

Flood and Water Management Act 2010

Section 19 Flood Investigation Report

Storm Dennis –

Flood Investigation Area RCT15
(Rhydyfelin & Hawthorn)

July 2022

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This report should be read in its entirety

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EXECUTIVE SUMMARY

This report has been produced through the duties placed upon Rhondda Cynon Taf County Borough Council under Section 19 of the Flood and Water Management Act 2010. The Act states, “On becoming aware of a flood in its area, a lead local flood authority must, to the extent that it considers it necessary or appropriate, investigate:

- a) which risk management authorities have relevant flood risk management functions and
- b) Whether each of those risk management authorities has exercised, or is proposing to exercise those functions in response to the flood”.

This Section 19 investigation provides an investigative report of the storm event that occurred on the 15 and 16th of February 2020 within the Rhondda Cynon Taf County Borough Council area, focusing investigation on the flooding at Rhydyfelin and Hawthorn in the Taf valley (Flood Investigation Area RCT15, Figure 1).

This report was undertaken to identify the mechanism of flooding, establish which Risk Management Authorities have relevant flood risk management functions under the Flood and Water Management Act 2010 and ascertain if those Risk Management Authorities had undertaken or were planning to undertake actions related to those functions to manage the risk of flooding.

The flooding that affected RCT on the 15 and 16th of February 2020 was a result of an extreme rainfall event, designated by the Met Office as ‘Storm Dennis’. The impact of the event at investigation area RCT15 resulted in internal flooding to 28 residential properties, 5 commercial properties and extensive flooding to the highway. These impacts were identified through inspections made by RCT’s Flood Risk Management Team during the days following the storm event, as well as information collated by residents, RCT’s Public Health team, RCT’s Highway and Streetcare Depot, Natural Resources Wales and Dŵr Cymru Welsh Water.

It has been established from the evidence gathered within this report that the primary source of flooding at RCT15 on the 15 and 16th February 2020 was a result of significant overland runoff being generated from the steep hillsides above Rhydyfelin draining to lower ground via a series of ordinary watercourses, many of which became overwhelmed with water and debris and eventually overtopped, impacting several properties on its course of flow.

On review of the hydraulic performance of the three culvert inlets identified as sources of flooding, it was confirmed that all three inlets became overwhelmed with debris, causing a reduction in hydraulic capacity which resulted in surcharge.

The investigation also noted the overtopping of the Nant Lonydd ordinary watercourse at several locations as a primary source of flooding during Storm Dennis. This was heavily influenced by the unprecedentedly high river levels within the River Taf which caused a backing up of flow upstream. A review of NRW's Flood Risk Assessment Wales maps identified the impacted properties at high to low risk of flooding from the main river, however there are no formal flood defences currently in place.

RCT as the Lead Local Flood Authority (LLFA) and Land Drainage Authority (LDA) has been determined as the relevant Risk Management Authority responsible for managing the ordinary watercourse and surface water flooding that occurred at RCT15 during Storm Dennis.

In response to the flooding at investigation area RCT15, the LLFA has undertaken 15 actions and have proposed to undertake a further 9. A summary of which include;

- Undertaken clearance works to the culvert inlet structures identified as sources of flooding following the storm event (assisted by the Highway Authority);
- Carried out survey, jetting and cleansing operations to an estimated 1539 metres of ordinary watercourse drainage network length within the investigation area;
- Undertaken repair works to the river retaining wall which falls on unregistered land to the rear of Hawthorn Crescent and was identified as damaged during the storm event;
- Led on the development of a central Control Room, to compliment the Council's Contact Centre and CCTV Centre, to provide a comprehensive and informed response to residents during storm events;
- Initiated an interim Property Flood Resistance project offering expandable flood gates to properties deemed at high risk of ordinary watercourse and surface water flooding; and
- To engage with NRW to work collaboratively to manage the flood risk caused by the influence of the River Taf upon the Nant Lonydd ordinary watercourse

The event that occurred on 15 and 16th February 2020 was extreme, and it is unlikely flooding from a similar event could be prevented entirely. It is concluded that Risk Management Authorities satisfactorily carried out their flood risk management functions in response to the flood event, however, further functions have been

proposed by RMAs to better address preparedness and response to future flood events.

ABBREVIATIONS

CaRR – Communities at Risk Register

DCWW – Welsh Water

FRMP – Flood Risk Management Plan

FWMA – Flood and Water Management Act 2010

LDA – Land Drainage Authority

LFRMS – Local Flood Risk Management Strategy

LLFA – Lead Local Flood Authority

NRW – Natural Resources Wales

Q – Return Period (1 in X chance of an event occurring in any given year)

RCT - Rhondda Cynon Taf CBC

RCT15 – Flood Investigation Area RCT 15

RMA – Risk Management Authority

SAB – Sustainable Drainage Approval Body

SFRA – Strategic Flood Risk Assessment

SOC – Strategic Outline Business Case

SuDs – Sustainable Drainage Systems

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1. INTRODUCTION

1.1. PURPOSE OF INVESTIGATION

On the 15th and 16th of February 2020, RCT was impacted by an extreme weather event which was designated by the Met Office as ‘Storm Dennis’. Due to the extent and impact of the event, the LLFA opted to undertake a formal investigation.

The storm resulted in widespread residential and commercial flooding within the Rhondda Cynon Taf County Borough Council area. This report will focus on Flood Investigation Area RCT 15 which covers the communities of Rhydyfelin and Hawthorn in the Lower Taf region.

The reason behind RCT’s investigation is in response to the duties of the local authority regarding Section 19 of the Flood and Water Management Act 2010, which states:

1. “on becoming Aware of a flood in its area, a lead local flood authority must, to the extent that it considers it necessary or appropriate, investigate:
 - a) “Which risk management authorities have relevant flood risk management functions and,
 - b) Whether each of those risk management authorities has exercised, or is proposing to exercise, those functions in the response to the flood.”
2. “When an authority carries out an investigation under subsection (1) it must (a) publish the results of its investigation, and (b) notify any relevant risk management authority”¹

The purpose of the investigation is to determine which RMAs have relevant flood risk management functions and which functions have been exercised in response to a flood.

Specific details of Storm Dennis, such as rainfall analysis are covered within a separate overview report that covers the wider RCT area. The report is titled ‘Storm Dennis February 2020 – Overview Report’ and will be referred to as ‘FRM – Storm Dennis – Overview Report’².

¹ Flood and Water Management Act 2010 – Section 19 - <https://www.legislation.gov.uk/ukpga/2010/29/section/19>

² [Flood Investigation Reports | Rhondda Cynon Taf County Borough Council \(rctcbc.gov.uk\)](https://www.rctcbc.gov.uk/flood-investigation-reports)

1.2. SITE LOCATION

The area investigated within this report straddles the A470 dual carriageway and covers sections of both the Rhydyfelin electoral ward to the north, and the Hawthorn electoral ward to the south. The investigation area is located within the southeastern region of the county borough, to the south-east of Pontypridd, in the Lower Taf catchment (Figure 1).

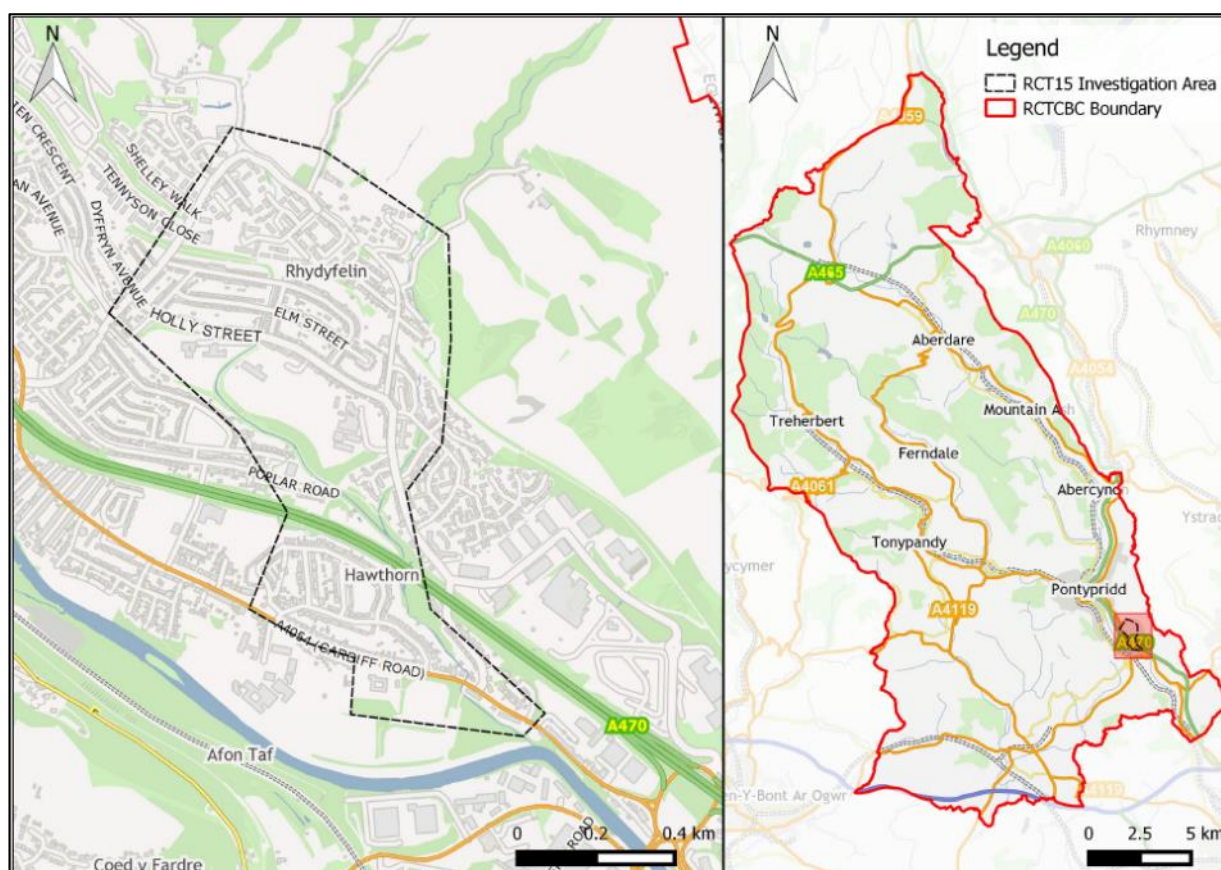


Figure 1: Flood Investigation Area RCT15 Location Plan

North of the investigation area is mostly rural owing to the steep topography of the highlands in the north which are predominately used for agricultural purposes. Residential development is confined to the base of the valley, of which the investigation area largely encompasses. The main River Taf flows west to east to the south of RCT15.

There are several ordinary watercourses that drain the eastern highlands above RCT15 and convey through the investigation area, including the Nant Corrwg and the

Nant Lonydd. These watercourses are partially culverted beneath residential development before discharging into the River Taf.

The electoral wards of Rhydyfelin and Hawthorn are ranked 47th and 9th respectively in terms of surface water flood risk according to RCT's FRMP. Additionally, the community area of Rhydyfelin is ranked 9th in Wales for surface water and ordinary watercourse flood risk according to the CaRR.

Flood risk is generally associated with the network of ordinary watercourses within Rhydyfelin and Hawthorn, notably from culvert inlets and bank breaches. A high and medium flood risk is present across the majority of the investigation area, as illustrated in Figure 2 which is an extract from Natural Resources Wales' Flood Risk Assessment Wales (FRAW) mapping.

A low risk of main river flooding is also noted within the lower extent of RCT15 within the Hawthorn area, sourced by the River Taf.

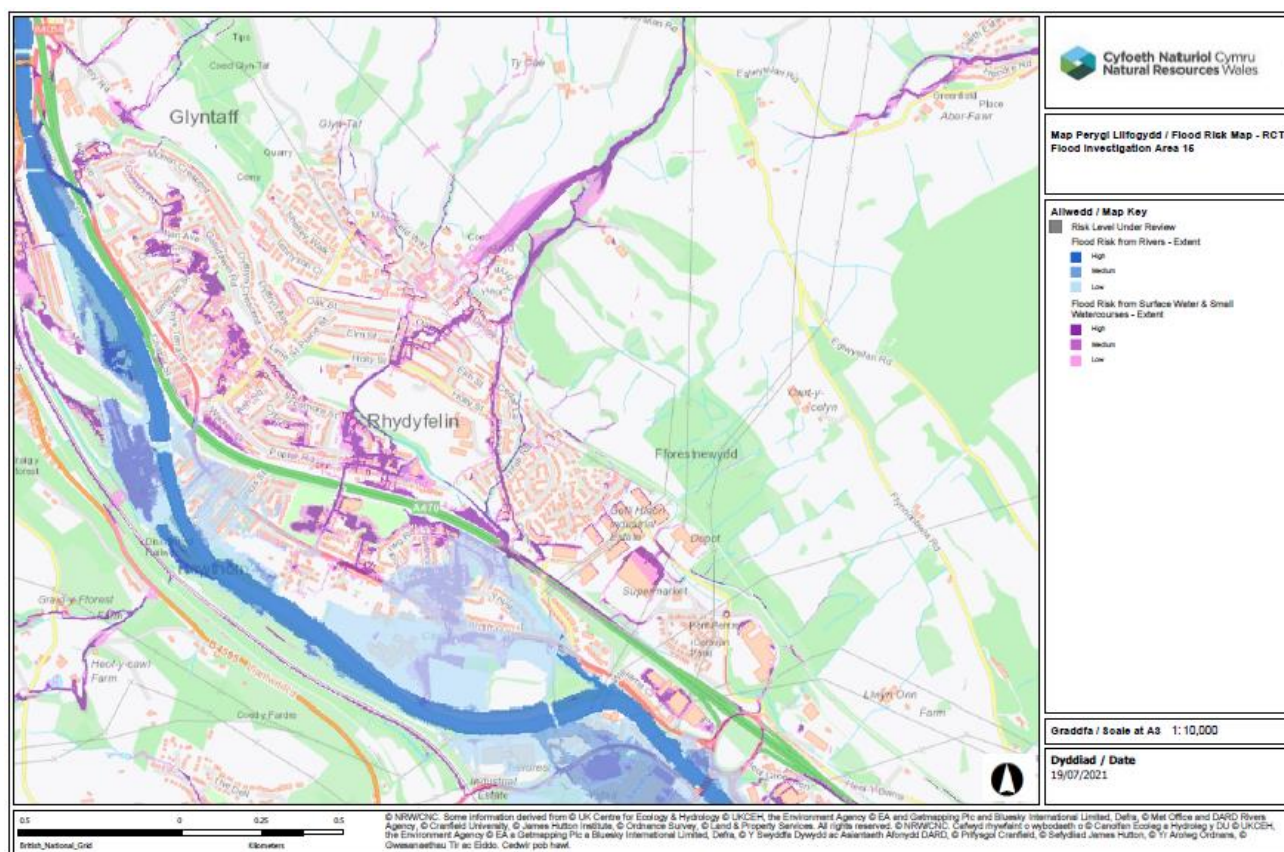


Figure 2: Natural Resources Wales' Flood Risk Assessment Water (FRAW) map for rivers and ordinary watercourse and surface water flood risk at RCT15. Contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved

1.3. DRAINAGE SYSTEM

The surface water drainage system that serves RCT15 is that of the highway drainage network designed to manage the surface water within the highway and public surface water sewer and combined sewer network operated by Dŵr Cymru Welsh Water.

1.4. INVESTIGATION EVIDENCE

To support the investigation, a range of qualitative and quantitative evidence has been gathered from numerous sources, the summary of which is listed in Table 1.

Table 1: Investigative evidence gathered in preparation of this Storm Dennis Section 19 report

Source	Data
Residents	Photos, videos, statements, email correspondence, public engagement survey responses
Responders' statements	Local responders' statements
CCTV Surveys	Internal surveys of the local drainage networks
Met Office Data	Weather Warning information (see FRM – Storm Dennis – Overview Report)
Rain Gauges	RCT and NRW operated rain gauge information (see FRM – Storm Dennis – Overview Report)
Natural Resources Wales	River Level and Flood Warning data
RCT Flood Risk Management Plan	Site specific information and data for each electoral ward in RCT
Communities at Risk Register	Flood risk ranking and scores for all flood types based on community data in Wales
Flood Investigation Report (Redstart's FIR)	A summary of the source-pathway-receptors, culvert capacity assessment and hydraulic modelling work undertaken by Redstart. The Flood Investigation Report was commissioned by RCT prior to writing the Section 19 report.

Evidence sourced from the 'Flood Investigation Report', commissioned by RCT, will be further referred to as 'Redstart's FIR' throughout this report.

1.5. PUBLIC ENGAGEMENT

Following the initial flooding event that occurred on the 15 and 16th February during Storm Dennis, flood risk officers from the RCT Flood Risk Management department were deployed to areas across the borough to investigate reports of internal flooding by residents. Residents were engaged with by the Flood Risk Management team to determine the initial impacts caused by the flooding event and to investigate the potential source(s) and pathway(s) of flood water during the event. Due to the volume of calls received by RCT's Out of Hour department, visits were prioritised to those areas experiencing significant internal flooding to residential properties.

To support the flood investigations, a public engagement exercise was undertaken between 4th and 25th January 2021 by Redstart on behalf of RCT. The aim of this was to engage with the local residents who were affected by the flood event to capture details on how they were impacted, the source and movement of flood water within the area, how receptors were impacted as well as drawing on local knowledge to query how local conditions could have exacerbated the event. This data is useful to help the LLFA better understand and validate our assessment of the flood event to support the investigation under Section 19 of the FWMA.

2. FLOODING HISTORY

2.1. PREVIOUS FLOOD INCIDENTS

Previous incidences of flooding to properties within the wider investigation area have occurred over the past twenty years, often in relation to the network of ordinary watercourses and culverted infrastructure which convey a substantial volume of water from the eastern highlands and through the village of Rhydyfelin. Despite this, no storm event has resulted in flooding so extreme as the flooding that occurred during Storm Dennis.

Information relating to historical flood incidences prior to Storm Dennis is limited however, in recent years the frequency and impact of property flooding has increased with the most notable flood events being Storm Bronagh on 20-21st September 2018, Storm Callum on 12-13th October 2018 and the June 2009 flood event.

According to RCT's Flood Risk Management team, ordinary watercourse and surface water flooding along Maeshyfryd, Dynea Road and Wordsworth Gardens has been observed to occur during extreme storm events.

More recently, significant flooding to several properties within Rhydyfelin occurred during October 2021, caused by the surcharging of several culvert inlets. The flooding causes and impacts during the October 2021 storm event have been discussed in a separate Section 19 report.

2.2. FLOOD INCIDENT

The flooding that occurred on the 15th and 16th February 2020 was a result of an extreme rainfall event, designated by the Met Office as ‘Storm Dennis’, which affected the majority of RCT and caused widespread flooding to communities.

Specific details of Storm Dennis, such as rainfall and river level analysis are covered within a separate overview report that covers the wider RCT area, referenced ‘FRM – Storm Dennis – Overview Report’².

The post event inspections undertaken on the days following the storm event by RCT’s Flood Risk Management team and RCT’s Public Health, Protection and Community team identified 27 residential properties and 5 non-residential properties as internally flooded within the investigation area.

A summary of the source(s) and pathway(s) of flooding within investigation area RCT15 during Storm Dennis have been outlined in Table 2 and further described throughout this section.

Table 2: Summary of the source(s), pathway(s) and receptor(s) affected during Storm Dennis within investigation area RCT 15.

Source(s)	Pathway(s)	Receptor(s)
<p>Intense rainfall running off the hillsides to the northeast of Rhydyfelin draining to lower ground via a series of unnamed ordinary watercourses.</p> <p>A culvert inlet to the north of Wordsworth Gardens surcharged during the storm event.</p>	<p>Surcharging flows from the culvert inlet flowed towards Masefield Way where the topography of the land directed the flow towards the junction at Wordsworth Gardens where water conveyed south towards the properties within the lower reaches of Wordsworth Gardens.</p>	<p>The flow path towards Wordsworth Gardens was the primary source of flooding to 14 residential properties at Wordsworth Gardens.</p>
<p>A culvert inlet to the north of Maesfield Way surcharged during the storm event.</p>	<p>Surcharged flows from the culvert inlet conveyed onto Masefield Way where the topography of the land directed the flow eastwards. Some flow was re-directed back into the watercourse downstream.</p>	<p>External flooding to one residential property opposite the culvert inlet.</p>

<p>A culvert inlet associated to the Nant Corrwg ordinary watercourse surcharged during the storm event. The inlet is located adjacent to Dynea Caravan Site.</p>	<p>Surcharged flows travelled south along the highway network, along Dynea Road, towards the lower reaches of Rhydyfelin.</p>	<p>Contributed surface water flows towards the lower streets at Rhydyfelin but was not identified as a source of flooding to properties.</p>
<p>The Nant Lonydd ordinary watercourse overtopped its banks at various locations.</p> <p>The River Taf is considered to have influenced the overtopping of the Nant Lonydd watercourse.</p>	<p>Water overtopped the watercourse and conveyed into the rear of several residential properties along Hawthorn Crescent, Ynyslyn Road and Cardiff Road, in addition to commercial properties within Melin Corrwg Business Park.</p>	<p>9 residential properties at Hawthorn Crescent and 4 residential properties at Cardiff Road were internally flooded as a result of the overtopping of the Nant Lonydd.</p> <p>4 commercial properties within Melin Corrwg Business Park were also confirmed as internally flooded.</p> <p>External flooding to the rear gardens of properties at Ynyslyn Road was also reported.</p>
<p>An ordinary watercourse channel within the Upper Boat Recreation Area below the A4054 (Cardiff Road) overtopped during the storm event.</p>	<p>Water overtopped the watercourse and conveyed onto the A4054 (Cardiff Road), flowing in both directions.</p>	<p>Surface water along the A4054 (Cardiff Road) resulted in internal flooding to one commercial property at Cardiff Road.</p>
<p>Intense rainfall, overland flow from the surcharged culverts and the overtopping of watercourses resulted in surface water accumulation along several streets.</p>	<p>Surface water conveyed via the highway network towards the lower reaches within the investigation area.</p> <p>Highway drainage at localised low points is considered to have become overwhelmed, resulting in surface water accumulation along several streets including Cardiff Road, Ynyslyn Road and Wordsworth Gardens.</p>	<p>Contributed to the internal flooding of several residential and commercial properties within RCT15.</p> <p>Internal flooding to one residential property at Ynyslyn Road was also confirmed.</p>

On review of Table 2, the principal source of flooding in this incident originated from intense rainfall generating significant surface water runoff from the steep hillsides to the north and east of Rhydyfelin draining to lower ground. This runoff was routed towards the investigation area via several ordinary watercourse, many of which became overwhelmed during Storm Dennis and caused flooding associated to blocked culvert inlets.

Figure 3 depicts the topographic watershed of the River Taf and Nant yr Aber valleys (bold pink line), with rainfall to the southwest of the watershed draining to the River Taf catchment. On review of the area of land that would expect to drain towards the investigation area, LIDAR based assessment produced by Redstart's FIR (Figure 4) show the valley hillsides above Rhydyfelin's urban settlements to be steeply inclined and absent of any ridge-like features that may divert surface water flows. These steep slopes above the investigation area largely contributed to the rapid surface water and ordinary watercourse flows travelling down the hillside during heavy rainfall.

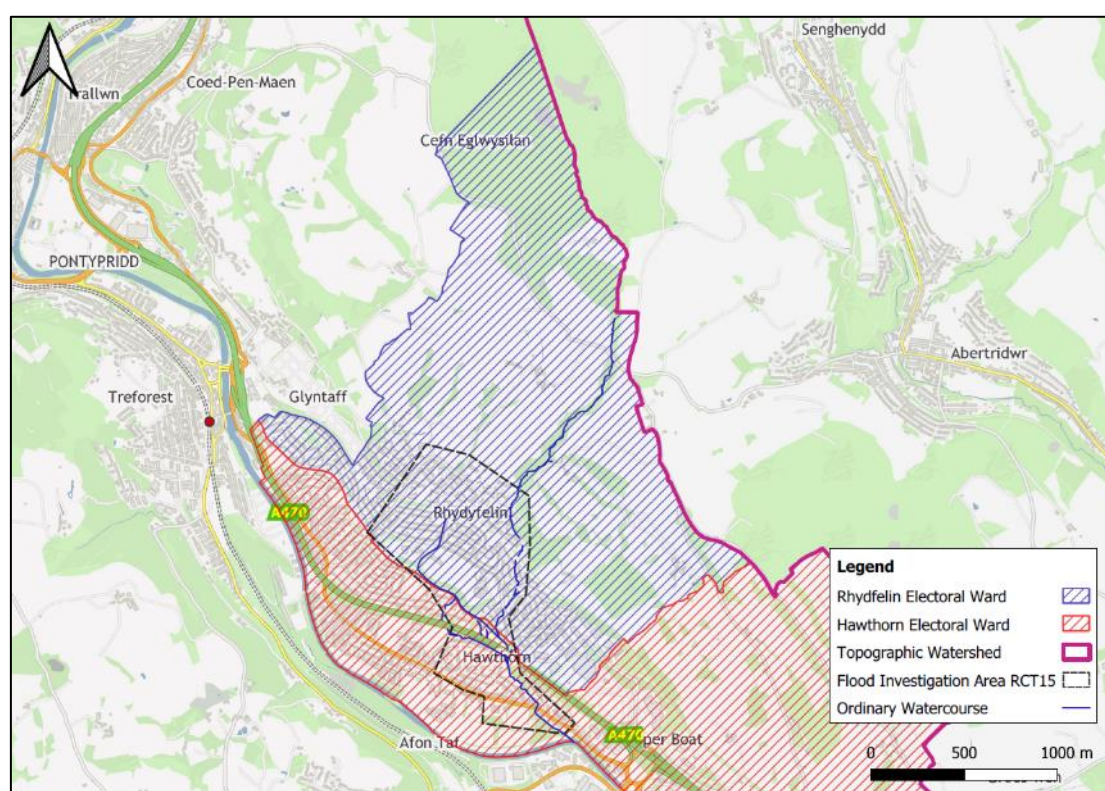


Figure 3: Rainfall Topographic Watershed above investigation area RCT15 and the electoral ward boundaries for Rhydyfelin and Hawthorn

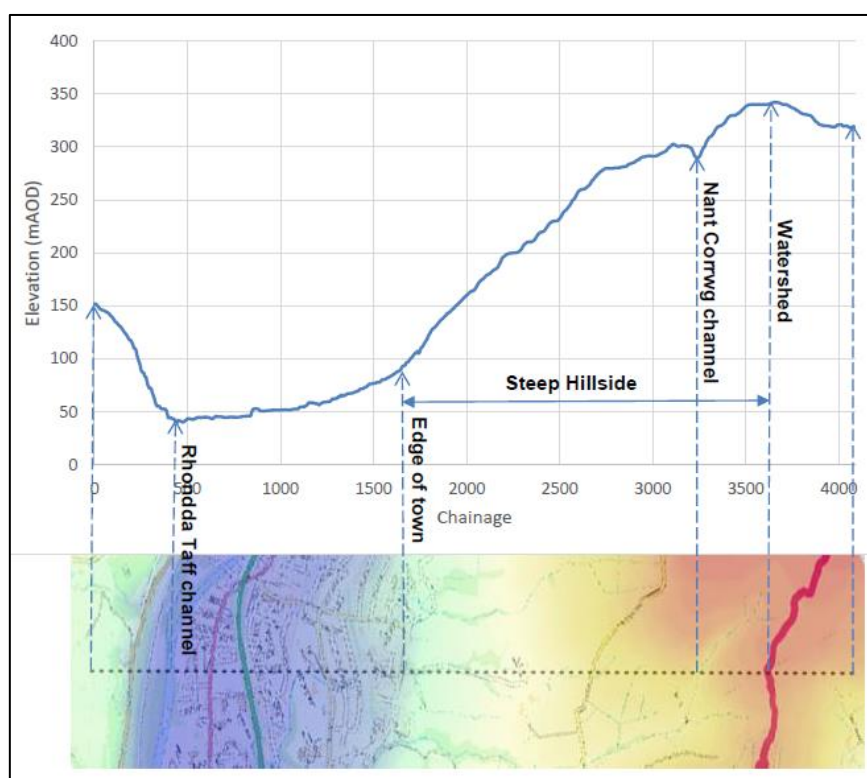


Figure 4: Partial LiDAR Cross Section of the Rhondda Taf Valley at Rhydyfelin

The flood incident at investigation area RCT15 will be further described in two parts: the incident in the Rhydyfelin electoral ward area, north of the A470 (red hatched area, Figure 3), and the incident south of the A470, in the Hawthorn electoral ward area (blue hatched area, Figure 3).

2.2.1. RHYDYFELIN

The steep hillsides to the north and east of the investigation area is drained by a network of ordinary watercourses, with the Nant Corrwg ordinary watercourse being the most notable. These watercourses are partially culverted beneath Rhydyfelin's residential development.

Figure 5 depicts the observed pathways of flooding within the Rhydyfelin area during Storm Dennis. The infrastructure known to have surcharged and contribute to the flooding are also illustrated in Figure 5.



Figure 5: Observed flow paths within the Rhydyfelin area during Storm Dennis (16th February 2020)

Several calls were received from residents at Wordsworth Gardens on 16th February 2020 to report water ingress into multiple residential properties. The residents' reports reference two culvert inlets, north of Rhydyfelin (labelled 'Culvert Inlet 1 and 2', Figure 5), as sources of flooding. Both inlets were inspected by RCT's Highway and Streetcare Depot during the storm events' emergency response, and both showed evidence of surcharge. Following the storm event, on 17th February 2020, a site inspection of both culvert inlets was also undertaken by RCT's Flood Risk Management team in order to gain further investigative evidence of the flooding impacts.

A culvert inlet located above Masefield Way (labelled 'Culvert Inlet 1' in Figure 5). showed evidence of surcharge. Evidence of mobilised silt and debris, indicative of the surcharging flows, suggest that the exceedance flows from 'Culvert Inlet 1' conveyed over the embankment, onto Masefield Way, and onwards towards properties within the lower reaches of Wordsworth Gardens. 14 residential properties at Wordsworth Gardens were confirmed as internally flooded as a result of the ordinary watercourse flows.

Water conveyed through two rows of residential properties at Wordsworth Gardens and onwards towards Oak Street and Holly Street before re-entering the unnamed watercourse adjacent to Heol-y-Celyn School. No further property flooding was reported as a result of this flow path.

Resident accounts and observations made during post-storm inspections indicate that 'Culvert Inlet 1' surcharged as a result of unprecedented high flows and the presence of debris at the culvert inlet debris screen. Figure 6 depicts the material, consisting of large woody debris, which was cleared from the culvert inlet during emergency cleansing operations by RCT's Highway and Streetcare Depot. Large stones and scour material was also identified behind the upper debris screens, indicative of powerful flows within the watercourse during the storm event.

The exceedance flows were also observed to have damaged a section of highway retaining wall immediately below 'Culvert Inlet 1' (Figure 7), in addition to a retaining wall opposite the impacted properties at Wordsworth Gardens (Figure 8).



Figure 6: Image of the debris that was cleared from 'Culvert Inlet 1' during emergency cleansing operations (image captured by RCT's Flood Risk Management team on 17th February 2020)



Figure 7: Damaged highway retaining wall below 'Culvert Inlet 1' (image captured by RCT's Flood Risk Management team on 17th February 2020)



Figure 8: Damaged retaining wall at Wordsowrth Gardens caused by the surcharging of 'Culvert Inlet 1' (image captured by RCT's Flood Risk Management team on 17th February 2020)

A second culvert inlet, located west of 'Culvert Inlet 1', was also observed as surcharging during the storm event (labelled 'Culvert Inlet 2' in Figure 5). Post event

inspections identified 'Culvert Inlet 2' to have surcharged, with evidence of saturated and flattened grass, and mobilised silt and debris, indicative of the exceedance flows. These flows overtopped the culvert inlet and conveyed onto Masefield Way before being re-directed back into the downstream unnamed ordinary watercourse. Some of the flows originating from 'Culvert Inlet 2' were also identified to have flowed east along Masefield Way, contributing to the flow path from 'Culvert Inlet 1'.

'Culvert Inlet 2' is identified to have contributed to the internal flooding of 14 residential properties at Wordsworth Gardens, in addition to causing external flooding to the highway and nearby properties at Masefield Way.

Residents at Dynea Road also reported flooding during Storm Dennis. RCT's Flood Risk Management team identified the flooding to have originated from a surcharged culvert inlet adjacent to Dynea Caravan Park (labelled 'Culvert Inlet 3' in Figure 5). This culvert inlet is associated to the primary Nant Corrwg ordinary watercourse.

Post event inspections identified evidence of vegetation and debris on the highway, indicative of the surcharging flows from 'Culvert Inlet 3' along Dynea Road. RCT's Highway and Streetcare Depot carried out emergency clearance works to the culvert inlet, overflow system and debris screens during the storm event to remove the accumulated debris. No internal flooding to properties was recorded as a result of the surcharged culvert, however significant overland flows along the highway was observed.

2.2.2. HAWTHORN

The network of ordinary watercourse which drain the steep hillsides above Rhydyfelin are culverted beneath the A470 and discharge into the Nant Lonydd ordinary watercourse which flows through the village of Hawthorn and discharges to the River Taf downstream.

Figure 9 depicts the observed pathways of flooding within the Hawthorn area during Storm Dennis.

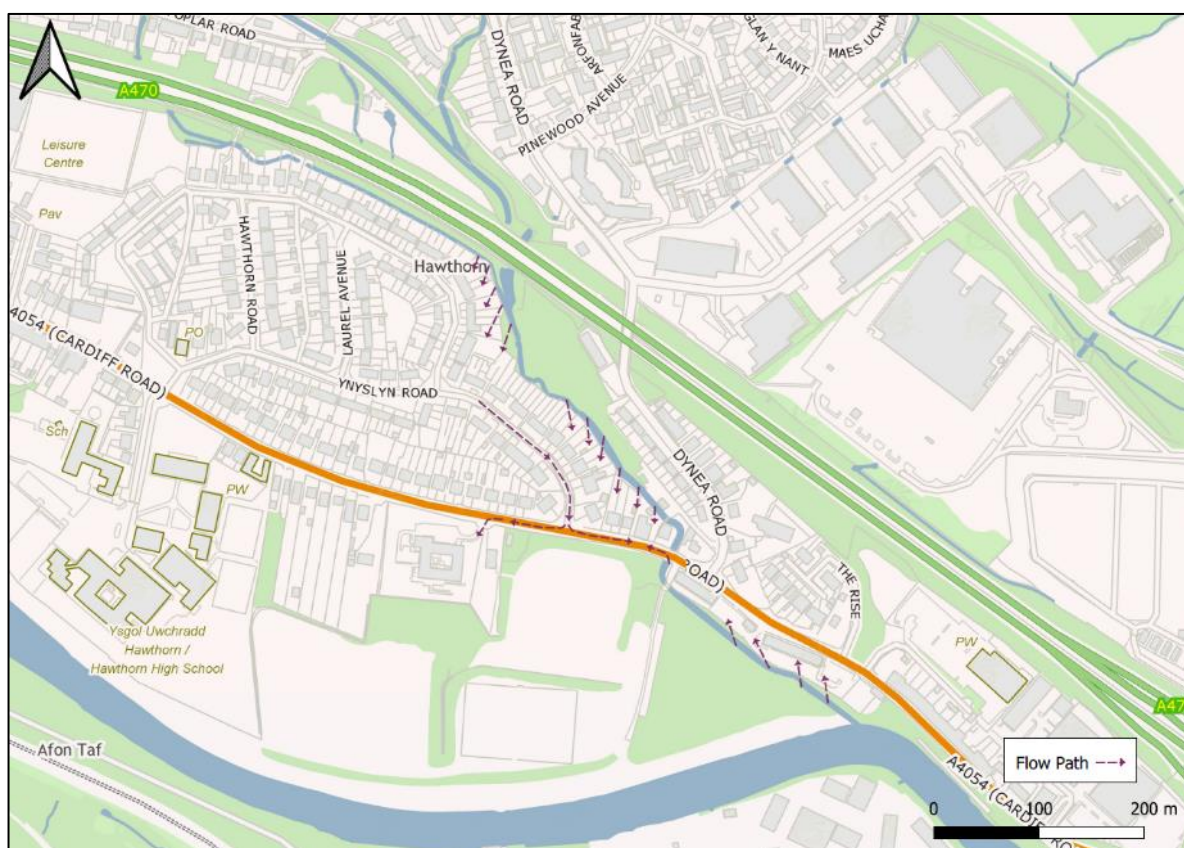


Figure 9: Observed flow paths within the Hawthorn area during Storm Dennis (16th February 2020)

Several calls were received from residents at Hawthorn Crescent on the 16th February 2020 to report water ingress into multiple residential properties. Reports of flooding reference the Nant Lonydd ordinary watercourse which flows to the rear of Hawthorn Crescent and Ynyslun Road before being culverted beneath the A4054 (Cardiff Road) and discharging into the River Taf.

Upon a site inspection undertaken by RCT's Flood Risk Management team on 17th February 2020, the Nant Lonydd showed evidence of overtopping at several locations

along its length, impacting properties at Hawthorn Crescent, Ynyslyn Road and the A4054 (Cardiff Road). A section of the privately owned retaining wall to the rear of Hawthorn Crescent was identified as damaged following the overtopping of the Nant Lonydd watercourse. This led to partial compartmentalisation of flooding within the rear extents of several properties along the channel length.

Post event inspections confirmed internal flooding to 9 residential properties at Hawthorn Crescent, 4 residential properties at Cardiff Road and a further 4 commercial properties at Melin Corrwg Business Park. External flooding to the rear gardens of properties at Ynyslun Road was also confirmed.

Figures 10 and 11, captured by residents during the storm event, show evidence of flooding at Hawthorn Crescent (Figure 10) and Melin Corrwg Business Park (Figure 11), associated to the overtopping of the Nant Lonydd.



Figure 10: Flooding observed at Hawthorn Crescent from the Nant Lonydd ordinary watercourse during Storm Dennis (image provided by resident)



Figure 11: Flooding observed at Melin Corrwg Business Park from the Nant Lonydd ordinary watercourse during Storm Dennis (image provided by resident)

Observations made during the site inspection identified sections of damaged retaining wall at Melin Corrwg Business Park (Figure 12), indicative of the forceful flows which occurred during the storm event. The Nant Lonydd is identified to have breached the retaining wall at Melin Corrwg Business Park, resulting in significant flood depths within the affected commercial properties. Figure 13 shows water depth marks of over 2 metres in height within the flooded properties.



Figure 12: Damaged retaining wall at Melin Corrwg Business Park following the breach of the Nant Lonydd watercourse during Storm Dennis (image captured by RCT's Flood Risk Management team on 17th February 2020)

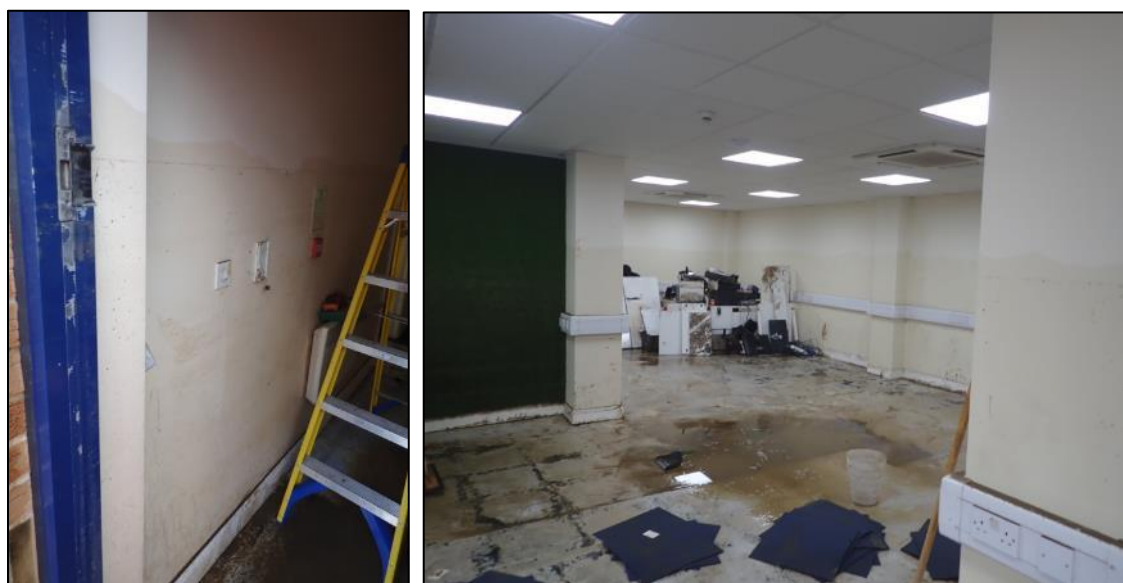


Figure 13: Water depths recorded within the impacted commercial properties at Melin Corrwg Business Park (image captured by RCT's Flood Risk Management team on 17th February 2020)

The downstream section of the Nant Lonydd ordinary watercourse, below the A4054 (Cardiff Road), is heavily influenced by river levels on the River Taf. The high river levels on the River Taf during Storm Dennis were identified to have influenced the overtopping of the Nant Lonydd watercourse, contributing to the flooding of properties at Cardiff Road and Melin Corrwg Business Park. The watercourse was also observed to have overtopped onto the highway and contribute secondary surface water runoff along the A4054 (Cardiff Road).

An ordinary watercourse ditch which flows at the northern boundary of the Upper Boat Recreation Field was identified by investigating officers to have overtopped and convey onto the A4054 (Cardiff Road), contributing additional surface water runoff along the highway. Figure 14 shows evidence of silt and mud deposited along the highway as a result of the overtopped watercourse channel.

One commercial property along the A4054 (Cardiff Road) was confirmed as internally flooded as a result of these surface water flows. An additional residential property at Ynyslun Road was also reported as internally flooded due to the accumulation of surface water on the highway.



Figure 14: Evidence of mud and silt along the A4054 (Cardiff Road) identified post event as a result of the overtopping of the Nant Lonydd and an ordinary watercourse channel which runs behind the fence (image captured by RCT's Flood Risk Management team on 17th February 2020)

2.3. RAINFALL ANALYSIS

See RCT's 'Overview Report' of Storm Dennis, reference 'FRM – Storm Dennis – Overview Report'², for a detailed analysis of the rainfall and ordinary watercourse response.

3. POSSIBLE CAUSES

3.1. CULVERT CONDITIONS

Within investigation area RCT15 there are several unnamed watercourses which drain the hillsides above the village of Rhydyfelin and discharge into the River Taf. Many of these watercourses are culverted beneath Rhydyfelin and Hawthorn's urban settlements.

Several culvert inlets were inspected by RCT's Flood Risk Management team and Council's Highway and Streetcare Depot following the flood event to assess their condition and help determine whether they served as a contributing factor to the flooding at RCT15. CCTV survey inspections of the culvert networks were undertaken to ascertain both the operational condition of the network, and its structural integrity along sections of the network.

Figure 15 outlines the culvert inlet structures identified as sources of flooding during Storm Dennis and highlights the two associated culvert networks which were surveyed post event.

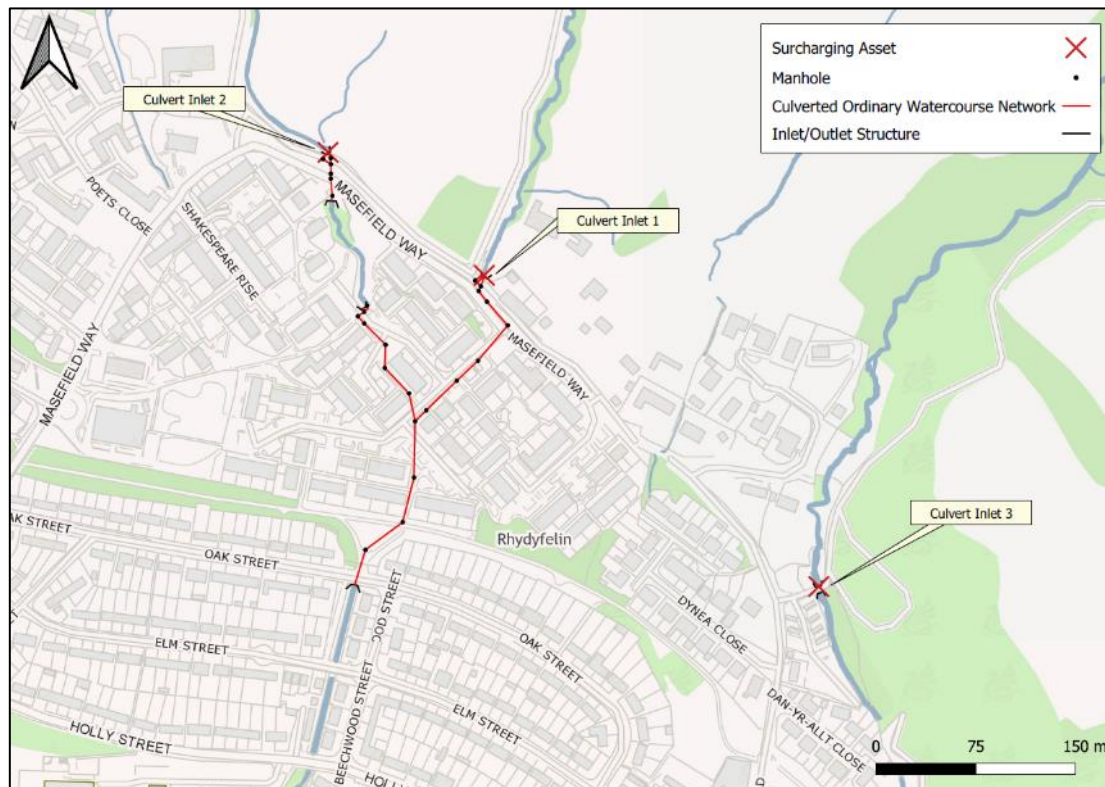


Figure 15: Surveyed culverted ordinary watercourse networks within RCT15

It should be noted that all surveys reported in this section were undertaken post flood event. It's not possible to say what debris identified in the survey was mobilised and deposited as a result of the storm event and what had been deposited by previous events. As such, the following should be considered to be reflective of the asset condition at the end of the storm event and may not necessarily be reflective of the condition of the assets prior to the onset of the storm event.

The culvert inlet structure and networks associated to 'Culvert Inlet 1 and 2' were both assessed as being in acceptable condition with no significant defects identified nor significant deposits or silt identified within the networks. Flooding was observed only at the inlet and not elsewhere along the culvert network during the storm event. It is thereby inferred that the primary cause of surcharge at both 'Culvert Inlet 1 and 2' was due to blockages caused by debris mobilised from the upper catchments which reduced the hydraulic capacities of both inlets, and associated overflow systems, to manage the flow of water, leading to surcharge.

Evidence of debris, inclusive of stones and woody debris, was identified to have been cleared from 'Culvert Inlet 1' (Figure 6) and 'Culvert Inlet 2' during post event inspections. Evidence of deposited debris within the channels, in addition to debris trapped behind the upper debris screen was also observed post event, indicative of the entrainment of material within the watercourses during the storm event. Figures 16 and 17 illustrate the condition of the channels upstream of 'Culvert Inlet 1 and 2' before and after Storm Dennis and depict the identified debris accumulation within the channels and upper debris screen.



Figure 16: Upstream view of 'Culvert Inlet 1' before Storm Dennis (left) and post Storm Dennis (right) showing debris behind the upper debris screen (captured by RCT's Flood Risk Management team)



Figure 17: Upstream view of 'Culvert Inlet 2' before Storm Dennis (left) and post Storm Dennis (right) showing silt and stone deposition within the channel (captured by RCT's Flood Risk Management team)

The source of flooding along Dynea Road was identified as originating from a blocked culvert inlet adjacent to Dynea Caravan Park on the eastern edge of the investigation area, labelled 'Culvert Inlet 3' in Figure 15 (Figure 18). According to the investigating officer, the debris screens upstream of the culvert inlet became blocked with significant scour material mobilised from the upper reaches of the Nant Corrwg watercourse. The blockage at the debris screens restricted the flow of water entering the culvert and overflow system, resulting in the overtopping of flows over the western headwall. The condition of the culvert inlet structure is not considered to have impacted the surcharge.

No internal flooding to properties was reported as a result of 'Culvert Inlet 3' surcharging. The ordinary watercourse flows conveying south down Dynea Road are considered to have been drained by the highway drainage infrastructure.



Figure 18: Image of 'Culvert Inlet 3' showing initial debris screen and safety grid (captured by RCT's Flood Risk Management team post event)

All three culvert inlets identified as sources of flooding during Storm Dennis are identified as Council owned assets and fall under the responsibility of RCT as the Highway Authority. In response to the identified debris, all three culvert inlets were cleared by RCT's Highway and Streetcare Depot in the days following the storm event.

3.2. ORDINARY WATERCOURSE CONDITIONS

Several sections of natural ditches and open watercourses which drain the steep hillsides above RCT15 are identified to flow through the investigation area and discharge into the River Taf to the south of the investigation area (Figure 19). The most notable watercourses include the Nant Corrwg and the Nant Lonydd.

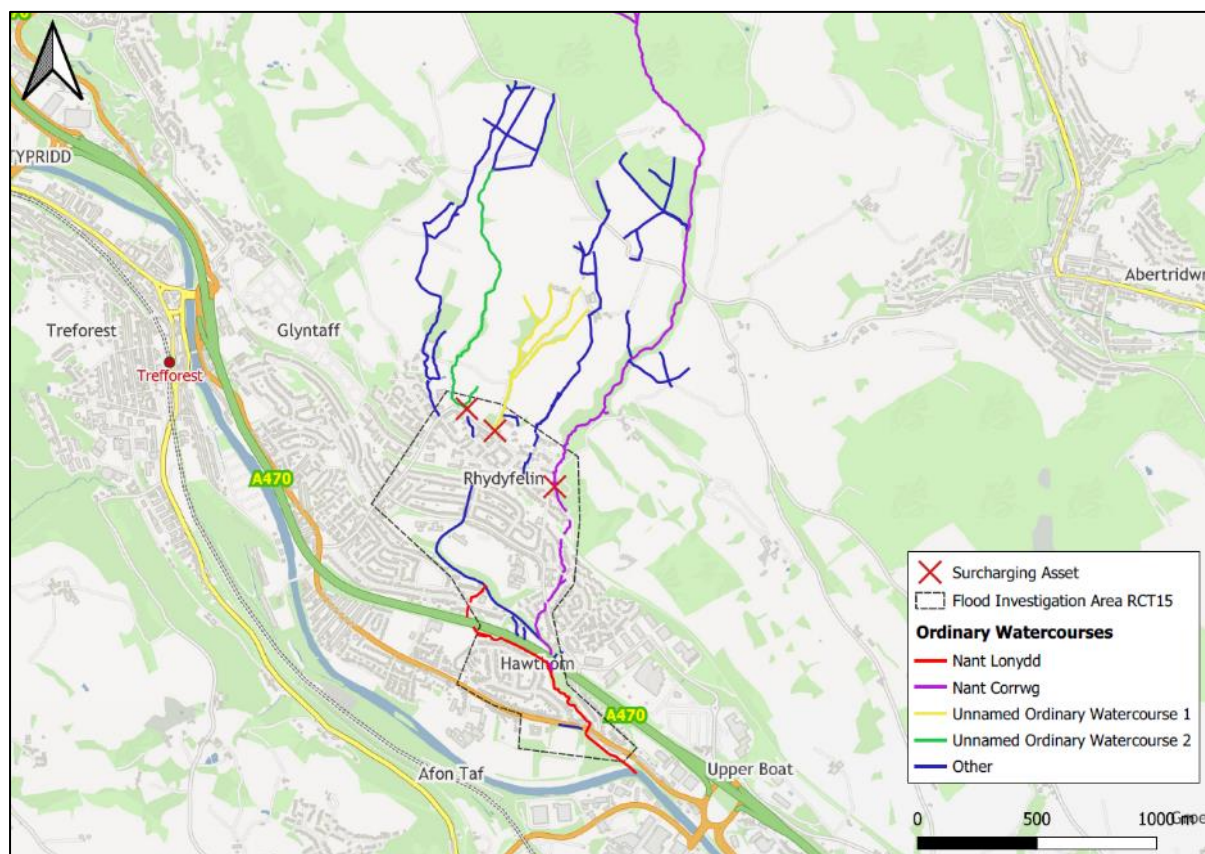


Figure 19: Map of Ordinary Watercourses which feed into and flow through investigation area RCT15

Following the storm event, RCT Flood Risk Management officers carried out a site walk-over assessment, where possible, of the ordinary watercourses upstream of the culverted infrastructure identified as sources of flooding (highlighted in Figure 15) to assess the condition of the watercourses for any signs of overtopping, evidence of scour and any land movement of the hillsides.

3.2.1. UNNAMED ORDINARY WATERCOURSE 1

A general assessment of 'Unnamed Ordinary Watercourse 1', upstream of 'Culvert Inlet 1', revealed evidence of loose materials within the channel. This material consisted of natural scour material including stone, silt and dead vegetation. Figure 16 in Section 3.1 illustrates the condition of the upper debris screen operating with significant accumulation of natural material, considered to have been mobilised by the fast flows during the storm event.

The watercourse consists of several meanders which during high flow would have resulted in natural erosion and the associated deposition of scoured material downstream. Evidence of debris alongside the channel also suggests that the watercourse overtopped its normal depth in areas, contributing minor surface water flows along the adjacent lane.

Based on data captured by RCT's Rhydyfelin monitoring station, the storm resulted in two peaks in the level of flow within 'Unnamed Ordinary Watercourse 1'. Both peaks are illustrated in Figure 20 and align with the peak recorded rainfall.

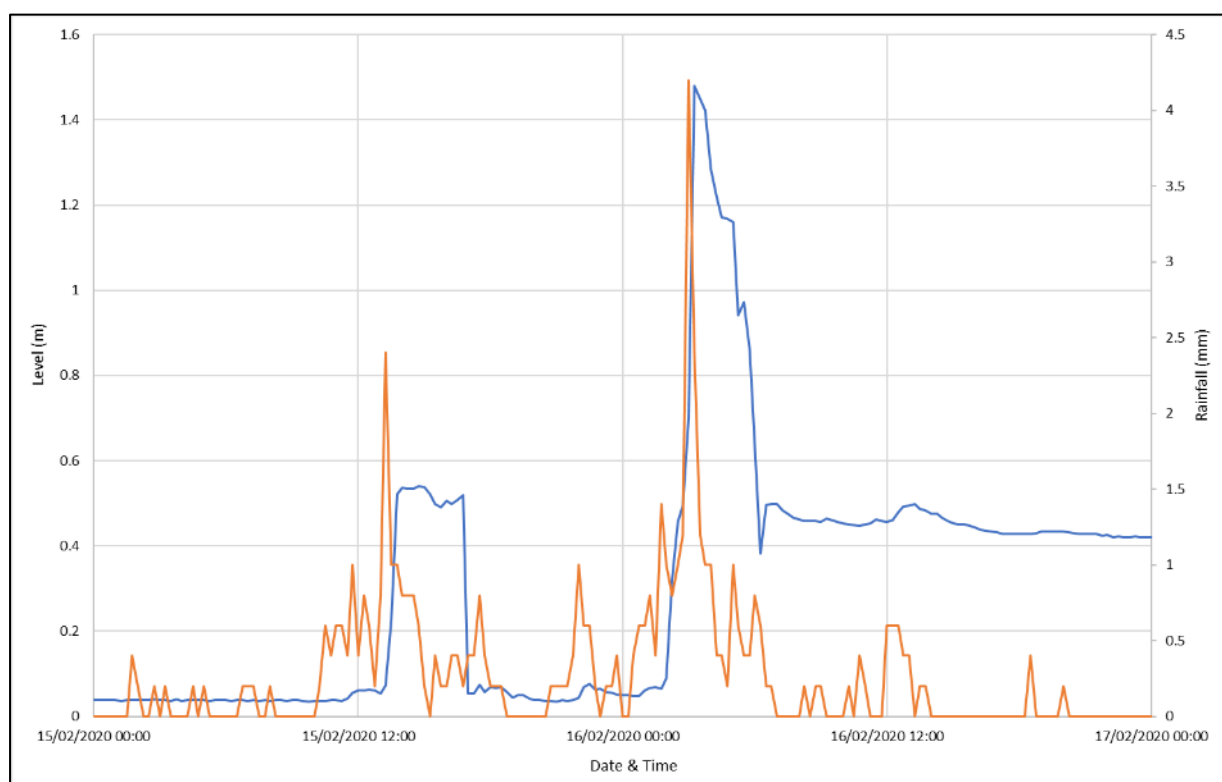


Figure 20: Water level (m) within the unnamed ordinary watercourse upstream of 'Culvert Inlet 1' and rainfall amounts (mm) during Storm Dennis (15 – 16th February 2020) captured at RCT's Rhydyfelin monitoring stations

The initial peak occurred at 14:45 on 15th February and rose to a depth of half a metre, approximately only one hour after the initial peak in rainfall. Levels within the channel fell sharply during the evening of 15th February, before spiking significantly at 03:15 on 16th February, resulting in a peak level of 1.48 metres. The second, more significant peak, in levels occurred only 15 minutes after peak rainfall was recorded at 03:00 (4.2mm/00:15). Water levels fell dramatically very shortly after the peak.

Figure 20 highlights the exceptionally short lag time between peak rainfall and peak discharge within the watercourse. This is primarily attributed to the catchment conditions of Rhydyfelin, which are characterised by steep valley sides, susceptible to intense rainfall and associated flash flooding. The rapid response to rainfall is considered to have overwhelmed the ordinary watercourse, resulting in some out-of-bank flows, whilst also highlighting the exceptional flows which would have been conveying towards the inlet carrying significant debris.

3.2.2. UNNAMED ORDINARY WATERCOURSE 2

A general assessment of 'Unnamed Ordinary Watercourse 2', upstream of 'Culvert Inlet 2', also revealed evidence of loose materials within the channel. This material consisted of natural scour material including stone, silt and dead vegetation. Figure 21 illustrates the condition of the upper debris screen, located approximately 200 metres upstream of 'Culvert Inlet 2', operating with significant accumulation of natural material, considered to have been mobilised by the fast flows during the storm event.



Figure 21: Evidence of debris trapped behind the upper debris screen above 'Culvert Inlet 2' (captured by RCT's Flood Risk Management team on 17th February 2020)

The channel upstream of 'Culvert Inlet 2' is man-made and comprises of blockstone. The channel did not display evidence of significant scour however there was some evidence of overtopping where the levels within the watercourse over capacitated the channel in some areas. Further upstream the watercourse is of natural makeup, with very steep embankments and comprising of bare ground, which suggests that the upper catchment area likely contributed the majority of scour material towards the inlet during the storm event. Due to the steep slopes above RCT15, the upper channel inspections were restricted.

Based on data captured by RCT's Rhydyfelin monitoring station, the storm resulted in a rapid but sustained peak in the level of flow within 'Unnamed Ordinary Watercourse

2'. The water level and recorded rainfall during the storm event is illustrated in Figure 22.

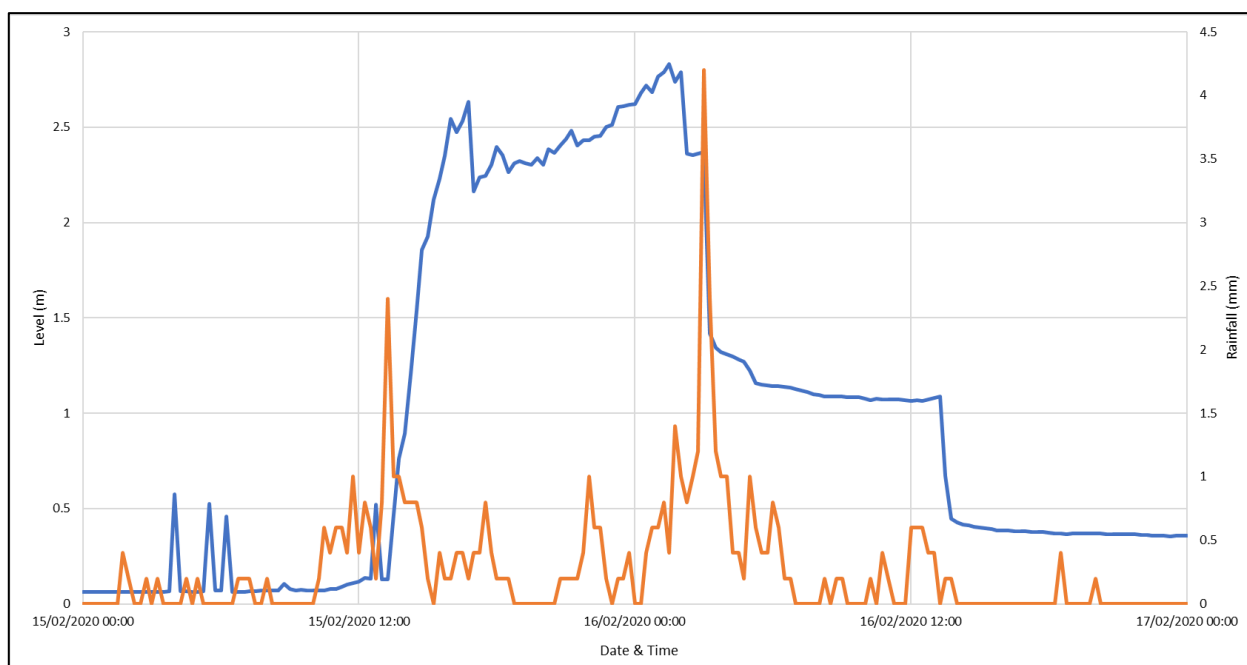


Figure 22: Water level (m) within the unnamed ordinary watercourse upstream of 'Culvert Inlet 2' and rainfall amounts (mm) during Storm Dennis (15 – 16th February 2020) captured at RCT's Rhydyfelin monitoring stations

Following the initial peak in rainfall at 13:15 on 15th February 2020, the watercourse rose sharply to reach a peak level of 2.6 metres at 16:45 on 15th February, approximately two hours after the peak rainfall. Based on the available telemetry data, levels within the watercourse at 'Culvert Inlet 2' remained high despite the receding rainfall. It is considered that debris became deposited at the sensor during the initial peak which caused a sustained rise in water levels, reaching a second peak of 2.8 metres at 01:30 16th February. Levels reduced sharply shortly after due to the initial operational clearance of debris from 'Culvert Inlet 2'. This was followed by a second cleansing operation during the afternoon of Sunday 16th February 2020, which would explain the observed staged and sharp falls in water level.

Although the monitoring stations provide an indication of the ordinary watercourse response during the storm event, the debris mobilised by the fast flows towards both culvert inlets are considered to have impacted the monitoring equipment and associated sensor readings. The results provided in Figures 20 and 22 should be considered an indication of the rapid response of Rhydyfelin's catchments to rainfall.

Based on data captured by RCT's Rhydyfelin monitoring stations, and accounts provided by residents and inspecting officers, it is considered that the volume of water within the unnamed ordinary watercourses conveyed towards the culvert inlets at exceptionally rapid rates and likely exceeded the capacity of the inlet structures during the early hours of Sunday 16th February 2020. The blockages caused by the mobilisation of debris are however considered the primary cause of surcharge at 'Culvert Inlet 1 and 2' due to the reduction in hydraulic capacity to manage the flow of water entering the culverted systems.

3.2.3. NANT CORRWG ORDINARY WATERCOURSE

The Nant Corrwg ordinary watercourse is a large watercourse which is fed by the headwaters along the topographic watershed of the Taf valley. The Nant Corrwg flows along the eastern boundary of the investigation area.

A general assessment of the Nant Corrwg ordinary watercourse could not be undertaken post storm event due to the steep and restrictive nature of the watercourse upstream of 'Culvert Inlet 3'. Based on a desktop assessment of the watercourse, the channel is very steep and consists of several meanders which during high flows is considered to have contributed significant natural scour material downstream.

This material is considered to have restricted the flow of water entering 'Culvert Inlet 3' and has been attributed as the primary cause of surcharge.

3.2.4. NANT LONYDD ORDINARY WATERCOURSE

In response to the observed overtopping of the Nant Lonydd ordinary watercourse, a channel walkover assessment of the Nant Lonydd in the Hawthorn area was undertaken post event by RCT's Flood Risk Management team. Observations and images captured during the assessment have been discussed below.

The ordinary watercourses upstream of the Nant Lonydd were identified primarily as manmade channels which were stepped in some areas, notably along sections of channel ahead of the confluence with the Nant Corrwg above the A470 (Figure 23). Heavy overgrowth of vegetation was also observed along the channel banks in some areas however, this is not considered to have contributed to the flooding observed during Storm Dennis.

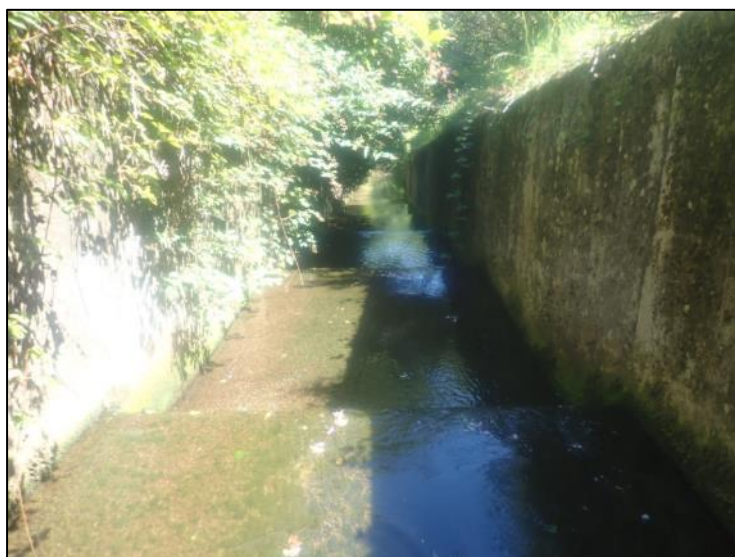


Figure 23: Stepped concrete channel to the rear of Poplar Road (captured by RCT's Flood Risk Management team post event)

The Nant Corrwg watercourse is culverted beneath the A470 and outfalls below the highway, adjacent to Hawthorn Crescent (Figure 24, left). An unnamed ordinary watercourse to the east of the Nant Corrwg is also culverted beneath the A470 and discharges into the Nant Corrwg below the highway (Figure 24, right), before merging into the Nant Lonydd watercourse.



Figure 24: Nant Corrwg culvert outfall (left) and an unnamed ordinary watercourse culvert outfall (right) below the A470 (captured by RCT's Flood Risk Management team post event)

The channel to the rear of Hawthorn Crescent is relatively shallow and was also observed to be heavily silted during the assessment. These deposits are considered to have primarily originated from Rhydyfelin's upper catchment and transported downstream. Figure 25 depicts the deposition of silt and stone within the Nant Lonydd, to the rear of Hawthorn Crescent. A fallen tree was also identified within the channel however this is not considered to have significantly contributed to the overtopping of the Nant Lonydd.

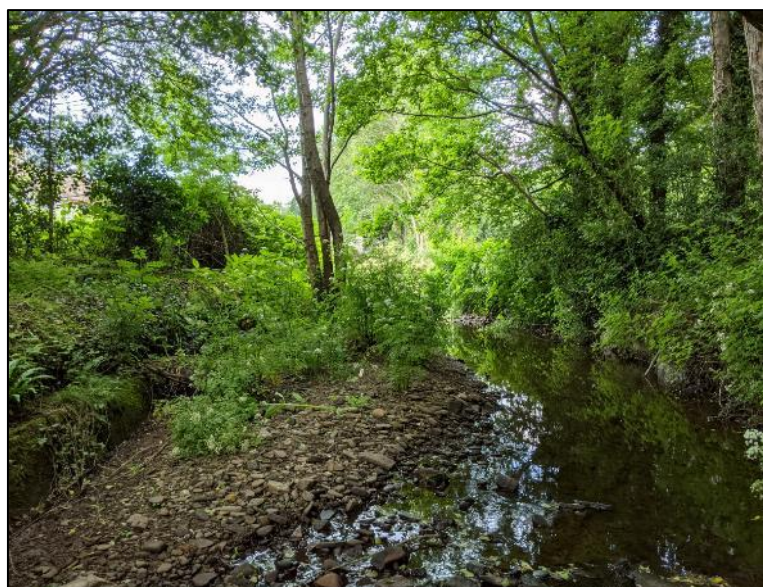


Figure 25: Significant build-up of debris and silt deposits within the Nant Lonydd ordinary watercourse to the rear of Hawthorn Crescent (image provided by RCT during post event inspections)

Based on observations made during post event inspections of the channel, the area behind Hawthorn Crescent is considered to have been more susceptible to the overtopping of the Nant Lonydd during Storm Dennis due to the shallow and heavily silted channel bed, in addition to the relatively low height of the privately owned retaining wall which bounds the western embankment of the Nant Lonydd.

It was also identified by residents and on-site inspectors that the retaining wall to the rear of Hawthorn Crescent was badly damaged as a result of the overtopping of the Nant Lonydd. Sections of scour along the concrete and masonry structures were identified during post event inspections, indicative of the forceful and erosive flows within the Nant Lonydd watercourse during Storm Dennis. Figure 26 depicts a section of damaged retaining wall to the rear of the impacted properties. The retaining wall falls on unregistered land and is identified as a privately owned structure.



Figure 26: View of damaged channel retaining wall to the rear of Hawthorn Crescent looking upstream (captured by Edwards Diving Services post storm event)

The poor condition of the retaining wall is considered to have contributed to the flooding of 9 properties at Hawthorn Crescent during Storm Dennis however, it is considered that the Nant Lonydd watercourse exceeded its usual capacity as a result of intense rainfall and associated ordinary watercourse flows from the upper catchment during the storm event. The overtopping resulted in more severe flooding

impacts at Hawthorn Crescent, but also resulted in external flooding to several rear gardens along the channel length.

Towards the downstream section of the Nant Lonydd watercourse the channel was observed to have overtopped the concrete channel walls and impacted 4 residential properties at Cardiff Road. Below the A4054 (Cardiff Road) the Nant Lonydd watercourse also overtopped at Melin Corrwg Business Park and surcharged at the culvert outlet shown in Figure 27, resulting in internal flooding to 4 commercial properties and significant flooding to the highway.



Figure 27: Nant Lonydd culvert outfall below the A4054 (Cardiff Road) which was identified as surcharging during Storm Dennis (image captured by RCT officers post event)

According to the inspecting officer during Storm Dennis, the Nant Lonydd overtopped at this location primarily due to the main River Taf backing up flow upstream of the confluence of the Nant Lonydd and River Taf. Significant flood depths were recorded within the Business Park in addition to thick mud and silt deposits along the channel embankments and the highway network as a result of the overtopping (Figure 28).



Figure 28: Mud and silt deposited adjacent to Melin Corrwg Business Park as a result of the Nant Lonydd ordinary watercourse overtopping (captured by RCT's Flood Risk Management team on 17th February 2020)

The backing up of the River Taf upstream is not considered to have significantly impacted the overtopping of the Nant Lonydd watercourse at Hawthorn Crescent due to its relative distance from the confluence, however, the River Taf is considered to have significantly influenced the overtopping of the Nant Lonydd watercourse at Melin Corrwg Business Park and the A4054 (Cardiff Road). The River Taf is also considered to have influenced the overtopping of the unnamed ordinary watercourse channel at Upper Boat Recreation Park which contributed to the internal flooding of one commercial property along Cardiff Road.

3.3. MAIN RIVER

The designated main River Taf flows west to east to the south of the investigation area (Figure 18). The river levels on the River Taf are considered to have influenced the overtopping of the Nant Lonydd ordinary watercourse, resulting in internal flooding to 4 residential and 4 commercial properties along the A4054 (Cardiff Road).

3.3.1. MAIN RIVER LEVELS AND FLOOD WARNINGS

The hydrograph in Figure 29 illustrates the significant rise in the River Taf's levels in response to rainfall between the 14 – 17th February 2020. River level data was captured at NRW's Upper Boat station, located approximately 0.5 km downstream of RCT15.

NRW issued a 'Flood Alert' (indicating possible flooding) for the entirety of the River Taf at approximately 13:30 on the 15th of February; at which point the main river was over 2 metres in depth and continuing to rise at Upper Boat station. At approximately midnight on the 16th of February the River Taf began to rise again, reaching a peak level of 5.49 metres at 06:00 on 16th February; the highest level recorded for the River Taf at Upper Boat since 2001.

The green bar displayed on the hydrograph shows the typical level of the River Taf at the Upper Boat station, ranging between 0.2 and 1.2 metres. The river level was above this green line for over 48 hours, highlighting the severity of the storm event and its unprecedented nature. At its peak, the River Taf at Upper Boat was over four metres higher than its average level.

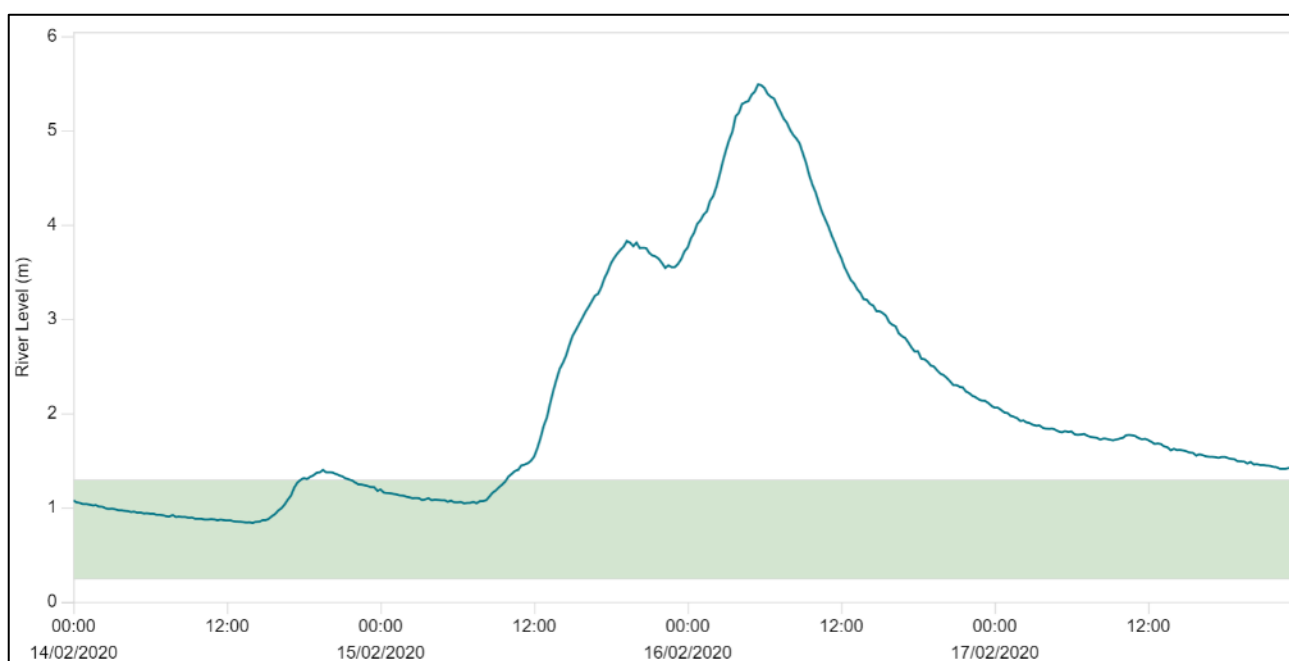


Figure 29: The River Taf levels at Upper Boat station between the 14th and 17th February 2020 (Natural Resources Wales)

Investigation area RCT15 falls partially within NRW’s Hawthorn and Rhydyfelin Flood Warning Area. The Flood Warnings issued by NRW, and associated river levels at Upper Boat gauging station (i.e., nearest gauging station to RCT15), for the River Taf at investigation area RCT15 during Storm Dennis are shown in Table 3.

Table 3: Flood Warnings issued by NRW for the River Taf at RCT15 during Storm Dennis

Flood Warning Type	Location	Start Time	River Level (m) at Upper Boat
Flood Alert	River Taf	13:27 15/02/2020	2.24
Flood Warning	River Taf at Hawthorn and Rhydyfelin	04:00 16/02/2020	5.188

NRW issued a ‘Flood Warning’ alert (indicating flooding is expected) for the River Taf at Hawthorn and Rhydyfelin at 04:00 on the 16th of February; at which point the main river was over 5.1 metres in depth. Based on the available evidence, flooding to properties within Melin Corrwg Business Park had already commenced. This flooding is considered to have conveyed from the Nant Lonydd ordinary watercourse which was influenced by the river levels on the River Taf backing up flow upstream.

NRW have acknowledged within their 'Flood Incidence Response Review'³ that "the operation of the Flood Warning Service came under significant pressure during February and at times became overwhelmed", resulting in flood warnings being issued late (after the onset of flooding) or not issued at all. At this location (RCT15), this is in reference to the 'Flood Warning' alert for the River Taf at Hawthorn and Rhydyfelin.

Improvements to their flood forecasting and warning services are being internally investigated by NRW and where feasible implemented to deliver the recommendations outlined within their Flood Incident Response Review³.

3.3.2. MAIN RIVER FLOOD RISK

As outlined in Section 2, river levels on the River Taf are considered to have influenced the Nant Lonydd ordinary watercourse, a tributary to the River Taf, to overtop due to a 'backing up' effect of flow, resulting in internal flooding to 4 commercial properties at Melin Corrwg Park and contributing to the flooding of 4 residential properties along the A4054 (Cardiff Road).

The flood risk presented by the River Taf at RCT15 is illustrated within Figure 30; an excerpt from NRW's Flood Risk Assessment Wales (FRAW) mapping exercise which depicts the main river flood risk extents for the 'Defended' scenario, i.e., with the presence of flood defence assets. The darker shading identifies areas at higher risk of flooding (more frequent/less extreme rainfall events) and lighter shading showing the lower risk areas (less frequent/more extreme rainfall events).

A high risk of flooding means that an area has a chance of flooding of greater than 1 in 30 (3.3%) each year; a medium risk of flooding signifies a yearly chance of flooding between 1 in 100 (1%) and 1 in 30 (3.3%); meanwhile a low risk of flooding means that an area has a chance of flooding of between 1 in 1000 (0.1%) and 1 in 100 (1%) each year.

³ [February 2020 Floods in Wales: Flood Incident Management Review \(cyfoethnaturiol.cymru\)](https://www.cyfoethnaturiol.cymru/)



Figure 30: Natural Resources Wales' Flood Risk Assessment Wales (FRAW) map for River sources at RCT15. Contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved.

The FRAW map (Figure 30) depicts a high to low main river flood risk within the Nant Lonydd ordinary watercourse. The flooding that occurred within the Hawthorn area of RCT15 during Storm Dennis is largely consistent with the modelled outputs of NRW's FRAW map (Figure 30), with the affected commercial properties at Melin Corrwg Business Park falling within an area of high main river flood risk, associated to its close proximity to the confluence between the Nant Lonydd ordinary watercourse and the River Taf. The impacted residential properties situated upstream of the A4054 fall within an area of low main river flood risk.

On review of the FRAW maps for main river flooding, it is considered that the high river levels on the River Taf influenced the overtopping of the Nant Lonydd ordinary watercourse by causing a backing up of flow upstream. NRW's Flood Hazard map does in fact indicate that in a high-risk flood event, main river flow is identified to flow upstream of the Nant Lonydd watercourse. The indicative flow direction is illustrated in NRW's Flood Hazard Map for velocity in Figure 31.

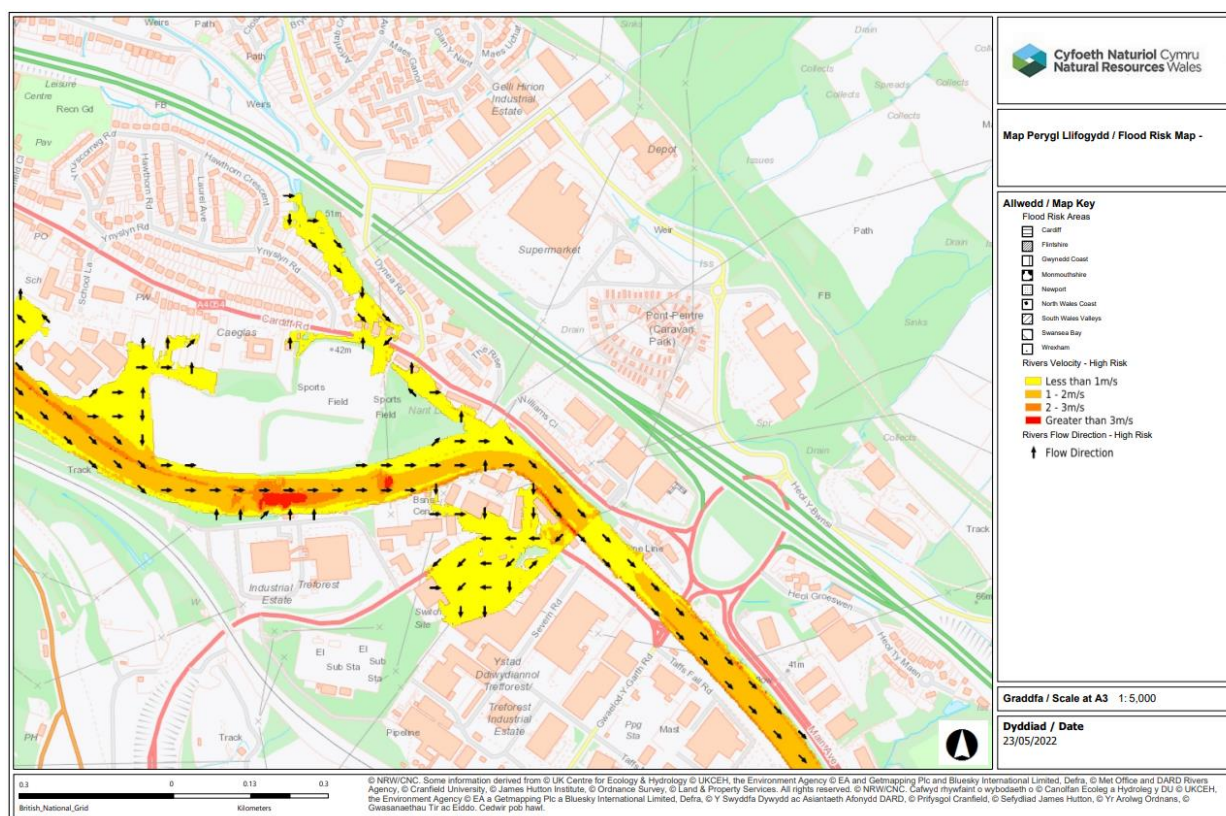


Figure 31: NRW's Flood Hazard map for High Risk River Flood Velocity and flow direction in the Hawthorn area. Contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved.

Upon post event inspections, the investigating officer identified evidence of debris and wrack marks along the highway to suggest that the outlet of the Nant Lonydd ordinary watercourse, which conveys under the A4054 (Cardiff Road), surcharged during the storm event. Flooding at the outlet is further evidence that the Nant Lonydd was being influenced by the high river levels on the River Taf during Storm Dennis.

3.3.3. MAIN RIVER FLOOD DEFENCES

As illustrated in Figure 32 (demarcated by a bold red line), there are approximately 800 metres of formally designated flood defence infrastructure along the northern banks of the River Taf, located upstream of the confluence with the Nant Lonydd ordinary watercourse. This infrastructure is operated and maintained by NRW.

There are no formal flood defences under the operation and maintenance of NRW in the area near the confluence of the Nant Lonydd watercourse and the River Taf, and the properties identified at high risk of main river flooding within Melin Corrwg Business Park do not fall within an area benefitting from flood defences, as depicted in Figure 32.

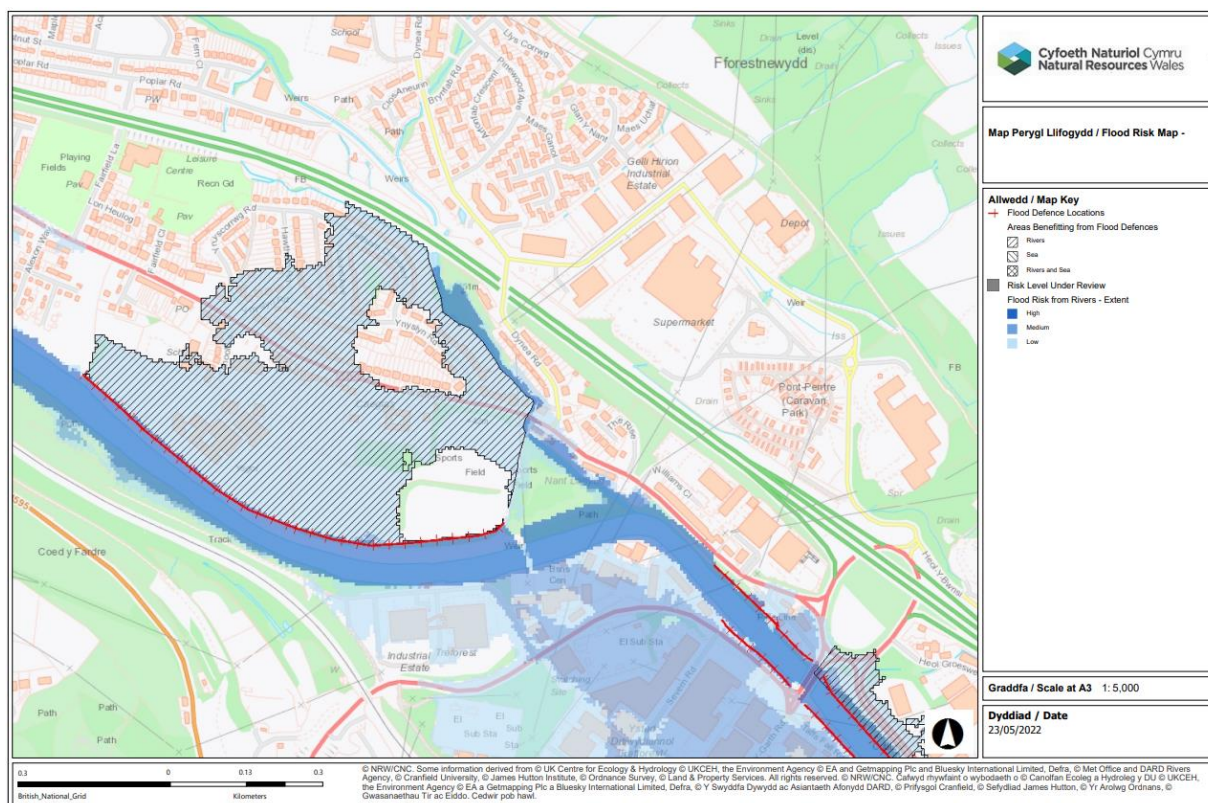


Figure 32: Natural Resources Wales' map for Main River flood defences and areas benefiting at RCT15. Contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved.

3.4. HIGHWAY DRAINAGE CONDITION

Surface water runoff along the highway was reported by residents at various locations within the investigation area during Storm Dennis, however, there is no evidence to suggest that the condition of the highway drainage within RCT15 significantly contributed to the flooding of properties. The highway drainage infrastructure was overwhelmed by intense rainfall and subsequent surface water flows, in addition to ordinary watercourse flooding associated to culvert infrastructure surcharging, which led to the accumulation of standing water entering properties within the lower reaches of the investigation area.

Overland flows from areas of hillside, runoff originating from surcharged culvert infrastructure, and the overtopping of the Nant Lonydd influenced by the River Taf, resulted in deposition of mud, silt and debris across several streets which is assumed to have entered the highway drainage network via gullies. In these instances, it is likely that highway drainage assets will have had a limited capacity to intercept flows within the investigation area.

Highway drainage is not designed to manage overland flows from private areas, parks or open space. In this instance, the capacity of the highway drainage was exceeded by the substantial surface water flows entering the drainage network across RCT15. Given the severity of the storm, the maintenance condition of the highway surface water drainage system is not considered to have significantly impacted on the flooding experienced within RCT15.

3.5. DCWW APPARATUS

There is no evidence from this investigation that DCWW apparatus contributed to the flooding that occurred during Storm Dennis within investigation area RCT15.

DCWW reported no issues within RCT15 during Storm Dennis and it is not believed that any DCWW infrastructure was damaged during the storm event. Whilst DCWW have concluded that their assets were working and operating as designed during Storm Dennis, the majority of drainage infrastructure within the investigation area is comprised of combined sewer networks which are likely to have become overwhelmed during the storm event for the reasons outlines in Section 3.4.

3.6. SURFACE WATER

Surface water flooding as a result of ordinary watercourse flooding associated to blocked, damaged and overwhelmed culvert infrastructure, in addition to overland flows originating from areas of hillside, has been determined as a contributing source of flooding to several residential and non-residential properties within the lower reaches of RCT15, particularly along Wordsworth Gardens, Dynea Road and Cardiff Road, where water naturally accumulates. This is highlighted in Figure 33 which depicts the surface water and ordinary watercourse flood extents based on NRW's FRAW mapping exercise.

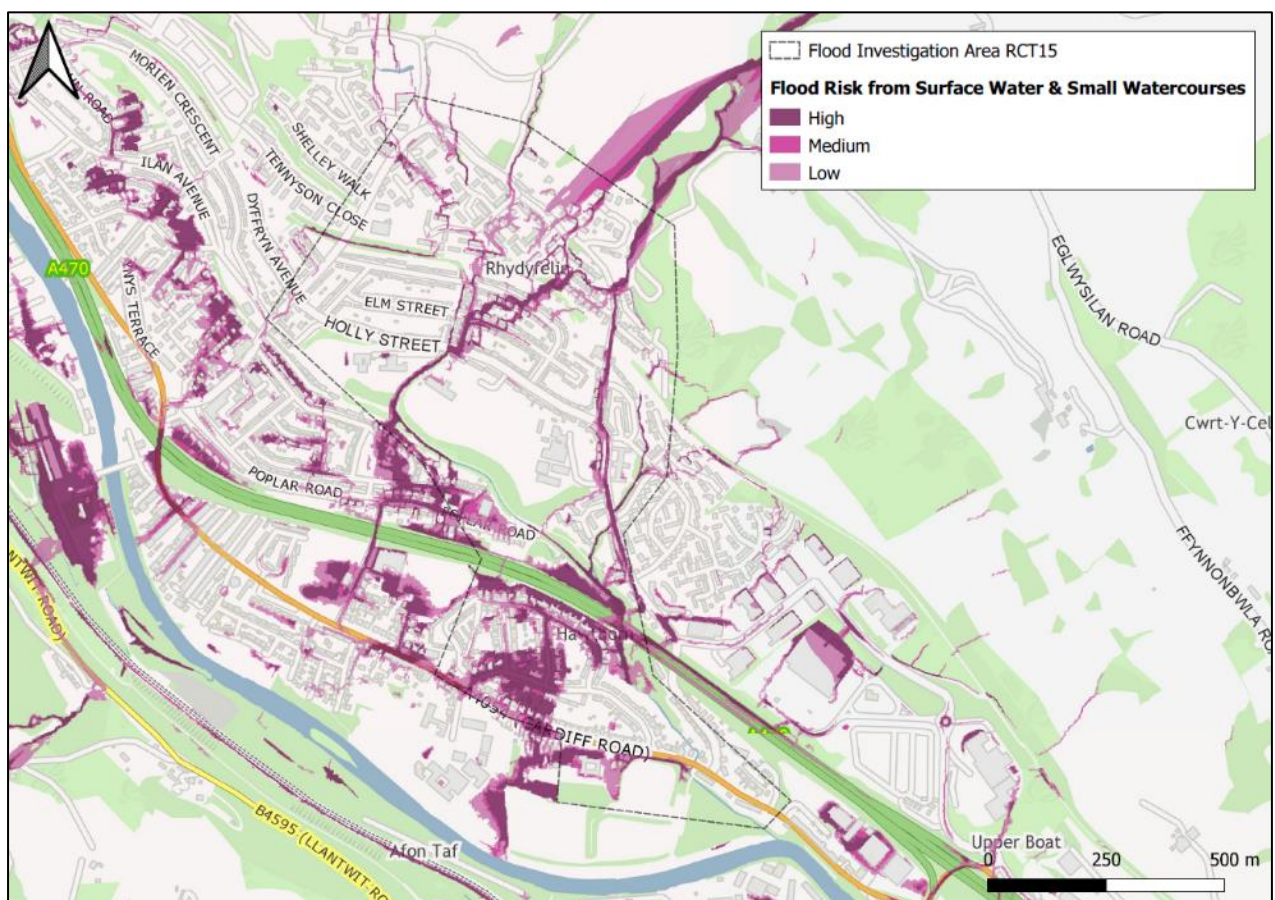


Figure 33: Natural Resources Wales' FRAW map for surface water and ordinary watercourse sources within investigation area RCT15. Contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved.

The pathways for surface water runoff during the storm event was observed primarily along the highway network, but also as overland flows originating from areas of hillside within the investigation area. Indicative surface water and ordinary watercourse flow

paths observed during the storm event have previously been illustrated in Figures 5 and 9.

The volume of water conveying to these low points within RCT15 during Storm Dennis would have been unable to drain away via the surface water drainage systems, resulting in surface water accumulation on the highway which entered several properties. Blockages to the highway drainage infrastructure caused by mobilised debris is also considered to have exacerbated the surface water flooding observed across RCT15.

Figure 33 also notes no flood risk from surface water and ordinary watercourse sources along the lower extent of the Nant Lonydd ordinary watercourse, further reinforcing that the impacted properties at Cardiff Road and Melin Corrwg Business Park were influenced by flooding associated with high river levels on the River Taf backing up flow upstream of the Nant Lonydd.

3.7. ACCESS STRUCTURES

No access structures were identified during the asset investigations within the area, as such 'access structures' have not been considered within this report.

3.8. SYSTEM AT CAPACITY

The capacity of the culverted ordinary watercourse structures identified as sources of flooding at RCT15 during Storm Dennis have been described below.

The culvert networks within the investigation area (Figure 15) were surveyed post event to ascertain the internal condition of the networks, the results of which fed into a review of the hydraulic performance of the network to ascertain its current standard of protection using Causeway Flow modelling. The results of the culvert inlet capacity assessments are summarised in the Table below (refer to Figure 15 for culvert labels)

Table 4: Summary of culvert capacity assessment results which indicate the current standard of protection of the culverted networks in free flowing and blockage conditions within RCT15

Culvert Network	Standard of Protection (SOP) – Free Flowing	Standard of Protection (SOP) – Blockage Conditions
Culvert Inlet 1	Q100 (1% AEP)	>Q100 (>1% AEP)
Culvert Inlet 2	Q100 (1% AEP)	>Q100 (>1% AEP)
Culvert Inlet 3	Q100 (1% AEP)	Q50 (2% AEP)

The results from the culvert capacity assessments and hydraulic modelling undertaken by RCT, infer that all three culvert inlets provide adequate standards of protection in free-flowing conditions up to 1 in 100 annual probability flood event (Q100) plus 30% climate change allowance. This is in accordance with current design standards, as defined by CIRIA C786.

A sensitivity analysis was undertaken to review the impact of flooding during ‘medium’ (67%) blockage conditions⁴ to assess the impact of debris blockages. In blockage conditions, the capacity of all three culvert inlets is reduced to below Q100. On review of the condition of all three culvert inlets post storm event, it was also concluded that the total blockage percentage on the structures was greater than 67%, further reducing the capacity of the culvert inlets to manage the flow of water, which would account for the surcharging at all three locations.

⁴ Natural Resources Wales Guidance Note (Ref No GN43)

3.9. SUMMARY OF POSSIBLE CAUSES

The above sections have identified and described the possible causes of flooding within investigation area RCT15 during Storm Dennis which occurred on the 15 and 16th February 2020. A summary of the identified source(s) and possible cause(s) of flooding (issue) has been outlined below in Table 5.

Table 5: Summary of source(s) and possible cause(s) of flooding in RCT15 during Storm Dennis (15-16th February 2020)

Ref No	Asset (Source)	Issue	Asset Owner	Type of Flooding
1	Culvert Inlet 1	The culvert inlet surcharged during the storm event after becoming blocked with debris mobilised from the ordinary watercourse upstream, causing water to overtop at the inlet and flow south towards Wordsworth Gardens, resulting in flooding to 14 residential properties.	RCT Highway Authority	Ordinary Watercourse
2	Culvert Inlet 2	The culvert inlet surcharged during the storm event after becoming blocked with debris mobilised from the ordinary watercourse upstream, causing water to overtop at the inlet and flow towards Masefield Way and contribute to the flooding at Wordsworth Gardens.	RCT Highway Authority	Ordinary Watercourse
3	Culvert Inlet 3	The culvert inlet surcharged during the storm event after becoming blocked with debris mobilised from the ordinary watercourse upstream, causing water to overtop at the inlet and flow south along Dynea Road.	RCT Highway Authority	Ordinary Watercourse
4	Nant Lonydd Ordinary Watercourse	Unprecedentedly high levels within the Nant Lonydd ordinary watercourse resulted in the watercourse overtopping its banks at several locations, in addition	Private Landowner(s)	Ordinary Watercourse

		to breaching through sections of retaining wall, and conveying into the rear of 12 residential properties and 4 commercial properties.		
5	River Taf	Unprecedentedly high river levels on the River Taf resulted in the main river flowing upstream the Nant Lonydd ordinary watercourse tributary, contributing to the overtopping of the downstream section of watercourse which resulted in flooding to 4 residential properties and 5 commercial properties along Cardiff Road.	Mixed Ownership	Ordinary Watercourse
6	Surface water drainage network across RCT15	Intense rainfall across RCT, combined with the overtopping of several ordinary watercourses within RCT15, severely overwhelmed highway drainage infrastructure, resulting in the accumulation of surface water on many streets throughout the investigation area.	RCT Highway Authority	Surface Water

4. RISK MANAGEMENT AUTHORITY ACTIONS

A Welsh Risk Management Authority is defined in Section 6 of the Flood and Water Management Act 2010 as NRW; a LLFA, a district council for an area where there is no unitary authority, or a highway authority wholly in Wales; an internal drainage board for an internal drainage district that is wholly or mainly in Wales; a water company that exercises functions in relation to an area in Wales. As the LLFA, RCT has the responsibility to coordinate the management of flood risk and the interaction of Risk Management Authorities across Rhondda Cynon Taf.

An overview of the relevant Risk Management Authority in relation to flood type is provided in Table 5. For further details of the roles and responsibilities of individual Risk Management Authorities in managing flooding, refer to Welsh Government's National Strategy for Flood and Coastal Erosion Risk Management, Section 4 'Roles and Responsibilities'⁵, and RCT's 'FRM – Storm Dennis - Overview Report'**Error! Bookmark not defined.**

Table 6: Risk Management Authority with relevant functions to manage the risk for different flood types

Type of Flooding	Relevant Risk Management Authority
Flooding from Main River, reservoirs and the sea (including coastal erosion).	Natural Resources Wales
Flooding from ordinary watercourses, surface water and groundwater	Lead Local Flood Authority
Flooding from water and sewage systems	Water Companies (Dŵr Cymru Welsh Water)
Flooding from the highway	Highway Authority
Flooding from the highway (motorways and major trunk roads)	Welsh Government Trunk Road Agency

Risk Management Authorities have direct flood risk management functions under the Flood and Water Management Act 2010, as well as the Water Resources Act 1991, Land Drainage Act 1991 and the Highways Act 1980. Through analysis of the flooding that impacted RCT03, the flood risk management functions exercised, or proposed to be exercised, by relevant RMAs was recorded pursuant to Section 19 of the Flood and Water Management Act 2010, which states;

⁵ [National Strategy for Flood and Coastal Erosion Risk Management in Wales \(English\) \(gov.wales\)](#)

“On becoming aware of a flood in its area, a lead local flood authority must, to the extent that it considers it necessary or appropriate, investigate:

- a) Which risk management authorities have relevant flood risk management functions and,
- b) Whether each of those risk management authorities has exercised, or is proposing to exercise, those functions in the response to the flood.”

Through the investigation process, the source(s) and possible cause(s) of flooding in investigation area RCT15 as a result of Storm Dennis has been previously identified and summarised within Table 5. The Risk Management Authorities responsible for managing that flooding have been listed within Table 7 below, along with a series of recommendations presented by the LLFA.

Table 7: Recommendations provided by the LLFA to be considered by the relevant Risk Management Authority identified in response to the source(s) of flooding in RCT15 (as per Table 5)

Ref No	Asset (Source)	Asset Owner	Type of Flooding	Relevant Risk Management Authority	Recommendations	
1	Culvert Inlet 1	RCT Highway Authority	Ordinary Watercourse	Lead Local Flood Authority and Land Drainage Authority	R1A	The LLFA and LDA to identify asset ownership and responsibility.
					R1B	The LLFA and LDA to investigate the standard of protection and the condition of the culvert structure and network as a whole.
					R1C	Jet and cleanse the ordinary watercourse network.

					R1D	The LLFA and LDA to review the risk of scour potential within the ordinary watercourse channel.
					R1E	The LLFA to install remote telemetry monitoring at Culvert Inlet 1 to monitor the risk of blockage.
2	Culvert Inlet 2	RCT Highway Authority	Ordinary Watercourse	Lead Local Flood Authority and Land Drainage Authority	R2A	The LLFA and LDA to identify asset ownership and responsibility.
					R2B	The LLFA and LDA to investigate the standard of protection and the condition of the culvert structure and network as a whole.
					R2C	Jet and cleanse the ordinary watercourse network.
					R2D	The LLFA and LDA to review the risk of scour potential within the ordinary watercourse channel.

					R2E	The LLFA to install remote telemetry monitoring at Culvert Inlet 2 to monitor the risk of blockage.
3	Culvert Inlet 3	RCT Highway Authority	Ordinary Watercourse	Lead Local Flood Authority and Land Drainage Authority	R3A	The LLFA and LDA to identify asset ownership and responsibility.
					R3B	The LLFA and LDA to investigate the standard of protection and the condition of the culvert structure and network as a whole.
					R3C	Jet and cleanse the ordinary watercourse network.
					R3D	The LLFA and LDA to review the risk of scour potential within the ordinary watercourse channel.
4	Nant Lonydd Ordinary Watercourse	Private Landowner(s)	Ordinary Watercourse	Lead Local Flood Authority and Land	R4A	The LLFA and LDA to identify drainage asset ownership and responsibility.

				Drainage Authority	R4B	The LLFA and LDA to investigate and assess the condition of the ordinary watercourse.
					R4C	The LLFA and LDA to work with landowners to identify suitable management methods to reduce the risk of ordinary watercourse flooding to properties.
5	River Taf	Mixed Ownership	Ordinary Watercourse	Lead Local Flood Authority and Land Drainage Authority	R5A	The LLFA and LDA to engage with NRW to work collaboratively to manage the flood risk caused by the influence of the River Taf upon the Nant Lonydd ordinary watercourse.
6	Surface water drainage network	RCT Highway Authority	Surface Water	Lead Local Flood Authority and Highway Authority	R6A	The Highway Authority to jet and cleanse the highway drainage network and action repairs accordingly.

					R6B	The LLFA and Highway Authority to evaluate surface water management options to alleviate pluvial flooding at locations across the investigation area.
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4.1. LEAD LOCAL FLOOD AUTHORITY

In review of Ref 1 – 6 in Table 7, the LLFA has been determined as a relevant Risk Management Authority in relation to the ordinary watercourse and surface water flooding which occurred at investigation area RCT15 during Storm Dennis.

The LLFA exercised the following functions in response to the flooding at investigation area RCT15:

- Officers investigated the initial flooding and have produced this report in line with Section 19 of the Flood and Water Management Act 2010.
- Officers contacted residents affected by flooding to offer support and advice to assist in the recovery following the event.
- A public engagement exercise carried out by Redstart, on behalf of RCTCBC as the LLFA, was undertaken in order to gain further local insight and anecdotal evidence to support the flood investigation.
- The LLFA and LDA have exercised their permissive powers under Section 64 of the Land Drainage Act 1991 to investigate the culvert structures and network condition and its impact on the flooding within the investigation area. **(R1B, R2B, R3B)**
- An estimated 1539 metres of culverted ordinary watercourse network length within RCT15 has been surveyed following the event to ascertain both the operational condition of the network, and its structural integrity along section of the network. **(R1B, R2B)**
- An estimated 35.5 tonnes of material and debris was removed from the culvert inlet structures and networks within RCT15 during jetting and cleansing operations. **(R1C, R2C)**
- The LLFA and LDA have undertaken clearance works to the culvert network systems which fall under the responsibility of the Authority. **(R1C, R2C, R3C)**
- The LLFA commissioned Redstart to investigate the standard of protection of the existing culvert networks in RCT15 to determine their hydraulic capacity following the identification of several structural and operational defects within sections of the network. **(R1B, R2B)**
- The LLFA has set up a central Control Room, to compliment the Council's Contact Centre and CCTV centre which is based at the Council's offices, to provide a comprehensive and informed response to the residents of RCT as appropriate during storm events.

- The LLFA have initiated an interim Property Flood Resistance project offering expandable flood gates to those properties deemed at high risk of flooding from local sources.
- The LLFA and LDA have initiated engagement with riparian landowners to ensure the ordinary watercourse infrastructure is free flowing and unobstructed.
- In review of Ref 4, the LLFA undertook a walkover assessment of the Nant Lonydd ordinary watercourse to assess the condition of the channel which was observed to have overtopped at several locations during the storm event. **(R4B)**
- In response to the damages caused by the overtopping of the Nant Lonydd watercourse, the LLFA commissioned Redstart to undertake a survey and principal inspection of the retaining wall at Hawthorn Crescent to ascertain the level of damage and to determine appropriate repair proposals. **(R4C)**
- The LLFA have carried out repairs to the retaining wall to the rear of Hawthorn Crescent which will minimise the risk of ordinary watercourse flooding to properties in the area. The works include the re-profiling of the channel, removal of silt and debris, anti-scour matting and repairs to the retaining wall and rock armour. **(R4C)**
- The LLFA have installed remote telemetry monitoring devices at key culvert structures to enable operators to ensure the drainage systems in Rhydyfelin are operating effectively. **(R1E, R2E)**

The LLFA propose to exercise the following functions in response to the flooding at investigation area RCT15:

- Following the surveying of culvert network in RCT15, the LLFA propose to input and update all relevant asset data. **(R1A, R2A, R3A, R4A)**
- The LLFA and LDA intend to communicate with drainage asset owners and management responsibilities to make them aware of their personal risk. To ensure landowners manage the risk in compliance with the relevant legislation, a team of Flood Enforcement Officers including legal support is to be appointed.
- The LLFA and LDA will work with landowners and property owners to manage their personal flood risk through local measures, such as property resilience and resistance measures.
- The LLFA and LDA will continue to engage with riparian landowners and regulate the ordinary watercourse infrastructure to ensure the infrastructure is free flowing and unobstructed.

- The LLFA will develop a Strategic Outline Business Case to better understand the risk of flooding using a whole catchment approach to provide recommendations for suitable management mechanisms to reduce the wider risk of flooding to people and properties from local sources (Ordinary Watercourse, Surface Water and Groundwater).
- As part of RCT's comprehensive review of the County Borough's most at risk communities, the LLFA are proposing to undertake a formal SFRA of the Lower Taf catchment area to better understand the overall risk from ordinary watercourse and surface water flooding in order to target investment to areas of highest risk. The SFRAs also aim to encourage whole catchment measures, including working with natural processes, to alleviate flood risk in those areas of highest risk. **(R1D, R2D, R3D, R4C, R6B)**
- The LLFA and LDA propose to undertake Geomorphological assessments of the upper catchments in Rhydyfelin to determine the risk of culvert blockages as a result of scour and debris potential. In addition to this, the LLFA and LDA will engage with riparian landowners to identify suitable management methods to reduce the risk of scour within the ordinary watercourses. **(R1D, R2D, R3D)**
- In response to the mobilisation of debris from Rhydyfelin's upper catchment, the LLFA have secured grant funding from the Welsh Government to install an additional debris basin and overflow structure upstream of 'Culvert Inlet 2', to minimise the risk of debris mobilisation and to alleviate the peak flows entering the network.
- The LLFA and LDA will engage with NRW to work collaboratively to manage the flood risk caused by the influence of the River Taf upon the Nant Lonydd ordinary watercourse. **(R5A)**

4.2. NATURAL RESOURCES WALES

Natural Resources Wales were not directly identified as a relevant Risk Management Authority in relation to the flooding at investigation area RCT15 because the flood type was identified as primarily ordinary watercourse and surface water flooding which is the responsibility of the LLFA to manage. However, the Authority, as the LLFA and LDA, has engaged with NRW in relation to Storm Dennis, specifically regarding the influence of the River Taf (main river) on the overtopping of the Nant Lonydd ordinary watercourse.

NRW has exercised the following functions in response to the flooding at investigation area RCT15:

- NRW have carried out post event data collection including an assessment of the properties impacted by main river flooding and a survey of wrack marks, i.e., the marked high-water level.
- NRW specifically outline within their 'Flood Incident Management Review'³ that "more Severe Flood Warnings should have been issued based on the flooding impacts experienced" in the Lower Taf region. Utilising post event data and information, NRW have reviewed the Resultant Thresholds for the River Taf at Hawthorn and Rhydyfelin Flood Warning Area (FWA). This is critical for assessing the performance, timeliness and accuracy of the warning service after a flood.
- NRW has introduced improved digital services to provide comprehensive flood risk, river level and rainfall information to households, businesses and communities across Wales. The improved service was launched in September 2020 on the NRW website and will, according to NRW, improve how live flood warning and water level data is shared before and during flood events.
- NRW have commissioned a Lower Taf Flood Modelling Project which is currently ongoing. **(R5A)**
- Following the flooding events of February 2020, NRW published a review of its incident response to Storm Ciara and Dennis in October 2020⁶. This review contains several recommendations for improvements to their ways of working and services which NRW are in the process of implementing through an internal delivery programme.
- NRW have developed a detailed Implementation Programme to address the areas of improvement work required to deliver the recommendations of the

⁶ [Natural Resources Wales / Our response to Storm Ciara and Storm Dennis](#)

Flood Warning Service Review carried out by NRW in 2018. Several of the recommendations directly link to the recommendations set out by NRW within their Flood Incident Management Review.

NRW propose to exercise the following functions in response to the flooding at investigation area RCT15:

- Following the completion of NRW's Lower Taf Flood Modelling Project, NRW propose to undertake an initial economic assessment of the viability of potential flood risk management options. Greatest consideration should be given to areas at high risk of flooding from rivers on a prioritised basis. **(R5A)**
- Following the completion of NRW's Lower Taf Flood Modelling Project, NRW propose further threshold work and flood warning area amendments. **(R5A)**
- NRW will undertake a review of the modelled outputs and adopt changes to their maintenance program within the investigation area if required.

4.3. WATER COMPANY

DCWW were not identified as a relevant authority in relation to the flooding at investigation area RCT15 during Storm Dennis. Furthermore, the authority does not propose to undertake any functions in relation to the event.

4.4. HIGHWAY AUTHORITY

During the investigation into the flooding at investigation area RCT15 during Storm Dennis, the Highway was identified as flooding as a result of ordinary watercourse and surface water flooding associated to blocked and overwhelmed culverted watercourse infrastructure.

Ref 6 of Table 7 identified the Highway Authority as a relevant Risk Management Authority in relation to the surface water flooding that occurred along the highway in the lower reaches of RCT15.

RCT as the Highway Authority have exercised the following functions in response to the flooding at investigation area RCT15:

- The Highway Authority assisted with the emergency response during the event by supplying equipment and sandbags to residential and commercial properties and by using sandbags to redirect flood water away from properties.
- The Highway Authority exercised their functions under Section 100 of the Highways Act 1980, to arrange for all gullies and open drains in the highway to be inspected and cleansed following the influx of flood water to ensure the safety of the highway post event. **(R6A)**
- The Highway Authority has undertaken emergency clearance and repair works to the culverted infrastructure identified as sources of flooding. **(R1C, R2C, R3C)**
- The Highway Authority have increased their resource capacity by establishing a dedicated 'Pluvial Drainage Team' to focus entirely on the refurbishment and maintenance of RCT's existing and enhanced highway.

RCT as the Highway Authority propose to undertake the following functions in relation to the event at investigation area RCT15:

- The Highway Authority to work with the LLFA to evaluate surface water management options to alleviate pluvial flooding at location across the investigation area. **(R6B)**

5. USEFUL LINKS/CONTACTS

Blue Pages – property Resilience - <http://bluepages.org.uk/>

Flood Re – Flooded Property Insurance Scheme - <https://www.floodre.co.uk/>

Natural Resources Wales – Check Flood Warnings - <https://naturalresources.wales/flooding/check-flood-warnings/?lang=en>

Natural Resources Wales - Long Term Flood Risk - <https://naturalresources.wales/evidence-and-data/maps/long-term-flood-risk/?lang=en>

Rhondda Cynon Taf CBC - Local Flood Risk Management Plan - <https://www.rctcbc.gov.uk/EN/Resident/ParkingRoadsandTravel/Roadspavementsandpaths/FloodAlleviation/Floodriskregulations2009.aspx>

Rhondda Cynon Taf CBC - Local Flood Risk Management Strategy - <https://www.rctcbc.gov.uk/EN/Resident/ParkingRoadsandTravel/Roadspavementsandpaths/FloodAlleviation/LocalFloodRiskManagementStrategy.aspx>

Rhondda Cynon Taf CBC – Sustainable Drainage – <https://www.rctcbc.gov.uk/EN/Resident/ParkingRoadsandTravel/Roadspavementsandpaths/SustainableDrainage/SustainableDrainage.aspx>

Welsh Government - National Strategy for Flood and Coastal Erosion Risk Management - <https://gov.wales/sites/default/files/publications/2019-03/national-strategy-for-flood-and-coastal-erosion-risk-management-in-wales.pdf>

Welsh Water – How to Contact Us – <https://www.welshwater.com/en/Contact-Us.aspx>