Stage 3 SFCA

Six Bells Report

May 2012

Prepared for:
Blaenau Gwent County Borough Council

UNITED KINGDOM & IRELAND

REVISION SCHEDULE					
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1 INTRODUCTION

1.1 Commission

URS Infrastructure & Environment UK Limited (URS) was commissioned by Blaenau Gwent County Borough Council (CBC) to undertake a Stage 3 Strategic Flood Consequences Assessment (SFCA) for the Lower Plateau site at Six Bells, near Abertillery.

1.2 Background

The site reference within the emerging Local Development Plan (LDP) is ED1.2 and is allocated for non-resident education use and it is understood that the site will be developed as a Primary School. Following completion of the Stage 2 SFCA, discussion with the Environment Agency (EA) (see Appendix A) identified the requirements for a Stage 3 SFCA for site ED1.2 at Six Bells, near Abertillery. This was intended to investigate the likelihood of flooding at the site from the Ebbw Fach River and the associated impact upon opportunities for development of a primary school.

EA Flood Zone Mapping indicates that the site is predominantly located within Flood Zone 3 (at risk during a 1 in 100 year event) and Flood Zone 2 (at risk during a 1 in 1000 year event), associated with the Ebbw Fach River. The Welsh Assembly Government (WAG) Development Advice Map (DAM) indicates that the site is predominantly located in Zone C2 (undefended zone at risk during a 1 in 1000 year event). However, the Ebbw Fach River flows within a large culvert (known as the Six Bells Culvert) beneath the western site boundary, which is likely to have a significant impact upon flood risk in the local area and has not been considered in detail as part of the EA Flood Zone Mapping.

In February 2011 an assessment was undertaken by URS to identify the flow required to exceed the culvert capacity and therefore provide an outline assessment of the potential flood risk posed to the site. This assessment made the following conclusions:

- Flows within the Ebbw Fach River were estimated using the FEH statistical approach to be:
  - 45.9m^3/s during a 1 in 100 year event;
  - 55.1m^3/s during a 1 in 100 year event (inclusive of climate change);
  - 77.9m^3/s during a 1 in 1000 year event.
- The Six Bells Culvert beneath the site has a capacity of approximately 78m^3/s at its entrance and approximately 34m^3/s from 80m along its length, which was estimated using hand calculations;
- As a result, the culvert has the potential to cause constriction of flows during very high flow events;
- The likelihood of floodwater reaching the site in the event of a capacity exceedance is reduced due to the high headwall at the culvert entrance and local topography creating preferential flooding to areas north (upstream) of the site;
- It is recommended that the site be continued through the LDP process, but hydraulic modelling should be undertaken to confirm the likelihood of fluvial flood risk.

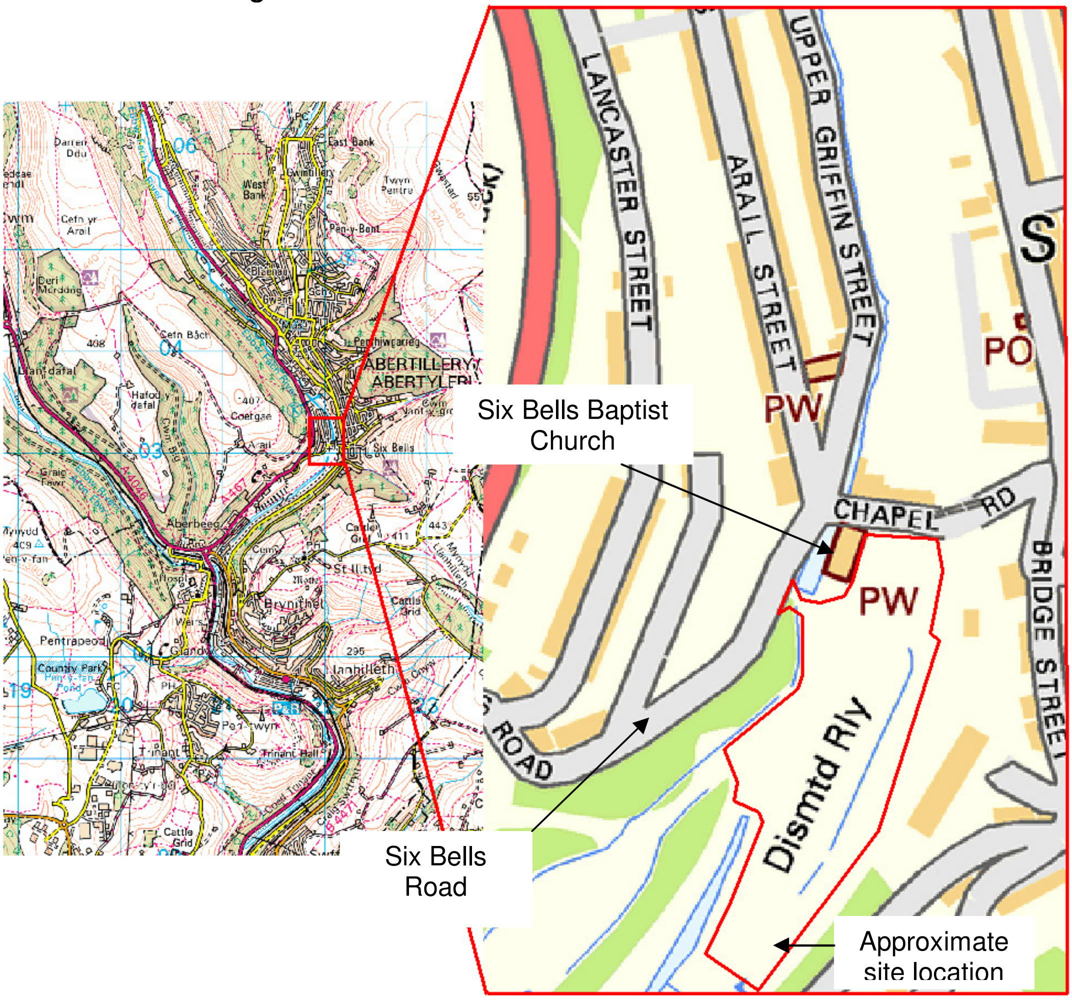
The culvert capacity assessment found that the Six Bell Culvert did not have sufficient capacity to convey extreme flood events and therefore flooding within the vicinity of the site was thought likely. Therefore more detailed hydraulic modelling was required to quantify fluvial flood risk, which is summarised within this report.

The EA holds two hydraulic models of the Ebbw Fach River within the vicinity of the site, which consists of the Abertillery and Six Bells Pre-Feasibility Modelling Study undertaken by Halcrow in 2006 and the Risca Hazard Mapping Study undertaken by JBA in 2009. These form the basis of the hydraulic modelling prepared as part of this Stage 3 SFCA.

1.3 Site Location

The Lower Plateau site at Six Bells is located near the town of Abertillery, Blaenau Gwent within part of the former Six Bells Colliery. The approximate Ordnance Survey National Grid Reference (OSNGR) for the site is SO 220 029. The site is bordered to the north by Chapel Road and the Six Bells Baptist Church. To the east are existing residential properties, which are elevated above the site. The western boundary of the site is defined by sloping ground that rises up to Six Bells Road. To the south of the site is existing open space, also associated with the former colliery. Figure 1 provides an illustration of the site location.

Figure 1: Lower Plateau, Six Bells, near Abertillery Site Location. © Crown copyright, All rights reserved. 2012. License number 0100031673.



1.4 Site Layout and Topography

The site is relatively flat and predominantly consists of undeveloped land (Plate 1 and Plate 2). To the east and west of the site, the land rises steeply. The land to the north of the site (e.g. Chapel Road and Upper Griffin Street, Figure 1) is set at a lower topographical level than the majority of the site. To the south of the site, the topography remains relatively uniform, falling in a downstream direction with the gradient of the river.

The Ebbw Fach River flows from north to south. Through the majority of its length through the site the river is conveyed via the Six Bells Culvert, which passes beneath the western boundary of the site. To the north and south of the site, the river flows as an open channel and is deeply incised with high banks (Plate 3 and Plate 4). To the north of the site, the river flows beneath Chapel Road Bridge (Plate 5 and Plate 6).

Plate 1: Six Bells site looking south from northern boundary

Plate 2: Six Bells site looking north from southern boundary

Plate 3: Ebbw Fach River River and culvert, looking downstream (south). The building on the left is the Six Bells Baptist Church

Plate 4: Ebbw Fach River River at culvert outlet, to the south of the site, looking downstream (south)

Plate 5: Ebbw Fach River River flowing beneath Chapel Road, looking upstream (north) from Chapel Road

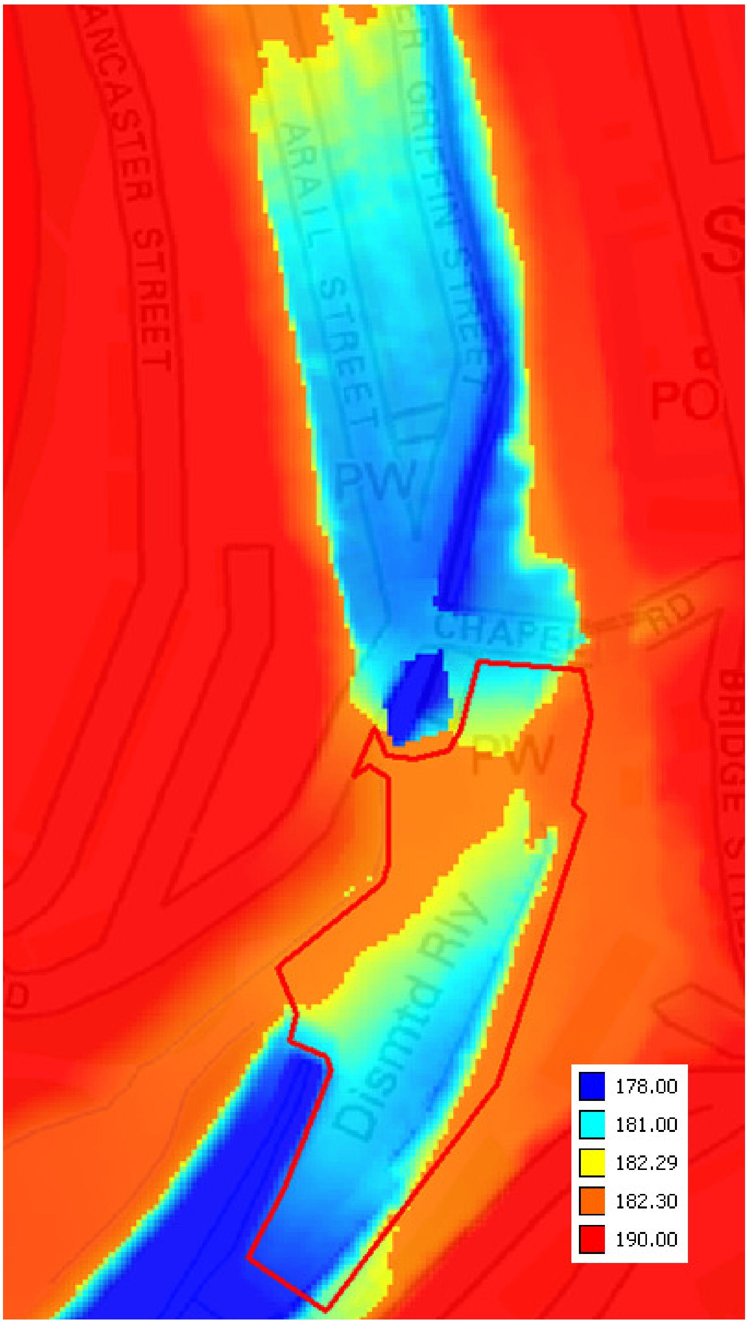
Plate 6: Ebbw Fach River River and Chapel Road bridge, looking upstream (north) from headwall of the culvert

From Chapel Road ground levels rise on both banks of the Ebbw Fach River in a downstream direction (south). On the west (right) bank, ground levels rise along Six Bells Road, up the steep valley side.

On the east (left) bank, ground levels rise from Chapel Road, at a level of between 180m AOD and 181m AOD, into the site and through an existing car park. Ground levels rise through the site to a minimum level of approximately 182.3mAOD. The topography in the vicinity of the site is shown in Figure 2.

The colour palette identifies the location of the 182.3mAOD contour, with the abrupt colour transition from yellow to orange. If flood levels do not exceed 182.3mAOD, only the northern part of the site is likely to flood, alongside Chapel Road.

Figure 2 Topography and Site Boundary. © Crown copyright, All rights reserved. 2012. License number 0100031673.



This forms a raised mass of land with its crest positioned approximately parallel to the Six Bells Culvert. This is considered to prevent the movement of floodwater in a downstream direction and will cause water to accumulate upstream.

1.5 Proposed Development

It is understood that the proposed primary school will consist of:

- A main school building;
- Various recreational pitches;
- Car parking;
- A formal access road linking to Six Bells Road.

1.6 Purpose of this Report

Hydraulic modelling has been undertaken to quantify fluvial flood risk at the site. This is intended to determine whether the Lower Plateau site at Six Bells is suitable for development of a primary school. The purpose of this report is to summarise the hydraulic modelling undertaken and present the findings. This has included:

- A review of the existing one-dimensional (1D) ISIS hydraulic models made available from the EA;
- Consideration of how the hydraulic models can be used for application to the site;
- Simulation of the 1 in 100, 1 in 100 plus climate change and 1 in 1000 year events. The hydraulic model has also been used to assess the impact of structure blockage scenarios;
- Derivation of refined Flood Zones applicable to the site to help determine whether it is suitable for the proposed development, in accordance with current guidance (Technical Advice Note 15 (TAN15) Development and Flood Risk);
- Identification of potential flood mitigation measures to increase the level of protection offered at the site, if necessary.

2 REVIEW OF EXISTING DATA

The EA Abertillery and Six Bells Pre-Feasibility Modelling Study was undertaken by Halcrow in 2006 to investigate flood alleviation measures on the Ebbw Fach River in Abertillery and Six Bells. As part of the study a 1D ISIS hydraulic model was prepared of the Ebbw Fach River. The hydraulic model extends to the southern limits of Six Bells at OSNGR SO 214 039, just downstream of the site.

A further modelling study (Risca Hazard Mapping Study) was undertaken for the EA by JBA in 2009. The upstream extent of the hydraulic model is in the region of Six Bells, and overlaps the Halcrow model.

Both hydraulic models and associated documentation were provided by the EA for review and application to this project. This included the following:

- Abertillery and Six Bells Pre-Feasibility Study Report and ISIS model;
- Watercourse topographic survey data and photographs;
- Light Detection and Ranging (LiDAR) data;
- Risca Hazard Mapping Study ISIS model.

No report or supplementary information was provided for the Risca Hazard Mapping Study.

2.1 Hydrological Review

Both of the hydraulic modelling studies include hydrological estimates of the Ebbw Fach River. However, the Abertillery and Six Bells Pre-Feasibility Report states that the lack of a suitably rated gauging station of the River Ebbw is a matter of concern. It concluded that further investigations should be carried out following monitoring and data collection in order to provide higher confidence in the recorded flows.

URS also undertook a hydrological analysis to estimate a range of flood flows for the site at Six Bells in February 2011. This hydrological assessment did not incorporate data from the gauge at Aberbeeg (NFRA Station Number 56019)[1] because it was not considered suitable for estimation of QMed (Median Flood) or Statistical Pooling. Since this assessment, the EA has completed work on improving the Stage/Discharge relationship at the gauge Aberbeeg. The results of this study were provided and included peak flow estimates for the Ebbw Fach River at Six Bells. These are summarised in Table 1.

URS has undertaken a check using the revised EA rating equation at Aberbeeg. The AMAX values for Aberbeeg were recalculated using values provided within HiFlowsUK to derive a revised QMED value, this value was then transferred using the methods described in the Kjeldsen (2010) to Six Bells. In addition, growth curve factors provided by the EA from the Statistical Pooling Group method were compared with the URS Hydrological Analysis (February 2011) and were the same up to the 1 in 100 year return period, with minor differences at flows greater than the 1 in 100 due to the method used. It is therefore considered that the flows provided by the EA are suitable for use within the hydraulic modelling.

A hydrograph shape has been derived from the ReFH methodology, using catchment descriptors.

[1] This is located in Aberbeeg approximately 5km downstream of the site.

TABLE 1: ENVIRONEMNT AGENCY FLOW ESTIMATES	
Return Period	**Peak flow (m3/s)**
QMED	13.6
25	26.4
100	36.0
1000	64.8

2.2 Hydraulic Review

Upon review of the Abertillery and Six Bells Pre-Feasibility Study Report and the ISIS model the following key information can be summarised:

- An unsteady-state 1D ISIS model was developed of the Ebbw Fach River through Abertillery and Six Bells;
- Cross sections consist of a combination of extended sections and sections trimmed to the bank top;
- The model is based on a cross-section survey undertaken on the Ebbw Fach River for the EA in October 2006 by Longdin and Browning, which was supplemented with LIDAR data used to represent the floodplain;
- The LIDAR data was flown May 2000 and March 1998 and has a spatial resolution of 2m;
- Minor tributaries have not been represented in the hydraulic model;
- Manning's values have been set to be 0.045 and 0.1. the value of 0.045 was used to represent the channel, whilst the value of 0.5 was applied to the floodplain and river banks heavily vegetated with trees;
- Bridge units were initially added to the model in the form of USBPR bridges and the water levels reached the soffit of the majority of bridges for the 1 in 100 probability of flooding events. Because the USBPR bridge modelling approach in ISIS does not model the losses particularly well when water levels rise above the soffit of the bridge the ISIS model was modified and orifice units were introduced in place of 'USBPR bridge units'. It was noted that the introduction of orifice units generally resulted in an approximate 400mm increase in water levels upstream of structures under the 1 in 100 probability event;
- Normal depth has been used as the downstream boundary condition.

It is understood that there have been no major man-made changes or improvements to the Ebbw Fach River since the construction of the model.

Approximate dimensions of cross sections and structures within the vicinity of the site were visually checked in the field and were considered to be appropriate. URS has undertaken this comparison only within the vicinity of the site, where any inaccuracies may influence the estimate of flood risk at the site. One variation was observed and is discussed within Section 3.2.5

Upon review of the Risca Hazard Mapping Study ISIS model the following key information can be summarised:

- An unsteady-state ISIS model was developed of the Ebbw Fach River;
- Cross sections consist of a combination of extended sections and sections trimmed to the bank top;
- Cross sections were imported into ISIS from a previous HEC-RAS model (River Ebbw Flood Risk Mapping Model, JBA);

- Manning's values have been set to be 0.04 and 0.06. the value of 0.04 was used to represent the channel, whilst the value of 0.06 was applied to the floodplain and river banks heavily vegetated with trees.

3 FLOOD HYDRAULIC MODELLING

3.1 Background

Section 2.2 outlines a review of the existing hydraulic modelling data provided by the EA. This has allowed the following conclusions to be made with respect to the construction of the hydraulic model for Lower Plateau site at Six Bells:

- Cross section data should be extracted from both the existing hydraulic models to form a single 1D hydraulic model of the Ebbw Fach River, for an appropriate reach in the proximity of Six Bells.
- Flood inundation within the site can only be quantified accurately through the construction of a two-dimensional (2D) hydraulic model, which should be linked to the 1D channel model of the Ebbw Fach River.

The key conclusion of this review process was the requirement to prepare a linked 1D-2D model, with the 2D element used to represent the floodplain (using TUFLOW). Consequently, an ISIS-TUFLOW hydraulic model has been constructed, which makes use of the existing ISIS hydraulic models.

The ISIS-TUFLOW hydraulic modelling has been undertaken in four stages:

1. Baseline model construction (Section 3.2);
2. Model calibration (Section 3.3);
3. Review of baseline model results (Section 3.4); and,
4. Sensitivity testing (Section 3.5).

Each stage is discussed below in turn.

3.2 Baseline Model Construction

3.2.1 *Hydrology*

Hydrological estimates have been provided by the EA and have been used as upstream boundary conditions within the ISIS-TUFLOW hydraulic model (see Section 2.1 for further details).

3.2.2 *Model Software and Approach*

ISIS is an industry standard computational (1D) hydraulic modelling package that provides a comprehensive range of methods for simulating flows and levels in open channels, structures, floodplains, reservoirs and estuaries. It can provide the 1D component of the water level within the channel and on the floodplain.

The 1D ISIS model has been linked to a 2D TUFLOW floodplain model. TUFLOW represents complex hydrodynamics of floodplain flow in two dimensions allowing a more sophisticated and reliable tool for representing inundation extent and floodplain flow paths.

The following versions of hydraulic modelling software were used during this study:

- ISIS v3.5;
- TUFLOW v2010-10-AF-w32.

3.2.3 *Topography*

Topographic survey data of the Ebbw Fach River was included within the existing ISIS hydraulic models provided by the EA. As discussed within Section 2.2, a review of the cross section and structure data within the vicinity of the site confirmed that it was appropriate for use.

Floodplain topography has been defined using LiDAR data (Light Detection and Ranging). The LiDAR data for the site has a resolution of 2m and is the best information available. The LiDAR data is an October 2009 composite of survey data and has a stated accuracy of ±150mm. Upon comparison with topographical survey this stated accuracy was considered a fair reflection. However, the LiDAR data poorly defined the ground levels in the vicinity of the Chapel Road Bridge. Accurate definition of ground levels in this area was important to allow for a good representation of the flood mechanism in the proximity of the site.

Consequently, a topographic survey was commissioned to ensure that accurate ground level data was available for Chapel Road, the site and other key areas. This is included in Appendix B.

A DTM of the topographic survey was created using MapInfo Vertical Mapper software. This was stamped onto the LiDAR data forming a composite of floodplain topography.

3.2.4 *Hydraulic Model Extent*

A cross section (model node) location plan is included in Figure 3. Cross section interpolates were included within the ISIS element of the model to improve its stability. The naming convention has been based upon the names in the original ISIS models.

Bed levels are over 12m lower at the downstream extent of the hydraulic model, compared to bed levels observed within the vicinity of the site. Therefore, the hydraulic model has been extended sufficiently far downstream to ensure that any uncertainties associated with the downstream boundary condition, do not influence the estimation of flood risk at the site.

3.2.5 *Structures*

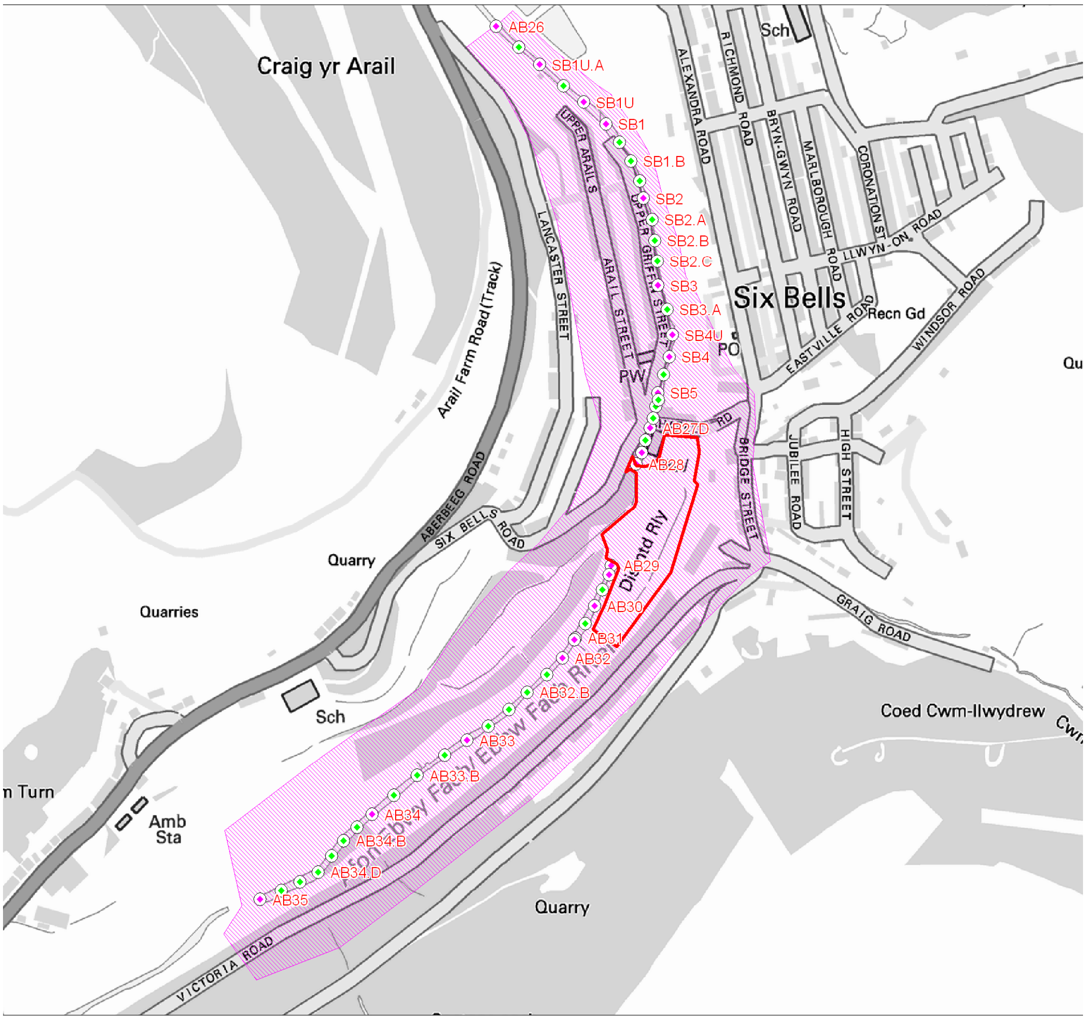
All channel structures within the model extent were represented in the ISIS element of the model and are summarised in Table 2. This incorporated one bridge, two culverts and a weir, each of which were anticipated to have an impact on local water levels, especially during flood flows.

TABLE 2: DESCRIPTION OF INLINE STRUCTURES

Location	Node	Details
Chapel Road Bridge	AB27U-1	Open span bridge
Six Bells Culvert	AB28U	Large stone faced culvert
Downstream of site	AB31spU	Weir
Downstream extent of model	AB35A	Culvert

Spill units have been incorporated at each structure, where appropriate, to allow flow to spill over the structure and onto the floodplain and/or back into the river downstream. Spill units have been incorporated into the 2D model (rather than the 1D model), within the vicinity of the site. This allows a more accurate representation of the flood mechanism and allows floodwater to spill onto the 2D surface of bridge decks etc. and potentially route onto the adjacent floodplain.

Figure 3: Cross Section (Model Node) Location Plan and 2D Model Extent (pink polygon) © Crown copyright, All rights reserved. 2012. License number 0100031673.



A culvert inspection report (Structure Inspection Report Six Bells Culvert, December 2008) was made available by BGCBC. It included measured dimensions of the Six Bells Culvert. The large culvert opening on the upstream face changes abruptly approximately 80m through the structure. The Abertillery and Six Bells Pre-Feasibility Study model allowed for a smooth transition in culvert dimension through the structure. This abrupt transition was included in the URS hydraulic model.

The Abertillery and Six Bells Pre-Feasibility Study model included orifice units in place of 'USBPR bridge units' for stability. It was noted that orifice units generally resulted in an approximate 400mm increase in water levels upstream of structures under the 1 in 100 probability event. Orifice units were retained in the URS model, where appropriate.

3.2.6 *Linking ISIS with TUFLOW*

Cross sections and spill units in the ISIS hydraulic model were trimmed to the bank-top to allow connection with 2D TUFLOW domain. The 1D ISIS node locations were then exported into MapInfo to allow linkage to the 2D TUFLOW floodplain domain, utilising CN (connection) lines and HX (head boundary with an external source) lines.

Individual reaches were also created (using HX lines) between any breaks within the ISIS hydraulic model domain (i.e. between junctions and / or structures).

A 3m grid was created for use within the 2D TUFLOW floodplain domain, which forms a representation of the floodplain topography based upon LiDAR and survey data. The extent of the 2D model is shown in Figure 3.

3.2.7 *Downstream Boundary Conditions*

The downstream boundary condition in the ISIS model was represented using normal depth. A head-time downstream boundary condition was applied in TUFLOW for the floodplain, which was based upon the upstream slope of the floodplain.

3.2.8 *Roughness Coefficient (Manning's 'n' Value)*

The roughness coefficients used in the hydraulic model are represented by Manning's 'n' values. Values of Manning's 'n' for the channel (1D) and floodplain (2D) were estimated from visual inspection of the channel and floodplain and with reference to Open Channel Hydraulics (Chow, 1973 Table 5-6). These are summarised in Table 3.

TABLE 3: MANNING 'N' VALUES

Feature (1D/2D)	Manning's 'n' Value
Channel (1D)	0.045
Buildings (2D)	0.500
Grass areas (2D)	0.045
Roads (2D)	0.020
Urban (2D)	0.065

3.2.9 *Model Run Parameters*

Default model run parameters were applied for all modelled scenarios, unless where stated in Table 4.

TABLE 4: MODEL RUN PARAMETERS

1D	
Run time	11 hours
Timestep	0.25 seconds
dflood	5
Maximum iterations	19
Spill threshold	0.05
Weight	0.01
2D	
Timestep	0.5 seconds
Hazard	Conservative
HX Additional FLC	0.3

During development of the hydraulic model, computational instabilities were experienced at the interface between the 1D and 2D elements in the vicinity of the Six Bells culvert. Following a number of internal URS reviews and modifications to the model parameters and schematisation, external assistance was requested from the Isis software developers and Tuflow software developers.

Following further reviews and analysis, it was recommended to specify the 'HX Additional FLC = 0.3' command in the Tuflow run parameters. This command essentially applies an additional head loss as water is transferred from the 1D to the 2D domain.

The use of this command is recommended where re-circulating flow patterns are experienced in the vicinity of the 1D-2D interface. It is a similar stability fix to applying an increased roughness co-efficient along the extent of the river banks, which is often standard practice when modelling complex topography that is challenging to represent using conventional modelling techniques.

Some minor instabilities were also experienced at the start and end of model simulations, as the channel was drying out in various places during these periods of low flow. In order to prevent this form occurring a minimum baseflow of $10m^3/s$ was specified within the hydrological inflow boundaries. As the peak flood levels in the vicinity of the site are dominated by the conveyance of key structures located adjacent to the site, an increased baseflow at the start and end of the model runs it not considered to be significant.

The run parameters which have specified in order to produce a stabilised model are considered to be appropriate, based on expert guidance sought from in house specialists in addition to the Isis and Tuflow software developers. In order to provide additional confidence in the model outputs and quantify the potential accuracy of estimated flood levels, rigorous sensitivity testing has been completed as discussed in section 3.5.

3.2.10 *Model Runs*

The baseline model was run for the following scenarios:

- 1 in 100 year event;
- 1 in 100 year plus 20% for climate change event;
- 1 in 1000 year event;
- 1 in 100 year plus 20% climate change event (50% blockage of Six Bells Culvert).

It has been agreed with the EA that the 1 in 100 year plus 20% climate change event (50% Six Bells Culvert Blockage) will be used to demonstrate TAN 15 requirements. Therefore, to add confidence to the modelled outputs additional model runs of this scenario have been undertaken as part of the sensitivity analysis (see Section 3.5).

3.3 Review of Baseline Model Results

This section presents the results of the four scenarios identified above. Flood depth, level and hazard maps are included in Appendix C.

3.3.1 *Flood Mechanism - 1 in 100 Year Event*

Marginal flooding is observed within the model reach during this event, which is a result of a low level left bank of the Ebbw Fach River upstream of Chapel Road. Floodwater is contained to the riparian area beside the river.

3.3.2 *Flood Mechanism - 1 in 100 Year + Climate Change Event*

With the addition of climate change a relatively large backwater affect is observed associated with the conveyance restriction of the Chapel Road Bridge and the Six Bells Culvert. Peak water levels exceed the soffit level of both the Chapel Road Bridge and the Six Bells Culvert.

Additional floodwater spills over the left bank of the Ebbw Fach River, which flows downstream and inundates Chapel Road. Inundation is increased by floodwater spilling out of the Ebbw Fach River onto the deck of the Chapel Road Bridge.

Floodwater accumulates within the low lying land to the north of the site, including parts of the Upper Griffin Street and Arail Street. Peak water levels observed were approximately 180 m AOD and were not sufficient to affect the site.

3.3.3 *Flood Mechanism - 1 in 1000 Year Event*

The 1 in 1000 year event results in significant flood inundation, with a significant backwater affect from the Six Bells Culvert observed. Floodwater overtops the wall that runs along the right bank of the Ebbw Fach River upstream of Chapel Road spilling onto the floodplain.

Flood inundation accumulates upstream of the site, which rises and floods the existing car park located within the northern part of the site. As flooding continues to accumulate, it creeps south further into the site. This is contained by the raised ground levels, as discussed in Section 1.4 and floodwater only affects the northern portion of the site. Eventually, flood levels become sufficient to spill south and into the wider site. However, flooding is limited to the lower parts of the site, adjacent to the eastern boundary, which forms a conveyance route through the site under this extreme event. Sufficient flooding is not observed for the flow path to route through the entire length of the site, instead floodwater is stored within the low spot, rather than flowing back into the Ebbw Fach River.

3.3.4 *Flood Mechanism - 1 in 100 Year + Climate Change Event (50% Six Bells Culvert Blockage)*

The 1 in 100 year plus climate change event with 50% blockage at the Six Bells Culvert results in significant flood inundation to the north of the site, with a significant backwater affect from the Six Bells Culvert observed. Floodwater overtops the wall that runs along the right bank of the Ebbw Fach River upstream of Chapel Road spilling onto the floodplain.

As during the 1000 year event flood water accumulates upstream of the site, which rises and floods the existing car park located within the northern part of the site. However, floodwater is contained onsite by the raised ground levels, as discussed in Section 1.4 and therefore floodwater only affects the northern portion of the site.

3.4 Model Calibration

The EA has provided a historic flood level of 179.03 m AOD at Chapel Road Bridge for an event in 1979. It is noted that there is no date or time provided for this level and EA notes state that debris (trees) within the channel were affecting the recorded water level. Analysis of the peak flow at the Aberbeeg gauge in 1979 with return period flow estimates using the growth curve factors applied to Aberbeeg indicates that this event was between a 1 in 5 year and 1 in 10 year flood. However, reliance on one observed level, which is affected by an unknown quantity from a tree blockage, restricts application of the observed data for calibration purposes.

The 1 in 10 year return period event was run within the hydraulic model with a 50% blockage scenario at the inlet to the Chapel Road Bridge (i.e. the same location where the observed level was taken). This was intended to simulate the 1979 event to determine how well the hydraulic model was performing, in comparison to observed data.

Peak water levels at the Chapel Road Bridge in the hydraulic model were 179.14 m AOD, which compared very well with the observed level (179.03 m AOD). This suggested that the hydraulic modelling is performing well. However, numerous uncertainties exist with the observed water level and it should be noted that this does not constitute a calibration exercise.

3.5 Sensitivity Testing and Blockage Analysis

Due to a lack of gauged data or anecdotal evidence, it was determined that a series of sensitivity analyses should be undertaken on the baseline model. The 1 in 100 year plus climate change event with 50% blockage at the Six Bells Culvert forms the key (baseline) scenario tested as part of the sensitivity analysis.

Sensitivity testing has been undertaken on the hydraulic model to assess the impact of altering key parameters within the model and observing the change in output. This provides an indication of the robustness of the hydraulic model.

The following key parameters were adjusted as part of the sensitivity testing:

- Upstream inflow boundary condition;
- Manning's 'n' roughness coefficients;
- Weir coefficients.

All of the model runs were variations of the baseline model using the 1 in 100 year plus climate change event with 50% blockage at the Six Bells Culvert.

In addition to the above, further blockage scenarios of the hydraulic structures have been undertaken to test the impact upon the likely flood extents. The removal of existing buildings from the floodplain, which may offer protection, has also been modelled.

Table 5 identifies a series of nodes that were used to compare the resulting peak water levels for each model run. The nodes selected are representative of the model reach, the locations of which are illustrated in Figure 3.

TABLE 5: KEY NODES USED TO COMPARE WATER LEVELS	
1D	
SB1	Upstream extent of Upper Griffin Street
SB3	Mid-section of Upper Griffin Street
SB5	25m upstream of Chapel Road Bridge
AB27U	Upstream face of Chapel Road Bridge
AB28	Upstream face of Six Bells Culvert
AB30	50m downstream of Six Bells Culvert outlet
AB33	260m downstream of Six Bells Culvert outlet
AB35	Downstream extent of 2D model

Where peak water levels deviate by more than 0.20m from the corresponding 1 in 100 year event peak water level, the particular peak water level in the table has been highlighted with a bold font. This has been undertaken for each of the sensitivity tests and helps to identify the more sensitive nodes and aids comparison of individual sensitivity tests.

3.5.1 *Upstream Boundary Condition (Inflows)*

Inflow sensitivity has been tested by running the hydraulic model with a ±20% change in flow throughout the duration of the hydrograph. A summary of the results of the sensitivity analysis for inflow is presented in Table 6.

Table 6 indicates that the ±20% change in flow sensitivity scenarios result in a change in peak water level by ± 1m where compared to the baseline scenario in the vicinity of the two hydraulic structures (i.e. Chapel Road Bridge and the Six Bells Culvert).

The +20% flow on the 100 year climate change event (which already includes 20% flow increase for climate change), would result in a flood extent similar to the 1000 year event, shown in Appendix C. Therefore, the northern portion of the site would be inundated with floodwaters and a narrow flow path would extend the entire length of the site.

TABLE 6: MODEL INFLOW SENSITIVITY TESTING RESULTS			
Node/Cross Section	**Q100CC+50% Blockage (AB28) Flow Water Level (mAOD)**	**Q100CC+50% Blockage (AB28) +20% Flow Flood Level (mAOD)**	**Q100CC+50% Blockage (AB28) -20% Flow Flood Level (mAOD)**
SB1	183.69	183.87	**183.49**
SB3	181.56	**182.66**	**180.65**
SB5	181.60	**182.65**	**180.25**
AB27U	181.63	**182.72**	**180.19**
AB28	181.44	**182.59**	**179.77**
AB30	176.46	176.58	**176.26**
AB33	170.65	170.77	170.52
AB35	167.44	**167.75**	**167.08**

3.5.2 *Roughness Coefficient (Manning's 'n' Value)*

Channel and floodplain roughness sensitivity has been tested by running the hydraulic model with ±20% Manning's 'n' value. The impact observed on peak water level as a result of the varying Manning's 'n' values are shown in Table 7.

Table 7 indicates that a 20% increase in the roughness coefficient has a relatively minor impact on peak water levels where compared to the 1 in 100 year plus climate change event with 50% blockage at the Six Bells Culvert scenario.

A 20% reduction in the roughness coefficient results in a peak water level reduction of approximately 0.4m, which is most notably observed upstream of the Chapel Road Bridge and to a slightly lesser extent upstream of the Six Bells Culvert. The impact upon floodplain inundation is limited and no flooding of the site is observed.

TABLE 7: MANNING'S 'N' VALUES SENSITIVITY TESTING RESULTS

Node/Cross Section	Q100CC+50% Blockage (AB28) Flow Water Level (mAOD)	Q100CC+50% Blockage (AB28) +20% Manning's Flood Level (mAOD)	Q100CC+50% Blockage (AB28) -20% Manning's Flood Level (mAOD)
SB1	183.69	183.87	**183.49**
SB3	181.56	181.68	**181.15**
SB5	181.60	181.65	**181.19**
AB27U	181.63	181.67	**181.23**
AB28	181.44	181.55	**181.10**
AB30	176.46	176.57	176.31
AB33	170.65	170.78	170.49
AB35	167.44	**167.66**	**167.14**

3.5.3 *Spill and Weir Coefficients*

Spill and weir coefficient sensitivity has been tested by running the hydraulic model with ±20% of the value used in the 1D model. The impact observed on peak water level as a result of the varying coefficient values are shown in Table 8.

The typical change in peak water level compared to the 1 in 100 year event is less than ±0.20m for both sensitivity tests, which is illustrated by the entirety of non-bold cells. Therefore the hydraulic model is not considered to be sensitive to spill coefficient values.

TABLE 8: COEFFICIENT VALUE SENSITIVITY TESTING RESULTS

Node/Cross Section	Q100CC+50% Blockage (AB28) Flow Water Level (mAOD)	Q100CC+50% Blockage (AB28) +20% Coefficients Flood Level (mAOD)	Q100CC+50% Blockage (AB28) -20% Coefficients Flood Level (mAOD)
SB1	183.69	183.69	183.69
SB3	181.56	181.44	181.45
SB5	181.60	181.42	181.43
AB27U	181.63	181.45	181.46
AB28	181.44	181.32	181.33
AB30	176.46	176.42	176.49
AB33	170.65	170.65	170.65
AB35	167.44	167.38	167.47

3.5.4 *Blockages*

In addition to the 50% blockage at the Six Bells Culvert used for the 100 year plus climate change sensitivity analysis, further blockage analyses of other hydraulic structures on the Ebbw Fach River have been undertaken. Hydraulic structures may potentially become blocked with debris and increase the backwater effect, thus reducing the channel conveyance capacity. This will cause increasing water levels upstream of the particular structure.

As with the blockage at the Six Bells Culvert, blockage nodes were included in the model schematic to mimic a 50% blockage scenario at the Chapel Road Bridge during the 100 year plus climate change event.

A comparison of water levels during a blockage at each of these structures with the 100 year plus climate change event (no blockage scenario) is provided in Table 9. Each potential blockage was modelled independently to consider the impact of the blockage in isolation.

TABLE 9: SENSITIVITY TESTING 50% STRUCTURE BLOCKAGE SCENARIOS

Node/Cross Section	Q100CC Flow Water Level (mAOD)	95% Blockage (AB27U) Flow Water Level (mAOD)	95% Blockage (AB28) Flow Water Level (mAOD)
SB1	183.69	183.69	183.69
SB3	180.80	**181.13**	**181.56**
SB5	180.03	**181.07**	**181.60**
AB27U	179.87	**181.15**	**181.63**
AB28	179.67	179.68	**181.44**
AB30	176.52	176.54	176.46
AB33	170.69	170.70	170.65
AB35	167.55	167.58	167.44

All of the blockage scenarios result in a rise in maximum flood level upstream, causing increased floodwater to spill out of bank onto the floodplain. The impact of the 50% blockage scenario is relatively localised, especially at the Chapel Road Bridge (AB27U). This is shown in Table 9, with only three nodes experiencing a change in peak water level of over 0.2m. These nodes are located directly upstream of the structure. Peak water levels downstream of Chapel Road Bridge are similar to the no blockage scenario.

The impact of the 50% blockage scenario at the Six Bells Culvert (AB28) results in an increase in water levels, greater than 1.5m, immediately upstream of the culvert. The flooding mechanism for this event is described in Section 3.3.4 with mapping output provided in Appendix C.

A comparison of water levels during the 95% blockage scenario at the Six Bells Culvert (AB28) and at the Chapel Road Bridge (AB27U) during the present day 100 year event is provided in Table 10. The present day 100 year event no blockage scenario is also provided. Again each potential blockage was modelled independently to consider the impact of the blockage in isolation.

TABLE 10: SENSITIVITY TESTING 95% STRUCTURE BLOCKAGE SCENARIOS			
Node/Cross Section	**Q100 Flow Water Level (mAOD)**	**95% Blockage (AB27U) Flow Water Level (mAOD)**	**95% Blockage (AB28) Flow Water Level (mAOD)**
SB1	183.53	183.53	183.57
SB3	180.63	181.46	183.22
SB5	179.24	181.44	183.22
AB27U	178.97	181.52	183.25
AB28	178.77	178.72	183.21
AB30	177.30	177.32	176.96
AB33	170.57	170.58	170.53
AB35	167.21	167.24	167.12

The 95% blockage scenario prevents almost any flow passing through the associated structure. Whilst at node AB27U (Chapel Road Bridge) peak water levels are significantly higher than compared to the 50% blockage scenario, the 2D model does not suggest a significant impact upon the extent of floodplain inundation. This is because floodwater spills over Chapel Road and back into the river downstream, over the road surface.

However, the 95% blockage scenario of the Six Bells Culvert (AB28), almost entirely removes the pathway of floodwater within the channel. Floodwater can only spill back into the river downstream of the site. Similar to that experienced in the 1 in 1000 year event, floodwater accumulates upstream of the culvert. Peak water levels upstream of the culvert are over 4m greater than under the corresponding baseline conditions, as shown in Table 10. Floodwater accumulates to a level sufficient to spill through the site. With only a minor discharge allowed to pass through the culvert the majority of flow from the Ebbw Fach River accumulates upstream or passes through the site. Consequently, the 95% blockage scenario results in the most onerous conditions observed within the site, exceeding that experienced under the 1 in 1000 year event.

Maximum flood depths of over 1.2m are experienced within the lower portion of the site, towards the east site boundary. This is exacerbated by the depth of the ditch present in this location. Towards the centre of the site, flood depths are typically 0.3m.

3.5.5 *Undefended Scenarios*

Undefended scenarios for the present day 1 in 100 year and 1 in 1000 year events have been undertaken to identify whether the existing building on the left bank immediately upstream of Chapel Road Bridge (AB27U) offers protection to the site during a flood event.

This building has been removed from the 1D domain by lowering the left bank in the ISIS model from approximately 185m AOD to 179m AOD. In the 2D domain the building was removed using the ZSHP function within TUFLOW.

The Six Bell Baptist Church, located on the left bank, immediately downstream of Chapel Road Bridge, has also been removed from the 2D domain using the ZSHP function within TUFLOW.

Flood mapping shown in Appendix C indicates that flood extents for these undefended scenarios are similar to flood extents with the building in place. This suggests that the existing buildings offer no significant protection to the site.

3.5.6 *Summary*

The sensitivity analysis indicates that an additional 20% increase in flow on the 1 in 100 year plus climate change event (which already includes a 20% flow increase for climate change) and 50% blockage at the Six Bells Culvert will flood the site to a similar extent as the present day 1 in 1000 year flood extent. However, this particular sensitivity analysis is considered to be extremely precautionary and unreasonable to be the basis of any TAN 15 requirements.

The hydraulic model has not been found to be particularly sensitive to changing the other key parameters, such as the roughness coefficients and weir coefficients. None of these scenarios resulted in flooding of the site under the 1 in 100 year including climate change event with a 50% blockage. The 100 year event 95% blockage scenario resulted in the majority of the site becoming inundated with floodwater.

Flood mapping shown in Appendix C indicates that flood extents for these undefended scenarios are similar to flood extents with the building in place. This suggests that the existing buildings offer no significant protection to the site.

4 DISCUSSION

4.1 Position of Six Bells Culvert

The EA has recommended that all buildings should be located outside the zone of influence of the Six Bells Culvert. No buildings should be situated on the ground surface within the 45 degree zone either side of the outer walls of the culvert and taken upwards to the surface from its invert level. The EA also stated that if buildings are located within the zone of influence (not over/above the culvert) the foundations will need to be taken down below the invert of the culvert.

At this time, the precise position of the culvert is unknown. However, the position can be defined approximately through consideration of the inlet and outlet structure. This has been identified on Figure 4, shown by blue lines representing the outer edge of the culvert. It also includes an additional 5m buffer zone, to account for any uncertainty. The 1 in 1000 year flood extent is also included in Figure 4.

4.2 Flood Risk

Hydraulic modelling of the Ebbw Fach River has demonstrated that the Lower Plateau site at Six Bells does not flood under the 1 in 100 year or 1 in 100 year plus climate change event.

It has been agreed with the EA that the 100 year plus climate change event with 50% blockage at the Six Bells Culvert will be used to demonstrate TAN15 requirements. This scenario indicates that with the exception of the northern portion of the site, the site is located outside of this flood extent. Where considering the sensitivity scenarios modelled the site does not flood, except when increasing the flow by 20% (similar to the 1 in 1000 year extent) and the 95% blockage scenario of the Six Bells Culvert (see Section 4.3).

Under the 1 in 1000 year event sufficient floodwater accumulates in the proximity of Chapel Road, to inundate the northern part of the site and eventually spills south into the wider site, although it remains contained within a low lying narrow strip of land that runs the entire site.

Development of the site does not conflict with the recommendations outlined in TAN15, which suggests that development should be designed to be flood free during the 1 in 100 year fluvial event.

Policy requirements outlined in TAN15 do not generally permit the construction of more vulnerable development, which includes schools, in Flood Zone C2. However, the hydraulic modelling effectively refines the EA Flood Zones currently available for the site. Development of the new school can be steered out of the inundated area. It is recommended that this inundated area is formalised to form a more controlled pathway of floodwater through the site. This could increase the land available for development and is discussed in more detail in Section 4.4.

A new site entrance is proposed adjoining Six Bells Road, which will allow a dry and safe means on evacuation from the site, if required.

Figure 4: Six Bells Culvert Buffer Zone and 1 in 1000 year Flood Extent © Crown copyright, All rights reserved. 2012. License number 0100031673.

4.3 Residual Flood Risk – Culvert Blockage

The hydraulic model was not found to be particularly sensitive to changing parameters as part of the sensitivity analysis, except the Six Bells Culvert 95% blockage scenario.

A major blockage of the culvert would be required to result in flooding of the site under the 1 in 100 year event. A blockage ratio greater than 50% would be required. Under the 95% blockage scenario, the majority of the site experiences flooding, with overtopping of the culvert headwall observed.

It is considered extremely unlikely that the Six Bells Culvert would experience almost complete blockage conditions. The culvert opening has a large surface area, over 5m wide at its base. There are also various structures upstream that would effectively act as screens and filter flood debris from the channel. Inspections are made by BGCBC during possible flood conditions and attempts made to remove any debris blocking bridges and culverts. However, the Six Bells Culvert is not included in the inspection programme, which suggests that it is not a problem structure. Nevertheless, major blockage conditions cannot or should not be ruled out and appropriate mitigation measures should be identified or precautionary steps should be in place to protect the site from this scenario, if it were to occur.

4.4 Recommendations

Hydraulic modelling has demonstrated that the site is appropriate for development of a primary school, however a number of recommendations can be identified which will ensure that the school can be constructed in a safer and more sustainable manner. These are identified below:

- A survey should be undertaken to determine an accurate alignment of the Six Bells Culvert. This may allow more space for development, rather than prescription of a conservative buffer zone;
- All built development should be steered out of the floodplain, where possible. Therefore, development should be avoided in the northern and eastern portion of the site, as shown to be affected by the 1 in 1000 year event;
- The flow path identified through the site under the 1 in 1000 year event is relatively well defined. However, it is recommended that this is formalised by re-contouring ground levels to control flow through the site, in a swale like feature;

- Recreational areas or landscaping is considered to be appropriate in the 1 in 1000 year flood extent. However, car parking should be avoided in this area where possible;
- In order to protect the school building from the unlikely event that the Six Bells Culvert becomes entirely blocked, it should be designed using flood resilient construction techniques, or the overland flow pathway should be designed to accommodate larger flows associated with culvert blockage conditions.
- A Flood Consequence Assessment (FCA) should be undertaken for the site, which would be required as part of the planning application. This should investigate further detail with respect to the mitigation measures identified above, which should be achieved without increasing flood risk to third parties. This can be tested within the existing 1D-2D hydraulic model.
- As part of the FCA, the proposed site layout plan should be designed in a way to mitigate any detrimental impact upon flood risk, in accordance with TAN15. The position, extent and shape of the development should be defined on the basis of fluvial flood risk, as identified through the hydraulic modelling.

5 CONCLUSIONS

The proposed Lower Plateau site at Six Bells Colliery is included within the LDP for a new primary school.

According to current Environment Agency flood zone mapping, the site is located within Flood Zone 3 (potentially at risk during a 1 in 100 year event) and Flood Zone 2 (potentially at risk during a 1 in 1000 year event), associated with fluvial flooding from the Ebbw Fach River.

Hydraulic modelling has been undertaken as part of this Stage 3 SFCA to refine the EA Flood Zones available for the site. This is intended to determine whether the site is suitable for development of a primary school.

As part of this Stage 3 SFCA the following conclusions have been made:

- Updated hydraulic modelling undertaken in support of this Stage 3 SFCA shows that the site does not flood under the 1 in 100 year or 1 in 100 year plus climate change event. However, partial flooding of the site is observed under the 1 in 1000 year event;
- Updated hydraulic modelling undertaken in support of this Stage 3 SFCA shows that the local topography prevents the site from flooding under the 1 in 100 year and or 1 in 100 year plus climate change event, which results in preferential flooding to areas north (upstream) of the site;
- It has been agreed with the EA that the 100 year plus climate change event with 50% blockage at the Six Bells Culvert will be used to demonstrate TAN 15 requirements. This scenario indicates that with the exception of the northern portion of the site, the site is located outside of this flood extent;
- The hydraulic model was found to be sensitive to a 20% increase in flow during the 100 year plus climate change event with 50% blockage at the Six Bells Culvert. This sensitivity scenario resulted in a flood extent similar to the 1000 year extent affecting the northern part of the site and the low lying narrow strip of land across the site;
- The hydraulic model was not found to be sensitive to varying other key parameters. However, a 95% blockage scenario of the Six bells Culvert resulted in significant flooding at the site under the 1 in 100 year event;
- The hydraulic modelling has allowed new Flood Zones to be derived which should be used as part of the evaluation of flood risk at the site. Updated hydraulic modelling undertaken in support of this Stage 3 SFCA shows the site is partially located within Flood Zone 2. However, the majority of the site is located within Flood Zone 1;
- The majority of the site is located in Flood Zone 1 and is considered to be appropriate for the development of the primary school. However, various recommendations have been made which should be considered as part of a site-specific FCA, required as part of the planning application.

APPENDIX A – ENVIRONMENT AGENCY CORRESPONDENCE

Patrick Goodey
Scott Wilson
The Crescent Centre
Temple Back
Bristol
BS1 6EZ

Ein cyf/Our ref: SE/2007/102989/OR-03/AE1-L01
Eich cyf/Your ref:

Dyddiad/Date: 17 December 2010

Dear Mr Goodey

Blaenau Gwent County Borough Council Strategic Flood Consequences Assessment Stage 2

Thank you for sending us the following document for review, which we received on 15 November 2010:

- Blaenau Gwent County Borough Council. Strategic Flood Consequence Assessment Stage 2, Scott Wilson, September 2010 (DRAFT)

We have now reviewed the Stage 2 SFCA and we provide the following advice:

Section 1 Introduction

We note that following your Stage 1 SFCA, a screening exercise has now been undertaken of various candidate sites identified by Blaenau Gwent CBC as part of their emerging LDP for spatial planning purposes. This has resulted in you including nine candidate sites in this Stage 2 SFCA.

Section 2 Study area

We note that in paragraph 2.1.3 you state that the Castle Street, Abertillery has been removed from the LDP process and that the site will not be assessed as part of the Stage 2 report. However, we note that paragraph 5.1.1 in your Summary lists Castle Street, Abertillery as being a site that requires further investigation. Given that this site has been removed from the LDP process, we assume that its inclusion in paragraph 5.1.1 is in error. Furthermore, Roseheyworth Business Park is included in paragraph 2.1.1, but does not feature in paragraph 5.1.1. You may wish to clarify or amend this.

Assuming the above, we note the majority of candidate sites assessed are situated within Zone A/Flood Zone 1 apart from:

• Lower Plateau, Six Bells Colliery Site, Lower Ebbw Fach

This sites has been identified to require further study for the Stage 3 SFCA, with the 9 remaining sites, if allocated, requiring varying levels of site specific FCAs. This approach appears a reasonable way forward.

Section 3 Methodology

Section 3.2 You should amend this heading to state "Areas Susceptible to Surface Water Flooding " (not management).

We note that you have used our Areas Susceptible to Surface Water Flooding (AStSWF) maps to consider the risk of flooding from surface water (paragraph 3.2.1). Please be aware we recently sent all Local Authorities our Surface Water Flooding Maps, which supplement the AStSWF maps. You may wish to consider these Surface Water Flooding maps in any future SFCA stages.

We also seek clarification on whether you have sought information from Blaenau Gwent's drainage engineers. The Local Authority may have additional information on surface water flooding, which the SFCA should consider. You should explain whether you have done this (or why it has been omitted) in your Methodology.

Section 4 Candidate Site Assessment

We note the approach you have taken, and agree that it seems sensible for site specific FCAs to be undertaken for the sites you have suggested.

Section 4.8 North Rising Sun Industrial Estate: We note that the potential access to this site lies within Flood Zones 2 and 3. The SFCA may wish to flag up that any future FCA should consider whether operation access/ egress to the site can be achieved during a flood event.

Section 4.8 Lower Plateau, Six Bells Colliery : We agree that it is appropriate to undertake a Stage 3 SFCA for the Six Bells Colliery Site. We note how a culvert runs under this site. It appears likely that the culvert would convey much of the flow in the event of a flood event. Hence, mitigation for the flood risk appears likely to be possible.

We would be happy to discuss further with you the scope of the Stage 3 SFCA for this site. It may be possible to assess the flood risk without hydraulic modelling, as you may be able to do a coarse assessment of the flood risk, without the need for modelling. Whether this method is appropriate is partially dependent on the size of the culvert. We also advise that your Stage 3 SFCA assess whether mitigation in the form of opening up the culvert would be possible to create a more natural watercourse. It may be that this is not possible, due to the depth of the culvert underground, but we advise that the SFCA should explore the possibility. We would be pleased to provide further advice on the scope of the Stage 3 SFCA further with you; please contact us, should you wish to do so.

Section 5 Summary

We advise that you remove the reference to Castle Street, Abertillery to the list in paragraph 5.1.1 and include Roseheyworth Business Park, as discussed above.

Cont/d..

Additional issues: Compliance with tender brief

Your tender brief (dated December 2009) set out the points to be covered by the Stage 2 SFCA in paragraphs 3.1.2 and 3.2.5. It may be useful to ensure to state how the SFCA has addressed these points, and if it has not, give explanation for this. With reference to paragraph 3.1.2 of your Tender Brief, we seek clarity on how the SFCA has addressed the following points (in italics):

- *Assess the residual risk posed to potential sites following failure, breach or overtopping of flood management measures and identify areas within the relevant sites deemed to be at lowest residual risk of flooding:* The SFCA does not appear to have done this; we advise that you assess this, as it was included in your Tender Brief. If it is omitted because the certain sites are not defended, then the SFCA should explain this.

- *Provide appropriate outline guidance on flood risk management techniques, including the use of sustainable drainage methods and the indicative costs associated with the construction and maintenance of the proposed management technique:*   While we note that the Key Information tables associated with each site includes a brief description of the mitigation measures required, which sometimes includes the appropriate use of surface water management techniques, the SFCA does not appear to have provided guidance on the indicative costs of these. We advise that you include this in your SFCA, or explain why it cannot be done.

- *Identify the need for and the type of policies required as part of the LDP (where appropriate):* While we note that the SFCA has given guidance on how future FCAs should be undertaken to inform developments, the SFCA does not appear to have included any advice on the policies required in the LDP. We advise that the SFCA should do this, or justify why it has not done so.

Should you have any queries on the above, please do not hesitate to get in contact.

Yours sincerely

Kayna Tregay
Planning Liaison Officer

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Ffacs uniongyrchol/Direct fax 02920 362920
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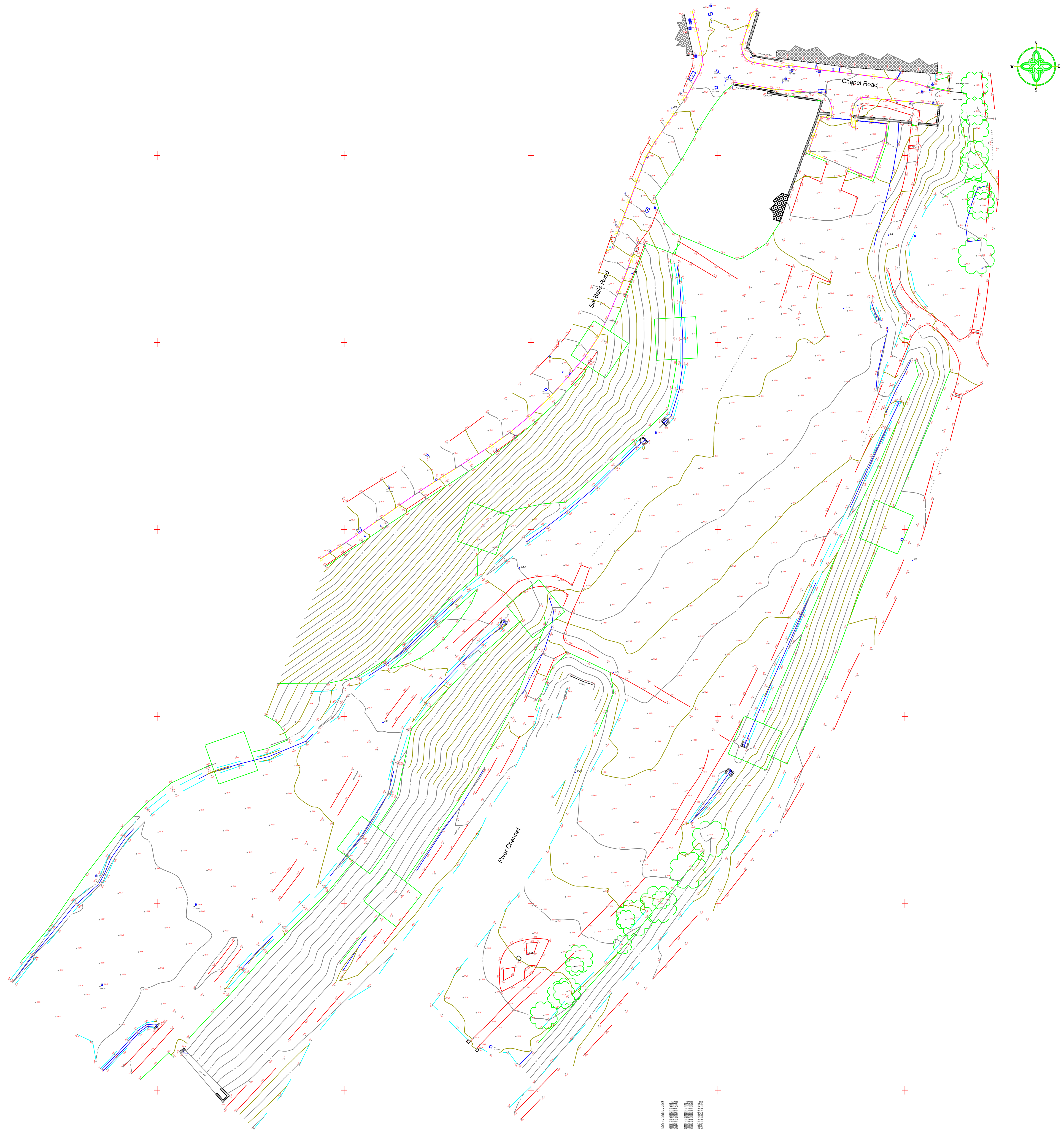
End

APPENDIX B – TOPOGRAPHIC SURVEY



Stn	Eastings	Northings	Level
J01	322027.061	203018.494	185.194
J02	322101.475	203005.856	184.150
J03	322120.657	203019.921	184.948
J04	322022.106	202911.646	180.861
J05	321960.435	202898.398	184.948
J06	322095.622	203028.696	183.258
J08	322101.986	202941.666	183.827
J09	322037.675	203062.722	180.664
J10	321995.707	202975.122	190.020
J11	322058.821	203076.308	179.921
J12	322087.402	203063.442	180.364
J13	322064.868	202868.943	182.946

2D Data

John I Jones
Land & Mineral Surveyors
27a Well Place, Cwmbach,
Aberdare, Mid Glamorgan,
CF44 0PB.
Tel.01685 876014, Fax 01685 879174
E.Mail johnijones@btinternet.com

TOPOGRAPHICAL SURVEY AT 6 BELLS ABERTILLERY

Scale:- 1/200 | Date:- November 11 | D.N. BG/6B/1

Grid	Local	O.S.
		⊗
Level	Local	O.S.
		⊗

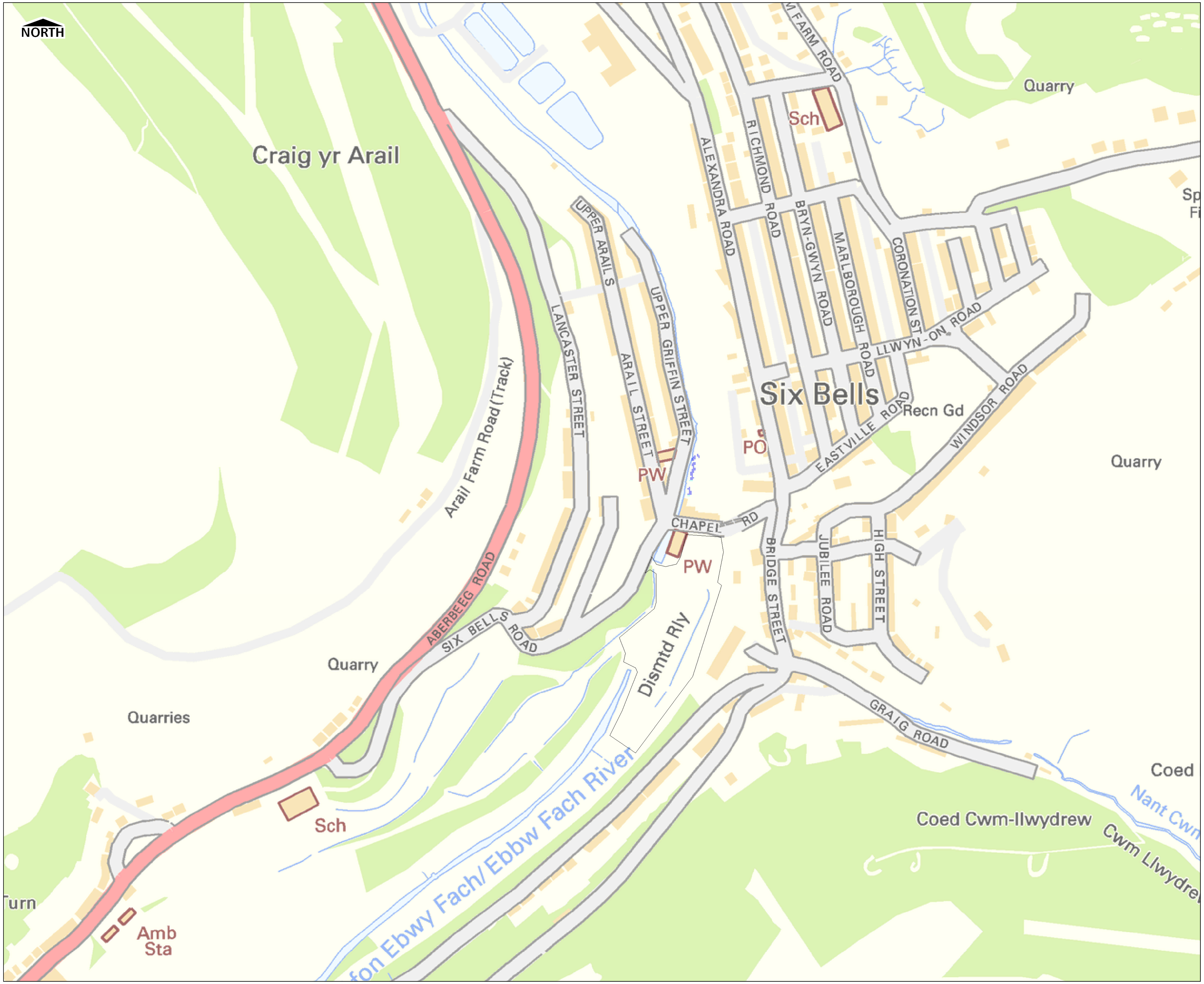
Revision	Date	By

Only visible and accessible features have been surveyed. Some detail may be obscured by parked vehicles etc..

Ref. No. 6B/1

Levels obtained by GPS observations related to Ordnance Survey National Grid And Level Datum OSGB(02)

APPENDIX C – URS FLOOD MAPS



KEY

Site Boundary

Maximum Flood Depth [m]

- 0.01m
- 0.50m
- 1.00m
- 1.50m
- 2.00m and greater

TECHNICAL NOTE
Hydraulic modelling has been undertaken using 1D-2D hydraulic modelling software (ISIS-TUFLOW), to quantify fluvial flood risk.

Hydraulic modelling has been based upon the best available data, as outlined in the report. Uncertainties exist and the flood depth, level or hazard identified is an approximation based upon data available.

FLOODABLE AREAS NOT SHOWN

Areas susceptible to drainage system inadequacies or localised ponding. Areas flooded due to debris blockage unless shown for specific structures. Please note that floodwater within the channel is not included in the maps.

DRAWN BY	CHECKED BY	DATE
NB		MAY 2012

SCALE @ A3	ISSUING OFFICE
1 : 40,000	Bristol

SIX BELLS, ABERTILLERY - STAGE 3 SFCA

MAXIMUM FLOOD DEPTH
1 in 100 YR (1% AEP)

Cyngor Bwrdeistref Sirol Blaenau Gwent County Borough Council

URS Infrastructure & Environment Ltd
The Crescent Centre, Temple Back
Bristol, BS1 6EZ
Tel: +44 (0)117 917 1200

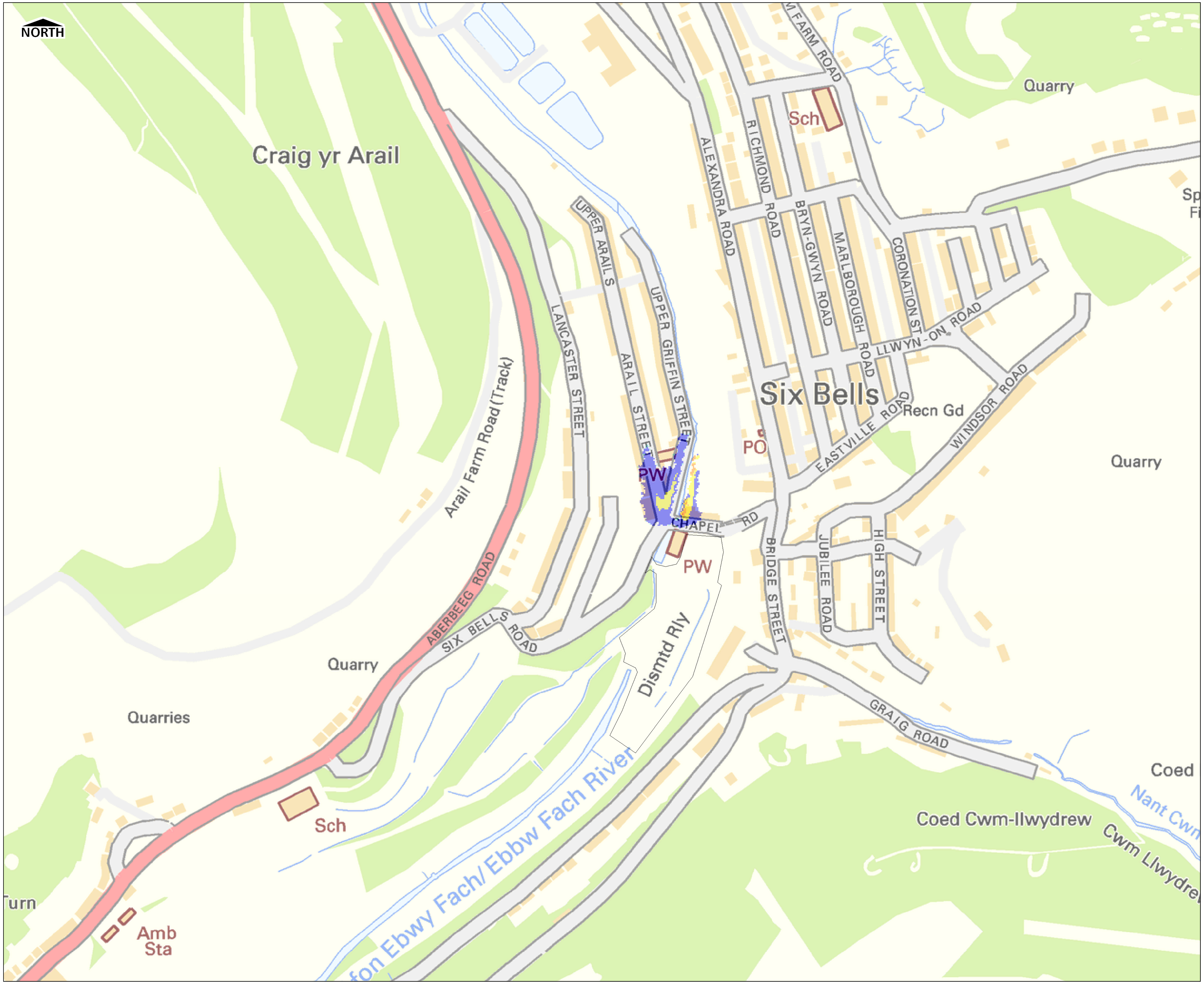
URS

DRAWING NUMBER

FIGURE A

REV 02

N:\Current Projects\4XXXXXXX Standard File Structure\06 GIS\WOR



KEY

Site Boundary

Maximum Flood Depth [m]

- 0.01m
- 0.50m
- 1.00m
- 1.50m
- 2.00m and greater

TECHNICAL NOTE
Hydraulic modelling has been undertaken using 1D-2D hydraulic modelling software (ISIS-TUFLOW), to quantify fluvial flood risk.

Hydraulic modelling has been based upon the best available data, as outlined in the report. Uncertainties exist and the flood depth, level or hazard identified is an approximation based upon data available.

FLOODABLE AREAS NOT SHOWN
Areas susceptible to drainage system inadequacies or localised ponding. Areas flooded due to debris blockage unless shown for specific structures. Please note that floodwater within the channel is not included in the maps.

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DRAWN BY	CHECKED BY	DATE
NB		MAY 2012

SCALE @ A3	ISSUING OFFICE
1 : 40,000	Bristol

SIX BELLS, ABERTILLERY - STAGE 3 SFCA

MAXIMUM FLOOD DEPTH
1 in 100 YR +CC (1% AEP+CC)

Cyngor Bwrdeistref Sirol Blaenau Gwent County Borough Council

URS Infrastructure & Environment Ltd
The Crescent Centre, Temple Back
Bristol, BS1 6EZ
Tel: +44 (0)117 917 1200

DRAWING NUMBER
FIGURE B

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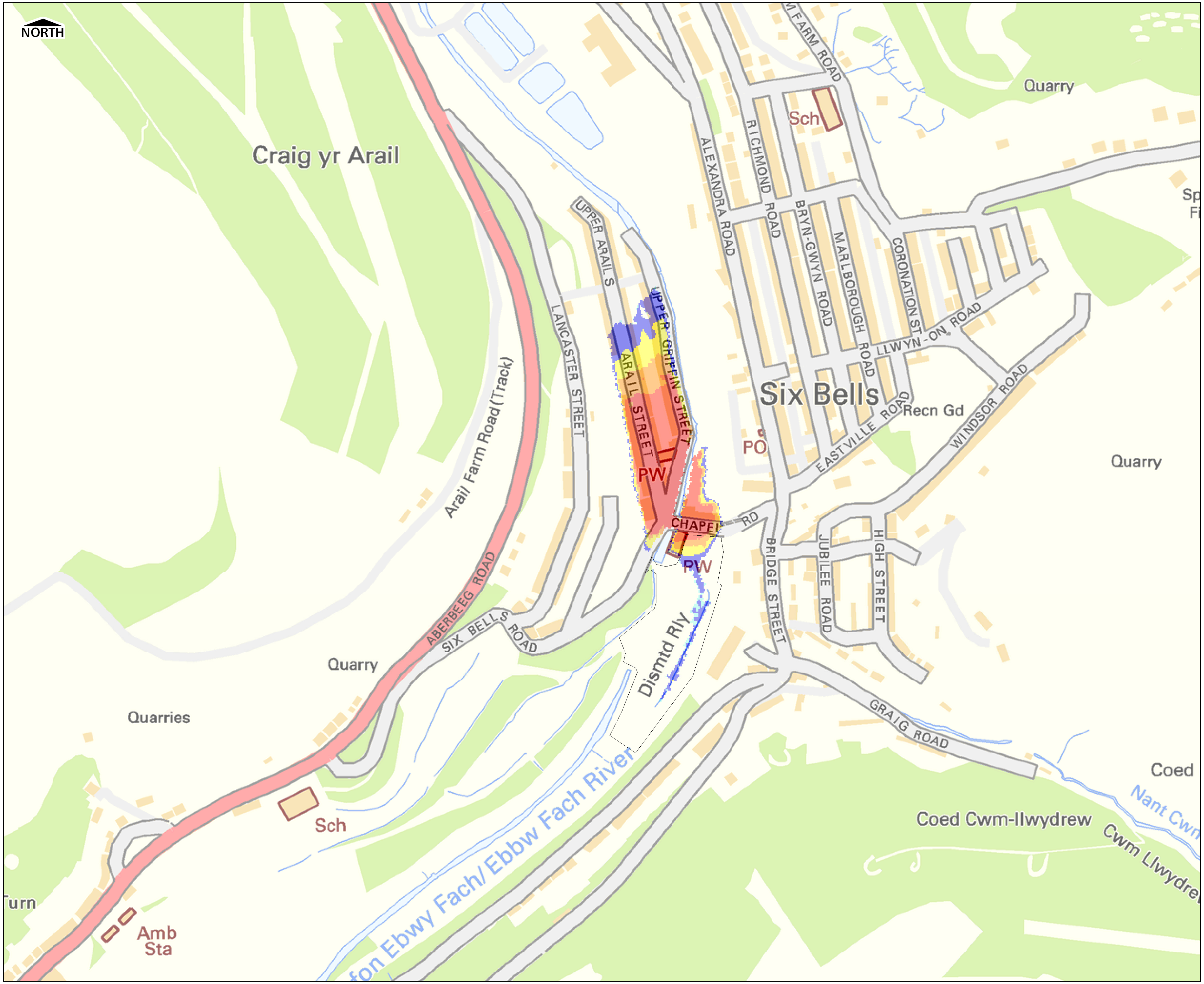

KEY

Site Boundary

Maximum Flood Depth [m]

- 0.01m
- 0.50m
- 1.00m
- 1.50m
- 2.00m and greater

TECHNICAL NOTE
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FLOODABLE AREAS NOT SHOWN

Areas susceptible to drainage system inadequacies or localised ponding. Areas flooded due to debris blockage unless shown for specific structures. Please note that floodwater within the channel is not included in the maps.

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NB		MAY 2012

SCALE @ A3	ISSUING OFFICE
1 : 40,000	Bristol

SIX BELLS, ABERTILLERY - STAGE 3 SFCA

MAXIMUM FLOOD DEPTH
1 in 1000 YR (0.1% AEP)

Cyngor Bwrdeistref Sirol Blaenau Gwent County Borough Council

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FIGURE C

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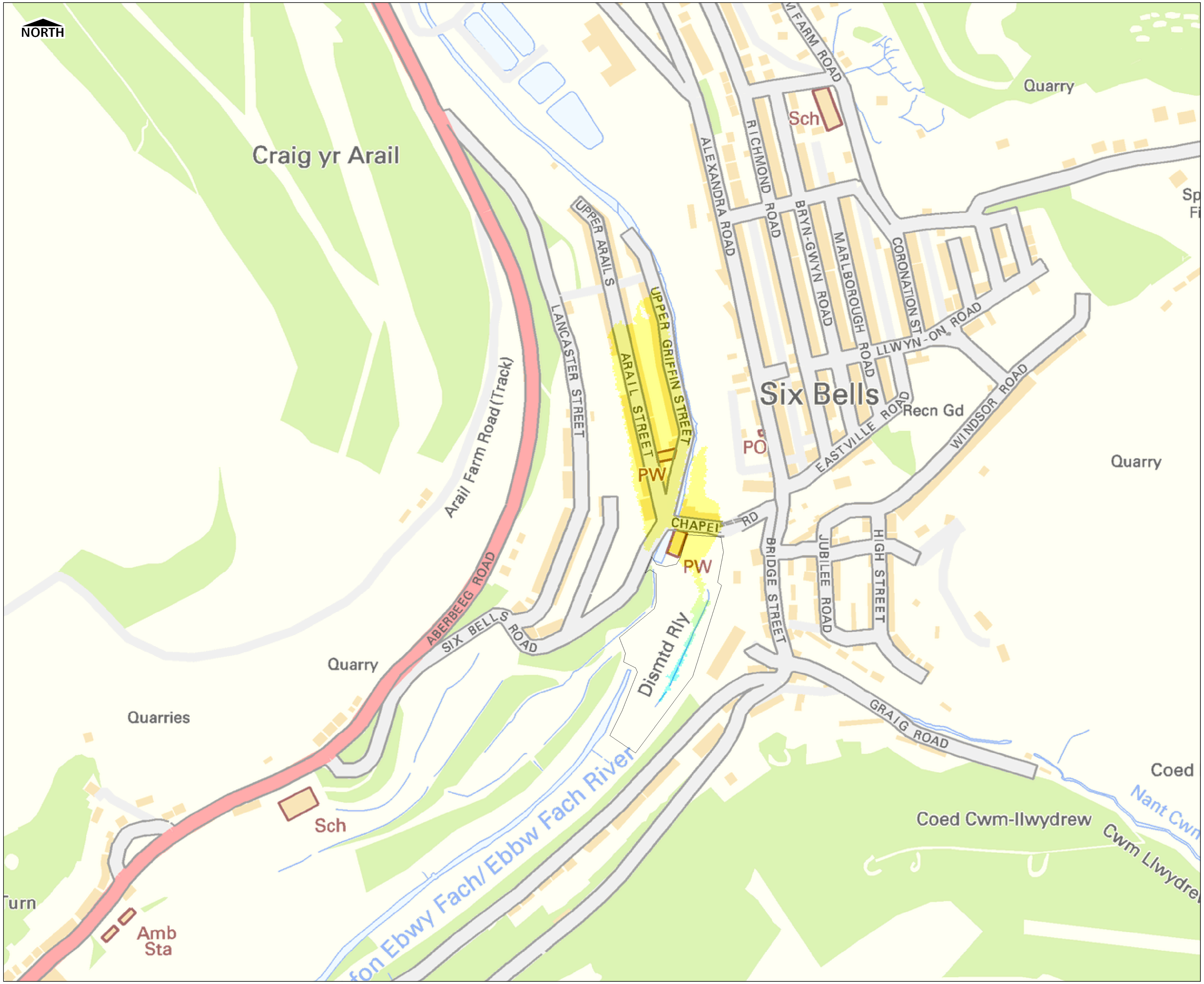

N:\Current Projects\4XXXXXXX Standard File Structure\06 GIS\WOR

KEY

Site Boundary

Maximum Flood Level (m AOD)

- 177.5m AOD
- 180.0m AOD
- 182.5m AOD
- 185.0m AOD
- 187.5m AOD

TECHNICAL NOTE
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SCALE @ A3	ISSUING OFFICE
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SIX BELLS, ABERTILLERY - STAGE 3 SFCA

MAXIMUM FLOOD LEVEL
1 in 1000 YR (0.1% AEP)

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FIGURE D

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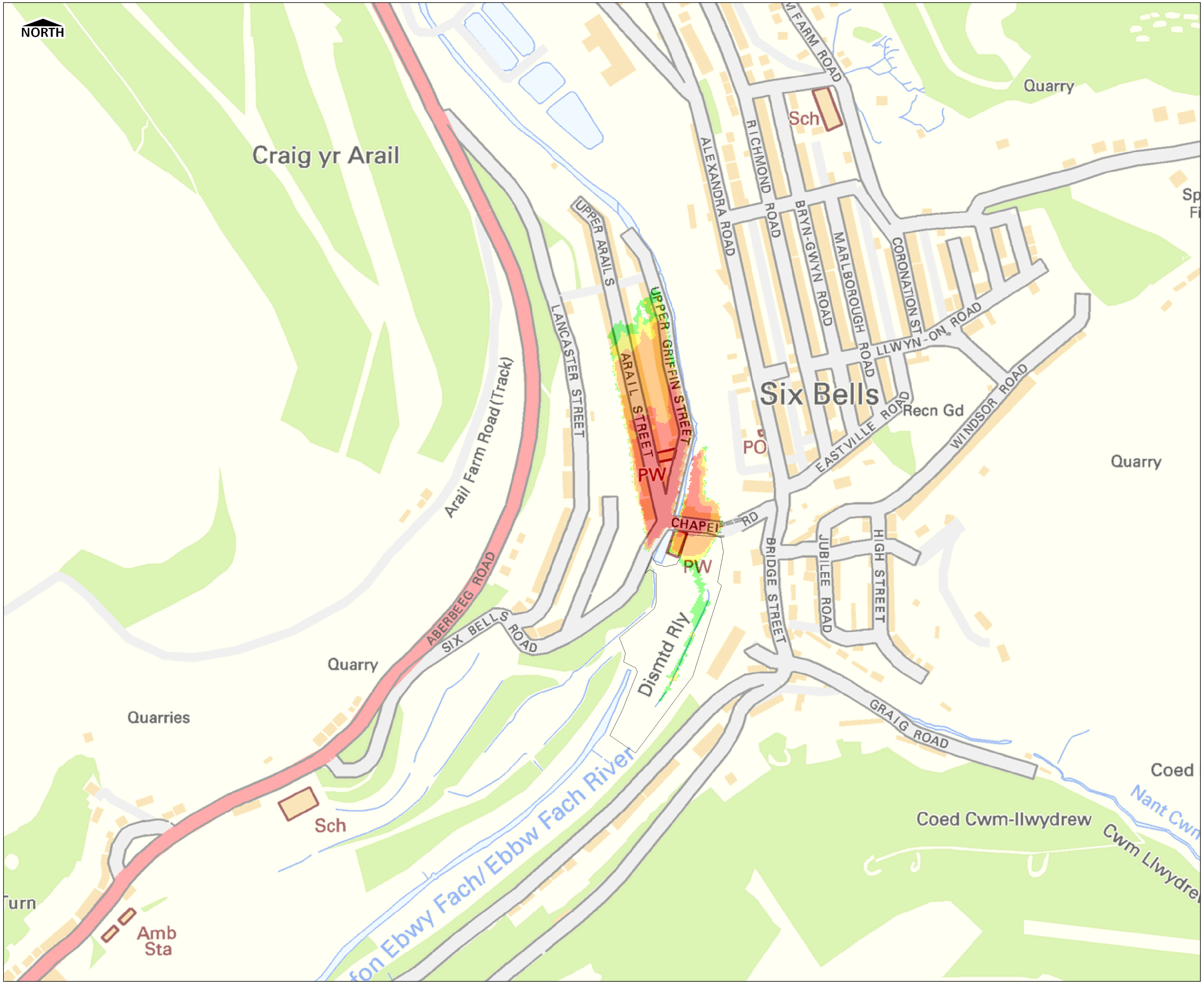

KEY

Site Boundary

Maximum Flood Hazard

- LOW
- MODERATE
- SIGNIFICANT
- EXTREME

TECHNICAL NOTE

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SIX BELLS, ABERTILLERY - STAGE 3 SFCA

MAXIMUM FLOOD HAZARD
1 in 1000 YR (0.1% AEP)

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FIGURE E

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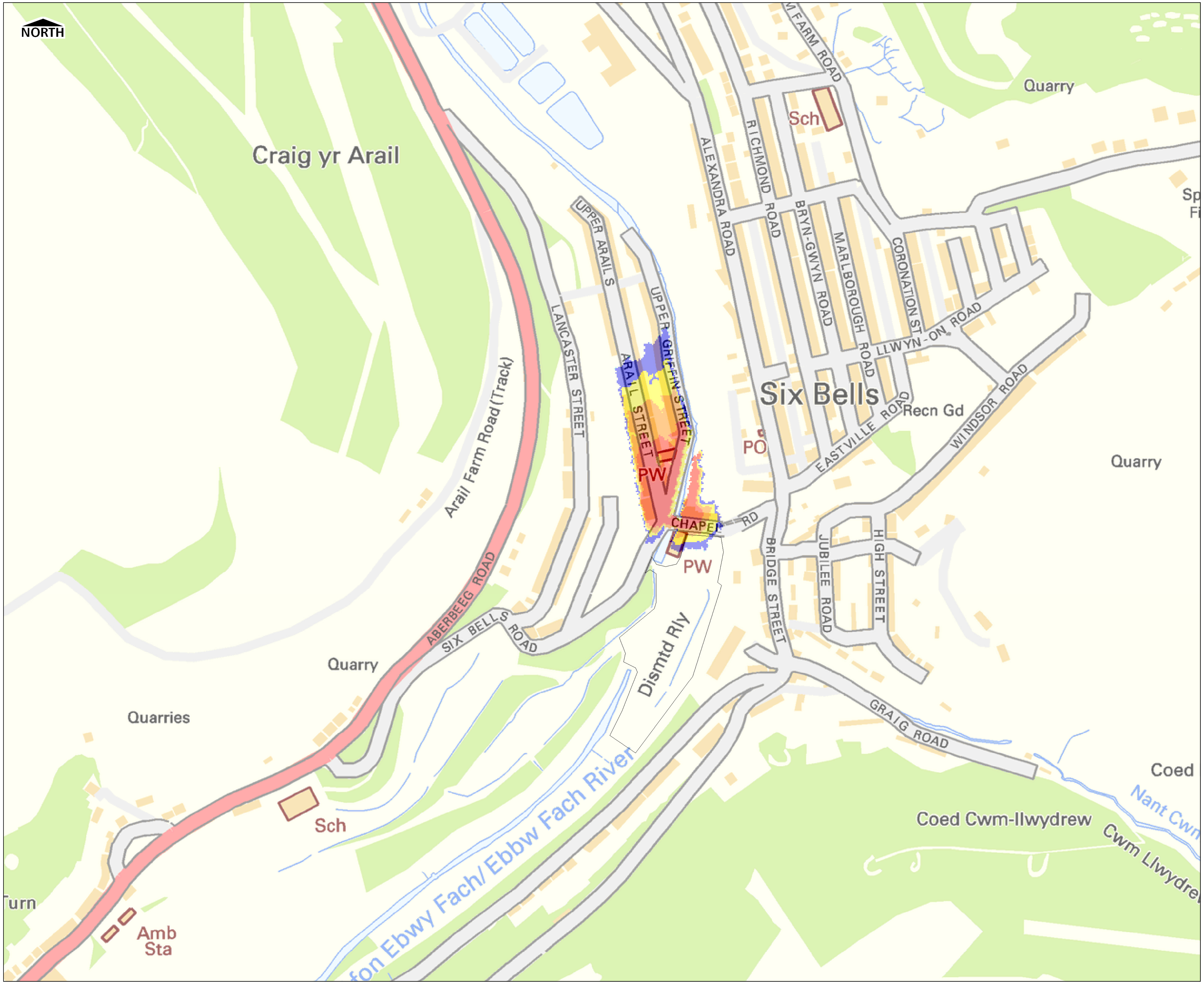

KEY

Site Boundary

Maximum Flood Depth [m]

- 0.01m
- 0.50m
- 1.00m
- 1.50m
- 2.00m and greater

TECHNICAL NOTE

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SCALE @ A3	ISSUING OFFICE
1 : 40,000	Bristol

SIX BELLS, ABERTILLERY - STAGE 3 SFCA

MAXIMUM FLOOD DEPTH
1 in 100 YR CC (1% AEP)
50% SIX BELLS CULVERT BLOCKAGE

Cyngor Bwrdeistref Sirol Blaenau Gwent County Borough Council

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FIGURE F

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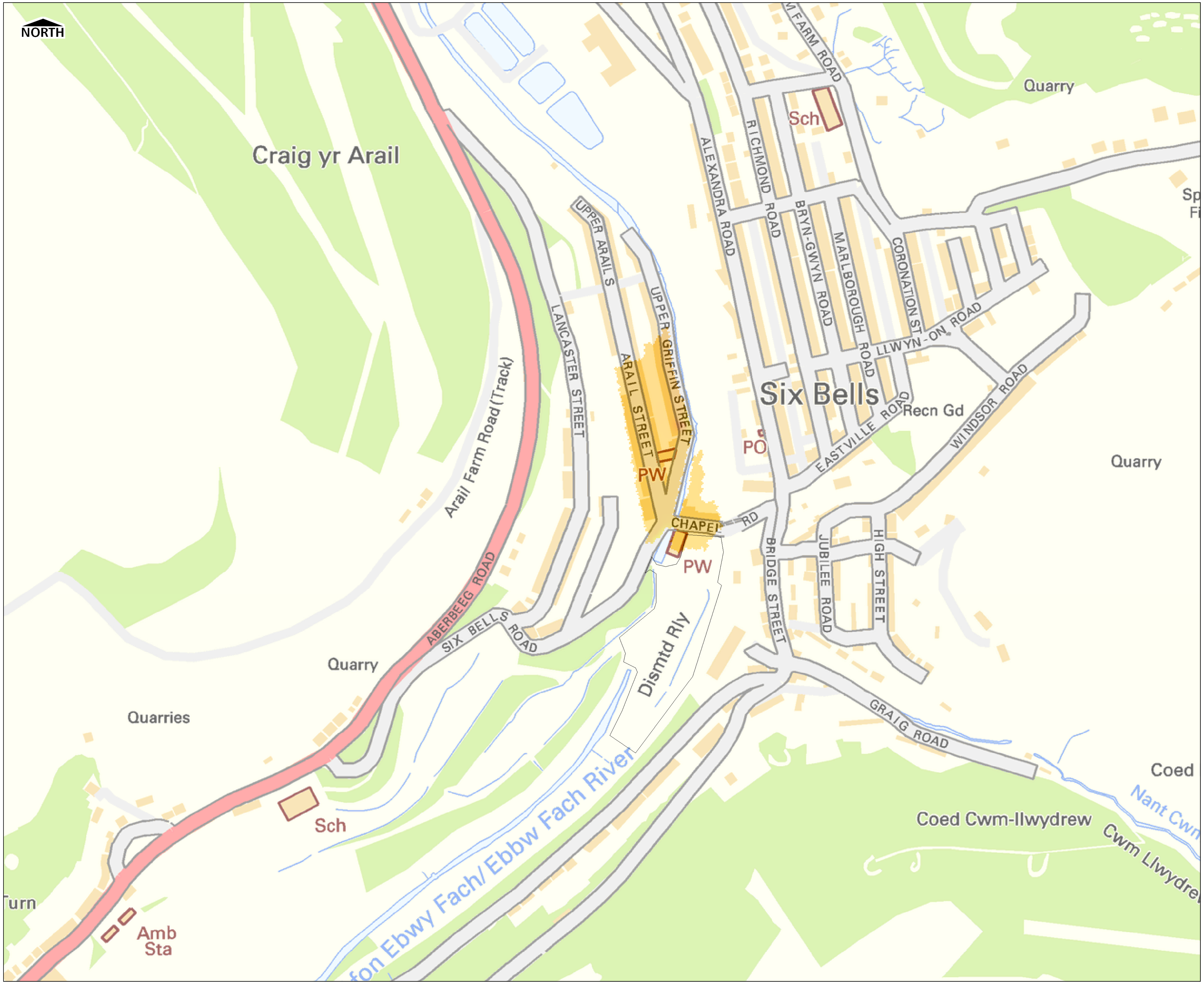

N:\Current Projects\4XXXXXXX Standard File Structure\06 GIS\WOR

KEY

Site Boundary

Maximum Flood Level (m AOD)

- 178m AOD
- 180m AOD
- 181m AOD
- 183m AOD
- 187m AOD

TECHNICAL NOTE

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SIX BELLS, ABERTILLERY - STAGE 3 SFCA

MAXIMUM FLOOD LEVEL
1 in 100 YR CC (1% AEP)
50% SIX BELLS CULVERT BLOCKAGE

Cyngor Bwrdeisdref Sirol
Blaenau Gwent
County Borough Council

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FIGURE G

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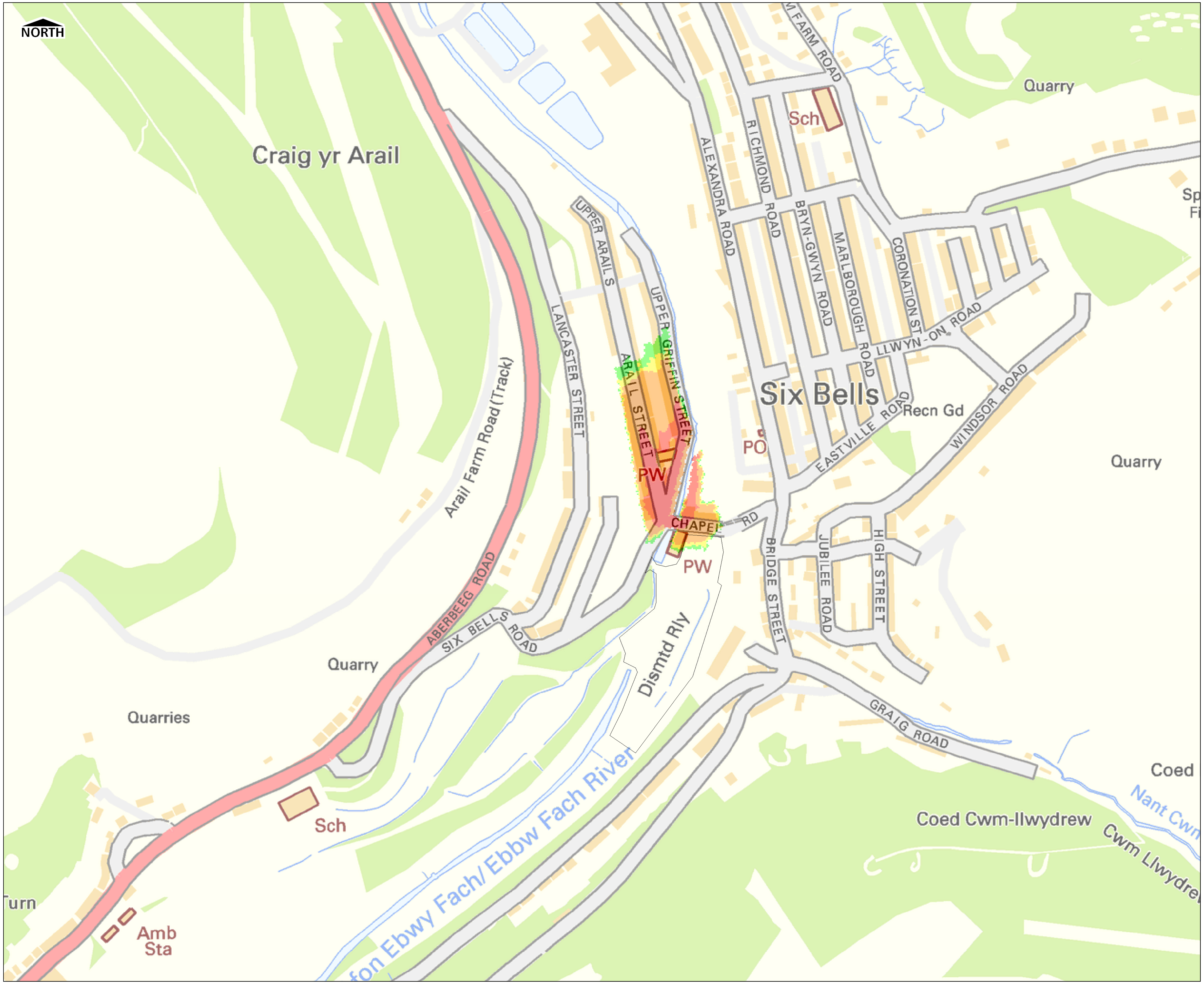

KEY

— Site Boundary

Maximum Flood Hazard

- LOW
- MODERATE
- SIGNIFICANT
- EXTREME

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SIX BELLS, ABERTILLERY - STAGE 3 SFCA

MAXIMUM FLOOD HAZARD
1 in 100 YR CC (1% AEP)
50% SIX BELLS CULVERT BLOCKAGE

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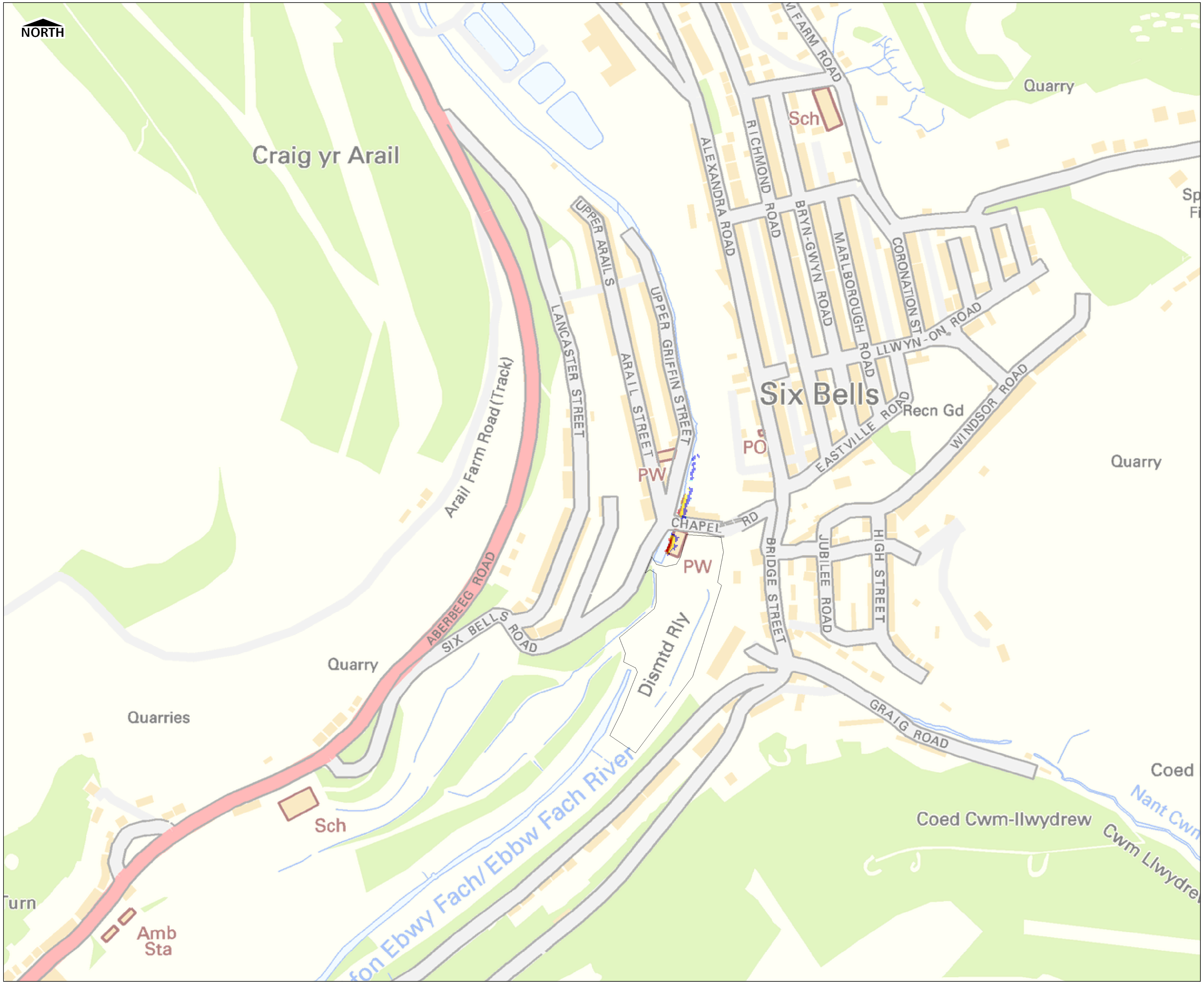

KEY

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Maximum Flood Depth [m]

- 0.01m
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SCALE @ A3	ISSUING OFFICE
1 : 40,000	Bristol

SIX BELLS, ABERTILLERY - STAGE 3 SFCA

MAXIMUM FLOOD DEPTH
1 in 100 YR (1% AEP)
UNDEFENDED

Cyngor Bwrdeistref Sirol Blaenau Gwent County Borough Council

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FIGURE I

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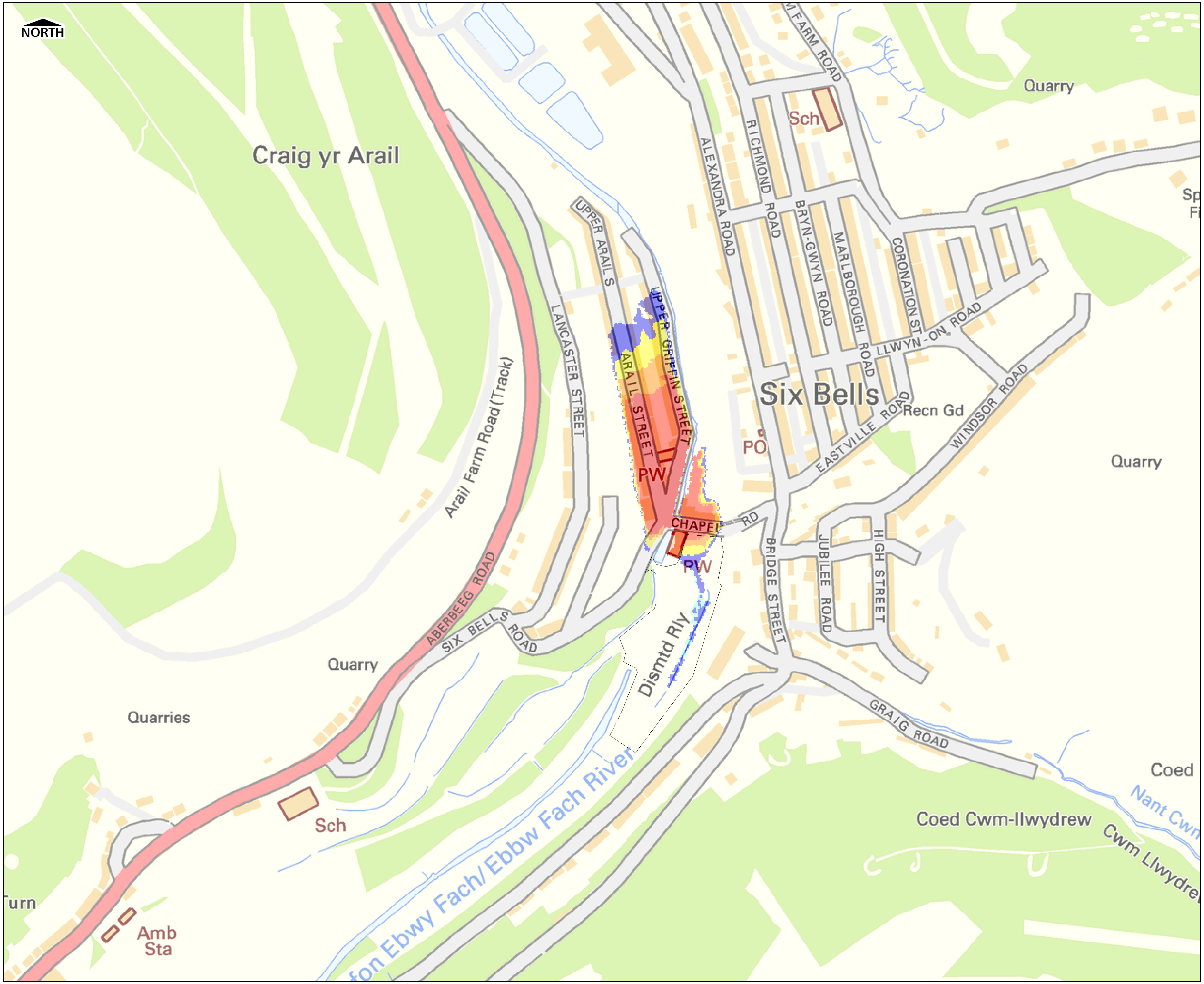

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SIX BELLS, ABERTILLERY - STAGE 3 SFCA

MAXIMUM FLOOD DEPTH
1 in 1000 YR (0.1% AEP)
UNDEFENDED

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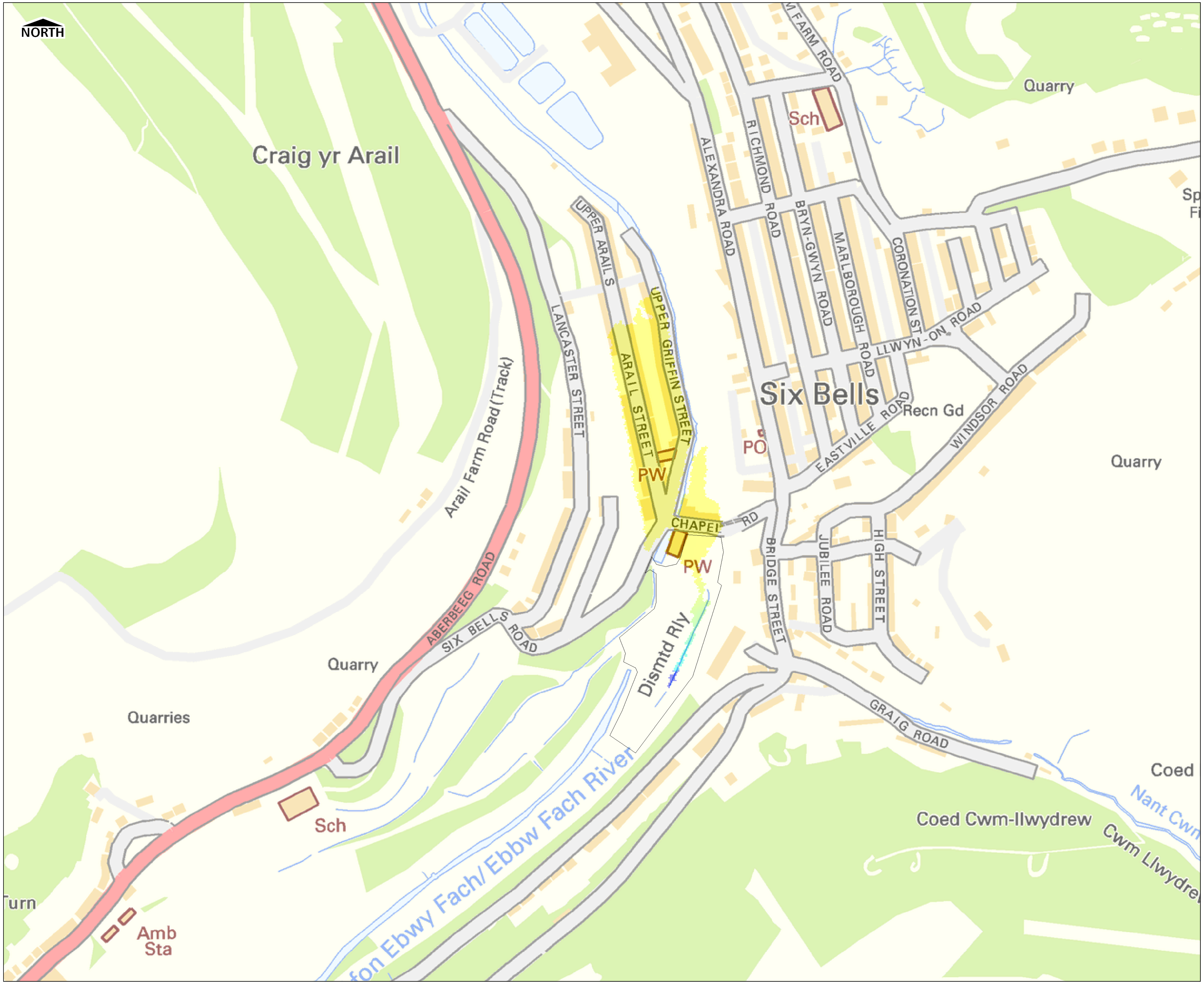

KEY

Site Boundary

Maximum Flood Level (m AOD)

- 177.5m AOD
- 180.0m AOD
- 182.5m AOD
- 185.0m AOD
- 187.5m AOD

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NB		MAY 2012

SCALE @ A3	ISSUING OFFICE
1 : 40,000	Bristol

SIX BELLS, ABERTILLERY - STAGE 3 SFCA

MAXIMUM FLOOD LEVEL
1 in 1000 YR (0.1% AEP)
UNDEFENDED

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URS Infrastructure & Environment Ltd
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FIGURE K

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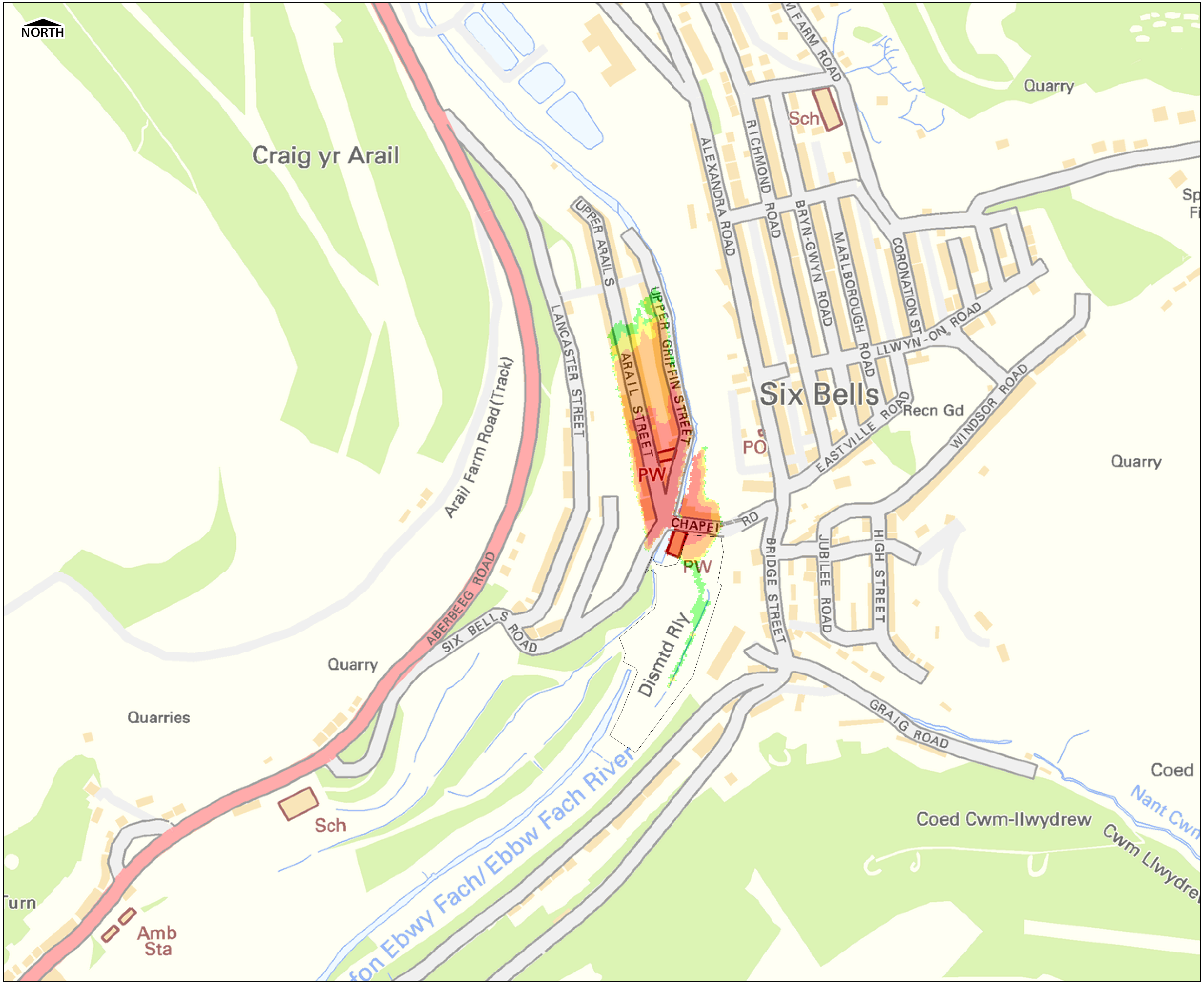

KEY

Site Boundary

Maximum Flood Hazard

- LOW
- MODERATE
- SIGNIFICANT
- EXTREME

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NB		MAY 2012

SCALE @ A3	ISSUING OFFICE
1 : 40,000	Bristol

SIX BELLS, ABERTILLERY - STAGE 3 SFCA

MAXIMUM FLOOD HAZARD
1 in 1000 YR (0.1% AEP)
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FIGURE L

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