SB54

Caerphilly County Borough Council

Strategic Flood Consequence Assessment, Navigation Colliery, Crumlin

Final Report

March 2009

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Creating the environment for business

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Report for

Victoria Morgan
Senior Planner
Strategic Planning
Caerphilly County Borough Council
Penallta House, Tredomen Park
Ystrad Mynach
Hengoed CF82 7PG

Main Contributors

Anne Kemlo
Barry Rodgers

Issued by

.....
Anne Kemlo

Approved by

.....
Peter May

Entec UK Limited

17 Angel Gate
City Road
London EC1V 2SH
England
Tel: +44 (0) 207 843 1400
Fax: +44 (0) 207 843 1410

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Caerphilly County Borough Council

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Purpose of this Report

This report is a Strategic Flood Consequence Assessment for the Navigation Colliery site near Crumlin in Caerphilly, South Wales. This site, on the River Ebbw is included in the Deposit Local Development Plan as a site for residential development.

The purpose of this report is to provide a strategic assessment of flood risk and the potential consequence of development at the site, to inform the Council planning process, and to identify any flood risk issues which potential developers at the site will need to consider.

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Appendices Separate Volume

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1. Introduction

1.1 Context

Entec were commissioned by Caerphilly County Borough Council to carry out a Strategic Flood Consequence Assessments at the Navigation Colliery site near Crumlin in Caerphilly, South Wales. This site, on the River Ebbw is included in the Deposit Local Development Plan (October 2008) as a site for residential development.

The purpose of this report is to provide a strategic assessment of flood risk and potential consequence of development at the site. It advises on restrictions that might apply and mitigation measures that could be implemented to reduce and manage flood risk in line with current policy requirements.

1.2 Sources of Data and Consultation

A list of parties consulted in carrying out this work is shown in Table 1.1.

Table 1.1 Consultation, Data and Information Sources

Site visit undertaken on 8/08/08 to inform understanding of site hydrology, existing infrastructure, and flood risk
Meeting with Caerphilly County Borough Council on 08/08/08 to discuss known issues and agree project scope.
Consultation, and data request (Darren Jones, External Relations, Jackie Walters, Planning, 04/08/08) from Environment Agency Wales, to find out about known flooding risks and historic flooding, existing flood defences, available hydraulic models. Response from EAW on 08/09/08.
Coal Authority (Dave Clark) to request any information on minewater flows at Navigation Colliery site. Information received 21/08/08.
Edward Ware Homes (Iestyn Lewis, 14/08/08) to determine additional information about plans for development at Navigation Colliery site. He reported that they had lots of information about the site, but they are no longer operating.
CCBC (V Phillips), to obtain licensed OS map data; received 25/08/08.
Comments on draft report received by CCBC 28/10/08
Comments on draft report received by EA 20/11/08 (first draft) 10/02/09 (second draft)

1.3 Structure of Report

The report is structured as follows:

- Section 2 describes the site, the proposed development as far as it is known at this stage, and the planning context to the Strategic Flood Consequence Assessment work;

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- Section 3 assesses flood risk from different sources;
- Section 4 details the hydraulic modelling carried out to assess flood consequence, and the results;
- Section 5 discusses flood risk management and mitigation actions which may be required at the site in order for development to be permitted; and
- Section 6 is a summary of the report, with conclusions and recommendations.

Technical detail and output from the hydraulic modelling, including figures, are provided in Appendices, which are presented in a separate volume.

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2. Site and Development Description and Planning Context

2.1 Site Description – Navigation Colliery

The Navigation Colliery site is located at ST 211 987 on the west (right hand) bank of the River Ebbw. The Ebbw flows north to south from its source in the Brecon Beacons approximately 15 km further north. The development site is at an elevation of approximately 140m AOD, and is relatively level for the most part, with the valley rising steeply along the western edge of the site, to approximately 150m. The valley rises further to the west of the site. The site itself is long and narrow, being approximately 480m long, and 75m from east to west at its widest point. The river channel runs along the length of the eastern boundary of the site, but the channel itself is outside the site boundary. It is culverted over much of its length at this point; there is a 30m section of open watercourse towards the north part of the site, and another 35m at the southern end; in between the culverted section is about 300m in length. The open channel has steep valley sides, and the banks are currently overgrown and thickly vegetated with trees and shrubs. A site visit was made on 8th August 2008 and at this time the river level was at least 3m below the level of the main site.

There are a number of buildings associated with the former mine located along the western boundary of the site. Caerphilly County Council reported that all the buildings are listed, some of them Grade 2. The mine closed in 1991, and since then some of the buildings have been in use as warehouses or workshops. A car breakers yard is currently in operation at the southern part of the site, and the central part of the site is being used as a building site and site office for works to the Ebbw Valley railway. All the other buildings are disused and boarded up.

Ground surface is mostly tarmac in poor condition or other hardstanding, but with some grass/soils particularly in the north part of the site.

A currently disused railway runs to the east of the site, then crosses the river to the south of the site boundary.

The valley rises steeply immediately to the west of the mine buildings and is thickly wooded as shown on photographs taken during the site visit, at Appendix A. Running water was heard behind a corrugated iron door and this was thought to be flow from a disused mineshaft (shown in Figure A.5).

The Ebbw Valley National Trail passes in a north-south direction to the west of the site.

The red line boundary for the site is shown at Figure 2.1. Photographs of the site taken at the site visit are shown in Appendix A.

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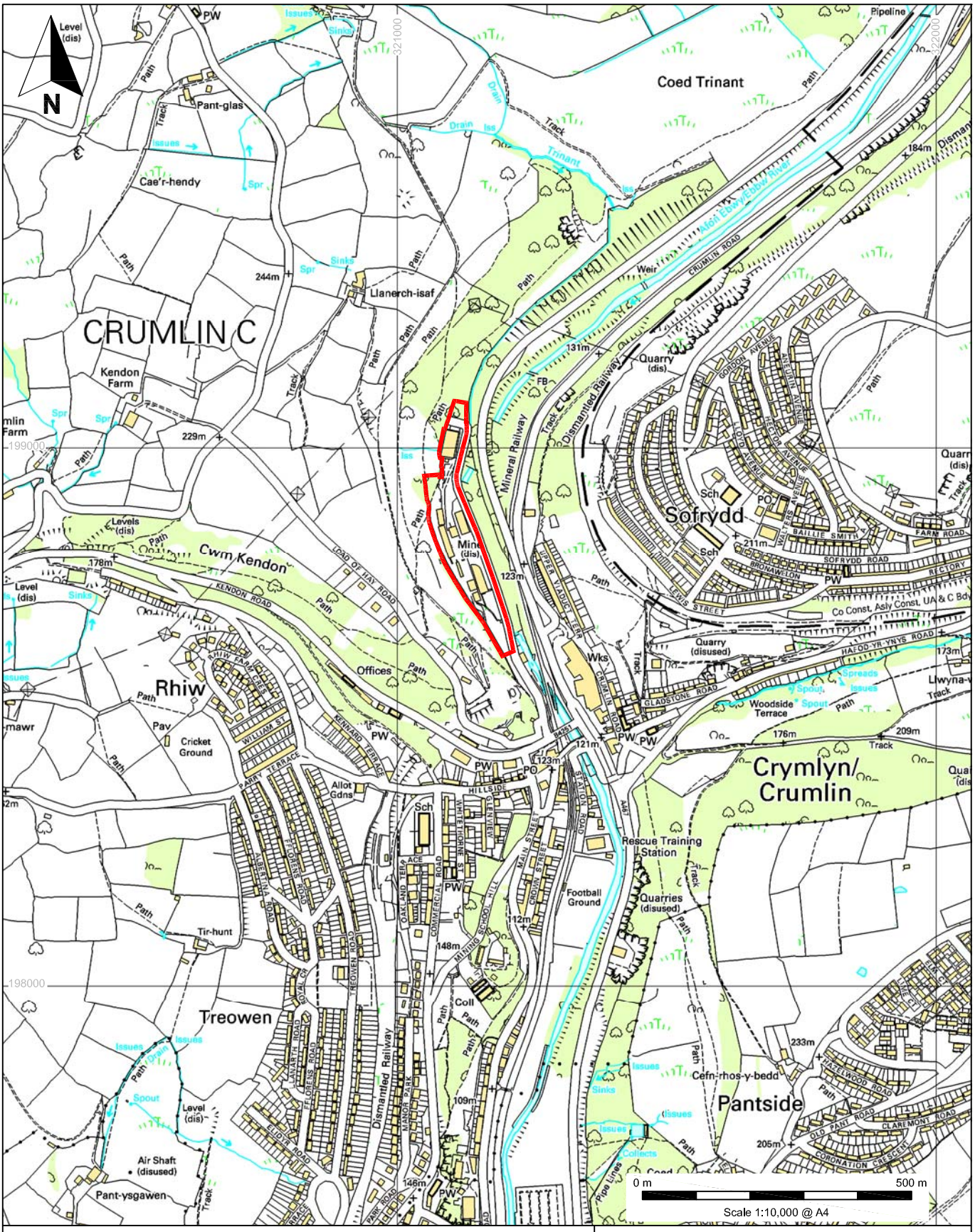

Key

Site boundary

Caerphilly County Borough Council, Strategic Flood Consequence Assessments, Caerphilly

Figure 2.1
Navigation Colliery Site, Crumlin

October 2008
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Based upon the Ordnance Survey Map with the permission of the Controller of Her Majesty's Stationery Office. © Crown Copyright. Caerphilly County Borough Council. AL100025372.

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2.1.1 Hydrology

The upstream catchment for the Navigation Colliery site is 80.7 km^2, at a mean catchment altitude of 369m AoD. Average annual catchment rainfall is 1473mm/year. A flow gauge operated by Environment Agency Wales located at SO 210 015 approximately 3km upstream of the site, was in operation from 1984 – 2005 (Ebbw at Brynithel). For this period the station recorded a mean daily flow of 2.71 m^3/s, a Q_{95} of 0.46 m^3/s and a Q_{10} of 6.1 m^3/s. These hydrological indicators are summarised in Table 2.1.

Flood risk mapping from the Environment Agency is available on the EA website and is shown for the Navigation Colliery site at Figure 2.2. This mapping shows an indicative extent of the 1 percent exceedance probability flood (the 100 year flood) in dark blue and the 0.1% annual exceedance probability flood (the 1000 year flood) in pale blue. The mapping indicates that the flood plain is narrow, and may be contained within the steep valley section below the site.

The indicative flood mapping was originally carried out for the whole of England and Wales using 2d model software called JFlow prior to the launch of the mapping on the website in October 2004. Since that time the digital terrain model has been improved and estimates of flood extent refined. This mapping is not sufficiently accurate for detailed local flood risk assessment, and the model was not intended to produce accurate water level information. Note that the flood map indicates flooding along the full length of the watercourse including the culverted section, and this is a consequence of the method of the broad scale national mapping exercise.

A flood risk mapping study for the River Ebbw was later commissioned by Environment Agency Wales and this work included constructing a HEC-RAS steady state model using surveyed cross sections, extended using Lidar data where appropriate. EAW said that while they considered that the model provided a good estimate of flood risk from the River Ebbw, they had limited confidence in the accuracy of the water level output from the model. The EA website flood mapping does not include this HEC-RAS output.

EAW did not comment on known historic flooding at the site, or whether there were flood defences managed by EAW or others upstream or downstream of the site. No flood defences are indicated on the EAW flood risk map.

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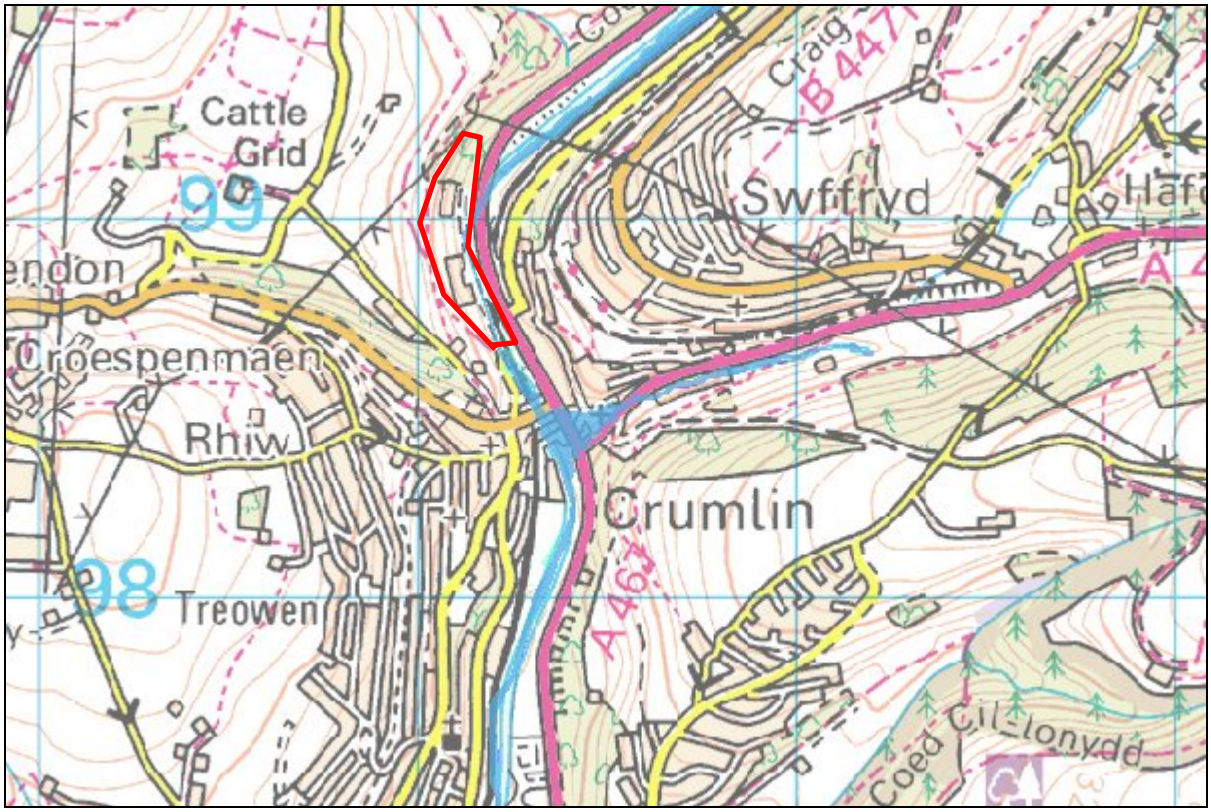
Figure 2.2 EAW Flood Risk Mapping Navigation Colliery Site



Dark blue indicates extent of flooding from rivers or sea from the flood with 1% annual exceedance probability (the 100 year flood).

Light blue indicates the flood extent from the 0.1% annual exceedance probability flood (1000 year flood).

The approximate site outline is in red.

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Table 2.1 Catchment Hydrology

	Navigation Colliery
NGR	ST 211 987
Upstream catchment area (km^2)	80.7
Annual average rainfall (mm)	1473
BFIHost	0.503
Average catchment altitude (mAoD)	369
Gauging station reference	56019 Ebbw @ Brynithel SO 210 015
Period of record	1984 – 2005
Mean daily flow (m^3/s)	2.71
High flow indicator (Q_{10})	6.1
Low flow indicator (Q_{95})	0.46

Taken from Centre for Ecology and Hydrology – National River Flow Archive

2.1.2 Hydrogeology and Soils

The Navigation Colliery site is on Sandstones of the Upper Pennant Measures, overlying Lower Pennant Measure Sandstones, overlying Upper and Lower Pennant Coal Measures, with no drift deposits. The disused mineshaft is located at ST 211500 988000. Natural soils are freely draining, acid, and loamy.

The Eastern Valleys Catchment Flood Management Plan Scoping Report (August 2007) says on hydrogeology:

> *Apart from the Carboniferous Limestone, which is classified as the major aquifer in the CFMP area, Old Red Sandstone, Millstone Grit and the Pennant Sandstones within the Upper Coal Measures also hold water. These contribute to high groundwater levels and reduce water infiltration, so increasing surface water runoff into rivers and increasing flood risk. The groundwater flow is believed to run perpendicular to the valley axis and supplies a component of baseflow to rivers either via spring discharges from valley sides or directly into the rivers. However, as with other parts of Wales, there is doubt surrounding the behaviour of groundwater levels and processes.*

This indicates that sandstone at the Navigation Colliery site may result in high groundwater levels and issues with groundwater protection that would need to be considered at detailed design stage, following ground investigations at site.

The site does not fall within a Groundwater Source Protection Zone (www.environment-agency.gov.uk)

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2.2 Development Proposals

There is no detailed plan for development of the former colliery site. It is identified in the Deposit Local Development Plan for residential development with 145 dwellings. Edward Ware Homes have previously drawn up a conceptual plan for a development at the site. This scheme involves opening up the existing culvert sections and re establishing the river bank with a footpath along it. The development would be of private houses, and a train station would be located at the southern end of the site to serve the recently reopened Ebbw Valley Railway. There is car parking proposed next to the station, and shops on the site. Note that the conceptual sketches provided by Edward Ware Homes indicate housing extending to both sides of the river, east to the railway/A467, whereas the development site under consideration in the LDP extends only to the western bank of the river.

The conceptual design for the development is included for information at Appendix B. It is indicative only and the layout does not form part of a planning application.

2.3 Planning Context

In Wales flood risk assessment and management for new developments is governed by Technical Advice Note 15: Development and Flood Risk, published by Welsh Assembly Government in July 2004. The purpose of the guidance is to provide a precautionary framework to guide planning decisions and direct new development away from areas of high flood risk, from river, tidal or coastal flooding, or surface water flooding from runoff, if possible. However the Guidance recognises the potential negative economic and social consequences if investment in existing urban areas, or redevelopment of brownfield land within Zone C was not to be permitted. Development will only be allowed in Flood Zone C for certain types of development if

- the Local Planning Authority can provide necessary justification for the location, as set out in Section 6 of TAN15; and
- the potential consequences of flooding at the site have been considered and it has been shown that they can be managed in accordance with requirements of Sections 5 and 7, and Appendix 1 of TAN15.

Flood Zone C is described in TAN15 as that based on Environment Agency extreme flood outline, equal to or greater than the 0.1% AEP (Annual Exceedance Probability) flood. The 0.1% Annual Exceedance Probability flood is that flood which will be equalled or exceeded once in 1000 years on average...Parts of each site are indicated on Environment Agency mapping as being within this Zone, as described in Hydrology Section 2.2.1. Zone C is further subdivided as shown in Table 2.2.

The Justification Test is considered in the next section. The flood consequence assessment is the purpose of this report. However this is a strategic study to inform CCBC and potential future developers of the key flood risk constraints at the site, rather than the detailed flood consequence assessment which would be needed to satisfy the requirements of TAN15 in support of a planning application.

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Table 2.2 Flood Zones Defined in TAN 15

Zone	Description of Zone	Use within TAN 15 precautionary framework
A	Considered to be at little or no risk of flooding	Indicates that justification test is not applicable and no need to consider flood risk further
B	Areas known to have been flooded in the past evidenced by sedimentary deposits	Used as part of a precautionary approach to indicate where site levels should be checked against the extreme (0.1%) flood level. If site levels are greater than those defining the extreme flood outline there is no need to consider flood risk further
C	Based on Environment Agency extreme flood outline, equal to or greater than 0.1% (river, tidal or coastal)	Indicates that flooding issues should be considered as an integral part of decision making by the application of the justification test including assessment of consequences
C1	Areas of the floodplain which are developed and served by significant infrastructure, including flood defences	Indicates that development can take place subject to application of justification test, including acceptability of consequences
C2	Areas of the floodplain without significant flood defence infrastructure	Indicates that only less vulnerable development should be considered subject to application of justification test, including acceptability of consequences. Emergency services and highly vulnerable development should not be considered

Land use types are also classified in TAN 15 according to their suitability for development in the different Flood Zones. Highly Vulnerable and Emergency Services should not in any case be permitted in Zone C2. Residential development is classed as highly vulnerable so at the Navigation Colliery site no residential development would be permitted in Zone C2.

Table 2.3 Land Use Development Categories from TAN 15

Development Category	Types
Emergency Services	hospital, ambulance stations, fire stations, police stations, coastgaurd stations, command centres, emergency depots and buildings used to provide emergency shelter in times of flood
Highly vulnerable development	all residential premises (including hotels and caravan parks), public buildings (e.g. schools, libraries, leisure centres), especially vulnerable industrial development (e.g. power stations, chemical plants, incinerators), and waste disposal sites
Less vulnerable development	General industrial, employment, commercial and retail development, transport and utilities infrastructure, car parks, mineral extraction sites and associated processing facilities, excluding waste disposal sites

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2.3.1 Justification Test

In applying the test of justification (described in Section 6 of TAN 15) it must be demonstrated that

- location of development in zone C is necessary to assist or be part of a local authority regeneration initiative or a local authority strategy required to sustain an existing settlement, or
- Its location in zone C is necessary to contribute to key employment objectives supported by the local authority and other key partners to sustain an existing settlement or region.

Broad Level Flood Risk Assessment

Caerphilly County Borough Council has produced a Broad Level Assessment (June 2008) in which they demonstrated the precautionary approach required by TAN 15 in selecting sites for the Deposit Local Development Plan, and provided justification for the location of the Navigation Colliery residential site in terms of social, economic and regeneration needs. This justification identified that a Strategic Flood Consequence Assessment had been commissioned for the site. The excerpt from the Broad Level Assessment is included at Appendix B.

Other Plans relevant to the site are:

Catchment Flood Management Plan

The Eastern Valleys Catchment Flood Management Plan is being developed, and this covers the Rhymney, Sirhowy and Ebbw catchments. An Inception Report was issued in September 2006 and a Draft Scoping Report in August 2007; the draft CFMP was published for consultation in September 2008

The CFMP represents the first 'tier' in the strategic flood risk management process, providing the overall framework within which more detailed assessment of flood risk, such as strategy plans and strategic flood consequence/risk assessments, can be carried out. The aim of the CFMP will be to set Strategic Flood Risk Management Policies for each policy unit.

Local Development Plan

A Deposit Local Development Plan was published by Caerphilly County Borough Council in October 2008.

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3. Assessing Flood Risk

TAN 15 requires that proposals for development in any part of Flood Zone C are subject to a justification test, which includes that "the potential consequences of a flooding event for the particular type of development are considered, and in terms of the criteria contained in sections 5 and 7 and Appendix 1 found to be acceptable".

The objectives of the flood consequence assessment are to understand:

- The consequences of flooding on the development;
- The consequence of development on flood risk elsewhere; and
- What mitigation measures can be incorporated within the design of the development, if required, to ensure that the flood risk to people and property within the development and elsewhere on the floodplain is minimised to an acceptable level.

3.1 Sources of Flooding

3.1.1 Fluvial Flooding

The risk of river flooding has been identified and is considered in detail in Section 4.

3.1.2 Tidal Flooding

There is no risk of tidal flooding at this site in the upper reaches of the Ebbw catchment.

3.1.3 Groundwater Flooding

Groundwater flooding occurs when groundwater levels rise above ground level after prolonged periods of rainfall. At the Navigation colliery site the underlying sandstone geology means that there may be potential for groundwater flooding. Historically groundwater levels are known to have risen after the closure of mines in the area in the 1990s, and the site visit confirmed there was a flow of water from what was assumed to be the location of the former mine shaft. Site investigations would need to be carried out as part of detailed planning for development at the site to determine the scale of groundwater flood risk if any, and appropriate means of mitigation.

3.1.4 Sewer Flooding

Flooding from sewers may occur when networks are overloaded following heavy rain events, or when outfalls are blocked by high river levels. Dwr Cymru Welsh Water is the sewerage undertaker responsible for the public

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network, while landowners are responsible for private sewers and drains. The Highway Agency is responsible for road drainage.

The risk of flooding from existing and proposed surface and foul sewers, including any history of flooding at or near the site would need to be discussed with DCWW and taken into account in detailed design proposals.

3.1.5 Surface Water Flooding

Runoff from rainfall can cause surface water flooding, and the risk of this form of flooding is greater when new development increases the proportion of hard, impermeable surfaces in a catchment. This results in greater volumes of runoff and higher peak rates of flow. Winter rainfall is projected to increase over future decades as a result of climate change, and rainstorms are likely to become more intense. This will increase the risk of surface water flooding, which was highlighted in the flooding events of summer 2007, and by the results of the Pitt Review published this year (Pitt, 2008). Surface water flooding down steep valley sides onto the development sites is also a risk.

The risk of surface water flooding on site and downstream of it, and onto the site from up catchment, will need to be considered in detailed design proposals for development. A drainage strategy will be required to show how runoff rates will be managed to acceptable levels, and incorporate Sustainable Drainage Systems (SUDS) where possible and appropriate.

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4. Fluvial Flood Risk

This chapter describes the hydraulic modelling undertaken for the Navigation Colliery site to assess fluvial flood risk.

4.1 Supplied Data

Key data supplied for use in this study are stated below:

- A 1D Steady State Hec-Ras model was supplied by the Environment Agency for use in this project under licence 080905. The model was built for the 'River Ebbw Tredegar to Aberbeeg Flood Risk Mapping study (Version 3.0)' and covers the Ebbw River through Crumlin. However, due to concerns about the steady-state nature of the model and its inability to define spill volumes, Entec converted this model into a 1D fully hydrodynamic ISIS model, as described below. The model was supplied with additional data including survey data in CAD format, cross section locations and a model report.

- OS 50k, 25k and 10k background map data has been supplied by Caerphilly County Borough Council.

4.2 Historic Flood Information

Discussions with Caerphilly County Borough Council and the Environment Agency revealed that there is no known history of flooding at the site. No information was provided on existing flood defences but none are shown on the EAW website flood map or TAN15 mapping.

4.2.1 Hydrology

Flood hydrographs for input to the hydraulic model were derived using Flood Estimation Handbook methods, and a review of hydrometry on the river Ebbw near to the site; statistical and rainfall runoff methods were considered. Appendix D describes the analysis in detail and the design hydrographs used.

To account for the impact of climate change on the 100 year flood event, flows have been increased by 20% to produce the 100 year flood with climate change. This is in line with section 2.8 of TAN15 which reports that peak flows for a given return period may increase.by 20% within 50 years as a result of climate change, and agreed in discussion with G Purnell, EAW, 21/11/08.

4.3 Model Build

The hydraulic model was constructed using ISIS and Tuflow which is standard industry modelling software and the model construction is detailed below.

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4.3.1 Navigation Colliery, Crumlin

Site Description

This former colliery site is located in the valley of the Ebbw River which is culverted for 300m through the site. The minimum elevation on site of 124.3m AOD is approximately 6m above the bed of the upstream channel before it enters the site. It has been reported that following closure of mine workings in the area and the cessation of associated groundwater pumping the level of the groundwater table has risen and some mine water enters the watercourse. For the purposes of this study considering extreme flood events any contribution to river flow from minewater is likely to be insignificant and no attempt has been made to quantify and locate mine inflows to the watercourse.

Statement of Objectives

A hydraulic model of the Ebbw River through Crumlin was constructed to gain a fuller understanding of the nature of flood risk at the site. The model was based on section geometry from an existing Hec-Ras model of the river, provided by EAW. The original report (River Ebbw Flood Risk Mapping Study v3) noted that the behaviour of the Ebbw River, whilst in flood condition, is dominated by the movement of water along the part of the floodplain directly adjacent to the watercourse.

The valley of the river along the reach of watercourse modelled in this study is also steep and well defined suiting its potential to steady-state modelling. However as part of this current study blockage scenarios of the culvert through the site have been considered. Although the site is located high above the watercourse, in the event of a significant blockage coinciding with a large flood event, the water may back up behind the culvert and overflow onto the site. The potential for such overflow was modelled using a 2 dimensional TUFLOW model in order to give a good understanding of flow paths, depths and velocities across the site. Obtaining a volume of water to be used as input to the TUFLOW model required an unsteady fully hydrodynamic model to be constructed which can simulate the time varying behaviour of a flood hydrograph and define any associated spill volumes.

Floods with annual probabilities of 50 % (2 year), 20% (5 year), 10% (10 year), 5% (20 year) 2% (50 year), 1% (100 year) and 1% (100 year) with climate change were modelled in ISIS and mapped for the purposes of this study. In addition a blockage sensitivity analysis on the culvert through the site was considered by simulating a 50% area blockage and an 80% area blockage. Both of these were undertaken for the 1% climate change event to illustrate an extreme scenario. Flow shown to be spilling over the culvert through the site was extracted from the output of the ISIS model and modelled in 2D using a TUFLOW model across the site. A 0.1% annual probability flood (1 in 1000 year event) was then modelled to show the effect of this extreme flood, as required by section A1.15 of TAN15.

The annual exceedance probability of an event is the likelihood that such an event will be exceeded by a more extreme event, in any year. Thus there is a 1% chance that the 1% annual exceedance flood event will be exceeded

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in any year, and it will be exceeded once in 100 years on average. The 10% annual exceedance event will be exceeded once in 10 years on average.

A final model run was undertaken to simulate the impact on flood risk if the culvert were to be removed as part of the development.

In discussion with Environment Agency Wales, Carl Llewellyn (Development Control Officer) stated that a blockage scenario of at least 50%, and potentially greater depending on the site in question, should be considered in flood consequence assessments to support planning applications.

A detailed description of the hydraulic modelling, including the hydrology for the model inflows, is presented in Appendix D. The results are discussed in Section 5. The model files are provided in a CD with this report.

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5. Results from Flood Modelling

5.1 Model Results

Results of the flood modelling are shown in Figures 2- 19 in Appendix E. These show the extent of flooding across the site for the range of flood events considered i.e. annual exceedance probabilities of 50 % (2 year), 20% (5 year), 10% (10 year), 5% (20 year) 2% (50 year), 1% (100 year) 1% (100 year) with climate change, 0.1% (1000 year); 50% and 80% blockage scenarios; the final scenario is for the 1% AEP (100 year) event with the culvert opened up.

The Figures map the maximum depth of flooding as well as the velocity profiles and flood hazard which combines the risk of velocity and depth of flood water.

For both sites the output shows that there is no out-of-bank flooding up to and including the 1% AEP (100 year) event with or without the potential effects of climate change.

The blockage scenarios, however, do result in flooding. If the culvert through the site is blocked or partially blocked then the models have shown that for the 1% AEP (100 year) flood event with climate change, water will back up behind the culvert to such a depth that overtopping will occur and the site will be subject to flooding.

The culvert passing under the site is quite substantial in cross sectional area (7.97m x 4.93m). For all modelled events up to and including the 1% with climate change the culvert does not surcharge and flow is generally unaffected by the culvert. In the blockage scenarios, both 50% and 80% blockage) flow cannot all pass through the remaining culvert area, resulting in backing up of water and eventual overtopping onto the site. Results for the culvert blockage and removal scenarios are outlined below.

Culvert Blockage

Figures 13 to 18 in Appendix E show the impact on site that blockages of 50% and 80% of the culvert area would have. Once flow overtops the culvert and flows onto the site it generally flows along a linear route over the site with a 60m wide swathe. Depths reach 0.5-1.0m across a large part of the flooded extent for the 80% blockage scenario (Figure 16) and greater than 1.0m in some small areas. Flow then spills back into the river at the downstream end of the site. The volume of water flowing over the site is large (a peak flow of 92 m^3/s for an 80% blockage). This gives rise to high hazard values along the 60m wide swathe and it would be preferable (and required by TAN15) to locate development outside of this area to avoid the consequences of residual risk associated with such a blockage.

Culvert Opening

Modelling the culvert as being open was achieved by assuming a constant linear gradient and a similar cross sectional channel shape to upstream and downstream sections. The model has shown that opening or ‘daylighting’

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the culvert would have minimal impact on downstream flows for all events up to and including the 1% with climate change event. It would have the benefit of removing the residual risk associated with culvert blockage and should be considered as a preferred option.

Flooding from the Extreme Event

TAN 15 requires the extreme flood (0.1% annual probability flood or 1000 year flood) to be modelled to give an indication of the depths and velocities across the site during such an event. The results in Appendix E (Figures 9 – 12) show the extent of flooding which covers all of the flat part of the site, extending west to the existing mine buildings. The maximum depth of flood water is 0.5-1.0m over a large extent of this area, and greater than 1.0m in small parts of the site.

Velocity for the extreme flood is shown to be greater than 2.0m/s over a significant part of the flatter area of the site Hazard values are shown as high for areas of the site with greatest depth and velocity values combined (Figure 12).

Indicative limits of acceptable depth and velocity from the extreme flood, as stated in TAN15 are shown in Table 5.1. Clearly these limits are exceeded over significant parts of the site, and it would not be appropriate to locate buildings or access routes, as relevant, at these locations. On the other hand were the culvert to be opened up, as recommended above to reduce residual flooding risk, the flood extent and hazard, would be reduced at the site.

Table 5.1 Indicative Tolerable Conditions under Extreme Flood Event from TAN 15

Development Type	Maximum depth flooding (mm)	Maximum rate of rise of floodwaters (m/hr)	Maximum speed of inundation of flood risk area (hrs)	Maximum velocity of floodwaters (m/s)
Residential	Property 600 Access 600	0.1	4	Property 0.15 Access 0.3

5.2 Flood Risk Mitigation

With the culvert in place flooding may occur at the site in the event of a culvert blockage during a 100 year (1% annual probability) event. This risk should be planned for in design, so that potential consequences are managed if this scenario should occur. Any development plans for the sites should consider the overland flow routes mapped by the 2D model and promote flow management to ensure that flow does not enter buildings. This can be done through utilising roads as preferential flow routes in such an event or locating green space in areas of greatest risk. Residential and employment buildings should be located outside the areas of greatest risk, with finished floor levels above the level of the 80 % blockage scenario flood. Safe access and egress routes must be provided for all

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buildings in the event of the blockage scenario flood. If the culvert were to be removed however, this would remove the risk of flooding due to the 100 year flood. This option is recommended.

Flooding also occurs at the site during the extreme flood, that is the 0.1% or 1000 year annual probability flood. Again detailed design of any development would need to consider this risk, and how it varies across the site. Buildings and access/egress routes would need to be located outside the areas of greatest depth and velocity, taking into account the limiting values indicated in Table 5.1 and confirmed in discussion with EAW. Areas of higher depth and velocity may be suitable for more flood compatible uses such as car parking, or designed as open areas e.g. for landscape or recreation.

If the culvert is to be opened then whilst the model shows that there is minimal risk to the site itself (provided the new channel is representative of the upstream and downstream dimensions), there is the potential to increase risk downstream. During extreme events the culvert capacity was reached and water backed up behind the culvert and was stored in the channel (albeit to very high depths). With the culvert removed this additional storage is no longer utilised as conveyance rates are improved, resulting in increased flow of water downstream and increasing the risk to any downstream receptors. However this effect is not very marked at the Navigation Colliery site,

Whilst the detailed nature of any mitigation works is beyond the nature of this study one potential mitigation option may be to provide flood storage in the vicinity of the site to compensate for the extra volume of water released downstream. Some of this compensation would occur in the new channel itself provided its volume to bankfull is greater than the volume in the culvert it is replacing. In order to determine this storage volume a detailed study would need to be undertaken looking in more detail at the hydrology and associated critical storm durations. Entec would be able to carry out this further work if required.

Another option might be considered, particularly if the culvert at either site is not to be opened up, is installing a flood warning gauge upstream of the site. This, and the warning system would be managed by the Environment Agency, and a potential developer would need to discuss this option with EAW at an early design stage. However at the Navigation Colliery site because of the steep upstream catchment and flashy hydrology lead times would be too short to allow effective flood warning for the site.

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6. Summary and Conclusions

This flood consequence assessment has looked at the potential flood risk at Navigation Colliery near Crumlin in Caerphilly, South Wales.

The study identified a potential flood risk from groundwater flooding at the Navigation Colliery site. Risks of surface water and sewer flooding were also discussed, and all these would need to be considered in more detail at a later planning stage. A drainage strategy to manage surface water runoff would be required at each site.

A hydraulic model was built using ISIS 1 dimensional and Tuflow 2 dimensional software, to model the risk of flooding from the river Ebbw. The model used section data from a pre existing model provided by EAW.

The modelling showed that no flooding occurred out of bank for any of the scenarios up to the 100 year flood with climate change, except the culvert blockage scenarios. When the culverts were modelled 50% or 80% blocked, with the 100 year flood and climate change, flooding occurred over significant areas of the site. Depths greater than 1.0m and velocities of greater than 2.0 m/s were reached on parts of the flooded area.

Models were run with the culvert removed and this output confirmed that the site did not flood (for the 100 year flood with climate change), but there is an increase in flow rates downstream. It is recommended that the culvert is removed as part of any development. This would mitigate flood risk at the site and would also allow improvements to biodiversity. There would be an increase in flood risk downstream which would need to be considered and mitigated; the option of providing upstream flood storage areas could be considered. Entec would be able to carry out this further modelling work if required.

An estimate of the 1000 year (0.1% annual probability) flood was modelled and this showed that areas of the site were flooded. The indicative depth and velocity criteria from TAN 15 are exceeded in parts of the flooded area and careful design of any proposed development would need to consider a sequential approach to locating development types within the site to ensure that more vulnerable development types (e.g. residential properties and access/egress routes) are located in areas of least risk. As before it is recommended that the culvert is removed as part of the development, to reduce flood risk from the 0.1 AEP (1000 year) event.

Other mitigation measures including designing finished floor levels above the flood level, ensuring safe access/exit routes, flood resilient building design and use of flood storage areas, should be considered. The option of installing a flood warning gauge upstream of the site is unlikely to be workable at this site due to short lead times. Requirements for flood mitigation at the site should be discussed with the EA at an early stage in the detailed design of a development.

The modelling work has demonstrated that there is potential to develop the Navigation Colliery site, and manage flood risk in line with the requirements of TAN 15 if appropriate flood management and mitigation measures are implemented.

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7. References

CCBC (2008) Deposit Local Development Plan, Caerphilly County Borough Council, October 2008.

CCBC (2003) Council Approved Unitary Development Plan.

CEH (1999) Flood Estimation Handbook, Centre for Ecology and Hydrology.

EAW (2007) Eastern Valleys Catchments Flood Management Plan, Scoping Report, Environment Agency, Wales, August 2007.

EAW (2008) Draft Eastern Valleys Catchments Flood Management Plan, Environment Agency, Wales, September 2008.

Pitt (2008) The Pitt Review: Lessons Learned from the 2007 Summer Floods, Cabinet Office.

WAG (2004) Technical Advice Note 15: Development and Flood Risk, Welsh Assembly Government.

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Caerphilly County Borough Council

Strategic Flood Consequence Assessment. Navigation Colliery, Crumlin

Appendices

March 2009

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Document Revisions

No.	Details	Date
1	SFCA Appendices	November 2008
2	SCFA Appendices FINAL	March 2009

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Appendix A
Photographs of Site

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Figure A.1 Navigation Colliery Site looking north from centre of site

Figure A.2 Navigation Colliery Site looking south from centre of site

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Figure A.3 Navigation Colliery Site looking southwest from centre of site

Figure A.4 Navigation Colliery Site looking south from north of site

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Figure A.5 Former mining infrastructure at the Navigation Colliery site

Figure A.6 Looking north at the north part of Navigation Colliery site

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Figure A.7 River Ebbw exiting culvert at south part of Navigation Colliery Site

Figure A.8 Disused railway looking south from south of the Navigation Colliery site

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Appendix A

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Appendix B
Conceptual Plan for Navigation Colliery Site

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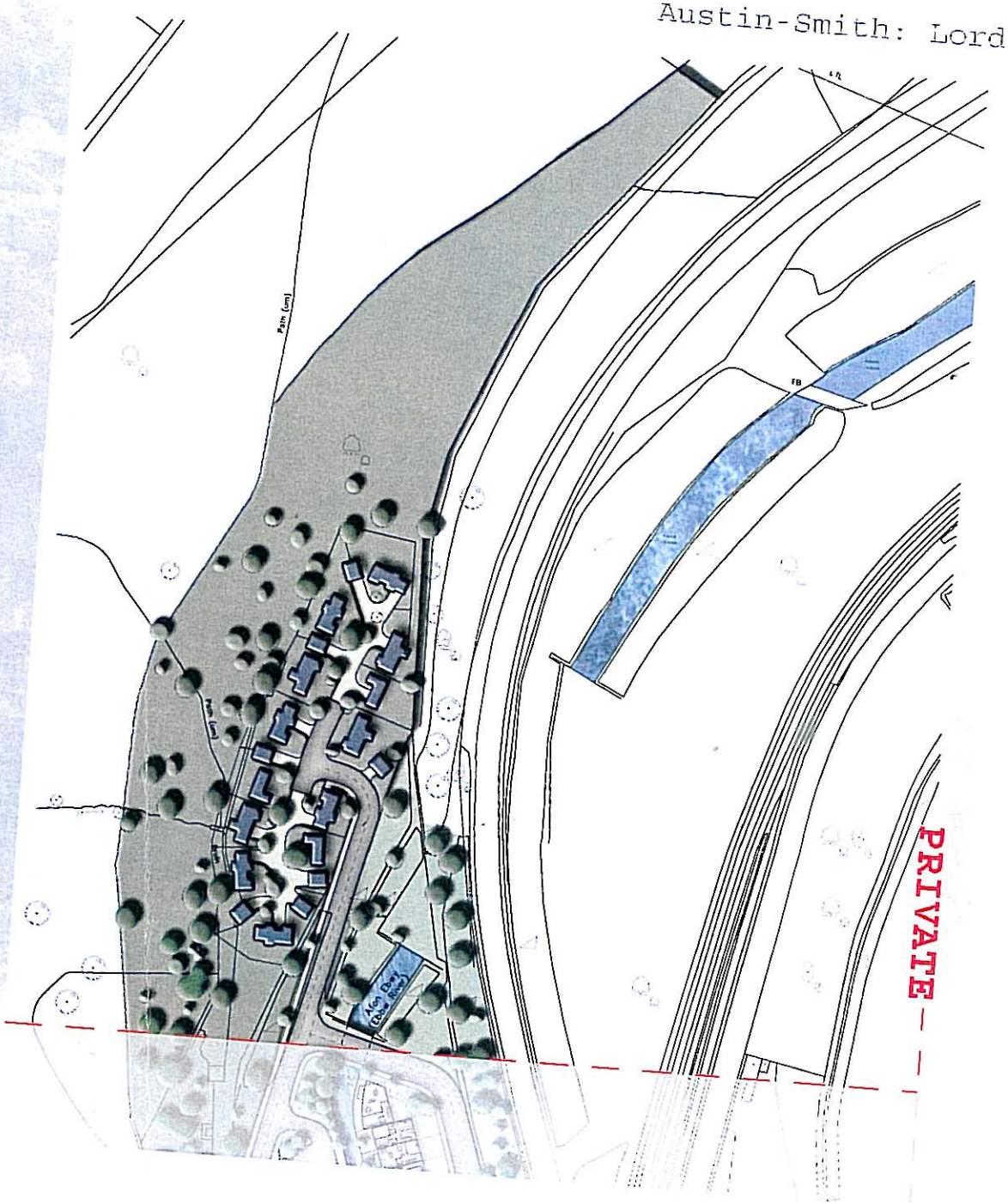
Navigation Colliery, Crumlin - September 2005

Austin-Smith: Lord

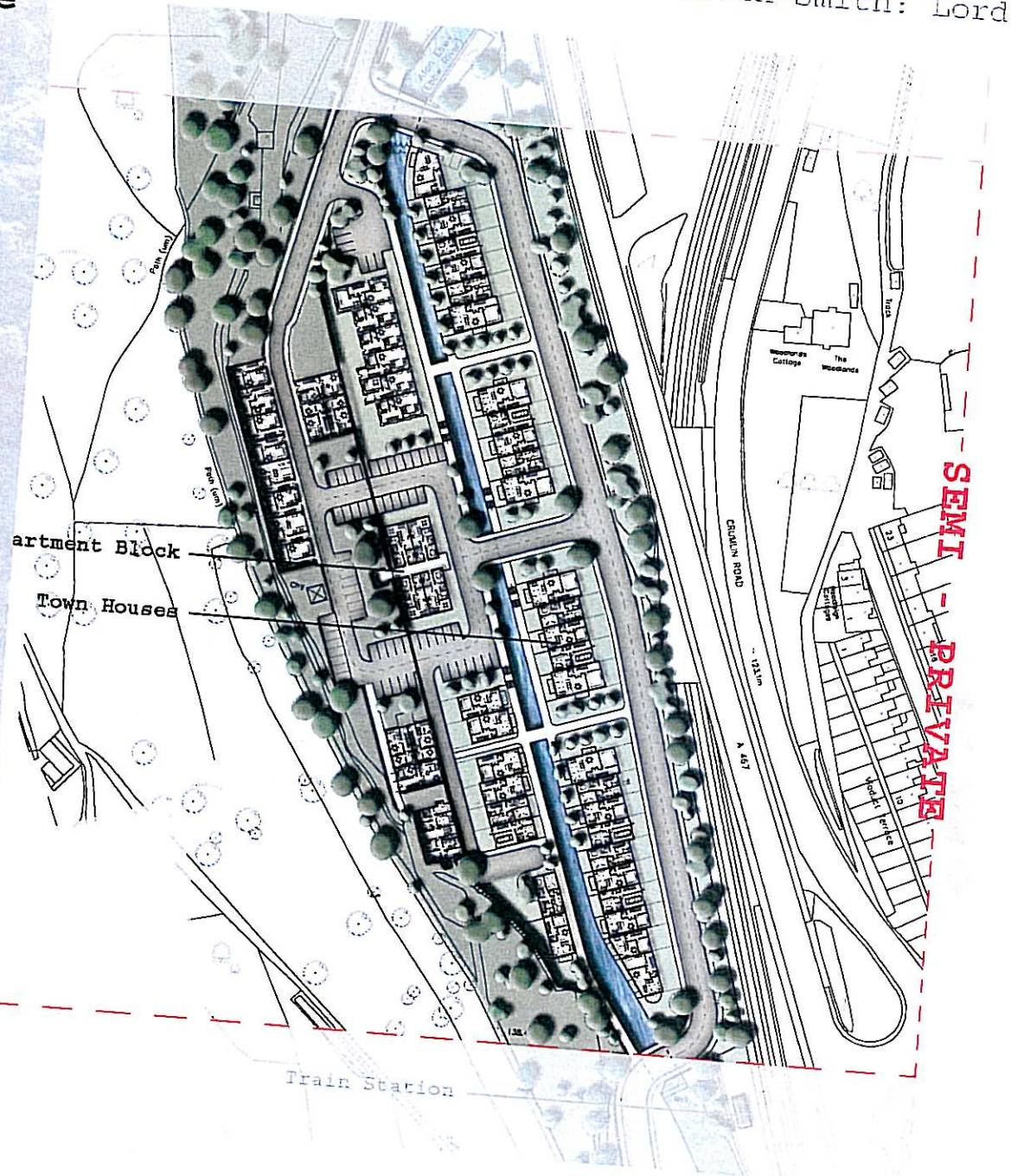
II Private Zone



Navigation Colliery, Crumlin - September 2005

Austin-Smith: Lord

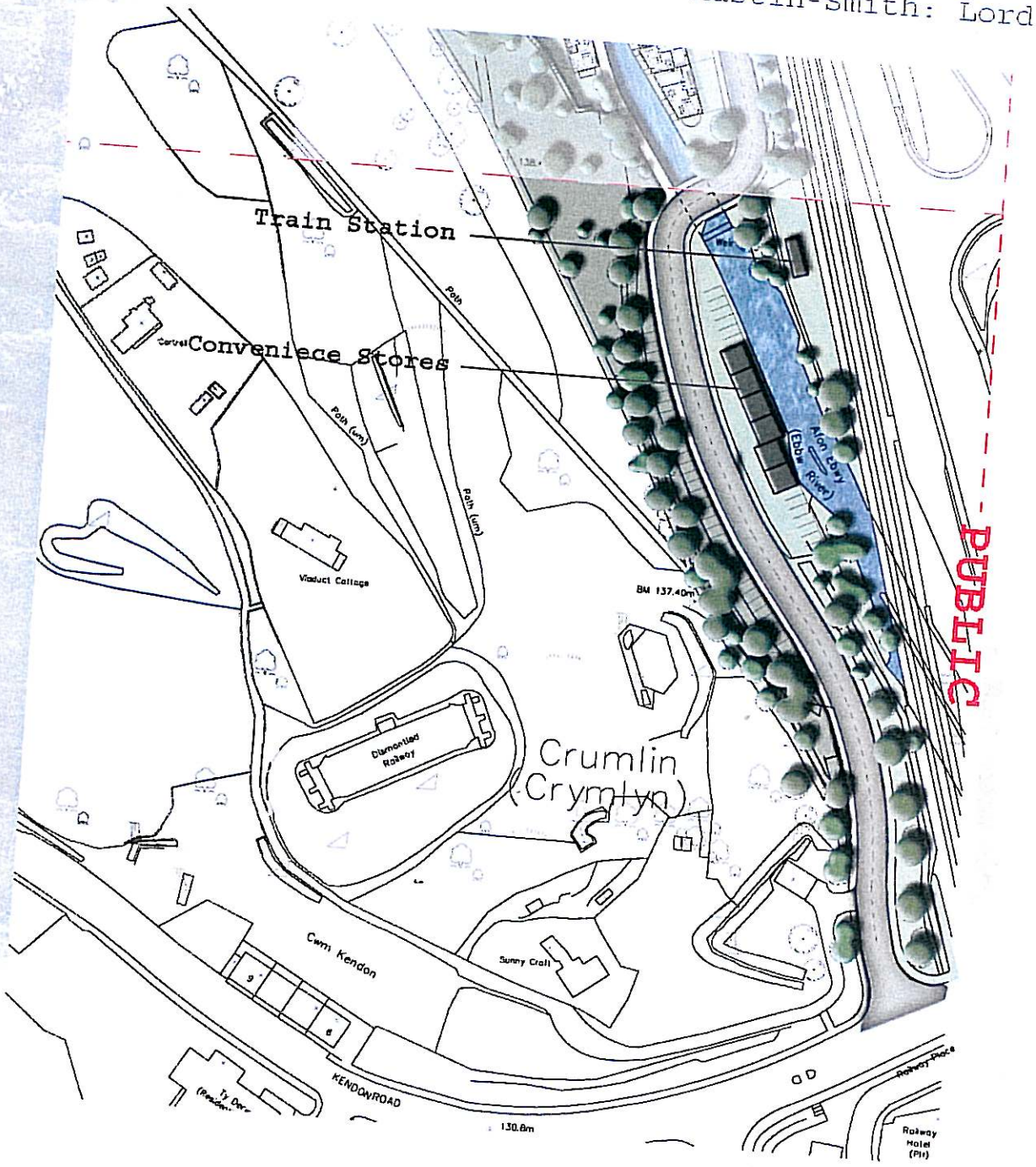
II Semi - Private Zone



Navigation Colliery, Crumlin - September 2005

Austin-Smith: Lord

II Public Zone

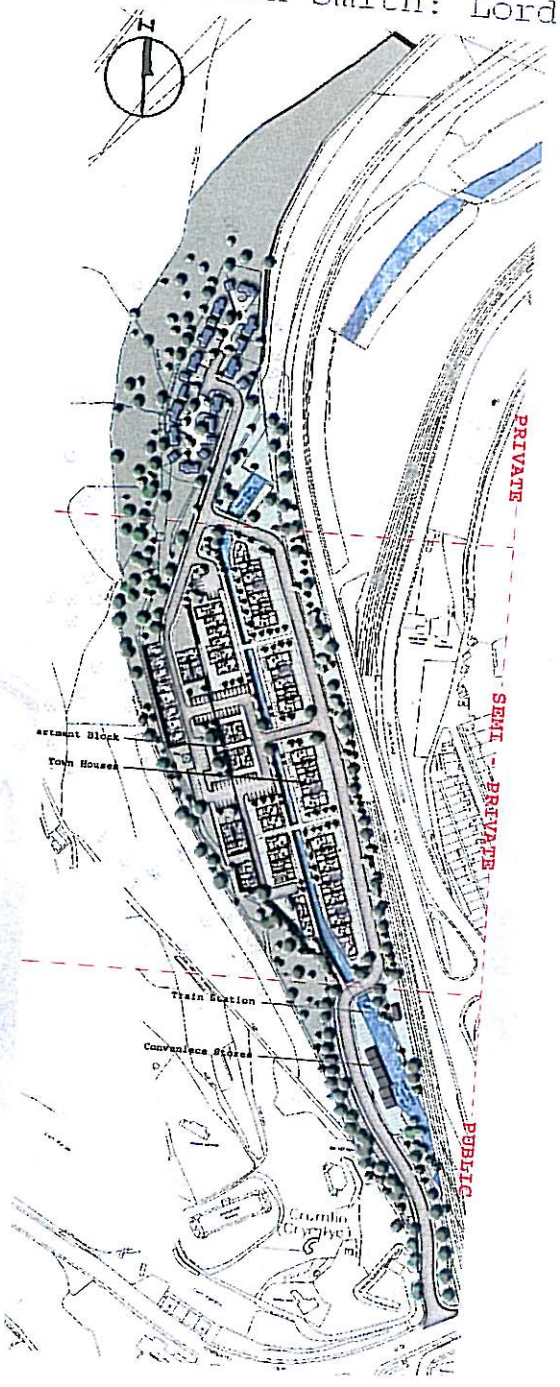


II Proposed Site Plan

Austin-Smith: Lord

Proposal: Subdivide the site into three distinct areas

- Private Zone: on the upper plateau, mainly new-build detached private houses and gardens
- Semi - Private Zone: inclusive of private new-build 3 storey town houses and access to public footpath along the re established river bank.
- Public Zone: zone accessible to the public, including stores and a train station with adjacent car parking area.



Appendix C
CCBC Justification For Development Site

Navigation Colliery - Excerpt from Broad Level Flood Risk Assessment, June 2008

Housing sites without planning consent

4.3.1 There are only two sites of the 578 submitted for consideration through the candidate sites process that are to be taken forward as housing allocations in the Deposit Local Development Plan that lie partially or completely within C1/C2 and do not have a current planning consent. These are:

- Navigation Colliery, Crumlin
- St Ilans Comprehensive, Caerphilly

4.3.3 These two sites received EA objections in earlier correspondence regarding potential housing sites, until such time as a Broad Level Assessment and Strategic Flood Consequences Assessment were undertaken and submitted to the EA for consideration. This paper forms the Broad Level Assessment for how Caerphilly has adopted the precautionary principle in the preparation of the Deposit LDP and the justification for the small number of housing sites being allocated on land partially within C1 or C2 zones.

4.3.4 Test of Soundness CE2 refers to the need for a robust and credible evidence base upon which the strategy, policies and allocations are based, having considered alternatives. It can be demonstrated that the potential allocations for housing are based on robust evidence as sites have been subject to stringent assessment tests and alternatives considered. Sites within zone C of the flood plain have only been taken forward where no more suitable alternative sites are available and there would be significant social and economic benefits gained from the allocation of the land.

4.3.5 One of the components of the LDP Strategy is to target development to reflect the role and function of individual settlements. A hierarchy of 5 principal towns (Caerphilly, Blackwood, Bargoed, Risca-Pontymister and Ystrad Mynach) and 4 key settlements (Newbridge, Bedwas, Nelson and Rhymney) is set out in the Strategy, with all other areas being identified as having a residential role.

4.3.6 Many of the former mining villages across the County Borough have a limited range of housing stock, dominated by large numbers of terraced properties. Whilst the candidate sites process promotes the consideration of a range of sites in a variety of settlements in order to diversify the housing stock, the

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topography of the valleys and site constraints have significantly impacted on the number of sites deemed acceptable for further consideration. Consequently, the opportunity to develop sites in some settlements is limited to the redevelopment of existing brownfield sites. In some cases the only sites available to help sustain local communities by the provision of housing are in the floodplain. This is the case in Crumlin where Navigation Colliery, which lies partially within a flood risk area, is being taken forward as an allocation.

4.3.7 It is noted in TAN 15 (paragraph 6.2) that only less vulnerable development can be justified within zone C where it is required as part of a regeneration initiative or to sustain an existing settlement, but highly vulnerable development such as housing should not be permitted. However, Crumlin is identified in the Strategy as having a residential role and therefore an expansion of range of houses in order to support the community would be considered more compatible with the aims of the strategy and adjoining sites than other uses that may be less vulnerable. Housing, as a use with the highest land value, offers the greatest opportunity for the promotion of a viable regeneration scheme. This is a particular issue in Crumlin, where the site is constrained by the need to restore the listed former colliery buildings on the site.

4.3.8 Furthermore, the EA have identified the site as one that may be potentially contaminated due to the historic use of the land and its allocation for housing will facilitate its reclamation, which may have wider benefits for water quality.

4.3.9 In assessing flood risk, it is also important to recognise that Crumlin has not been identified as a settlement with flood risk issues in the CFMP inception report (Appendix 1), nor has it been identified that any people, property or infrastructure is at risk in the settlement.

4.3.10 Whilst there are clear social, economic and environmental reasons for the allocation of Navigation Colliery, it is also necessary to demonstrate, as required by TAN 15, that the potential consequences of a flooding event for this type of development have been considered and found to be acceptable. In order to address this, the Council have commissioned a Strategic Flood Consequences Assessment to be undertaken in accordance with the requirements of TAN 15, which forms part of the evidence base for the LDP.

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Appendix D
Hydraulic Modelling

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1. Data for Modelling

1.1 Supplied Data

Key data supplied for use in this study are stated below:

- A 1D Steady State Hec-Ras model was supplied by the Environment Agency for use in this project under licence 080905. The model was built for the 'River Ebbw Tredegar to Aberbeeg Flood Risk Mapping study (Version 3.0)' and covers the Ebbw River through Crumlin. However, due to concerns about the steady-state nature of the model and its inability to define spill volumes this model is to be converted into a 1D fully hydrodynamic ISIS model. The model is supplied with additional data including survey data in CAD format, cross section locations and a model report.
- Lidar data has been supplied by the Environment Agency as two sets (filtered and unfiltered) of 3 tiles (0030864, 0045213, 0045693). Tiles have been supplied in asc grid format.
- OS 50k, 25k and 10k background map data has been supplied by Caerphilly County Borough Council

1.2 Historic Flood Information

Discussions with Caerphilly County Borough Council and the Environment Agency revealed that there is no known history of flooding at the site. They reported that there were no EAW or other known flood defences at or in the vicinity of the Rhymney site. EAW did not provide information on flood defences whether owned by them or others, at or near the site, but no defences are shown on the EA website flood map.

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2. Hydrology

This section describes how inflow hydrographs for the hydraulic model inputs were derived.

2.1 Background

The Navigation Colliery site is located alongside the River Ebbw in Crumlin, South Wales. The River Ebbw flows from north to south from around 600m elevation at the southern boundary of the Brecon Beacons to its outfall in the Usk estuary. Upstream of the site the rivers Ebbw Fawr and Ebbw Fach combine at Aberbeeg to form the main River Ebbw. Downstream of the site the River Sirhowy joins the River Ebbw and is its largest tributary. Annual average rainfall varies from 1800mm in the north to 1000mm in the south of the Ebbw catchment. The mild and wet climate combined with the mountainous landscape, steep river channels and heavily urbanised valley floors can lead to rapid rises in river levels during and after heavy rainfalls. Baseflow is generally low due to the low storage capacity of the underlying geology.

The catchment has historically been industrial in nature, dependent on steel manufacturing and coal mining.

2.2 Hydrometry

The Environment Agency's Highflows database contains a flow gauge located at Aberbeeg (NRFA ref. 56019) with records dating back to 1967. This gauge is upstream of the site and downstream of the confluence of the rivers Ebbw Fawr and Ebbw Fach. The gauge is a broad-crested weir and although QMED is within bankfull there are no gaugings to confirm a stage discharge relationship at bankfull level (max gauging is for 5.3 m^3/s). The AMAX series estimates QMED at 36.1m^3/s but due to the extrapolated rating curve this estimate is considered unreliable. The highest stage on record was for the event of October 1998 when the stage reached 1.41m (estimated flow 70.7 m^3/s).

Downstream of the confluence of the rivers Ebbw and Sirhowy there is another HiFlows gauge at Rhiwderin near Bassaleg (NRFA ref. 56002). It has been active since 1957 but was extensively refurbished in 1996, which included the replacement of the old measuring structure with a new flat-V weir. Before the refurbishment the rating curve was considered unreliable but following the upgrade ratings have been undertaken to QMED (maximum gauged flow 130.3 m^3/s). Following the upgrade to the gauge the highest stage on record is 2.625m (estimated flow 247.5m^3/s) reached in October 1998. QMED has been estimated from the AMAX series at 104.5m^3/s.

On the River Sirhowy tributary there was a HiFlows gauge at Wattsville before the confluence with the River Ebbw (NRFA ref. 56011). The gauge is now closed and has a record from 1970 to 1983. The gauged rating extended

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beyond QMED and the maximum flow on record is 113m^3/s which occurred in 1979 and is noted to be within the gauged limit.

The Eastern Valleys CFMP additionally notes the presence of a stage only gauge at Risca downstream of the confluence of the rivers Ebbw and Sirhowy. It is unlikely that this gauge will feature in any analysis of the river due to lack of a rating.

2.3 Flow Estimation

Three different methods will be used to estimate flows. A statistical analysis using a pooling group approach, an FEH unit hydrograph analysis and an ReFH analysis. These are detailed below.

2.3.1 Statistical Analysis

The statistical analysis involves the derivation of QMED and this is then multiplied by the growth curve to obtain design flow estimates. As there is no flow gauge at the site of interest QMED will be estimated from catchment descriptors and the growth curve will be derived from a pooling group of similar catchments using FEH WINFAP software.

QMED

Descriptors for the catchment have been obtained from the FEH CD-ROM v2 for a location immediately upstream of the site (321350, 199250). The upstream catchment has an area of 80.19 km2. Key descriptors are given in Table 2.1. A full explanation of these is provided in the FEH Handbook

Table 2.1 Catchment Descriptors, Crumlin

Area	SAAR	URBEXT2000	SPRHost	BFIHost	Propwet	Farl
80.19	1473	0.076	32.93	0.502	0.53	0.961

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With no gauged data at the subject site, initial QMED estimation is from FEH Catchment Descriptors using the updated regression equation detailed in FEH Guidance[1]. This gives a rural QMED estimate of 38.99m^3/s.

QMED Urban Adjustment

The catchment draining to the subject site is moderately urbanised (URBEXT2000 = 0.076). An urban adjustment is therefore required to QMED rural based on equations given in S9.2.3 of Vol. 3 of the FEH Handbook. Updating URBEXT to 2008 gives a value of 0.0775 which gives an adjustment factor of 1.12.

The value of QMEDurban to be used in the flood frequency estimation is **43.67m^3/s.**

QMED Donor Adjustment

Rhiwderin gauge is located on the River Ebbw downstream of the subject site. It has a gauged Annual Maxima record dating back to 1957 and is recommended by the HiFlows database as being suitable for estimating QMED. Use of this gauge record to refine the estimate of QMED at the subject site has been undertaken using the revised procedure for donor catchments with key data used in the calculation given below:

- QMEDgauged: 106.0m^3/s
- QMEDcds (with urban adjustment): 92.71m^3/s
- Distance from subject site (catchment centroids): 4.1km

The final adjusted value of QMEDurban for the subject site is **46.73m^3/s**

Pooling Group

As the subject site is ungauged a ‘pooled’ growth curve has been derived from a pooling group of ‘hydrologically similar’ gauged catchments based on descriptors for the subject site. The pooling group has been derived using the Hi-Flows dataset and only selecting from the group ‘sites suitable for pooling’. A rule of thumb is that the pooling group should contain around five times as many station years as the target return period. The target return period is 100 years but an initial pooling group was created with around 700 years worth of data.

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[1] Environment Agency (2008) Improvements to the Flood Estimation Handbook statistical method – operational instruction 940_08

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Following a review of the pooling group the catchments of least similarity were removed. The remaining group had a combined record of 567 years and was classed as heterogeneous (H2 3.95), indicating that a review of the pooling group is desirable. It was noted that the most hydrologically similar site, 50011, had a high discordancy value of 2.927 (although this was below the threshold). Investigations uncovered no justifiable reason for its removal so it was retained within the pooling group. Numerous attempts at improving the homogeneity of the group were attempted but could not be achieved on any justifiable basis and so no further changes were made to the group. The final pooling group is shown below

Crumlin Pooling group

Pooling group details for 999200 (gb 321350 199250 (st 21350 99250) @ Not Known)

	Station	Years	L-CV	L-Skewne	L-Kurtosis	Discordancy	Distance
1	50011 (Okement @ Jacobstowe)	23	0.257	0.254	0.406	2.927	0.172
2	73011 (Mint @ Mint Bridge)	37	0.197	0.290	0.157	0.747	0.252
3	21019 (Manor Water @ Cademuir)	39	0.191	0.149	0.233	0.160	0.315
4	56013 (Yscir @ Pontaryscir)	34	0.220	0.318	0.286	0.887	0.358
5	47007 (Yealm @ Puslinch)	43	0.127	-0.088	0.172	0.737	0.371
6	46008 (Avon @ Loddiswell)	26	0.196	-0.259	0.160	2.756	0.393
7	60006 (Gwili @ Glangwili)	38	0.204	0.236	0.206	0.242	0.410
8	48011 (Fowey @ Restormel)	45	0.263	0.163	0.091	1.894	0.416
9	63001 (Ystwyth @ Pont Llolwyn)	45	0.121	0.037	0.199	0.626	0.420
10	47004 (Lynher @ Pillaton Mill)	45	0.187	0.087	0.139	0.116	0.427
11	50012 (Yeo @ Veraby)	36	0.132	-0.091	0.100	0.665	0.455
12	8008 (Tromie @ Tromie Bridge)	54	0.242	0.185	0.135	0.844	0.455
13	73008 (Bela @ Beetham)	37	0.188	0.133	0.146	0.121	0.457
14	236007 (Sillees @ Drumrainey Bridg	25	0.085	0.150	0.147	1.708	0.470
15	78004 (Kinnel Water @ Redhall)	40	0.118	0.011	0.111	0.570	0.474
16							
17	Total	567					
18	Weighted means		0.193	0.126	0.194		

Add site | Move selected site | Remove selected site

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Growth Curve

The pooled growth curve was constructed by fitting the data to the Generalised Logistic distribution.

The resulting parameters of the growth curve are:

- Location 1
- Scale 0.196
- Shape -0.126

Growth curve fittings are shown in Table 2.2

Table 2.2 Fittings for Growth Curve, Crumlin

Return Period	2	5	10	20	50	100	200
Fittings	1	1.259	1.433	1.610	1.860	2.065	2.288

Values given include an urban adjustment to the growth curve

Flood Frequency Estimates

Combining the estimate of QMED at the subject site with the growth curve gives the flood frequency estimates. An urban adjustment has been applied to the growth curve using URBEXT2000 values updated to 2008. Final flood frequency fittings are provided in Table 2.3. The 100 year flood estimate is 96.51 m^3/s.

Table 2.3 Fittings for Flood Frequency Curve, Crumlin

Return Period	2	5	10	20	50	100	200
Peak Flow (m^3/s)	46.73	58.85	66.98	75.25	86.91	96.51	106.93

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2.3.2 FEH Rainfall Runoff

The rainfall-runoff method converts a theoretical design rainfall event into a design flood event using the unit hydrograph and losses model. With no gauged data available the analysis is based purely on regression analyses using the data provided in the catchment descriptors.

Table 2.4 Rainfall Runoff Peak Flows

Return Period	2	5	10	20	50	100	200
Peak Flow (m^3/s)	39.41	71.74	88.60	107.94	135.71	157.7	184.37

2.3.3 ReFH Rainfall Runoff

As for the Rainfall-Runoff method, the subject site is ungauged and so any derived peak flow estimates are based purely on catchment descriptors. URBEXT1990 has been used in the analysis updated to a present day value of 0.063 Peak flows are shown in Table 2.5. The critical storm duration was 6.5 hours.

Table 2.5 ReFH Peak Flows

Return Period	2	5	10	20	50	100	200	1000
Peak Flow (m^3/s)	55.28	71.98	85.37	98.31	119.22	138.92	163.49	247.94

2.3.4 Estimating the 1000 year flood

A hybrid method was used to obtain an estimate of the 1000 year flood. While the ReFH method is only calibrated up to return periods of 150 years, extreme event analysis beyond this and up to 1000 year return periods is likely to be more accurate for rainfall than for flow, because there is a considerably larger and longer dataset of rainfall available throughout the UK. For shorter return periods up to 150 years the statistical method is preferred. The hybrid FEH method as recommended in discussion by the EAW (pers. comm. Owain Sheppard, DC Team, South Wales, 21/11/08) is to determine the ratio of the 1000 year flood to the 100 year flood using the ReFH method and apply this to the 100 year flood from the Statistical method to determine a 1000 year flood estimate.

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Hence

ReFH Q_{1000}/Q_{100} = 247.94/138.92 = 1.78

Estimate Q_{1000} = 96.51 x 1.78 = 171.79 m^3/s.

2.4 Conclusions

While it is expected that results using the different methods will vary, and the rainfall runoff method tends to give larger estimates than the statistical method, the difference in this case is large. The 100 year flood peak is estimated as 96.51 m^3/s using the statistical method and 138.92 m^3/s in the ReFH method – the latter being 69% larger than the former. Overall results from the Statistical method should be favoured for events with return periods up to 150 years as this method is based on a much larger dataset of flood events, and has been more directly calibrated to reproduce flood frequency on UK catchments. As the rainfall runoff models are based purely on data given from catchment descriptors then these are likely to be less reliable. For these reasons also, there is quiate a large degree of uncertainty around the 1000 year flood estimate.

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3. Model Build

3.1 1D Model Build

The 1D model has been built using ISIS V3.1 and can be run using ISIS Free downloadable from www.halcrow.com/isis. The model build is outlined below

An existing Hec-Ras model constructed for the 'River Ebbw Tredegar to Aberbeeg Flood Risk Mapping study (Version 3.0)' has been used as the basis for which to construct the ISIS model. As part of the supplied data all river channel cross sections from the Hec-Ras model were supplied in ISIS format (but not as a working model).

The original model contained data for the entire Ebbw River from Six Bells to the A4042 road bridge at Tredegar Park. For this study it was not necessary to re-model the entire watercourse and so a model reach was selected that gave a suitable distance between the model boundaries and the site. The inflow was located 400m upstream from the site and the downstream boundary 580m downstream of the site. In a steep watercourse such as the Ebbw River these distances were considered acceptable so that any errors in the boundary will not affect levels at the site.

Sections used in the model have been left with their original name (based on river downstream chainage) from the Hec-Ras model. Modelled section begin upstream at Section 21650 (grid ref.321443 199293) to Section 20226 (grid ref. 321359 198076) at the downstream end. Structures were not supplied in ISIS format and are modelled slightly differently in ISIS to Hec-Ras. Structures have been added to the model by reference to the original survey drawings. Structures have been named according to the structure number identified with them on the survey. ISIS Spill units have been used to define spill thresholds over structures. Spill geometry has been derived from survey drawings.

During model runs it was noted that the model was prone to instability due to its steep gradient and as a result ISIS interpolate units have been added in places for model stability.

When constructing the model it was noted that many of the sections had been extended using lidar data to increase the extent of the modelled floodplain. However many of these sections had been extended above and beyond the likely limit of extreme flood levels in some cases by the order of tens of metres. The modelled floodplain sections were therefore trimmed back but still extended beyond extreme flood levels.

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Inflows

Inflow to the Crumlin model is from an ReFH boundary unit scaled to fit peak flows estimated from the FEH Statistical method (Section 2.3). A storm duration of 7 hours was applied to the inflow as whilst the peak is scaled to the FEH flow estimate the volume would still be affected by storm duration. 7 hours was deemed approximate to the catchment size.

Downstream Boundary

A normal depth boundary was applied at the downstream end of the model 580m downstream of the site boundary and 6.57m below the bed level of the channel at the sites downstream end. This boundary assumes established uniform flow, i.e. without influence from possible hydraulic changes further downstream. The location was deemed suitable in order to ensure that any errors in the boundary did not impact on levels at the site.

Roughness Parameters

Manning's n values of 0.04 and 0.06 have been used to represent the roughness in the channel and the floodplain. Due to very little floodplain the majority of Manning's values in the model are 0.04. As even the most extreme design flood events (1% with climate change) did not result in out of bank flooding sensitivity testing of the model to changes in roughness coefficient was not deemed necessary.

Sensitivity Testing

Sensitivity testing of the model by varying Manning's n values was not applied as all flood events remain in bank through the study area. Due to the nature of the steep watercourse and the presence of culverts the model is highly sensitive to culvert blockage. Two culvert blockage scenarios were carried out for the main culvert running through the site. The culvert was adjusted in size to represent a smaller cross sectional area to simulate blockage scenarios for a 50% blockage and an 80% blockage. These blockage scenarios have been undertaken and mapped for the 1% climate change event.

Running the Model

The model has been saved under a different name for each return period using the name:

Ebbw_Crumlin_v3_Q***.DAT

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Where *** is replaced by the return period. A new version of the model (v4) has been created which has the main culvert removed. This is for the 1% with climate change event only and has been named:

Ebbw_Crumlin_v4_Q100CC_no_culvert.DAT

The end time for all model runs is 20 hours and *.ief files are provided which contain all run parameters.

Model Results

Model results in terms of peak flows and levels for the sections shown in Figure 1 are provided in the spreadsheet:

Crumlin_1D_Model_Results.xls

Results are discussed in Section 5 of the main report.

3.1.1 2D Model Build

The 2D model has been constructed in TUFLOW version 2008-08-AE-iSP. The 2D model build is outlined below.

Topography

A model grid has been defined at 2m resolution by sampling elevations from supplied filtered lidar data. The 2D model boundary covers the Crumlin site and is extensive enough so as to include all flow across the site.

Boundaries

Inflows to the 2D model are provided as time series data (flow v time) that enter the 2D domain at the point where the culvert upstream face is located. Inflows have been extracted from the 1D model (node S27su).

The downstream boundary is a flow vs head (QH) boundary with a gradient set to 0.01 representing an approximate gradient for the site. Tuflow automatically assigns the QH rating based on this gradient and flow.

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Surface Roughness

The purpose of the model is to obtain a general indication of flow paths, depths, velocities etc. The site is small and mainly consists of neglected man made land that has been subject to growth by vegetation. For the purposes of the modelling exercise a universal surface roughness value of 0.035 has been applied to the modelled area.

Running the Model

The model is run from the Tuflow tcf file. The timestep is 1 second (half the 2D cell size). Two tcf files are provided:

- Crumlin_Q100CC_50.tcf (50% blockage)
- Crumlin_Q100CC_80.tcf (80% blockage)

Care should be taken to ensure the model inflow is correct for the scenario to be modelled (Ensure bc_dbase.csv contains link to relevant file i.e. 50% blockage or 80% blockage.)

3.1.2 Model Files

All model files are supplied on the accompanying CD.

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Creating the environment for business

Appendix E
Results from Flood Modelling

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Creating the environment for business

Appendix E

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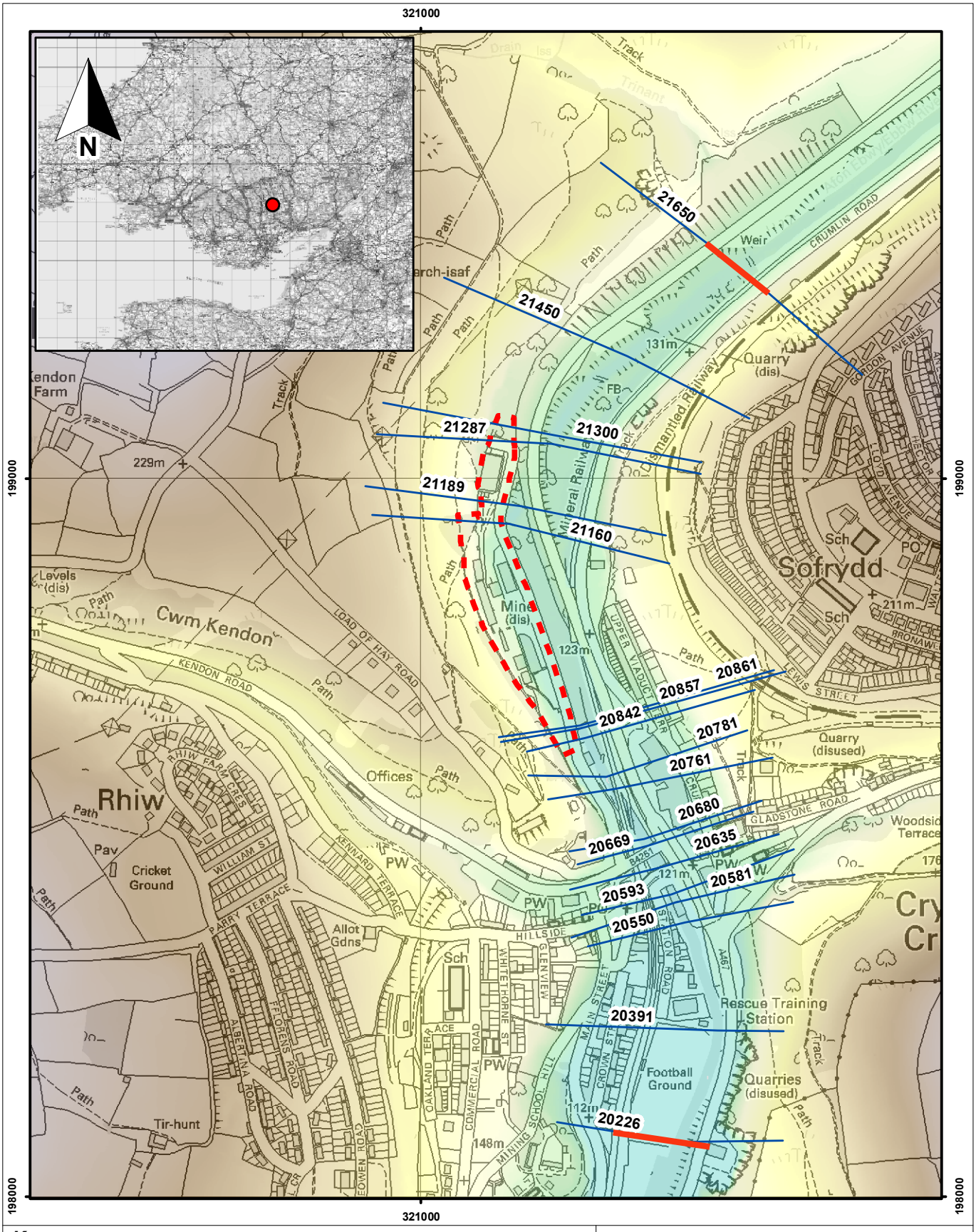
March 2009



Key:

- Model Extent
- Mapping Sections
- Site Boundary

Elevation

305m

109m

0 100 200 Metres

Scale: 1:7,500 @ A4

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\S01 Crumlin Location.mxd

Caerphilly SFCA

Figure E.1
Crumlin Location

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23549-S01 rodgb

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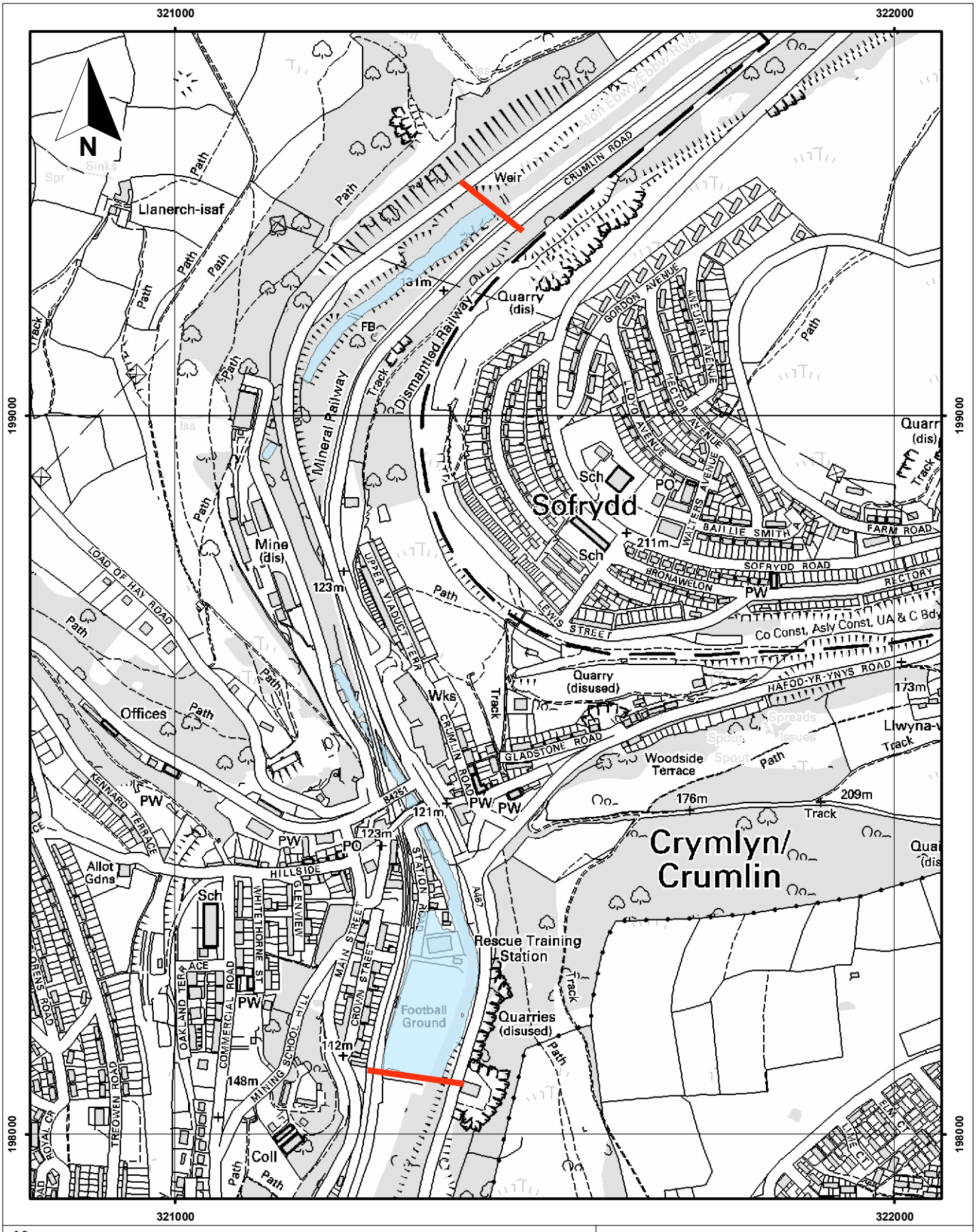

Key:

Model Extent

50% AEP Flood outline

0 100 200 Metres

Scale: 1:7,500 @ A4

Caerphilly SFCA

Figure E.2
Crumlin 50% AEP Flood

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\S03 Crumlin Q2.mxd

October 2008
23549-S03 rodgb

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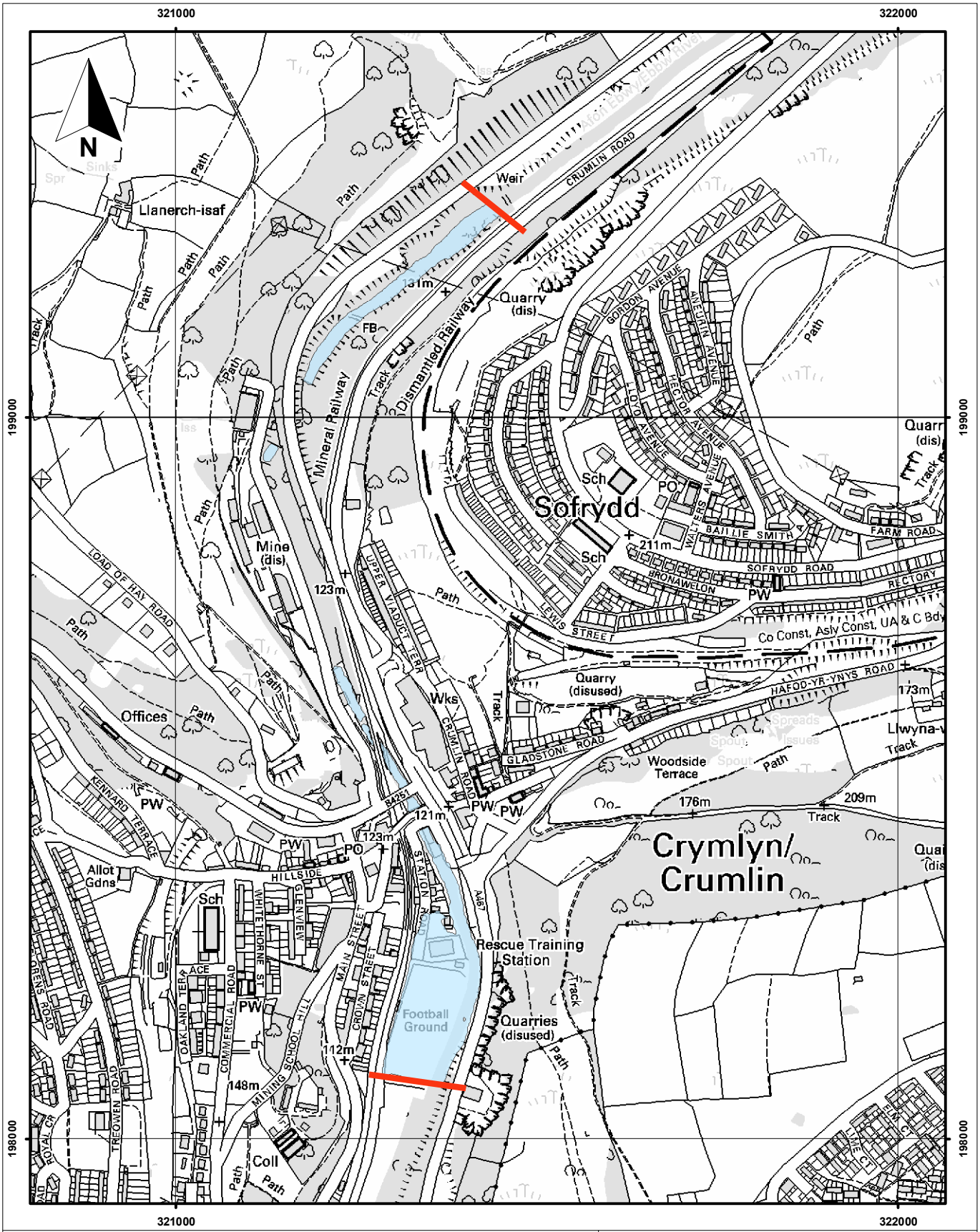

Key:

Model Extent

20% AEP Flood outline

0 100 200 Metres

Scale: 1:7,500 @ A4

Caerphilly SFCA

Figure E.3
Crumlin 20% AEP Flood

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\
S04 Crumlin Q5.mxd

October 2008
23549-S04 rodgb

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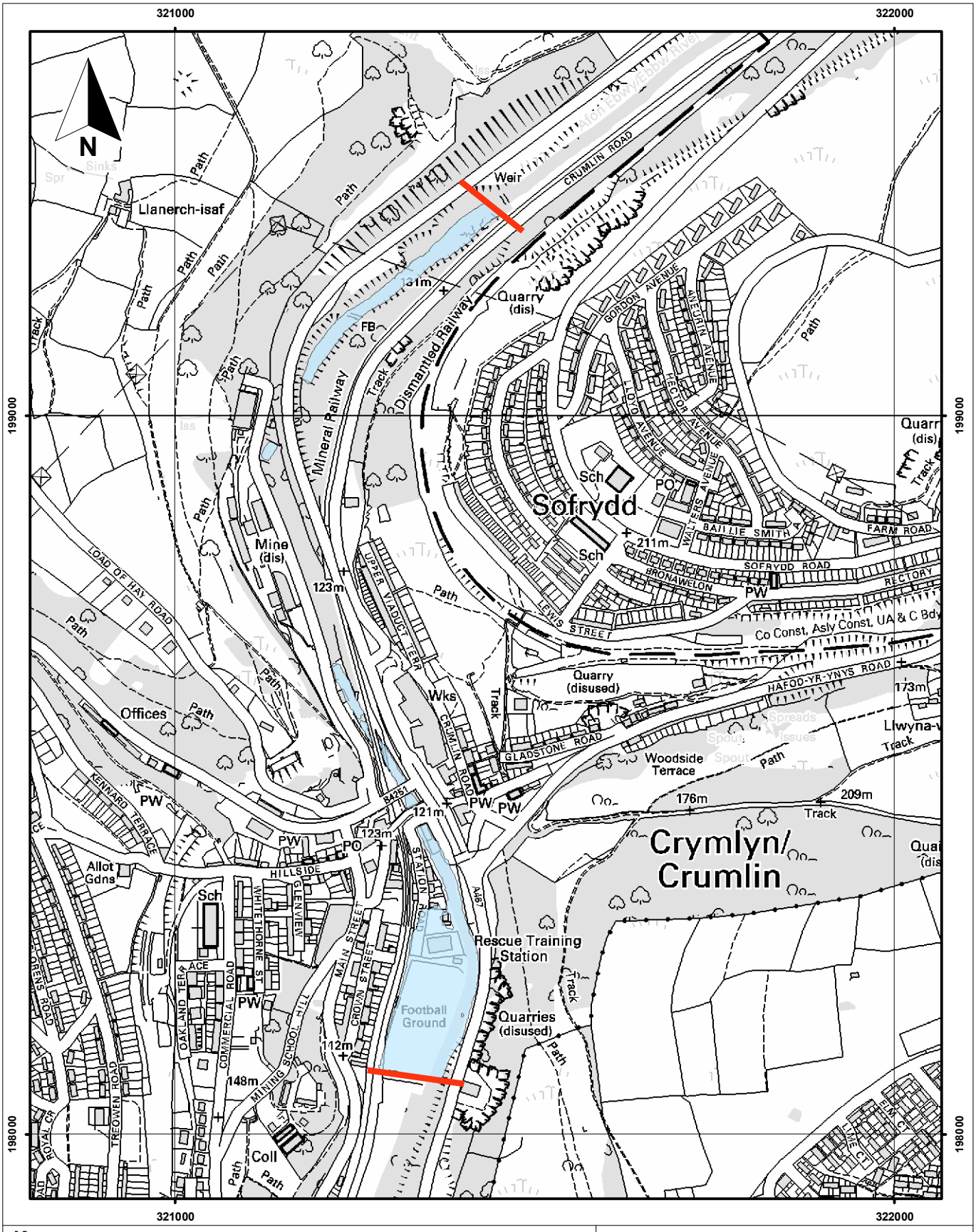

Key:

Model Extent

10% AEP Flood outline

0 100 200 Metres

Scale: 1:7,500 @ A4

Caerphilly SFCA

Figure E.4
Crumlin 10% AEP Flood

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\S05 Crumlin Q10.mxd

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23549-S05 rodgb

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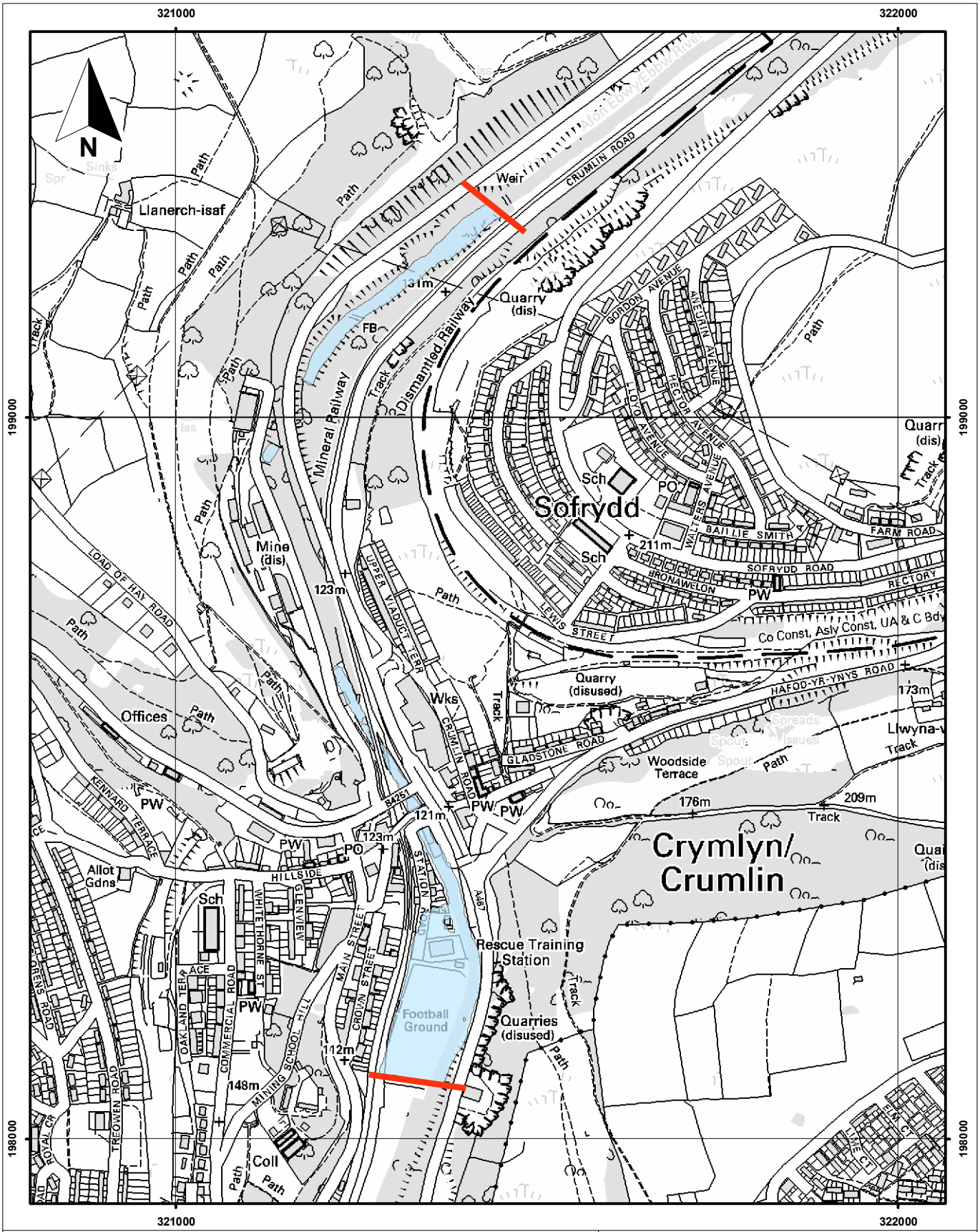

Key:

Model Extent

5% AEP Flood outline

0 100 200 Metres

Scale: 1:7,500 @ A4

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\S06 Crumlin Q20.mxd

Caerphilly SFCA

Figure E.5
Crumlin 5% AEP Flood

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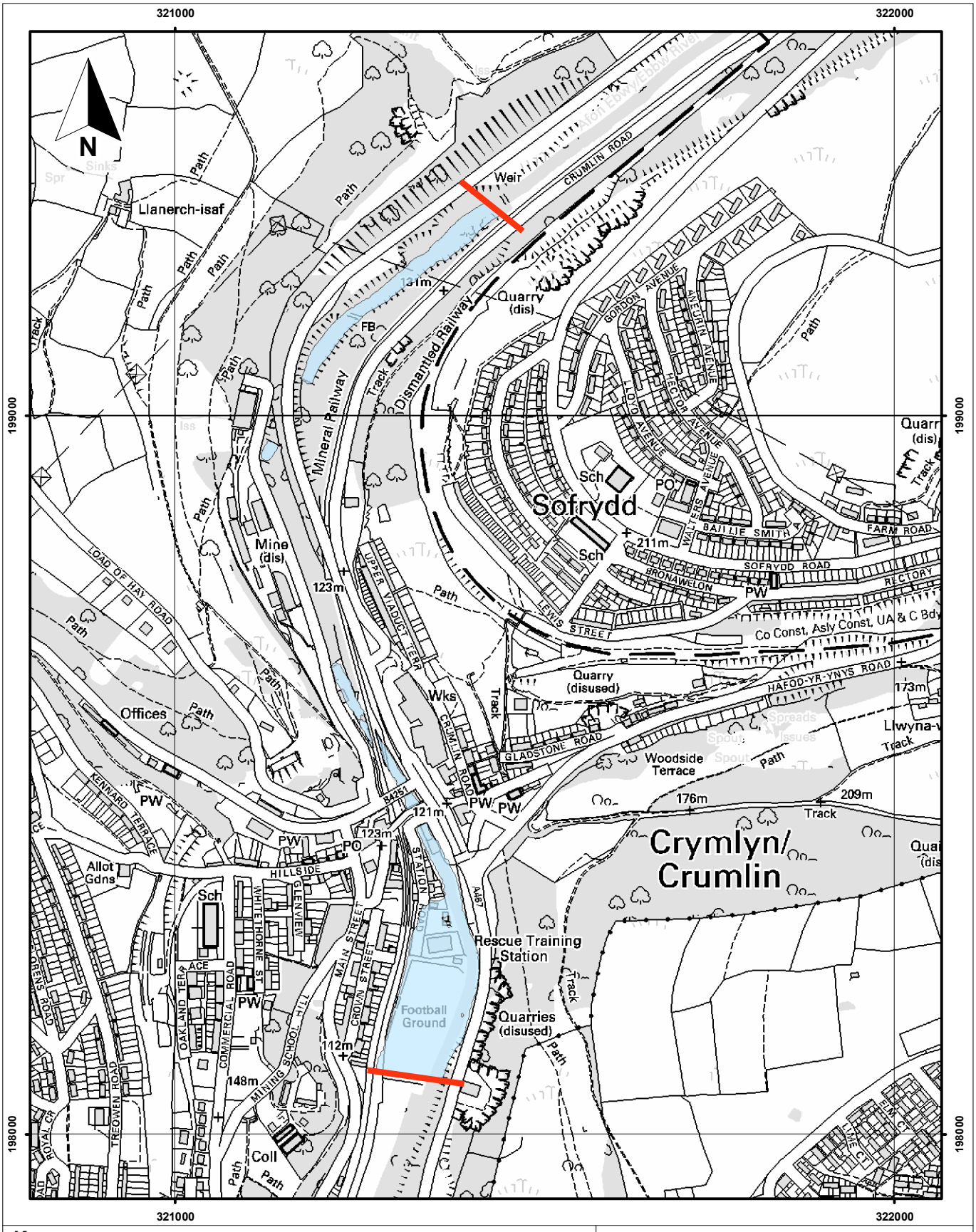

Key:

Model Extent

2% AEP Flood outline

0 100 200 Metres

Scale: 1:7,500 @ A4

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\S07 Crumlin Q50.mxd

Caerphilly SFCA

Figure E.6
Crumlin 2% AEP Flood

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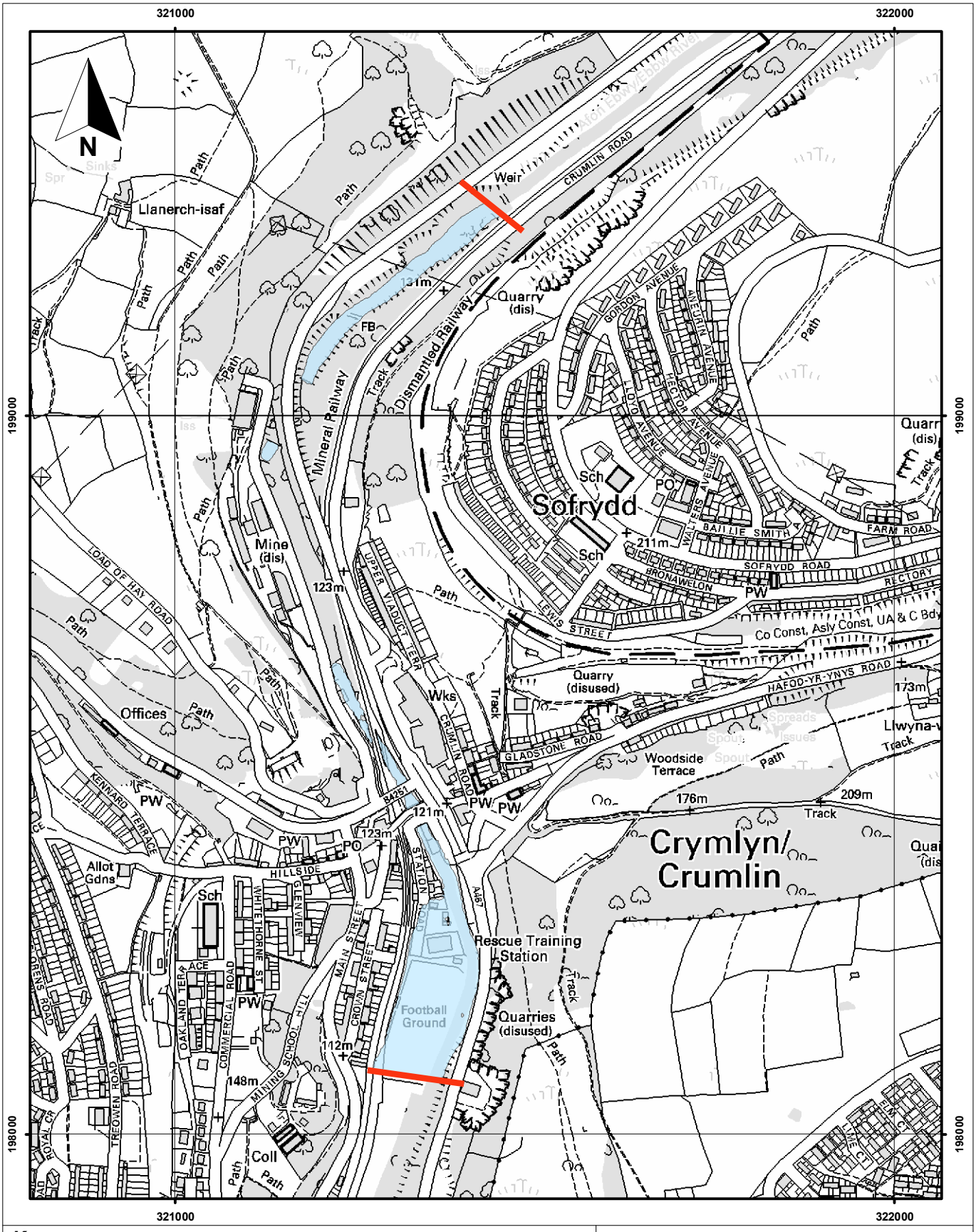

Key:

Model Extent

1% AEP Flood outline

0 100 200 Metres

Scale: 1:7,500 @ A4

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\S08 Crumlin Q100.mxd

Caerphilly SFCA

Figure E.7
Crumlin 1% AEP Flood

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23549-S08 rodgb

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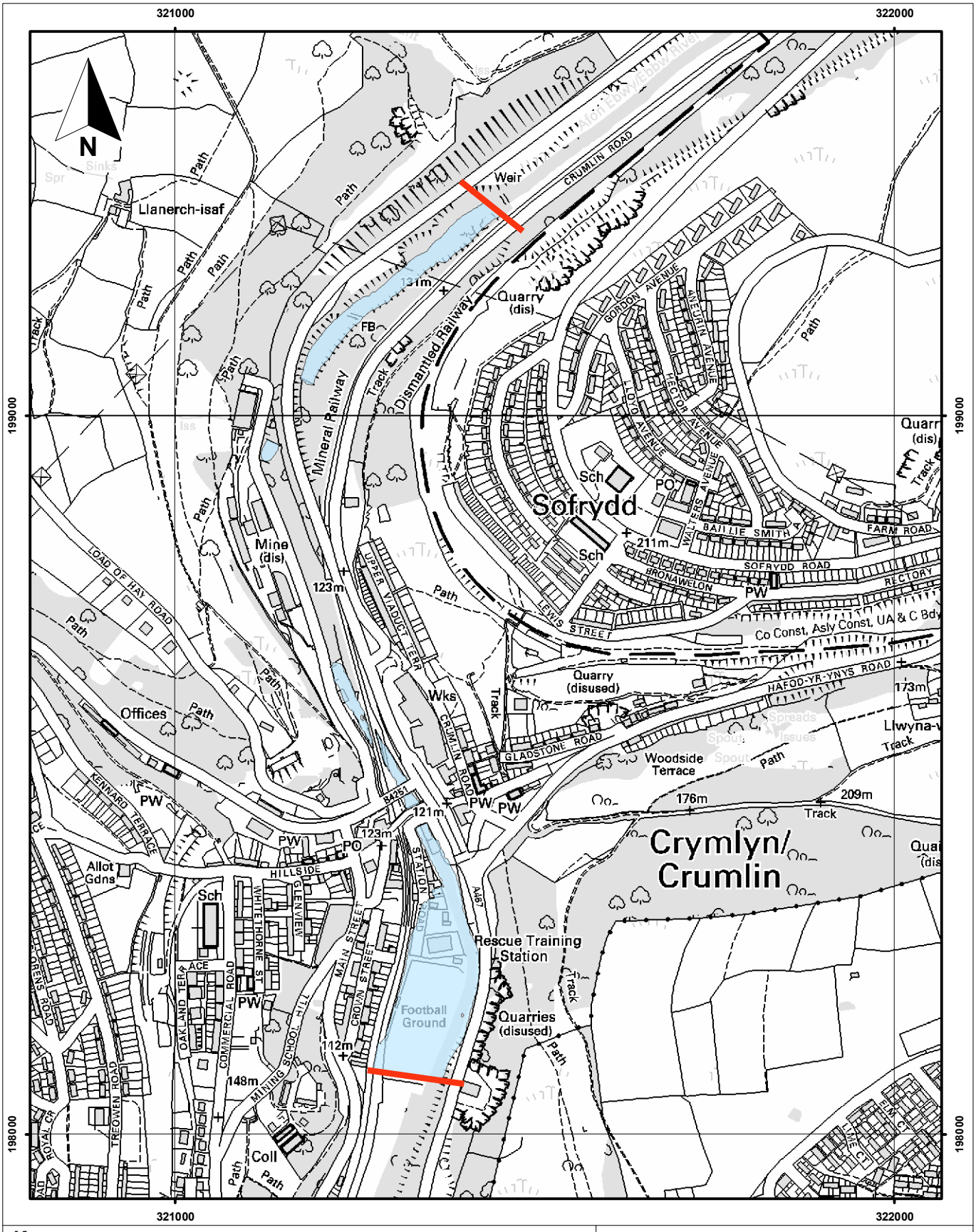

Key:

Model Extent

1% Climate Change AEP Flood outline

0 100 200 Metres

Scale: 1:7,500 @ A4

Caerphilly SFCA

Figure E.8
Crumlin 1%CC AEP Flood

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\
S09 Crumlin Q100CC.mxd

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23549-S09 rodgb

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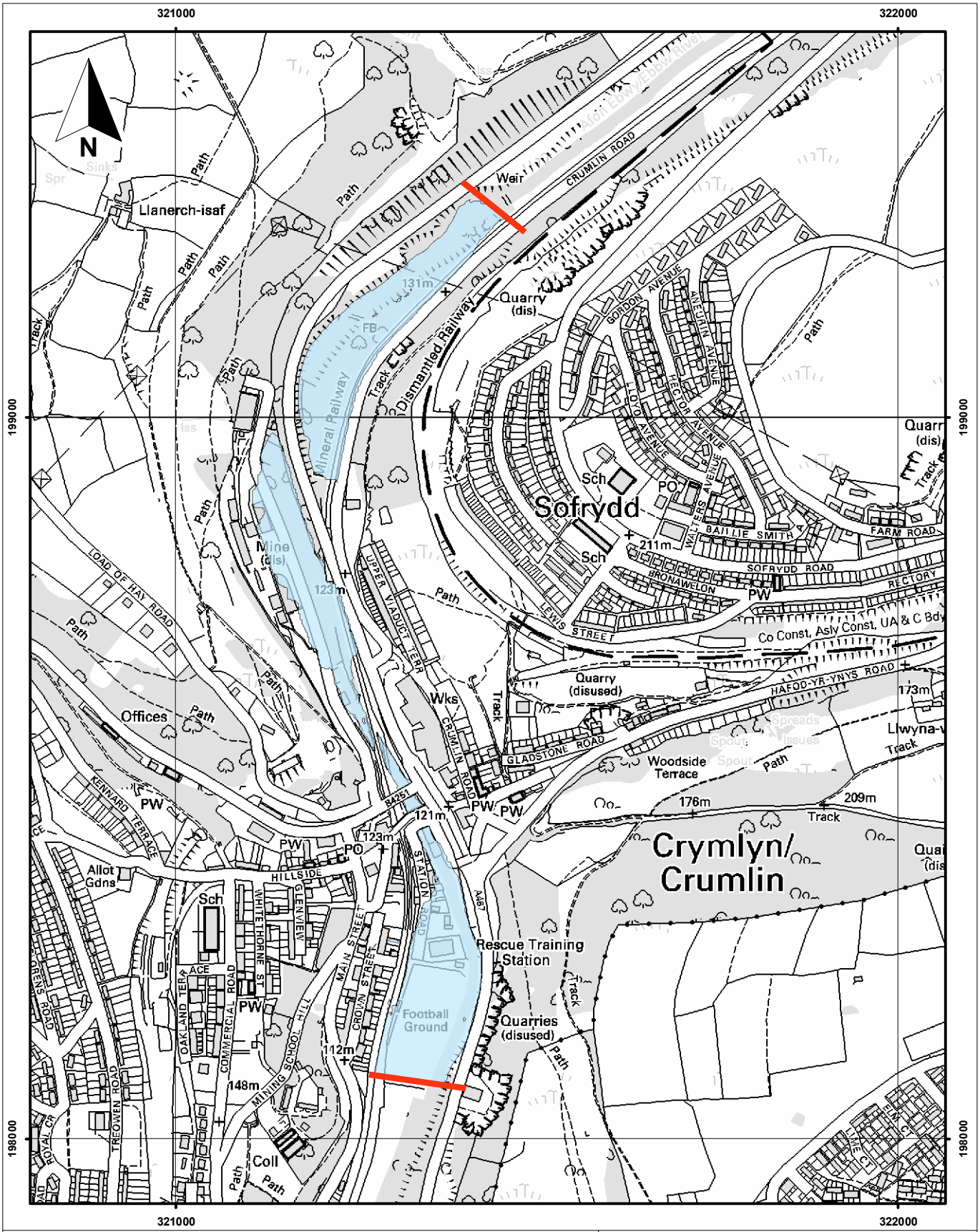

Key:

Model Extent

0.1% AEP Flood outline

Caerphilly SFCA

Figure E.9
Crumlin 0.1% AEP Flood

0 100 200 Metres

Scale: 1:7,500 @ A4

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\S37 Crumlin Q1000.mxd

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23549-S37 rodgb

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Key:

0.1% Flood depth

- < 0.05m
- 0.05m - 0.2m
- 0.2m - 0.5m
- 0.5m - 1.0m
- > 1.0m

2D Model Extent

0 20 40 Metres

Scale: 1:1,500 @ A4

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\S31 Crumlin Q1000 depth.mxd

Caerphilly SFCA

Figure E.10
Crumlin 0.1% AEP Flood Depth

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23549-S31 rodgb

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Key:

0.1% Max Flood Velocity

- < 0.5 m/s
- 0.5 - 1.0 m/s
- 1.0 - 2.0 m/s
- > 2.0 m/s

2D Model Extent

0 20 40 Metres

Scale: 1:1,500 @ A4

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\
S32 Crumlin Q1000 velocity.mxd

Caerphilly SFCA

Figure E.11
Crumlin 0.1% AEP Flood Velocity

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Key:

0.1% Flood Hazard

2D Model Extent

Very low hazard - caution

Danger for some

Danger for most

Danger for all

0 20 40 Metres

Scale: 1:1,500 @ A4

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\S33 Crumlin Q1000 hazard.mxd

Caerphilly SFCA

Figure E.12
Crumlin 0.1% AEP Flood Hazard

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23549-S33 rodgb

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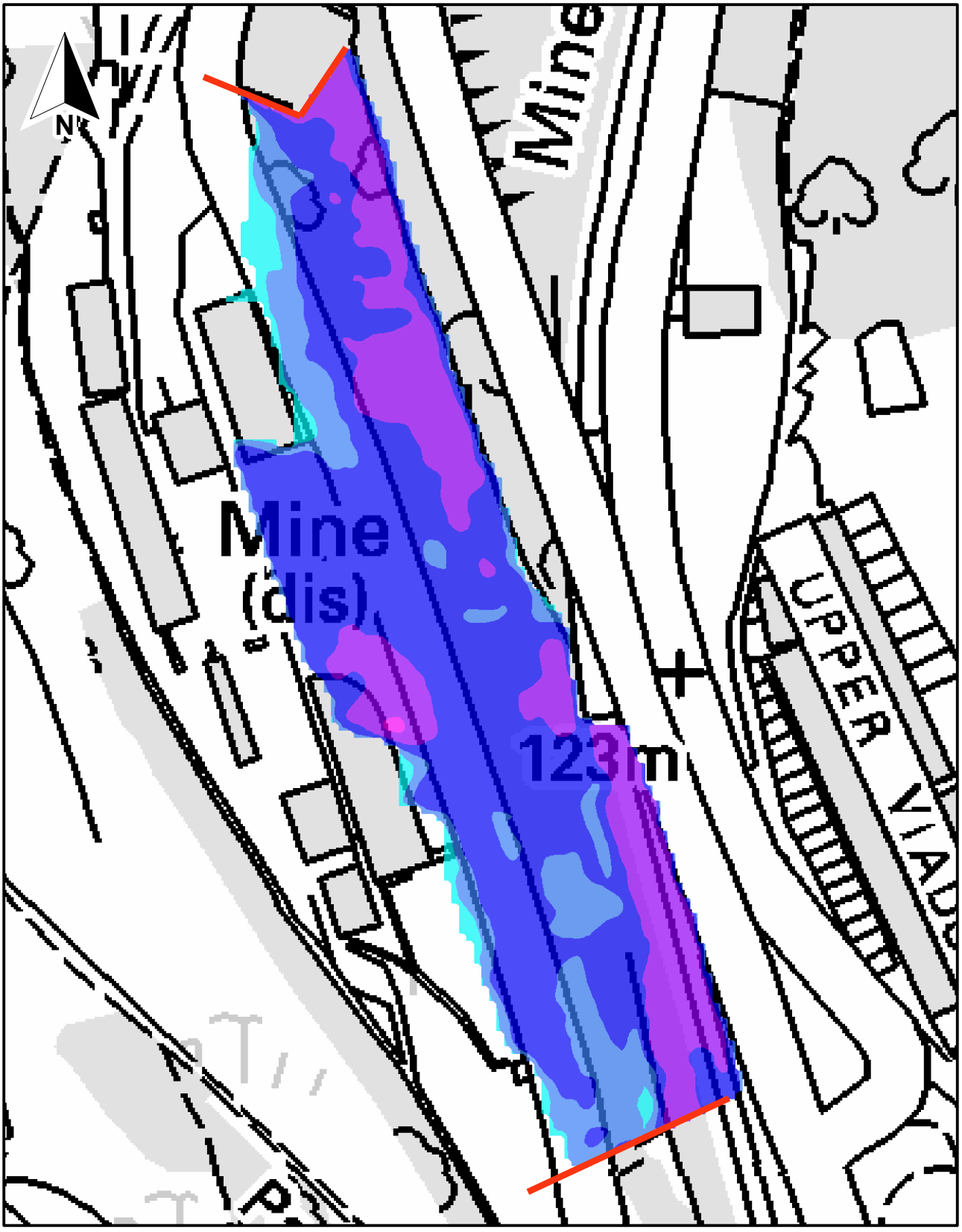

Key:

1% CC Flood depths

- < 0.05m
- 0.05m - 0.2m
- 0.2m - 0.5m
- 0.5m - 1.0m
- > 1.0m

2D Model Extent

0 20 40 Metres

Scale: 1:1,500 @ A4

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\
S10 Crumlin Q100CC 50% Block depth.mxd

Caerphilly SFCA

Figure E.13
Crumlin 1%CC AEP Flood
50% Culvert Blockage

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Key:

1% CC Max Flood Velocity

- < 0.5 m/s
- 0.5 - 1.0 m/s
- 1.0 - 2.0 m/s
- > 2.0 m/s

2D Model Extent

0 20 40 Metres

Scale: 1:1,500 @ A4

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\
S12 Crumlin Q100CC 50% Block velocity.mxd

Caerphilly SFCA

Figure E.14
Crumlin 1%CC AEP Flood
50% Culvert Blockage

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Key:

1% CC Flood Hazard

2D Model Extent

Very low hazard - caution

Danger for some

Danger for most

Danger for all

0 20 40 Metres

Scale: 1:1,500 @ A4

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\
S14 Crumlin Q100CC 50% Block hazard.mxd

Caerphilly SFCA

Figure E.15
Crumlin 1%CC AEP Flood
50% Culvert Blockage

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Key:

1% CC Flood depths

- < 0.05m
- 0.05m - 0.2m
- 0.2m - 0.5m
- 0.5m - 1.0m
- > 1.0m

2D Model Extent

0 20 40 Metres

Scale: 1:1,500 @ A4

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\
S11 Crumlin Q100CC 80% Block depth.mxd

Caerphilly SFCA

Figure E.16
Crumlin 1%CC AEP Flood
80% Culvert Blockage

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Key:

1% CC Max Flood Velocity

- < 0.5 m/s
- 0.5 - 1.0 m/s
- 1.0 - 2.0 m/s
- > 2.0 m/s

2D Model Extent

0 20 40 Metres

Scale: 1:1,500 @ A4

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\
S13 Crumlin Q100CC 80% Block velocity.mxd

Caerphilly SFCA

Figure E.17
Crumlin 1%CC AEP Flood
80% Culvert Blockage

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23549-S13 rodgb

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Key:

1% CC Flood Hazard

2D Model Extent

Very low hazard - caution

Danger for some

Danger for most

Danger for all

0 20 40 Metres

Scale: 1:1,500 @ A4

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\
S15 Crumlin Q100CC 80% Block hazard.mxd

Caerphilly SFCA

Figure E.18
Crumlin 1%CC AEP Flood
80% Culvert Blockage

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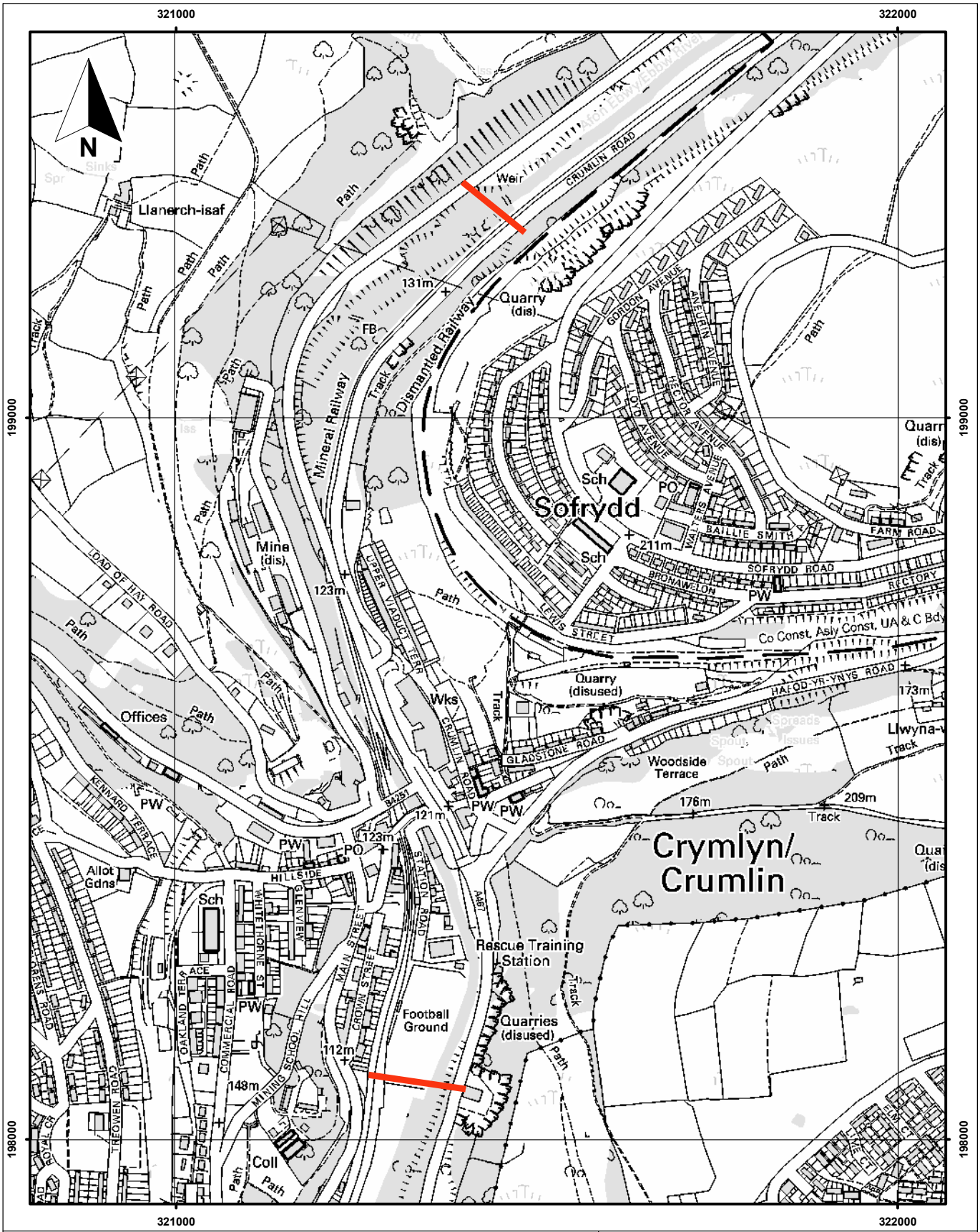

Key:

Model Extent

1% Climate Change AEP Flood outline

0 100 200 Metres

Scale: 1:7,500 @ A4

H:\Projects\HM-255\23549 Caerphilly SFCA\Drawings\
S16 Crumlin Q100CC_no_culvert.mxd

Caerphilly SFCA

Figure E.19
Crumlin 1%CC AEP Flood
Culvert Removed

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