SHOWING AREAS OF PROPOSED SOFT LANDSCAPING

ISSUE	AMENDMENTS	DRAWN	CHECKED	DATE
B	BOUNDARY AT SERVICE YARD D REVISED.	MJ	IP	NOV 15
A	TEXT HEIGHT INCREASED FOR CLARITY.	MAJ	IP	SEPT 15

CLIENT

MERTHYR TYDFIL
County Borough Council
Cyngor Bwrdeistref Sirol
MERTHYR TUDFUL

PROJECT

MERTHYR BUS STATION

TITLE

PROPOSED BUS STATION
DRAINAGE AREAS

PURPOSE

PLANNING APPLICATION

CAPITA
Property and Infrastructure
St Davids House, Pascal Close, St Mellons, Cardiff, CF3 0LW
T: 02920 803500 w: www.capita.co.uk/infrastructure
Capita Property and Infrastructure Ltd.

DRAWN	R J ARTHUR	DATE	AUGUST 2015
CHECKED	I. PRITCHARD	DATE	JULY 2015
SCALE	N T S	PROJECT No.	CS/74270
DRG. No.	CS/74270/PA/107	REVISION REF.	B

FILE: P:\Schemes_CS\cs0742xx\cs074270\CAD\Planning\107B Proposed Merthyr Bus Station_Drainage Areas.dwg

Appendix C NRW Correspondence

Cyfoeth Naturiol Cymru
Natural Resources Wales

Ein cyf/Our ref: SE/2015/118739/01-LO1
Eich cyf/Your ref: Merthyr Bus Station

Rivers House,
St Mellon Business Park,
Fortran Road,
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CF3 0EY

Ebost/Email:
Stewart.Rowden@naturalresources wales.gov.uk
Ffon/Phone: 03000 653355

Mr H.Roberts
Development Control
Merthyr County Borough Council
Unit 5 Triangle Business Park
Pentrebach
MERTHYR TYDFIL
CF48 4TQ

Dyddiad/Date: 27 February 2015

Dear Mr Roberts

TOWN AND COUNTRY PLANNING ACT 1990;
REGULATION 5 OF THE TOWN AND COUNTRY PLANNING (ENVIRONMENTAL IMPACT ASSESSMENT) REGULATIONS 2011
REQUEST FOR A SCREENING OPINION FOR RELOCATION OF MERTHYR BUS STATION TO SWAN STREET

Thank you for consulting Cyfoeth Naturiol Cymru / Natural Resources Wales about the above proposal on 12th February 2015.

From the information provided by the applicant, it appears that the proposal is a form of development described in Schedule 2(10(b)) of the *Town and Country Planning (Environmental Impact Assessment) Regulations 2011*.

Although there may be environmental risks from the proposed development, we do not consider that the development is likely to have significant environmental impacts requiring a formal EIA.

Notwithstanding the above, we consider that there are matters relating to flood risk, land contamination, Protected species, and Historic Landscapes which will need to be considered in any future planning application.

Flood risk

The site is located within Zone C2, as defined by the Development Advice Map (DAM) referred to in Technical Advice Note 15: Development and Flood Risk (TAN15) (July 2004). As stated in Section 2.2.3.6 the EIA scoping report, the NRW

Flood Map information indicates the site lies within the 1% (1 in 100 year) and 0.1% (1 in 1000 year) annual probability fluvial flood outlines of the River Taff.

A flood consequences assessment (FCA) should be undertaken for the development to ensure that all parties are aware of the risks to, and from, the development, and ensure that if practicable, appropriate controls can be incorporated in a planning permission to manage the risks and consequences of flooding.

Please find attached a document intended to help with the preparation of the FCA. It provides advice on the scope of the FCA, based on the information available to us. This document should be completed and sent to us with any draft or completed FCA our advice is sought on, as it will improve the effectiveness of our response.

Please note that a submission in line with our advice will enable a better understanding of the risks and consequences of flooding, but will not necessarily mean the risks and consequences are demonstrated as being managed acceptably in line with TAN15. We reserve the right to request further information in future if it is needed to establish the risks and consequences of flooding.

Should you have any queries in relation to our advice on the scope of the FCA, please contact Chris Nutt (Christopher.nutt@naturalresourceswales.gov.uk / 0300 0653 106) or contact me via email or letter.

Land Contamination

Due to the previous use of the site, we would expect any planning application to include an assessment of the site for soil and groundwater contamination.

We recommend that a Preliminary Source Survey is carried out, as advised by Capita in their Environmental Impacts Assessment Screening report (February 2015).

Landscape

The proposed site is located within an area listed in the *Register of Landscape of Historic Interest in Wales*: HLW(MGL)2 Merthyr Tydfil Landscape of Outstanding Historic Interest

We therefore recommend an Assessment of the Significance of the Impact of Development on Historic Landscape (ASIDOHL2) is carried out.

Ecological Assessment

A site assessment should be carried out by a suitably qualified ecologist to determine any site specific constraints which may need to be considered as part of

any planning application. We recommend that this assessment follows CIEEM guidelines.

This assessment should be informed by a desk study (including a data query to the Local Record Centre) and then followed by a walkover appraisal to identify habitat and protected species which are present, or likely to be, and identify the need for any further surveys.

The assessment must take into account all aspects of a development.

Biodiversity

Please note that we have not considered possible effects of the scheme on all local or regional biodiversity interests. Therefore, you should not rule out the possibility of adverse effects on such interests, and would remind you of your Authority's general duty to have regard to conserving biodiversity, as set out in section 40 of the Natural Environment and Rural Communities (NERC) Act (2006). We recommend that you speak to your Authority's Ecologist in this regard.

Yn gywir / Yours faithfully

Stewart Rowden

S. Rowden

Stewart Rowden
Development Planning Officer

Cyfoeth Naturiol Cymru
Natural Resources Wales

CHECKLIST : FULL Flood Consequence Assessment (FCA)

Information and action for the enquirer (applicant/ consultant/ agent)

This checklist is intended to help you prepare your FCA. It documents our advice to you on the scope of your FCA.

Please complete and send this checklist to us with any draft or completed FCA you wish to receive our advice on, as it will help us be as effective as we can be in responding to you.

Any omission may delay our response or result in your FCA not demonstrating that the risk and consequences of flooding can be managed.

If this checklist is being used without having received our scoping advice, please tick here ☐

Please note that a comprehensive submission will enable a better understanding but will not necessarily mean the risks and consequences of flooding could be manageable in line with TAN15.

We reserve the right to request further information in future if it is needed to establish the risk and consequences of flooding.

For internal use

Initial enquiry	
Date	
Method (e.g. phone)	
Contact name	
Contact address	
Contact email address	
Telephone number	
Site address	Merthyr Bus Station
OS grid reference/NGR	SO0485005951
Development proposal	New bus station development (existing buildings & car parks to be demolished)
LPA	Merthyr Tydfil CBC
Other/notes to help scoping	Ref: SE/2015/118739

Full FCA checklist

Full FCA elements

This checklist for a full FCA is based on the technical requirements for assessing flooding consequences in section A1.17 of TAN15. **They are summarised below, but you should also refer to the full descriptions in TAN15.**

Hydraulic modelling may need to be carried out as part of your submission. *Natural Resources Wales does not currently have specific guidance on its website with respect to modelling. In the interim we recommend you refer to the modelling best practice guidance available on the Environment Agency's website at:* http://intranet.ea.gov/policies/environmentalwork/29629.aspx.

We take a risk based approach to reviewing any modelling work.

Cross ref. to A1.17 of TAN15	Element description	For use by Natural Resources Wales only. Scoping advice: evidence needed? Yes/No (and why)	For use by enquirer (applicant/ consultant/ agent) If no evidence included, why?	Notes
1	Location plan showing all sources of flooding	Yes –fluvial risk from the River Taff, possible fluvial risk from the Nant Morlais		
2	Levels survey of existing and proposed development to Ordnance Datum (Newlyn)	Yes – Existing ground/floor levels, proposed site and finished floor levels.		
3	Standard and condition of flood alleviation measures already in place, and an assessment of the performance of the defences under flooding conditions	n/a		
4	Access/evacuation plan	Yes – assessment of flood risk on access/egress routes required		
5	Assessment of potential flood sources (rivers, tidal, coastal, groundwater, surface water, or combination, etc)	Yes –fluvial, possible risk of surface water flooding		
6	A plan of the site showing any existing information on extent and depth of flood events or on flood predictions	Yes – predicted flood levels and any historic information for the site.		

7	A plan and description of any structures which may influence local hydraulics	Yes – Plan and description of the bridges on the Taff adjacent to the site. To include an assessment of blockage at these structures and the potential impact on the site.		
8	Assessment of probability and trends of flooding (extent, depths, routes, etc)	Yes		
9	Cross-sections of the proposed development relative to the source of flooding	Yes - An indicative section across the watercourse and site showing existing and proposed ground levels.		
12	Volume of water displaced and runoff from the site following development	Yes – if significant changes to building footprint and hardstanding		
13	Assessment of impact of any displaced water elsewhere	Yes (as above)		
15	Assessment of the impacts of climate change for the design life of proposed development	Yes – 1% (1 in 100 year) fluvial flood scenario to include allowance for climate change (+20% flows).		
16	Assessment of residual risks after construction of defences (e.g. maintenance)	n/a		
17	Clear and comprehensive summary	Yes		
	Hydraulic model and modelling report - **If Natural Resources Wales hydraulic model used, please submit model control sheet.** **Please ensure all material has been submitted (to avoid delays in obtaining information) and indicate how the model has been submitted e.g. CD.**	The best available data for this area is the 2013 1D/2D model for the Gyratory Scheme held by Capita/Merthyr Tydfil CBC and we recommend this model is used to inform the FCA.		
	Additional notes			

Does your FCA satisfy the following acceptability criteria in TAN15?

Appendix 1 Paragraph A1.12, A1.14 and A1.15

Have you ensured.....	Note space for use by enquirer (applicant/ consultant/ agent)
Flood defences must be shown by the developer to be structurally adequate, particularly under extreme overtopping conditions (i.e. that flood with a probability of occurrence of 0.1%)	
The cost of future maintenance for all new/approved flood mitigation measures, including defences, must be accepted by the developer and agreed with Natural Resources Wales	
The developer must ensure that future occupiers of the development are aware of the flooding risks and consequences	
Effective flood warnings are provided at the site	
Escape/evacuation routes are shown by the developer to be operational under all conditions	
Flood emergency plans and procedures produced by the developer must be in place	
The development is designed by the developer to allow the occupier the facility for rapid movement of goods/possessions to areas away from the floodwaters	
Development is designed to minimise structural damage during a flooding event and is flood proofed to enable it to be returned to its prime use quickly in the aftermath of the flood	
No flooding elsewhere	
Development is designed to be flood free during the indicative threshold frequency for the type of development	
Development is assessed against the indicative tolerable conditions under extreme flooding conditions	

Cyfoeth Naturiol Cymru
Natural Resources Wales

Ein cyf/Our ref: CAS-15863-Y4D4

Eich cyf/Your ref: P/16/0048

Rivers House, St Mellons Business Park, St Mellons, Cardiff, CF3 0EY

Ebost/Email:
andrew.hurst@naturalresourceswales.gov.uk

Ffôn/Phone: 03000 653074

Huw Roberts
Merthyr Tydfil County Borough Council
Unit 5 Triangle Business Park
Pentrebach
Merthyr Tydfil
Cf48 4TQ

17 March 2016

Annwyl Mr Roberts/Dear Mr Roberts

CONSTRUCTION OF A NEW BUS STATION AND PUBLIC REALM IMPROVEMENTS THROUGH THE PROVISION OF HARD AND SOFT LANDSCAPING AND ASSOCIATED WORKS AT LAND NORTH OF SWAN STREET (FORMER POLICE STATION AND HOLLIES HEALTH CENTRE), MERTHYR TYDFIL

Thank you for consulting Cyfoeth Naturiol Cymru/Natural Resources Wales about the above, which was received on 22 February 2016.

We OBJECT to the application as submitted as it has not been demonstrated that the risks and consequences of flooding can be acceptably managed in line with the criteria of Technical Advice Note 15: Development and Flood Risk (TAN15)

Reasons

The proposal as submitted increases the extent and depth of flooding within St Tydfil's Shopping Centre and the adjacent service yard (and potentially to other adjacent properties) by restricting overland flood flow routes and reducing existing floodplain storage. Therefore we advise the development is not in line with the requirements of A1.12 of TAN15 which states that a site should only be considered if there is 'no flooding elsewhere' as a result of the proposal.

The flood consequences assessment (FCA) prepared by Capita and dated September 2015 has not properly assessed the impacts on flood risk elsewhere, including implications on floodplain storage. We have reviewed the hydraulic modelling which informs the FCA to provide you with this advice. The hydraulic modelling shows flooding extents and depths are increased as a result of the development.

In the first instance the FCA should include an assessment of these impacts. The FCA should then propose how the scheme can be designed in accordance with TAN15, particularly A1.12 and 'no flooding elsewhere' criterion. If the FCA cannot provide mitigation measures to satisfy TAN15 requirements, it must clearly identity and explain the increase in flood risk off site; any benefits in flood risk and provide detail on the changes in depth, velocity, rate of rise and flood extent and the type of property/infrastructure affected.

We can then provide you with a complete understanding of the risks and consequences of flooding prior to your determination of this application.

Without this further work the application as submitted does not meet the technical requirements of TAN15.

Further Advice
The application site lies within Zone C2, as defined by the Development Advice Map (DAM) referred to under TAN15. Our Flood Map information, which is updated on a quarterly basis, confirms the site to be within the 1% (1 in 100 year) and 0.1% (1 in 1000 year) annual probability fluvial flood outlines of the River Taff, which is a designated main river, and the Nant Morlais, an Ordinary watercourse.

The planning application proposes the construction of a bus station (less vulnerable development) on land previously occupied by a police station and health clinic within a flood risk area. Section 6 of TAN15 requires your Authority to determine whether the development at this location is justified. We refer you to TAN15 for these considerations. I refer you in particular to the justification tests at section 6.2. As part of this justification, the applicant should undertake and submit a Flood Consequence Assessment (FCA) prior to determination of the application that meets the criteria set out in TAN15.

If, contrary to TAN15, your Authority is minded to grant permission, we should be informed of all matters that influence this decision, prior to granting permission, allowing sufficient time for further representations to be made. We are required to report to the Welsh Government those instances in which recommendations for refusal on grounds of flood risk, have not been accepted by Local Planning Authorities. Therefore, if planning permission is granted contrary to our recommendation, we would be grateful if you would provide us with a copy of the Committee report, relevant Committee minutes and the decision notice.

We have provided further detailed comments to aid the consultant in Annex 1 of this letter. We recommend that the consultant contact us direct to discuss our concerns. They should contact Chris Nutt in our Flood Risk Analysis team through Christopher.Nutt@cyfoethnaturiolcymru.gov.uk .

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Notwithstanding our objection on flood risk, we have provided you with advice regarding protected species, land contamination, drainage and landscape.

European Protected Species – Bats
We have reviewed the following survey report submitted in support of this application

- Arial Survey of Bat Boxes at the former Hollies Heatlh Centre, Swan Street, Merthyr Tydfil, dated November 2015, produced by Capita, Project No: GC/002273

We note the bat boxes are present as mitigation for the loss of a common pipistrelle roost in the former Hollies Health Centre, which was previously demolished under bat licence 46939:OTH:EPS:2013, and welcome the recommendations made in section 4.2 of the above report.

Bats and their breeding sites and resting places are protected under the Conservation of Habitats and Species Regulations 2010 (as amended). Where bats are present and a development proposal is likely to contravene the legal protection they are afforded, the development may only proceed under licence issued by Natural Resources Wales, having satisfied the three requirements set out in the legislation. A licence may only be authorised if:

i. The development works to be authorised are for the purpose of preserving public health or safety, or for other imperative reasons of overriding public interest, including those of a social or economic nature and beneficial consequences of primary importance for the environment.

ii. There is no satisfactory alternative and

iii. The action authorised will not be detrimental to the maintenance of the population of the species concerned at a favourable conservation status in its natural range.

Paragraph 6.3.7 of Technical Advice Note 5: Nature Conservation and Planning (TAN5) states that your Authority should not grant planning permission without having satisfied itself that the proposed development either would not impact adversely on any bats on the site or that, in its opinion, all three conditions for the eventual grant of a licence are likely to be satisfied.

On the basis of the information provided, we are of the view that the proposed development is likely to give rise to the need for a licence application. However, we do not consider that the development is likely to be detrimental to the maintenance of the population of the species concerned at a favourable conservation status in its natural range.

<u>Conditions</u>
Should your authority be minded to grant planning permission, we advise that suitable conditions are attached to the permission to address the following:

- A suitable roosting resource is retained or provided for the bats, appropriate to the species and its use of the structure; and

- Inclusion of a planning condition on any planning permission that prevents the commencement of development works until your authority has been provided with a licence that has been issued to the applicant by Natural Resources Wales pursuant to Regulation 53 of the Conservation of Habitats and Species Regulations (2010) authorizing the specified activity/development to ahead, or Natural Resources Wales has informed the applicant in writing that such a licence is not required

Land potentially affected by contamination
Natural Resources Wales previously commented on an EIA scoping report (Merthyr Bus Station Relocation, Environmental impact Assessment Screening, February 2015, Project No: CS/074270, Doc Ref: CS/074270/EIA01, prepared by Capita, dated February 2015), our reference SE/2015/118739/01, response dated 27 February 2015.

Within the report it was stated that a Preliminary Sources Study for the site was currently underway due to the long industrial history of the surrounding area and that there may be some level of contamination. This survey has not been submitted in support of the application. However we are satisfied that there are generic remedial options available to deal with the risks to controlled waters posed by contamination at this site, which can be controlled via condition. Further details will be required in order to ensure that risks are appropriately addressed prior to development commencing.

In line with the advice given in Planning Policy for Wales we understand that the authority must decide whether to obtain such information prior to determining the application or as a condition of the permission. Should the LPA decide to obtain the necessary information under condition we would request that the following conditions are applied to any permission granted.

Condition
Prior to the commencement of the development approved by this planning permission (or such other date or stage in the development as may be agreed in writing with the Local Planning Authority), the following components of a scheme to deal with the risks associated with contamination of the site shall each be submitted to and approved, in writing, by the local planning authority:

1. A preliminary risk assessment which has identified;
- 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 a detailed assessment of the risk to all receptors that may be affected, including those off site.

3. The results of the site investigation and detailed risk assessment referred to in (2) and,

based on these, an options appraisal and remediation strategy giving full details of the remediation measures required and how they are to be undertaken.

4. A verification plan providing details of the data that will be collected in order to demonstrate that the works set out in the remediation strategy in (3) are complete and identifying any requirements for longer-term monitoring of pollutant linkages, maintenance and arrangements for contingency action.

Any changes to these components require the express consent of the local planning authority. The scheme shall be implemented as approved.

Reason
Natural Resources Wales considers that the controlled waters at this site are of high environmental sensitivity and contamination is known/strongly suspected at the site from the previous use of the site.

Condition
Prior to occupation of any part of the permitted development, a verification report demonstrating completion of the works set out in the approved remediation strategy and the effectiveness of the remediation shall be submitted to and approved, in writing, by the local planning authority. The report shall include results of sampling and monitoring carried out in accordance with the approved verification plan to demonstrate that the site remediation criteria have been met. It shall also include any plan (a “long-term monitoring and maintenance plan”) for longer-term monitoring of pollutant linkages, maintenance and arrangements for contingency action, as identified in the verification plan, and for the reporting of this to the local planning authority. The long-term monitoring and maintenance plan shall be implemented as approved.

Reason
To demonstrate that the remediation criteria relating to controlled waters have been met and (if necessary) to secure longer-term monitoring of groundwater quality. This will ensure that there are no longer remaining unacceptable risks to controlled waters following remediation of the site.

Condition
Reports on monitoring, maintenance and any contingency action carried out in accordance with a long-term monitoring and maintenance plan shall be submitted to the local planning authority as set out in that plan. On completion of the monitoring programme a final report demonstrating that all long- term site remediation criteria have been met and documenting the decision to cease monitoring shall be submitted to and approved in writing by the local planning authority.

Reason
To ensure that longer term remediation criteria relating to controlled waters have been met. This will ensure that there are no longer remaining unacceptable risks to controlled waters following remediation of the site.

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, a remediation strategy detailing how this unsuspected contamination shall be dealt with. The remediation strategy shall be implemented as approved.

Reason
Given the size/complexity of the site it is considered possible that there may be unidentified areas of contamination at the site that could pose a risk to controlled waters if they are not remediated.

Informative/advice to applicant
Natural Resources 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 our Guiding principles for land contamination for the type of information required 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.

Refer to our website at www.naturalresourceswales.gov.uk for more information.

Landscape
The proposed development site is within the Merthyr Tydfil Landscape of Outstanding Historic Interest, which is included on the Register of Landscapes of Historic Interest in Wales.

We do not consider that the proposals would result in a significant effect on the historic landscape. We do not consider that an ASIDOHL2 assessment is required. However the Glamorgan Gwent Archaeological Trust should be consulted with regard to potential archaeological impacts.

The site has already been cleared of former buildings and a modern design which takes references from the history of the area is proposed. The creation of areas of public realm linking the new bus station to the listed chapel, Conservation Area and High Street should be beneficial. We recommend that further consideration is given to comments by DCfW regarding the public realm, including simplification of the design of the floorscape and use of warmer materials, definition of the entrances and improvements to the route between the High St and the river.

Further advice to applicant - Drainage

We note that you do not intend to add a new outfall to the river but intend to use existing outfalls (e-mail from Abigail Morgan, Capita to Stewart Rowden, Natural Resources Wales, 13th April 2015). If this is still the case then we advise the following.

Any drainage from the site using existing outfalls to the River Taff will require a Class 1 type oil interceptor which would be required to service the vehicle parking and maintenance areas. A discharge permit would not be required for clean surface drainage should the appropriate interceptor be in place.

Effluent from vehicle cleaning areas must be discharged to the foul sewer. You will be required to get the appropriate permissions from Dwr Cymru Welsh Water (DCWW) for this. We advise you to contact DCWW in this regard.

Any refueling areas should be isolated from the surface water drainage system to prevent pollution incidents via spillage.

We trust our advice is clear. If you have any queries, please do not hesitate to get in touch.

Yn gywir/Yours faithfully

Andrew Hurst
Development Planning Assistant
Cyfoeth Naturiol Cymru/Natural Resources Wales
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Annex 1 – NRW Detailed Flood Risk Advice

The FCA (referenced CS/074270, September 2015) submitted in support of the application indicates:

- The police station and health centre on site have now been demolished. Model runs have therefore been undertaken for various flood events in the following scenarios; baseline (pre-demolition), existing (current situation) and proposed (Section 3.1).

- There are two proposed site access options, including either access or egress from Avenue de Clichy and Swan Street (Section 3.1).

- Blockage scenarios on the Nant Morlais culvert north of the site have been undertaken (67% and 100% blockage during the 1 in 100 year +climate change event) to confirm residual risk due to blockage by debris (Section 3.3).

- During the baseline scenario, flooding up to 0.75m depth occurs in the west of the site from the River Taff (overtopping Avenue de Clichy upstream of the weir) during a 1 in 50 year event. In a 1 in 100 year (including climate change) event, flooding from the Nant Morlais also occurs, joining the flow route from the River Taff in the west of the site, with depths up to 1m predicted. During the 1 in 1000 year event, the Nant Morlais overtops further upstream, leading to flood flow routes along High Street into the east of the site and a greater extent across the site. Peak flood depths and velocities on site during this event are given as ‘over 1.25m’ and 3m/s, respectively (Section 5.2).

- During the proposed scenario, the site is shown to be flood-free during a 1 in 100 (including climate change) event. During the 1 in 1000 year event, shallow flooding of less than 0.01m is shown across the site. Peak depths of 0.5m are predicted at the site access/egress routes from Swan Street and Avenue de Clichy, reducing to 0.1m in the east of Swan Street (Section 5.4).

- The FCA indicates that ground levels within the site are to be raised as part of the development. As a result, the flow route adjacent to Avenue de Clichy is restricted and flood depths are reduced in Cae-Draw downstream of the site, with a corresponding increase of up to 0.3m (1 in 1000 year scenario) in the service yard and within the St Tydfil Shopping centre to the north of the site. It is considered that the proposed development does not have a significant impact on flooding to third parties (Section 5.5).

- The FCA also states that ‘a difference in flood depth of +/- 25mm is considered at the limit of the model tolerance and considered negligible for the purposes of the FCA’ (Section 5.5.2).

- Blockage of the Nant Morlais culvert results in a minimal increase in the depths and velocities of flooding on site (0.05m and 0.06m/s) during the 1 in 100 year (inc. climate change) scenario (Section 5.5.11).

- Soft landscaping within the site is proposed to be broadly similar in area to the previous permeable surfacing, therefore surface water attenuation is not proposed (Section 6.1).

With reference to the above, we have the following comments:

- The FCA report does not include any information on the proposed site ground levels or the floor level of the bus station. The submitted Proposed Building Elevations plan with the planning application (Capita, CS/074270, 28/09/15) and information within the supplied hydraulic model indicates that current ground levels are below the level of the land to the north and Avenue de Clichy and will be raised across the majority of the site, with the maximum changes in the northwest area (currently indicated to be 165.9mAOD, to be raised by over 2 metres to 168.3mAOD). The new bus station is indicated to be set at 168.48mAOD. The changes to the existing and proposed ground/floor levels and the reduction in flood storage should be clarified within the FCA.

- Based on the proposed raising of the site, the bus station building and surrounding open areas are shown to be compliant with the requirements of Tables A1.14 and A1.15 in TAN15. The FCA indicates that flooding on the access to the site from Avenue de Clichy may be up 0.5m deep and over 2m/s velocity. Whilst in exceedance of the guideline values in Table A1.15, reduced flood depths and velocities on the access from Swan Street indicates a safer access/egress route from the site.

- We disagree with the statement ‘a difference in flood depth of +/- 25mm is considered at the limit of the model tolerance’. NRW guidance (attached) is that any detriment should be shown as less than 5mm. The FCA has not demonstrated that changes in depth to third parties meet these criteria and we recommend that the depth comparison figures in Appendix A are revised to clearly show the effects of the development.

- Given that ground levels within the site are to be raised, the existing flood flow route adjacent to Avenue de Clichy through the shopping centre service yard, western site area and over Swan Street is significantly reduced, resulting in ponding of floodwater to the north of the site increased flood depths and extents within the St Tydfil Shopping Centre (a maximum of 0.3m increase in the 1 in 1000 year scenario) and potentially increasing the onset of flooding. The development is not shown to be compliant with Section A1.12 of TAN15. It is not clear from the FCA what the volumetric reduction in floodplain storage is and if the change in water levels within the river increases risk downstream of Merthyr. Due to the changes in ground level, in-river levels are increased by up to 0.1m in the 1 in 100 year (inc climate change) event and locally over 0.1m in the 1 in 1000 year event. It should be noted that due to restrictions with ground levels on Avenue de Clichy, the soffit of the new road bridge is set at the 1 in 100 (including climate change) level. The effect of any increase in water levels on the bridge structure and the risk of debris accumulation should be considered within the FCA.

- The development is potentially beneficial to the properties immediately downstream of the site (Cae-draw) as the overland flood flows into this area have been

reduced and flood depths reduced by over 0.1m in the 1 in 1000 year scenario, it is unclear if any properties have been removed from the flood extents.

- It is noted that the FCA provides a conservative approach to flood risk as the model uses coincident flood events on the River Taff and Nant Morlais (i.e. combined 1 in 1000 year events), which are unlikely to occur in reality given the differences in catchment area and watercourse size. It is unclear from the model whether the upstream flood storage area on the Nant Morlais at Pant (north of the Heads of Valleys Road) has been taken into account when deriving the hydrology. If not, this could potentially reduce flood risk and extents from this source, although given the reduced risk to the site from the Nant Morlais compared to the River Taff the effect on the site may be minimal.

Ends

Minutes

6 April 2016

Merthyr Bus Station - Flood Consequences Assessment

St Davids House, St Mellons
Monday 4 April 2016 at 10:00

Present Christopher Nutt - Natural Resources Wales (CN), Ian Pritchard - Capita (IP)

Apologies Mohammed Mamun - Capita

1.	Minutes of last meeting held on <Last meeting date>	Action
2.	CN thought using 1 in 1000 return period for both the River Taff and the Nant Morlais at the same time was both onerous and unlikely. Asked if flood storage at head of Nant Morlais had been modelled. NRW may have storage information (also the Nant Morlais culvert beneath High Street).	CAP
3.	CN asked for ground levels for the site to be included. Report required clarification on ground level changes and effect on 3rd parties.	CAP
4.	IP said the buildings at ground level backing onto Service Yard C consisted of delivery and maybe storage areas. CN asked for photos and explanation to be included in report.	CAP
5.	Flood depths – CN asked that the 50 year flood at baseline and proposed be reported to give indication of onset of flooding. Also required current flood depth changes (on Figure A17 for example) for -0.025 to +0.025m to be split into: -0.025 to -0.005, -0.005 to +0.005 and +0.005 to +0.025m. This is to reflect the latest tolerances.	CAP
6.	Because the retaining wall at the south of the service yard is redirecting flood water back into the river channel, water now backs up from the new bridge which is set up at minimum 1 in 100 year + climate change. Need to report on what happens with debris as freeboard only exists over part of the structure.	CAP
7.	IP noted that pipes through the retaining wall were not feasible due to graded landscaping behind. CN stated the report should note that this has been considered and discounted.	CAP

8.	Noted that there are benefits to Caedraw Road however, this increases water level in channel. How far south is the model boundary and what is the effect downstream of the new bridge? This needs to be included in the report.	CAP
9.	The routing of vehicles under the latest proposals needs to be clarified i.e. in off Avenue de Clichy and out onto the service yard road. The report also needs to outline the current surface water drainage proposals for the site.	CAP

Ian Pritchard
Principal Engineer

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CAPITA

Merthyr Bus Station: Updates to Flood Consequences Assessment

Modelling Approach

The following document presents the modelling approaches proposed to alleviate concerns by Natural Resources Wales (NRW) over the flood risk resulting from a proposed new bus station for Merthyr Tydfil.

Previous Model

A model was previously built for the original Flood Consequences Assessment (FCA) for Merthyr Bus Station. It is comprised of short reaches of the River Taff and the Nant Morlais, a tributary of the River Taff that joins just upstream of the proposed bus station.

Concern 1 – Flood Storage Area (FSA) at Pant not accounted for

NRW suggested that an FSA upstream of the model extent on the Nant Morlais at Pant may not have been taken into account when deriving the hydrological inputs for the study. This may provide some alleviation to the predicted risk of flooding at the site.

Further examination of the Nant Morlais upstream of the model extent following the comments shows that the majority of the watercourse is culverted between the FSA at Pant and the upstream extent of the model. In one location within the existing model a culvert at the upstream of the Nant Morlais cannot convey the 1000-year flow and this causes an extensive flow route is predicted to open up along High Street. It is therefore possible that flows on the Nant Morlais are being overestimated by the model.

Proposed Modelling Approach:

- A 1D only ISIS model will be developed of the stretch of the Nant Morlais upstream of the model where survey data is available. This will cover the FSA at Pant down to just North of Rocky Road where the watercourse is joined by two tributaries.
- The ISIS model will be run and should represent any attenuation of flows by the FSA and culvert system modelled.
- The flow that reaches the bottom of the ISIS model will added to any intervening area flows between the termination of the 1D only model and top of the existing model. These will be used as the Nant Morlais inflow for the updated model.

Concern 2 – Raising the elevation of the site causes an increase in flood extent and depth in the surrounding area.

NRW suggested that the proposed development would involve raising ground elevations by over 2m in the northwest of the site. This caused the flow route adjacent to Avenue de Clichy through the shopping centre service yard is blocked. This causes an increase in flood depths and extents within the St Tydfil shopping centre to the North of the site.

This may be due to the method of representing buildings within the 2D Domain of a fluvial model. Generally, buildings are represented only as an area of elevated hydraulic roughness and no building footprint is raised. This causes water to be conveyed less efficiently across the areas where buildings would be but does not represent a physical barrier to flow. For this reason it is possible that the flow route adjacent to Avenue de Clichy is being overestimated in the baseline modelling where the previously existing police station and health centre walls were not represented within the model.

Proposed Modelling Approach:

- Update the baseline model by raising the Northern wall of the previously existing police station and health centre. See photo for evidence of wall.
- This may cause a reduction in the predicted flow route adjacent to Avenue de Clichy with the baseline model and therefore reduce the predicted increases in flood extent and depth as a result of the development.

Figure 1: The Northern wall of the previously existing Hollies Health Centre

Figure 2: Google Street view Image showing Hollies Health Centre

Concern 3 – The proposed development causes an increase in in-channel water and it is not clear whether this will increase flood risk downstream of Merthyr Tydfill. The soffit of the new road bridge (Gyratory Bridge) is set at the 1 in 100 (including climate change) level. The effect of any increase in water levels on the bridge structure and the risk of debris accumulation should be considered within the FCA.

NRW suggested that there is an increase in in-channel water levels of up to 0.1m in the 100-year event and locally by over 0.1m in the 1000-year event. This may cause increases in flood risk downstream of the maximum extent of the model.

The existing model (Merthyr Bus Station model) terminates approximately 690m downstream of the new Gyratory Bridge. Changes in peak water level of River Taff at the downstream of the hydraulic model are by 0.018m (100yr), 0.004m (100yrCC) and 0.003m (1000yr). It is likely this will not cause a significant increase in flood risk downstream of the model extent. It is hoped that the changes to the model proposed in 'concern 2' should help to alleviate the changes in in-channel water level of River Taff as a result of the proposed development.

The calculations in Tables 1 – Table 3 show that the updated Merthyr Bus Station model, referred to in this model as the existing model shows a much increased freeboard (see Table 3) between the bridge soffit level and the peak water level of the 100-year + CC event from the River Taff Central Link model used to do the calculations for the new Gyratory Bridge. This is as the Merthyr Bus Station model explicitly models the Nant Morlais tributary of the River Taff and therefore the timing of the peak for the two watercourses is different. This causes the peak water level of River Taff in the Merthyr Bus Station model to be lower than the River Taff Central Link model at the Gyratory Bridge.

Proposed Modelling Approach:

- No updates to the model are proposed.

Table 1: Peak Flow (m^3/s) used in the model.

Model	Watercourse	Modelled flow (m^3/s) for % AEP event				
		50	**2**	**1**	**1+CC**	**0.1**
River Taff Central Link, 2012	River Taff	136.3	291.3	339.1	406.9	599.3
	Nant Morlais*	-	-	-	-	-
Merthyr Bus Station, 2015	River Taff	118.3	253.6	295.3	354.3	522.8
	Nant Morlais	12.0	27.1	32.0	38.4	57.1

**Note –The Nant Morlais has not been included in the River Taff Central Link, 2012 hydraulic model. The inflow from this watercourse enters the Taff upstream of Penry Street Bridge and is accounted for in the flow estimates used for the River Taff*.

Table 2: Model predicted Peak Level at the new Gyratory Bridge.

Model	Scenario	Modelled predicted Peak Level for % AEP event			
		1+CC		**0.1**	
		Water Level (mAOD)	Difference (m)	Water Level (mAOD)	Difference (m)
River Taff Central Link, 2012	Baseline	164.88	-	165.73	-
	Proposed	164.90	+0.02	166.36	+0.63
Merthyr Bus Station, 2015	Baseline	164.74	-	165.93	-
	Proposed	164.78	+0.04	166.33	+0.40

Table 3: Modelled Freeboard at the new Gyratory Bridge.

Model	Location	Soffit (mAOD)	Modelled predicted Peak Level for % AEP event			
			1+CC		0.1	
			Water Level (mAOD)	Freeboard (m)	Water Level (mAOD)	Freeboard (m)
River Taff Central Link, 2012	East	164.90	164.90	0.00	166.36	-1.46
	West	166.30	164.90	+1.40	166.36	-0.06
	Average	165.6	164.90	**+0.70**	166.36	**-0.76**
Merthyr Bus Station, 2015	East	164.90	164.78	+0.12	166.33	-1.43
	West	166.30	164.78	+1.52	166.33	-0.03
	Average	165.6	164.78	**+0.82**	166.33	**-0.73**

Mamun, Mohammed (Capita)

From: Nutt, Christopher [Christopher.Nutt@cyfoethnaturiolcymru.gov.uk]
Sent: 03 May 2016 10:06
To: Mamun, Mohammed (Capita)
Cc: Tarrant, David; Pritchard, Ian (Capita)
Subject: RE: Merthyr Bus Station 160404_04

Follow Up Flag: Follow up
Flag Status: Flagged

Categories: Red Category

Hi Mamun,

As discussed, I have no objection to the proposed model updates.

Many thanks,

Chris

Chris Nutt
Flood Risk Analysis/Dadansoddiad Risg Llifogydd
Natural Resources Wales/Cyfoeth Naturiol Cymru

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From: Mamun, Mohammed (Capita) [mailto:Mohammed.Mamun@capita.co.uk]
Sent: 29 April 2016 12:00
To: Nutt, Christopher <Christopher.Nutt@cyfoethnaturiolcymru.gov.uk>
Cc: Tarrant, David <David.Tarrant@cyfoethnaturiolcymru.gov.uk>; Pritchard, Ian (Capita) <Ian.Pritchard@capita.co.uk>
Subject: RE: Merthyr Bus Station 160404_04

HI Chris,

As discussed please find attached the proposed updates to the Merthyr Bus Station Model following the concern of NRW, I would appreciate your feedback ASAP.

If you require any further information of have any queries then please let me know.

Kind Regard,
Mamun

Mohammed Mamun M. Eng (Water Resources), MCIWEM
Senior Flood Risk Specialist

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From: Nutt, Christopher [mailto:Christopher.Nutt@cyfoethnaturiolcymru.gov.uk]
Sent: 13 April 2016 13:42
To: Pritchard, Ian (Capita)
Cc: Mamun, Mohammed (Capita)
Subject: RE: Merthyr Bus Station 160404_04

Hi Ian/Mamun,

No problem with the meeting notes.

If you would like to discuss the available information for the Nant Morlais culverts/storage areas, please contact Dave Tarrant in our mapping team (David.Tarrant@naturalresourceswales.gov.uk / 0300 0653137).

Any further queries, please get in touch.

Thanks,

Chris

From: Pritchard, Ian (Capita) [mailto:Ian.Pritchard@capita.co.uk]
Sent: 06 April 2016 13:45
To: Nutt, Christopher <Christopher.Nutt@cyfoethnaturiolcymru.gov.uk>
Cc: Mamun, Mohammed (Capita) <Mohammed.Mamun@capita.co.uk>
Subject: Merthyr Bus Station 160404_04

Hi Chris

Flood consequences assessment

Further to our meeting on Monday please find attached the meeting notes. I trust that they are an accurate representation of our discussions. I would be grateful if you could let me know if you are happy with them or let me have your comments.

I look forward to hearing from you.

Many thanks

Ian Pritchard
Principal Engineer, Highways

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Appendix D Hydrological Update

D.1 Introduction

The objective of the Merthyr Tydfil Bus Station FCA is to understand the existing flood risk to the site and to assess the impact of the proposed bus station at Merthyr Tydfil town centre on the flood depths, velocities and outlines in the area. Hydraulic modelling was undertaken to fulfil this objective.

A detailed 1D/2D ESTRY TUFLOW model has been used to assess the impact of fluvial flooding at the proposed development site.

A review of the existing hydrology for the River Taff hydraulic model was undertaken, which identified the requirement to update the hydrological analysis to include a hydrology inflow on Nant Morlais tributary. The inflows provided on the River Taff remain unchanged.

D.2 Review of Existing Hydrology Inflows

A review of the hydrology inflows supplied with the existing model has been carried out and the main points are summarised below.

- Gauging station 57015 was used as the donor catchment for the flow nodes on the River Taff and the Nant Morlais tributary, for data transfer for QMED and the enhanced single site pooling methodology. This gauge is considered a suitable donor for the nodes on the River Taff, as it is within the subject catchment with good quality data.

- Gauging station 58006 Melte at Pont Nedd Fechan was used for the ReFH parameter adjustment for the flow nodes on the River Taff. The gauge is located in the catchment adjacent to the Taff. The catchment area is smaller and FARL higher, URBEXT is lower (esp for MO_01), but otherwise catchment descriptors are similar. This site was used as a donor for ReFH as the flood event analysis data was available in the ReFH supplementary report and it was beyond the scope of the commission to carry out further analysis. This is considered a reasonable approach.

- Gauging station 57006 Rhondda at Trehafod was used for the ReFH parameter adjustment for the flow node on the Nant Morlais. The calibration values were available in the ReFH supplementary report and were used to improve the hydrograph parameters on the Nant Morlais flow node. The gauge is a similar match in terms of hydrological characteristics and this is therefore considered a suitable approach.

- The previous hydrology used the ReFH method for calculation of final peak flows and hydrograph shape adjusted using the relevant donor catchment.

- The critical duration for node TA_02 calculated using the FEH equation (7.25 hrs) was used for all flow calculations as this is the critical duration for the River Taff at the Merthyr Tydfil gauge, which is close to the site of interest.

- The inflows for the River Taff (nodes TA_01 and TA_02) are deemed appropriate for the current FCA. The final flows provided for the upstream extent of the River Taff (TA_02) and the downstream extent (TA_01), remain unchanged and have been included in peak flows summary table (Table D.1).

- The 2011 hydrology report included flow estimations for the Nant Morlais tributary (flow node MO_01) however this flow node was not used in the final hydraulic model.

- The donor stations used for the previous Nant Morlais calculations are not considered suitable for detailed assessment of the flow mechanisms of the tributary. As the tributary was not the focus of the previous hydraulic modelling study this was not considered to be an issue.

- The existing hydrology calculation record suggests an alternative donor for the Nant Morlais should be considered if the model is to be used for future studies in the area. The report suggests using 57006 Rhondda at Trehafod as the level or urbanisation is more representative of the subject catchment.

D.3 Updated Hydrology for Nant Morlais

The hydrological assessment carried out for the Nant Morlais tributary flow node (MA_01) was undertaken using the two standard FEH methods; the FEH statistical method and the Revitalised Flood Hydrograph (ReFH) method. Each method provides their own advantages and limitations so both methods were carried out to provide comparisons and to see which offered the best flow representation for the tributary. The key decisions used in the flow calculations and the final flows are discussed below.

D.3.1 Donor Gauging Station

Potential flow gauge donor sites with similar catchment descriptor values have been listed in the appended hydrology calculation spreadsheet. These include Hi-Flows gauges in the Rhondda, Dulais, Irfon, Yscir, Lwyd, Senni and Ewenny catchments (all within the South Wales area). However, many of these sites are not deemed suitably representative due to size, distance from MO_01 and catchment characteristics, in particular FARL.

Hi-Flows gauge 57006 Rhondda at Trehafod was considered the best available donor. The size of the catchment at Trehafod is 102.7km^2; this is considerably larger than the area of the Nant Morlais catchment (11.37km^2) and would generally be ruled out as a donor catchment based on catchment area. However, the gauge is geographically much closer to the Nant Morlais catchment than any of the other appropriate donors available and therefore has a more significant weighting adjustment to the QMED values. The catchment descriptors are very similar for all of the key characteristics. In particular, the FARL value for 57006 is 0.986 and therefore closer to the study catchment value of 0.946. The other potential donors had very high FARL values (often a FARL of 1) and therefore did not display the attenuation characteristics that would be experienced in the Nant Morlais catchment. Likewise the level of urbanisation is closer to the Nant Morlais urbanisation for the Trehafod catchment, while the other potential donors were very rural. In summary, the alternative donor catchments tended to only demonstrate similar values for some but not all of the key catchment characteristics and did not compare favourably to the use of the Trehafod gauge as a donor.

The Trehafod gauge also has a long record of good quality data and is suitable for QMED and pooling according to the National River Flow Archive.

D.3.2 FEH Statistical Method

A statistical pooling group was generated for the Nant Morlais catchment using WINFAP-FEH v3.0. 16 catchments were used to generate 491 years of pooling data. Seven sites were removed from the initial pooling group due to unsuitable catchment characteristics or pooling data reliability. Permeable adjustment was not necessary as all sites were over the SPRHOST permeability threshold. The resulting flood frequency curve and growth curve show a good fit to expected values.

D.3.3 ReFH Method

ReFH flows were generated using the Nant Morlais catchment characteristics adjusted to the hydrograph parameter values of the Trehafod donor catchment. Data transfer was carried out using parameter values for baseflow recession fitting (BL and BR), Tp and Cmax from the Flood Estimation Handbook Supplementary Report[5] for 57006 Rhondda at Trehafod.

D.3.4 Final Method

The proposed method is a hybrid method in which the statistical method is used for peak flow and is applied to the ReFH adjusted hydrograph in ISIS. The reasons have been outlined below:

- The statistical pooling group shows an acceptable level of heterogeneity for 491 years of data and further review of the pooling group was not suggested by WINFAP.
- The best fit distribution is good and is the same as the UK recommended method (GL).
- There is greater confidence in the flows derived via the statistical method due to the large number of catchments with similar characteristics and reliable pooling data in the pooling group. In particular, FARL is included in the pooling group weightings and is deemed to have a significant influence on catchment flow characteristics.
- The resultant peak flows have been fitted to the ReFH hydrograph. The hydrograph has been adjusted to the hydrograph parameters of a suitable donor catchment.

D.4 Attenuation to Flows from the Upper Catchment

A Flood Storage Area (FSA) at Pant provides attenuation to flows from the upper Nant Morlais catchment was accounted for within the hydrological assessment.

D.4.1 Subcatchments

The Nant Morlais catchment was split into three subcatchments, MO_01 was retained as the entire catchment. The FEH CD-ROM suggested that there were two separate subcatchments upstream; these were named MO_02 and MO_03. According to the FEH CD-ROM MO_03 did not flow through the FSA at Pant; however research by the NRW suggested that both upstream subcatchments disputed this and found that both upstream subcatchments passed through the basin.

[5] Flood Estimation Handbook Supplementary Report (2007) Appendix C

D.4.2 Flow attenuation

Flow estimates were derived for the MO_02 and MO_03 subcatchments and an intervening area flow estimate for MO_01_In representing the area between the outflow of the FSA and the point where the Nant Morlais flows into the River Taff. The same hybrid method described in Section D.3 was used. A 1D only model was produced that represented the basin at Pant, the outflow structure and the culvert downstream of the basin. MO_01 and MO_02 were merged to form a composite inflow and this was routed through the 1D model. The outflow from this 1D model was added to the MO_01_In intervening area inflow and this was used as the Nant Morlais inflow to the ESTRY TUFLOW model. The degree of attenuation for each return period event is shown is presented in .

Table D-1: Degree of attenuation provided by the FSA at Pant for each return period event

RP	50	10	20	50	75	100	1000	100+CC
Flow into FSA (m^3/s)	6.2	9.4	11.2	13.8	15.4	16.4	29.2	19.6
Attenuated Flow (m^3/s)	4.7	5.5	5.8	6.2	6.3	6.4	6.7	6.5

D.5 Final Flows

A summary of the final flows is given in Table D-2. As previously mentioned values for TA_01 and TA_02 have been derived from the adjusted ReFH methodology and were taken directly from the original hydrology study (which used 58006 Melte at Pont Nedd Fechan as a donor for data transfer). The MO_01 values are from the statistical method using a QMED adjusted to the 57006 Rhondda at Trehafod donor catchment.

Table D-2: Summary of Final Flows

	Final Flow Estimates for return period (m^3/s)							
Flow Node	**2**	**10**	**20**	**50**	**75**	**100**	**1000**	**100+CC**
TA_01	136.3	209.9	241.1	291.3	318.1	339.1	599.3	406.9
TA_02	118.3	182.2	209.5	253.6	276.9	295.3	522.8	354.3
MO_02	3.1	4.7	5.6	6.9	7.7	8.2	14.6	9.8
MO_03	3.1	4.7	5.6	6.9	7.7	8.2	14.6	9.8
MO_01_In	5.8	9.0	10.6	13.2	14.5	15.6	27.8	18.7

The relevant calculations have also been included in the following sections.

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Study Site & Donor Site Final

Catchment Descriptors

Flow Node	AREA	BFIHOST	SPRHOST	FARL	$URBEXT_{1990}$	$URBEXT_{2000}$	PROPWET	SAAR	DPSBAR	DPLBAR
TA_01	130.24	0.355	49.48	0.866	0.032	0.040	0.55	1810	147.90	11.75
TA_02	111.18	0.352	49.89	0.850	0.009	0.012	0.55	1858	156.60	11.05
MO_01	11.37	0.364	45.62	0.946	0.159	0.173	0.54	1512	94.30	4.09
MO_02	2.65	0.472	36.74	1.000	0.070	0.100	0.54	1509	94.80	1.49
MO_03	2.41	0.346	47.16	0.943	0.003	0.011	0.54	1625	81.60	2.59

											Summary of Donor Suitability							
Donor Station ID (Station Name and Number)	AREA	BFIHOST	SPRHOST	FARL	$URBEXT_{1990}$	$URBEXT_{2000}$	PROPWET	SAAR	DPSBAR	DPLBAR	Catchment Descriptors	Station Data Quality	Type of Rating (Theoretical or Empirical)	Data Start	Data End	Suitable for QMED?	Suitable for Pooling?	Additional Comments
57006 (Rhondda at Trehafod)	102.70	0.365	47.76	0.986	0.059	0.076	0.49	2183	210.30	14.22	Same catchment as the study area	Good	Empirical	1967 1991	1980 N/A	Yes	No	

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FEH Statistical Method - QMED

	FEH Statistical Method QMED Equation for Flow Node Catchments									
Flow Node	AREA	BFIHOST	SPRHOST	SAAR	FARL	QMED (rural)	URBEXT2000	PRUAF (Kjeldsen, 2010)	UAF (Kjeldsen, 2010)	QMED (urban)
TA_01	130.24	0.355	49.48	1810	0.866	76.870	0.040	1.010	1.037	79.72
TA_02	111.18	0.352	49.89	1858	0.850	65.14	0.012	1.003	1.011	65.876
MO_01	11.37	0.364	45.62	1512	0.946	10.460	0.173	1.046	1.170	**12.24**
MO_02	2.65	0.472	36.74	1509	1.000	2.770	0.100	1.042	1.132	**3.14**
MO_03	2.41	0.346	47.16	1625	0.943	**3.13**	0.011	1.003	1.010	3.163

QMED (adjusted by all donors)		
57006 (Rhondda at Trehafod)		QMED adjusted with donor 1 and 2
78.042		78.042
11.969		11.969
3.068		3.068
3.066		3.066

Final QMED Summary Information				
Final QMED estimate	FEH equation	Urban or Rural Applicati	CDs or Adjusted	Donor if Adjusted
78.042		Urban	Adjusted	57006 (Rhondda at Trehafod)
		Rural		afod)
11.969		Urban	Adjusted	57006 (Rhondda at Trehafod)
3.068		Urban	Adjusted	57006 (Rhondda at Trehafod)
3.066		Rural	Adjusted	57006 (Rhondda at Trehafod)

	FEH Statistical Method QMED Equation for Donor Station Catchments												
Donor Stations	AREA	BFIHOST	SPRHOST	SAAR	FARL	QMED (rural)	URBEXT2000	PRUAF (Kjeldsen, 2010)	UAF (Kjeldsen, 2010)	QMED (urban)	QMED (Obs)	Source of Obs QMED (HiFlows-UK / WINFAP-FEH / Dataset?	QMED (Obs) / QMED (cd)
57006 (Rhondda at Trehafod)	102.70	0.365	47.76	2183	0.986	**114.630**	0.076	1.021	1.074	123.076	115.205	HiFlows and 15 minute flow data from EA	0.936

Revised Data Transfer Procedure

Flow Node	Centroid of flow node catchment (X and Y)		Donor Site 1	Centroid of donor catchment 1 (X and Y)		Geographical distance (km) between two points (dsg)		asg
TA_01	302852	213112	(Rhondda at Trehafod)	296994	196345	17.76		0.322445192
TA_02	302335	214033	(Rhondda at Trehafod)	296994	196345	18.47		0.31786866
MO_01	306874	208714	(Rhondda at Trehafod)	296994	196345	15.83		0.335297746
MO_02	306636	209592	(Rhondda at Trehafod)	296994	196345	16.37		0.331635854
MO_03	307679	210425	(Rhondda at Trehafod)	296994	196345	17.65		0.323161061

	Final QMED Summary Information					Confidence Limits			
Flow Node	Final QMED estimate	FEH or IoH 124 CD	Urban or Rural Application	CDs or Adjusted	Donor if Adjusted	68% Interval		95% Interval	
						Lower	Upper	Lower	Upper

FEH Statistical Method - Pooling Group

Pooling Group Summary Information

Pooling Group ID	Summary of changes	Years of AMAX Data	Heterogeneity	Goodness of fit			
				GL	GEV	P3	Final Distribution
Morlais							
Initial Pooling Group	Default Pooling Group	540	Heterogenous	0.506	-0.802	-1.4927	GL
Final Pooling Group	Default Pooling Group		Acceptably homogenous	-0.04	-1.1538	-1.9087	GL

Summary of Final Rural Growth Factors selected to represent the Flood Response at each Flow Node

		Final Rural Growth Factors												
Flow Node ID	Pooling Group	2	5	10	20	25	30	50	75	100	1 +CC	200	500	1000
TA_01	Morlais	1.0	1.30	1.54	1.82	1.92	2.00	2.26	2.49	2.67	N/A	3.17	4.00	4.77
TA_02	Morlais	1.0	1.30	1.54	1.82	1.92	2.00	2.26	2.49	2.67	N/A	3.17	4.00	4.77
MO_01	Morlais	1.0	1.30	1.54	1.82	1.92	2.00	2.26	2.49	2.67	N/A	3.17	4.00	4.77
MO_02	Morlais	1.0	1.30	1.54	1.82	1.92	2.00	2.26	2.49	2.67	N/A	3.17	4.00	4.77
MO_03	Morlais	1.0	1.30	1.54	1.82	1.92	2.00	2.26	2.49	2.67	N/A	3.17	4.00	4.77

Final Peak flow estimates based upon Final Rural Growth Factors

			Final FEH Statistical Method Peak Flow Estimates (From WinFAP)												
Flow Node ID	Urban or Rural Distribution	CD or Adj QMED / Identify Donor	Final QMED (m3/s)	20	10	5	4	3.33	2	1.33	1	1+CC	0.5	0.2	0.1
TA_01	Urban	Morlais	78.0	101.69	120.42	141.88	149.61	156.16	176.45	194.56	208.61	N/A	247.55	311.78	372.50
TA_02	Rural	Morlais	63.8	83.11	98.42	115.96	122.27	127.63	144.21	159.01	170.49	N/A	202.32	254.81	304.44
MO_01	Urban	Morlais	12.0	15.60	18.47	21.76	22.94	23.95	27.06	29.84	31.99	N/A	37.96	47.82	57.13
MO_02	Urban	Morlais	3.1	4.00	4.73	5.58	5.88	6.14	6.94	7.65	8.20	N/A	9.73	12.26	14.64
MO_03	Rural	Morlais	3.1	4.00	4.73	5.57	5.88	6.14	6.93	7.64	8.20	N/A	9.73	12.25	14.64

ReFH catchment descriptor derived parameters

Cumulative flow node catchment descriptor derived Tp, Cmax, BL and BR												
Flow node	Catchment descriptors (from FEH CD ROM v3)								Tp (hrs)	Cmax (mm)	BL (hrs)	BR
	AREA	BFIHOST	SPRHOST	URBEXT$_{1990}$ updated to 2015	PROPWET	SAAR	DPSBAR	DPLBAR				
TA_01	130.24	0.355	49.48	0.0316	0.55	1810	147.9	11.8	2.92	257.51	32.87	0.99
TA_02	111.18	0.352	49.89	0.0093	0.55	1858	156.6	11.1	2.98	255.44	34.52	0.98
MO_01	11.37	0.364	45.62	0.1593	0.54	1512	94.3	4.1	1.21	264.87	18.94	1.01
MO_02	2.65	0.472	36.74	0.0698	0.54	1509	94.8	1.5	0.87	339.02	22.04	1.34
MO_03	2.41	0.346	47.16	0.0028	0.54	1625	81.6	2.6	1.56	252.41	25.99	0.95

Donor site catchment descriptor derived Tp, Cmax, BL and BR												
Flow node	Catchment descriptors (from FEH CD ROM v3)								Tp (hrs)	Cmax (mm)	BL (hrs)	BR
	AREA	BFIHOST	SPRHOST	URBEXT$_{1990}$ updated to 2015	PROPWET	SAAR	DPSBAR	DPLBAR				
57006 (Rhondda at Trehafod)	102.70	0.365	47.76	0.0591	0.49	2183	210.30	14.22	3.08	271.82	34.05	0.98

Incremental flow node catchment descriptor derived Tp, Cmax, BL and BR												
Flow node	Catchment descriptors (from FEH CD ROM v3)								Tp (hrs)	Cmax (mm)	BL (hrs)	BR
	AREA	BFIHOST	SPRHOST	URBEXT$_{1990}$ updated to 2015	PROPWET	SAAR	DPSBAR	DPLBAR				
TA_01_In	19.06	0.372	47.09	0.1993	0.55	1530	97.2	5.03	1.19	269.55	17.88	1.04
MO_01_In	6.31	0.326	48.76	0.2649	0.54	1470	98.9	2.74	0.71	238.19	12.71	0.89

ReFH Parameter Adjustment

Donor site ReFH parameters from calibration												
Donor Site	**Tp (CD) (hrs)**	**Tp (Obs) (hrs)**	**Ratio Tp**	**C_{max} (CD) (mm)**	**C_{max} (Obs) (mm)**	**Ratio C_{max}**	**BL (CD) (hrs)**	**BL (Obs) (hrs)**	**BL Ratio**	**BR (CD)**	**BR (Obs)**	**BR Ratio**
7006 (Rhondda at Trehafc	3.08	2.26	**0.733**	271.82	321.5	**1.183**	34.05	35.20	**1.034**	0.98	1.4	**1.433**

Study site ReFH parameter adjustments from calibration data									
Flow node	**Donor Used**	**Tp (CD) (hrs)**	**Adjusted Tp (hrs)**	**C_{max} (CD) (mm)**	**Adjusted C_{max} (mm)**	**BL (CD) (hrs)**	**BL Adjusted (hrs)**	**BR (CD)**	**BR Adjusted**
TA_01	7006 (Rhondda at Trehafoc	2.92	**2.14**	**257.51**	**304.56**	32.87	**33.98**	0.99	**1.42**
TA_02	7006 (Rhondda at Trehafoc	2.98	**2.19**	**255.44**	**302.12**	34.52	**35.69**	0.98	**1.40**
MO_01	57006 (Rhondda at Trehafoc	1.21	**0.89**	**264.87**	**313.27**	18.94	**19.58**	1.01	**1.45**
MO_02	57006 (Rhondda at Trehafoc	0.87	**0.63**	**339.02**	**400.98**	22.04	**22.79**	1.34	**1.91**
MO_03	57006 (Rhondda at Trehafoc	1.56	**1.14**	**252.41**	**298.54**	25.99	**26.88**	0.95	**1.37**

Incremental Catchments ReFH Calibration Adjustment									
Flow node	**Donor Used**	**Tp (CD) (hrs)**	**Adjusted Tp (hrs)**	**C_{max} (CD) (mm)**	**Adjusted C_{max} (mm)**	**BL (CD) (hrs)**	**BL Adjusted (hrs)**	**BR (CD)**	**BR Adjusted**
TA_01_In	7006 (Rhondda at Trehafoc	1.19	**0.88**	**269.55**	318.81	17.88	**18.48**	1.04	**1.49**
MO_01_In	57006 (Rhondda at Trehafoc	0.71	**0.52**	**238.19**	281.72	12.71	**13.14**	0.89	**1.28**

Summary of flows

Summary of methods used for flow estimation

FEH Statistical Method - Pooled Analysis

Final Prefered Flows for Merthyr Model

Brief Method Summary	Using Rhonda as a donor for QMED.

Flows

		Final Flow Estimates for %AEP event (m3/s)												
Flow Node	QMED /50	20	10	5	4	3.33	2	1.33	1	0.5	0.2	0.1	1CC	0.1%/1% ratio
TA_01	78.0	101.7	120.4	141.9	149.6	156.2	176.5	194.6	208.6	247.6	311.8	372.5	250.3	1.8
TA_02	63.8	83.1	98.4	116.0	122.3	127.6	144.2	159.0	170.5	202.3	254.8	304.4	204.6	1.8
MO_01	12.0	15.6	18.5	21.8	22.9	23.9	27.1	29.8	32.0	38.0	47.8	57.1	38.4	1.8
MO_02	3.068	3.997	4.734	5.577	5.881	6.139	6.936	7.648	8.200	9.731	12.256	14.643	9.841	1.786
MO_03	3.066	3.996	4.732	5.575	5.878	6.136	6.933	7.645	8.197	9.727	12.251	14.636	9.836	1.786
TA_01_In	14.3	18.6	22.0	25.9	27.3	28.5	32.2	35.5	38.1	45.2	57.0	68.1	45.7	1.8
MO_01_In	5.8	7.6	9.0	10.6	11.2	11.7	13.2	14.5	15.6	18.5	23.3	27.8	18.7	1.8

ReFH unadjusted Method

Brief Method Summary	Flows estimated used catchment descriptor derived hydrograph parameters and ReFH1 boundary unit in ISIS

Flows

		Final Flow Estimates for %AEP event (m3/s)												
Flow Node	QMED /50	20	10	5		3.33	2	1.33	1	0.5		0.1	1CC	0.1%/1% ratio
TA_01														
MO_01														
MO_02														
MO_03														
TA_01_In														
MO_01_In														

ReFH Adjusted

Brief Method Summary	These flows are based on the ReFH1 methodology, with adjusted hydrograph parameters based on observed data at Rhondda. Parameters have been calibrated using the ReFH1 software. Tp adjusted based on 4 donor events Cmax not adjusted BL and BR adjusted based on 4 donor events

Flows

		Final Flow Estimates for %AEP event (m3/s)												
Flow Node	QMED /50	20	10	5		3.33	2	1.33	1	0.5		0.1	1CC	0.1%/1% ratio
TA_01														
MO_01														
MO_02														
MO_03														
TA_01_In														
MO_01_In														

Appendix E Hydraulic Modelling Update

Hydraulic Modelling Summary

Objectives

The aim of this study is to assess the current and potential flood risk at the location of a proposed Bus Station in Merthyr Tydfil.

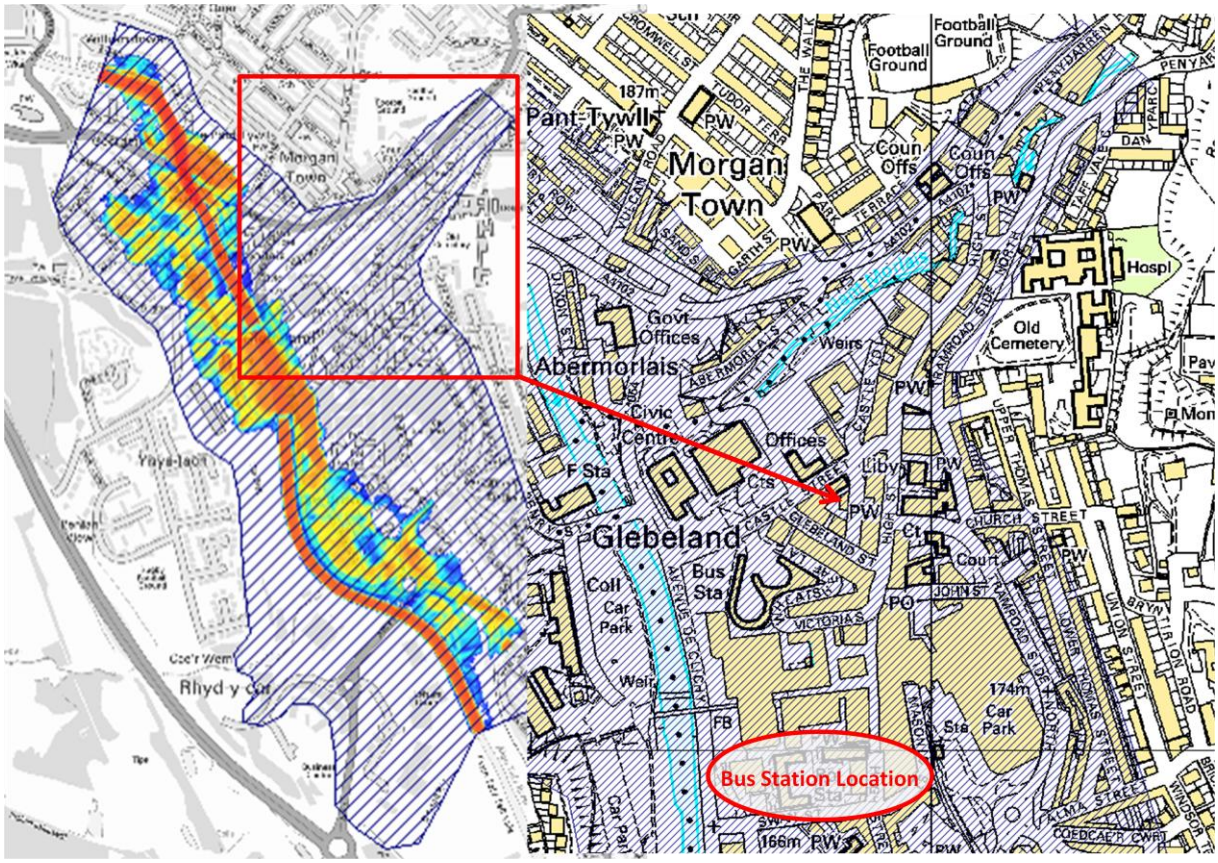
This study will extend the existing hydraulic model of the River Taff to include a the Nant Morlais which runs from Penyard Road north east of the town centre to its confluence near the Penry St. Bridge.

The study will assess the current and potential flood risks looking at three distinct scenarios:

1. Baseline – Conditions before demolition works began at the proposed development site.
2. Existing – Conditions after demolition works began at the proposed development site.
3. Proposed – Proposed conditions following completion of construction at the development site.

Model Extent

Watercourse	Upstream	Downstream
River Taff	Downstream of the Cyfarthfa Road Bridge. (NGR 304333, 206789)	Adjacent to the Dismantled Railway Line. (NGR 605160, 250370)
Nant Morlais	Penyard Road where the Nant Morlais appears above ground in Merthyr (NGR 305210, 206730)	Outfall structure where the Nant Morlais discharges to the River Taff just upstream of the Penry St Bridge. (NGR 304670, 206270)



Modelling Naming Convention & Model Scenarios

Baseline, Existing and Proposed Model

TAF_~s~_~e~_@@@

TAF – River Taff Hydraulic Model.

~s~ - The topography scenario of the model. **BSC** - represents the baseline scenario. **EXG** – represents the existing scenario. **PRP** – represent the proposed scenario. For the sensitivity runs BSC_SENS01 up to SENS06.

~e~ - The return period and year (i.e. current or future) that is being modelled.

@@@ - This represents the version number of the model run.

Model Scenarios

Baseline Scenario (BSC)

This model scenario includes:

- All completed works in the Merthyr area explored in the previous modelling study which includes:
    1. Removal of the Merthyr Learning Quarters (MLQ)building that has been demolished
    2. New MLQ building and changes to ground levels in front of building
    3. Inclusion of the River Taff Central Link Bridge
    4. Changes to road and car park levels within the MLQ site and at the access road / Penry Street and access road / Avenue De Clichy junctions.
- Surveyed ground and LiDAR levels taken before the demolition of the old health centre and police station at the proposed site. The Northern walls of the old health centre and police station were included in this scenario as they would block off the potential flow route parallel to the Avenue de Clichy (as agreed with NRW).

Existing Scenario (EXG)

This model scenario includes:

- Surveyed ground levels following demolition of the old health centre and police station at the proposed site.

Proposed Scenario (PRP)

This model scenarios includes:

- Proposed finished flood levels of the bus station development.

All scenarios were run for the 1 in 20, 50, 75, 100, 100 (with climate change) and 1000 year events

Sensitivity Scenarios	Increase	Decrease
Manning's n Value	SENS01 120% Channel (1D network) 150% Floodplain (2D model domain)	SENS02 80% Channel (1D network) 50% Floodplain (2D model domain)
Structure	SENS03	SENS04

	110% Culvert Loss coefficients along the Nant Morlais.	90% Bridge Loss coefficients along the Nant Morlais
Flows	SENS05 120% Inflow	SENS06 80% Inflow
Downstream Boundary	No Testing – The boundary is located far enough downstream from the side. At this location the floodplain narrows significantly and the flood waters have mainly returned to the 1D. There is a control structure, the A4102 road bridge located upstream of the boundary.	

All sensitivity scenarios have been run for the baseline scenario for the 1 in 100 year return period event with climate change.

Blockage Scenario

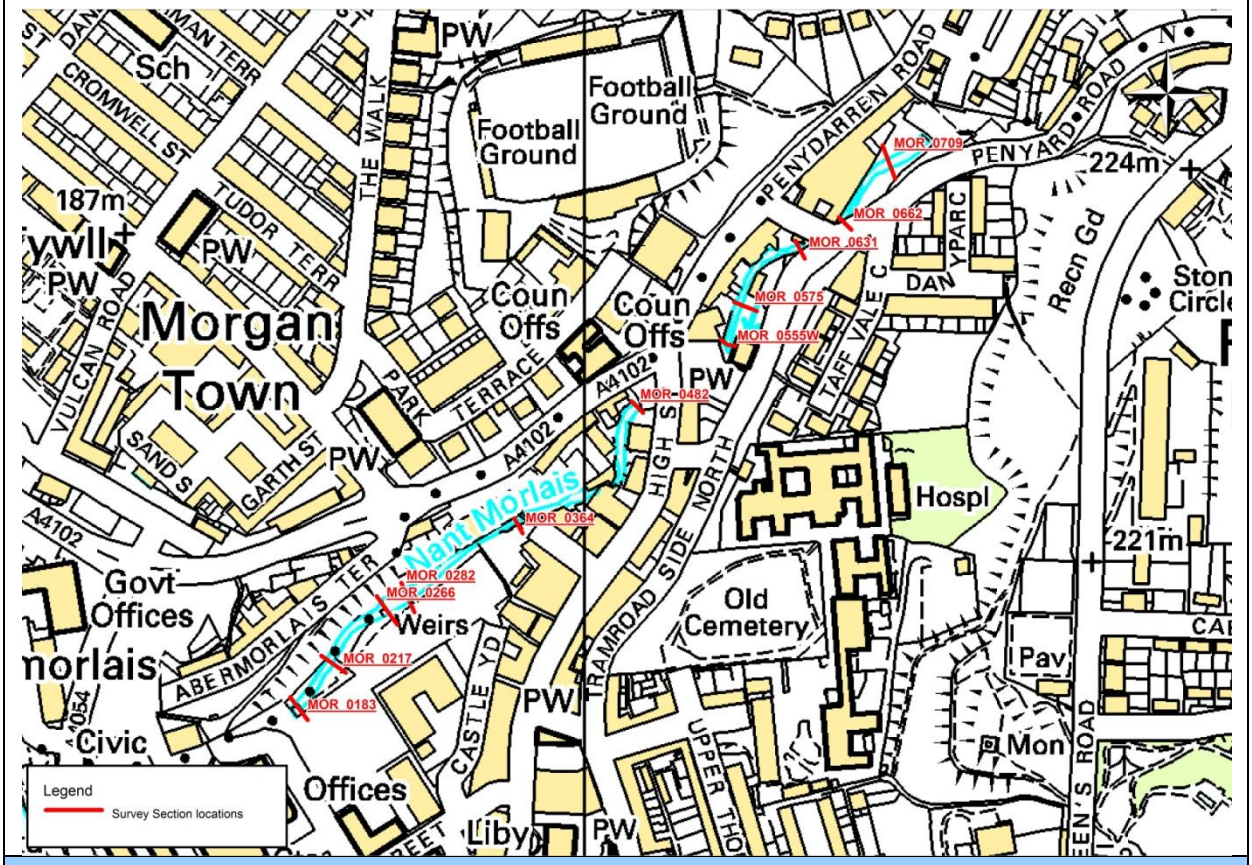
The blockage analysis involved blocking of the culvert at the downstream of Nant Morlais. Two blockages were assigned to the culvert, 100% and 67% (according to the CIRIA C689 guidance). The analysis was run using the 1 in 100 year flood event with climate change event for the proposed scenario. This scenario was chosen to determine the impact the blockage would have on flooding at the proposed development site.

Data

This section will present the data used specifically for this study. Any data used in the previous study can be cross checked in the River Taff Central Link (Gyratory) (Capita, 2012).

Data	Comment
Existing model	Existing model was built by Capita and owned by Merthyr County Borough Council. All data used in the production of the previous model is documented in Appendix F of the River Taff Central Link (Gyratory), Flood Consequences Assessment (Capita, Nov 2012) and should be referred to for more information.
Channel and structure survey completed by Alpine Land Surveyors (2011)	Collected as part of the previous study discussed above. The locations of the channel and structure cross sections along the Nant Morlais are shown in the figure below.
Morlais Brook Improvement – Phase 1 – Ivor Tip – Design Drawings	As built drawings of the Flood Storage Area (FSA) at Pant and associated culverts. Designs taken from November 1979.
Morlais Brook Improvement – Phase 2 – River Taff to Manhole no.2 – Design Drawings	Design drawings of the Nant Morlais outfall structure provided by Merthyr Tydfil Borough Council. Designs are from June 1975.
Topograpical survey completed by Alpine Land Surveyors (2011)	Collected as part of the previous study and used in tandem with LiDAR levels to inform the ground levels for the baseline scenario.
Topographic Survey of existing ground levels by Landmark Surveys (Wales) Ltd (September 2014)	Collected specifically for this study to inform to determine ground levels for the existing scenario.
Police Station Demolition Ground Levels	Collected specifically for this study to inform to determine ground levels for the existing scenario

Proposed Ground Levels provided by Capita Highways team	Finished floor levels for the development were provided to inform the proposed scenario for this study.
10K, 50K mapping and Mastermap	Provided for and adopted from the previous study.
LiDAR	Provided for and adopted from the previous study. Resolution of 2m and flown on July 2011.



Software Version

The model has been run using TUFLOW build 2013-05-AD-iDP-w64 software.

Model Parameters

Grid size assigned to the model is 4 m.

The model was simulated with a 1 second time step due to the topography and the grid size. The results and the mass balance indicate that this was a sensible time step to use.

Applied an 'a' factor of 0.3 to HX lines along the Nant Morlais to add additional energy losses between the 1D channel and 2D floodplain.

All other parameters are TUFLOW default values.

Structures

Along the Nant Morlais three culverts and two weirs have been modelled.

All culverts have been modelled in TUFLOW using an irregular culvert channel type with height width (HW) tables applied to represent the effective flow area. Weirs have been modelled using XZ tables to define the cross sections properties. Default vales for losses have been applied at all structures.

Located at the confluence of the Nant Morlais and the River Taff is a complex outfall structure. As built drawings of the structure were provided to Capita by Merthyr Tydfil County Borough Council. Investigations of the flow mechanisms surrounding this structure found that the upstream inlet from the Nant Morlais is the primary control. During a flood event, the peak of the Nant Morlais occurs prior to the peak of the River Taff. The combination of both of these factors mean that the full details of this complex structure would not have significant impacts on the model results if included in the model.

Reference	Description	Data Source	Modelling Approach
MOR_0662C	Culvert (NGR 305147, 206670)	Survey 2011 - Section CS109 and CS108.	ESTRY 1D Irregular Culvert network line, using HW table taken from CS109.
MOR_0555W	Weir that drops into second culvert on the Nant Morlais (NGR 305089, 206600)	Survey 2011 – Section CS106 used in conjunction with spot levels included in the plan topo of the watercourse which defined crest levels.	ESTRY 1D Weir unit using an XZ profile to define the cross section.
MOR_0545C	Culvert under the High St (NGR 305062, 206581)	Survey 2011 – Section CS106 details the cross sections properties of the weir and culvert and has been used to define the inlet properties. CS105 used to define the outlet cross section.	ESTRY 1D ESTRY 1D Irregular Culvert network line, using HW table taken from CS106.
MOR_0482	Footbridge over the Nant Morlais – unused and in poor condition. (NGR 304883, 206442)	Survey 2011 – Section CS104 is taken just downstream of the structure, no soffit levels provided.	Not modelled, data is not accurate enough and bridge is not likely to have a significant impact on modelled results.
MOR_0282W	Weir located 100m upstream of the Nant Morlais Culvert. (NGR 304669, 206244)	Survey 2011 – Sections CS103 and CS102 used to define upstream and downstream cross sections respectively. CS103A used to define the crest level of the weir.	ESTRY 1D weir network line, using XZ table to define the crest of the weir. Default weir factors applied.
MOR_0183C Inlet - MOR_0183W	Nant Morlais culvert, links the Morlais and the River Taff (NGR 304746, 206343)	Survey 2011 - Section CS100 used to define the cross section properties of the culvert. Plan topo survey used to define the inlet of the structure.	ESTRY 1D Weir unit used to define the inlet to the structure which is a vertical drop into the culvert. Default values used for the weir. ESTRY 1D ESTRY 1D Irregular Culvert network line, using HW table taken from CS100.
MOR_Out	Outfall Structure of the Nant Morlais (NGR 304659, 206577)	Design Drawings of the Nant Morlais outfall structure provided by Merthyr Tydfil Borough Council.	Modelled as a long culvert to account for the storage capacity at the downstream of the Nant Morlais.

Boundary Conditions

Upstream Inflow Boundaries applied at the top of the Nant Morlais and River Taff. Both upstream boundaries are applied as QT (flow versus time) inflows. The upstream boundary has been applied to the 1D at a location where the flow is well contained and ensures the potential flood flow routes from the Taff towards the site are represented in the model. The flows from the Nant Morlais had the attenuation provided by the FSA at Pant accounted for. A 1D only model of the basin, outflow structure and downstream culvert was built. The inflows attributed to any areas upstream of this point were routed through the 1D model. The outflow from the 1D model was added to an intervening area inflow representing the remainder of the catchment, this was the inflow for the Nant Morlais. The degree of attenuation provided by the FSA is shown in Table D-1 (Appendix D).

Return Period	Inflow (m^3/s)	
	River Taff	Nant Morlais
1 in 20 year	182	16
1 in 50 year	210	18
1 in 75 year	254	19
1 in 100 year	277	21
1 in 100 year with climate change	295	19
1 in 1000 year	523	31

At the downstream boundary a HQ boundary has been applied in the 1D domain of the model. The water level versus time relationship was derived using an ISIS utility (*Tabulate Cross-Section Properties*) to calculate the normal depth relationship based on the bed slope, calculated from the average slope between the downstream nodes and the Manning's n value of the channel. This relationship is inputted into the TUFLOW model through the bc database.

The downstream boundary is located sufficiently far from structures that normal depth flow conditions would be expected.

Roughness Values

1D Model Network

Along the majority of the River Taff and Nant Morlais 1D channel a Manning's n value of 0.04 has been applied considering the nature of the channel and vegetation.

2D Model Domain

Material ID	Manning's n	Description (MasterMap Feature Code)
1	0.300	Buildings, 1002 (Manmade; Glass House; Structure Manmade)
2	0.015	General Surface 1007 (Road Or Track; Manmade)
3	0.040	Unclassified 1021

4	0.040	General Surface,1005 (Natural)
5	0.025	General Surface, 1005 (Unknown)
6	0.035	Inland Water, 1008 (Natural)
7	0.015	Landform,Road Or Track, 1017 (Slope & Manmade)
8	0.030	Landform 1017 (Natural)
9	0.060	Natural Environment 1011 (Coniferous Trees (Scattered), Nonconiferous Trees (Scattered), Scrub, Nonconiferous Trees)
10	0.050	Natural Environment 1011 (Scrub, Grassland, Natural)
11	0.015	Manmade, 1011 (Path, Step)
12	0.020	Rail,1016

Model Topography

1D Model Network

Defined using channel survey collected by Alpine Land Surveyors (October, 2011) for the full extent for the model.

Baseline Model Scenario

The model topography has been defined in the 2D domain using a combination of LiDAR (flown 2011) and topographical survey completed by the Alpine Land Surveyors (October 2011) and proposed ground levels for the MLQ developments in Merthyr.

Existing Scenario

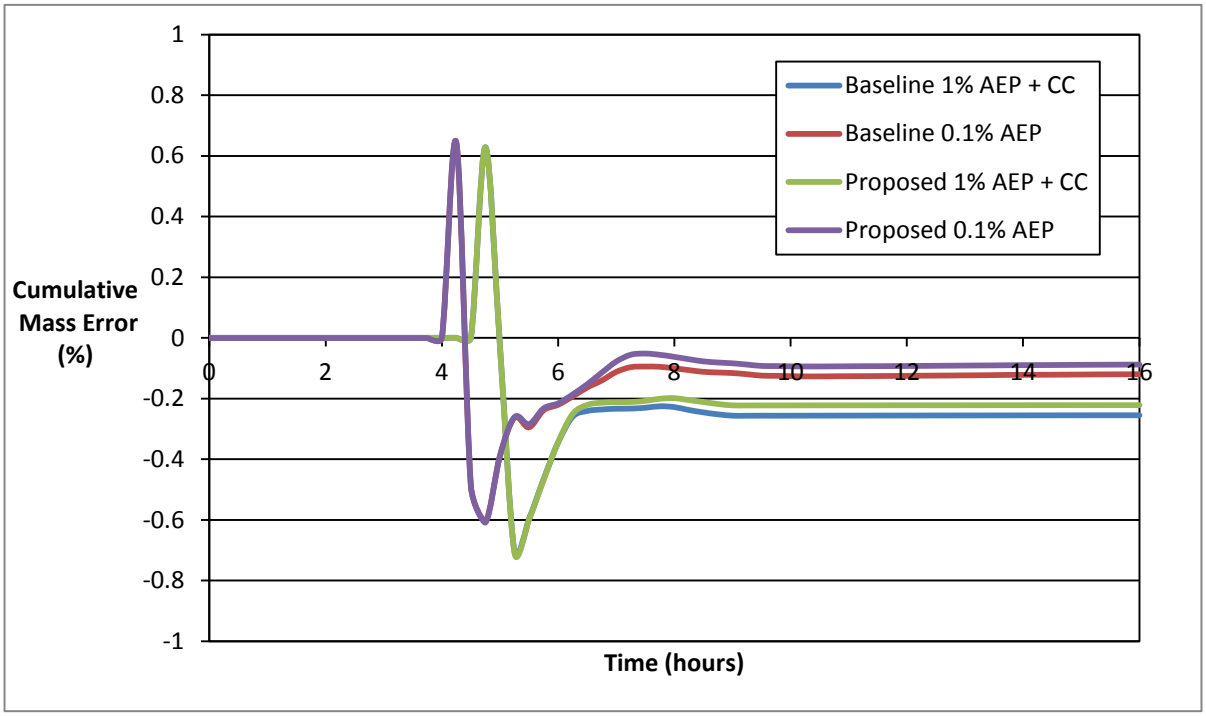
The model topography has been defined as in the Baseline Model with additional topographical survey completed by Landmark Surveys (Wales) Ltd in September 2014 added to represent ground levels post demolition at the site.

Proposed Model Scenario

The model topography has been defined as in the Baseline Model with additional levels specified using design drawings provided by the Capita's Highways Team.

Model Stability

Stability in a TUFLOW model is assessed by examining the cumulative mass error (or mass balance) of the model and the warnings outputted by the model during the simulation. The figures below show the cumulative error of the 1 in 100 year with climate change event and the 1 in 1000 year event for both of the scenarios. For all four events the cumulative mass error of the models are within the range of +/- 1.0 % throughout the simulation. There is high mass balance between 4 and 6 hours in all simulations at the onset of out of bank flooding in the simulation.For the baseline and proposed scenario there are warnings related to the checks undertaken by the model software when reading in data. These were reviewed to make sure that the proposals are correctly applied in the model and do not impact the model results.



Sensitivity Analysis

NB all sensitivity runs have been based on the Baseline model.

Roughness Values

The outcomes of the sensitivity analysis on the roughness values are:

- An increase in the roughness shows an increase in the flood extent and maximum flood depths adjacent to the confluence of the Nant Morlais and River Taff. Additional flooding is experienced on the right bank of the River Taff.
- A decrease in the roughness shows a decrease in the flood extent and maximum flood depths adjacent to the confluence of the Nant Morlais and River Taff. Additional flooding is experience on the right bank of the River Taff.
- At the area of interest, the proposed Bus Station development area, there is no difference in the flood extent however for both scenarios there is an increase in the maximum flood depth. For an increase in roughness there is an increase in 0.1 m and for a decrease in roughness there is an increase of 0.02m.

Structures

The outcomes of the sensitivity analysis of structure coefficients are:

- An increase or decrease in the loss coefficients have minimal impact on the flood extent and maximum flood depths.

Inflows

The outcomes of the sensitivity analysis for the change in inflow are:

- An increase in the flows applied to the River Taff and Nant Morlais show significant increase in the flood extent, especially through the centre of Merthyr.

- A decrease in the flows applied to the River Taff and Nant Morlais show reduction in the flood extent, the Nant Morlais and the structure are able to convey all the water within the bank, therefore no flooding occurs from Nant Morlais.
- For an increase in the flow a lot more of the site is within the 1 in 100 year with climate change flood extent.

Overall the results of the sensitivity testing indicate that the model is sensitive to the roughness values and the flows that have been applied to the model. At the proposed development site the model is sensitive to the flows that are applied to the model.

Blockage Analysis

Comparisons of the blockage results have been made for the 1 in 100 year with climate change proposed scenario results.

- Blockage of the Nant Morlais culvert shows an increase in the flood extent, there is flooding along the High Street and through the proposed bus station site.
- The blockage scenario shows an increase in the maximum flood depth by 0.4 m for a 67% blockage and 0.5 m for a 100% blockage, directly downstream of the culvert opening.
- At the proposed bus station site there is no flooding for the proposed scenario however for both blockage scenarios flooding now occurs across the proposed development site, however it is quite shallow reaching a maximum flood depth of 0.05 m.
- The maximum flood velocity experienced at the proposed Bus Station site would be 0.06 m/s for both blockages.

There are model instabilities for both model runs, this is due to the water being unable to flow through the Nant Morlais culvert and immediately inundating the floodplain.

Overall the blockage of Nant Morlais culvert redirects all the water from the Nant Morlais on the floodplain which shows flooding through the town centre. This indicates that there is a need for the council to ensure that the trash screen across the culvert is regularly cleaned.

TUFLOW Modelling Layers

Control Files

Baseline & Proposed Scenario

File name	Type/Format	Comment & Description
TAF_~s~_~e~_074.tcf	TUFLOW control file. Text file.	Contains 1D domain commands.
TAF_067.tgc	TUFLOW geometry control file. Text file.	
TAF_064.tbc	Tuflow boundary control file. Text file.	
bc_dbase_TAF_049.csv	Boundary control database. Csv file	
2d_mat_TAF_050.csv	Materials file. Csv file	

Sensitivity Scenarios

File name	Type/Format	Comment & Description
bc_dbase_TAF_SENS05_049.csv	Boundary control	Increasing flow by 20%

	database. Csv file	
bc_dbase_TAF_SENS05_049.csv	Boundary control database. Csv file	Decreasing flow by 20%
2d_MAT_SEN01_TAF_053.csv	Materials file. Csv file	Increasing roughness values by 50%
2d_MAT_SEN02_TAF_053.csv	Materials file. Csv file	Decreasing roughness values by 50%
Modelling Layers		
Baseline Scenario		
File name	**Type/Format**	**Comment & Description**
1d_nwke_TAF_PRP_028.MIF	1D ESTRY Layer, MapInfo Layer.	Defined using survey collected by Alpine Land Surveyors (2011)
1d_xs_TAF_PRP_028.MIF	1D ESTRY Layer, MapInfo Layer.	Defined using survey collected by Alpine Land Surveyors (2011)
1d_HW_TAF_030.MIF	1D ESTRY Layer, MapInfo Layer.	Defined using survey collected by Alpine Land Surveyors (2011)
1d_BG_TAF_024.MIF	1D ESTRY Layer, MapInfo Layer.	Derived using the Hydraulics Bridge Waterways Method.
1d_bc_TAF_038.MIF	1D ESTRY Layer, MapInfo Layer.	Location defined through hydrological assessment.
1d_WLL_TAF_023.MIF	1D ESTRY Layer, MapInfo Layer.	Displaying 1D results in the results grids.
2d_code_TAF_048.MIF	Geometry file layer, MapInfo.	Extent of the 2D domain
2d_loc_TAF_004.MIF	Geometry file layer, MapInfo.	
2d_bc_TAF_PRP_HXI_054.MIF	Geometry file layer, MapInfo.	Linking the 1D domain to the 2D domain, levels define using survey.
DTM_2M_LID_2011_MT_001.txt	Geometry file layer, MapInfo.	Grid created using LiDAR.
2d_zln_TAF_EA_Survey_040.MIF	Geometry file layer, MapInfo.	Levels extracted from Environment Agency provided by the EA collected 2010, AFONTAFF_EMBANKMENTDATA_2010
2d_zline_TAF_Baseline_Buildings_001.MIF	Geometry file layer, MapInfo.	Elevation of the Northern wall of the old health centre and police station.
2d_zsh_TAF_Bridges_012.MIF	Geometry file layer, MapInfo.	Levels defined (where required) using the LiDAR or Topographic survey, depending which is available.
2d_zsh_TAF_TopoSurvey_Ext_011.MIF	Geometry file layer, MapInfo.	Layers have been derived from the topographic survey. The survey has been defined using three layers, the extent of the topography (1st layer), elevation points extract from the survey (2nd layer) and TIN lines (3rd layer).

2d_zsh_TAF_TopoSurvey_Pts_010.MIF	Geometry file layer, MapInfo.	Read in for stability reasons.
2d_zsh_TAF_TopoSurvey_BLs_011.MIF	Geometry file layer, MapInfo.	
2d_zsh_TAF_ZptFix_024.MIF	Geometry file layer, MapInfo.	
2d_zsh_TAF_MLQBuilding_020.MIF	Geometry file layer, MapInfo.	Defining the floor levels of the MLQ building, extracted from proposed design drawings.
2d_zsh_TAF_ExistingBuildings_026.MIF	Geometry file layer, MapInfo.	Defining the floor levels of the existing buildings, extracted from the topographic survey.
2d_zsh_TAF_DemolishedBuilding_026.MIF	Geometry file layer, MapInfo.	Defining the floor levels of the building to be demolished, extracted from the topographic survey.
2d_MAT_TAF_004.mif	Geometry file layer, MapInfo.	Extent of the material types define using OS Master Maps.
2d_MAT_TAF_MMCorrection_006.mif	Geometry file layer, MapInfo.	Extent of the material types define using OS Master Maps.
2d_mat_TAF_MLQbuilding_020.MIF	Geometry file layer, MapInfo.	Extent of the MLQ building defined in the proposed design drawing.
2d_bc_TAF_DSB_007.MIF	Boundary file layer, MapInfo.	Downstream boundary.
2d_bc_MOR_hxi_049.MIF	Geometry file layer, MapInfo.	Linking the 1D domain to the 2D domain, levels define using survey.
2d_bc_sx_MorOufall_051.MIF	Geometry file layer, MapInfo.	Linking the 1D domain to the 2D domain, levels define using survey.
1d_nwke_MOR_074.MIF	1D ESTRY Layer, MapInfo Layer.	Defined using survey collected by Alpine Land Surveyors (2011)
1d_WLL_NMor_040.MIF	1D ESTRY Layer, MapInfo Layer.	Displaying 1D results in the results grids.
1d_xs_MOR_049.MIF	1D ESTRY Layer, MapInfo Layer.	Defined using survey collected by Alpine Land Surveyors (2011)
1d_HW_MOR_071.MIF	1D ESTRY Layer, MapInfo Layer.	Defined using survey collected by Alpine Land Surveyors (2011)
1d_HW_TAF_PRP_030.MIF	1D ESTRY Layer, MapInfo Layer.	Same as the baseline 1d height width table, and including details for the proposed bridge.
1d_BG_TAF_PRP_030.MIF	1D ESTRY Layer, MapInfo Layer.	Same as the baseline 1d bridge loss table, and including details for the proposed bridge.
2d_zsh_TAF_ProposedCont_Ext_031.MIF	Geometry file layer, MapInfo.	Additional layer to the baseline. Used to define the proposed design ground level, (drawing **PROPOSEDG CONTOURS (0.1m) 2012-10-12.dwg**). The contours have been defined using two layers, the extent of the changes (1st layer), polylines defining the

		levels and TIN lines (2nd Layer).
2d_zsh_TAF_Proposed_Ext_031.MIF	Geometry file layer, MapInfo.	Additional layer to the baseline. Used to define the proposed design road location and levels (drawing **PROPOSEDG 2012-10-11 (REV2).dwg**). The proposed road design has been defined using three layers, the extent of the proposed road (1st layer), elevation points extract from the survey (2nd layer) and TIN lines (3rd layer).
2d_zsh_TAF_Proposed_Pts_031.MIF	Geometry file layer, MapInfo.	
2d_zsh_TAF_Proposed_BLs_031.MIF	Geometry file layer, MapInfo.	Defining the kerb of the proposed road using a thin zline. Line and points extract from (drawing **PROPOSEDG 2012-10-11 (REV2).dwg**
2d_zln_TAF_Proposed_Kerb_031.MIF	Geometry file layer, MapInfo.	
2d_MAT_TAF_Proposed_031.MIF	Geometry file layer, MapInfo.	
2d_zsh_TAF_ZptFix_022.MIF	Geometry file layer, MapInfo.	Read in for stability reasons.
2d_zline_MorOufall_049.MIF	Geometry file layer, MapInfo.	Read in to define the invert levels of the Nant Morlais outfall structure.
2d_zline_MorOut_Banktop_052.MIF	Geometry file layer, MapInfo.	Read in to define a wall around the Nant Morlais outfall structure.
2d_mat_TAF_ProposedDemolishedBldgs_020.MIF	Geometry file layer, MapInfo.	Changing the material types for the demolition of the existing building.
2d_mat_MorOut_050.MIF	Geometry file layer, MapInfo.	Defines roughness within the Nant Morlais outfall structure.
Existing Scenario		
File name	**Type/Format**	**Comment & Description**
2d_zsh_EXG_BLDG1_extent_044.MIF	Geometry file layer, MapInfo.	Topographic survey data update to define grounds levels following demolition of the health centre building
2d_zsh_EXG_BLDG1_lines_053.MIF	Geometry file layer, MapInfo.	
2d_zsh_EXG_BLDG1_points_053.MIF	Geometry file layer, MapInfo.	
2d_zsh_EXG_BLDG2_extent_044.MIF	Geometry file layer, MapInfo.	Topographic survey data update to define grounds levels following demolition of the police station
2d_zsh_EXG_BLDG2_lines_053.MIF	Geometry file layer, MapInfo.	
2d_zsh_EXG_BLDG2_points_044.MIF	Geometry file layer, MapInfo.	

Proposed Scenario		
2d_zsh_PROP_BST_extent_053.MIF	Geometry file layer, MapInfo.	Finished ground levels provided by the design team for the proposed bus station.
2d_zsh_PROP_BST_points_053.MIF	Geometry file layer, MapInfo.	
2d_zsh_PROP_BST_contour_053.MIF	Geometry file layer, MapInfo.	
Sensitivity Scenario		
File name	**Type/Format**	**Comment & Description**
1d_nwke_SEN01_MOR_074.MIF, 1d_nwke_SEN01_TAF_PRP_053.MIF	1D ESTRY Layer, MapInfo Layer.	Increasing roughness values by 20%
1d_nwke_SEN02_MOR_074.MIF 1d_nwke_SEN02_TAF_PRP_053.MIF	1D ESTRY Layer, MapInfo Layer.	Decreasing roughness values by 20%
1d_nwke_SEN03_MOR_074.MIF 1d_nwke_TAF_PRP_028.MIF	1D ESTRY Layer, MapInfo Layer.	Increasing loss coefficient by 10% for the proposed model on the Nant Morlais.
1d_nwke_SEN04_MOR_074.MIF 1d_nwke_TAF_PRP_028.MIF	1D ESTRY Layer, MapInfo Layer.	Decreasing loss coefficient by 10% for the proposed model Nant Morlain
Blockage Scenario		
1d_HW_BLG01_MOR_074.MIF	1D ESTRY Layer	Reduced the flow area by 67% through the culvert
1d_HW_BLG02_MOR_074.MIF	1D ESTRY Layer	Reduce the flow area by 99% through the culvert

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